
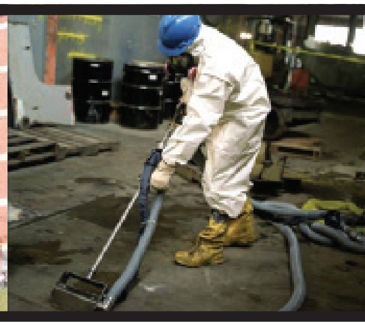

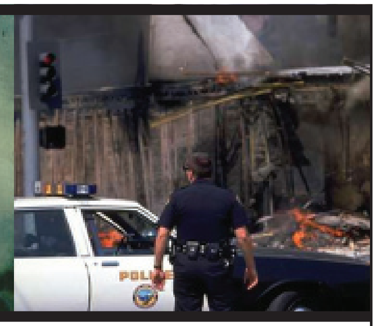

OSC Radiological Response Guidelines




United States Environmental Protection Agency

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PREFACE

It has never been more important that the U.S. Environmental Protection Agency's (EPA's) On-Scene Coordinators (OSCs) be prepared to respond to incidents involving radiological releases. The ruthlessness of the September 11 attacks, and the willingness of terrorists to sacrifice their lives to achieve their objectives, creates a new dimension in the fight against terrorism. In particular, experts are concerned that a "dirty bomb" event, in which a conventional explosive is used to disperse radioactive material, is almost certain to occur at some time. The great number of orphaned radioactive sources (i.e., sources that have fallen outside regulatory control) both within and outside the U.S. creates an increased threat of terrorist incidents involving radiological releases and increases the risk of non-terrorist incidents in which EPA must ensure that the public health is protected.

The purpose of this document is to provide EPA OSCs with up-to-date technical information on radiological emergency response that can be used as a reference and as a training tool for developing a better understanding of the potential challenges. The document contains information that may be of interest to other federal, state, and local responders, but has been designed primarily for EPA OSCs and incorporates by reference existing EPA protocols, policies, and guidance. These guidelines are intended to be a "living document" that will be updated in the future by the National Decontamination Team in EPA's Office of Emergency Management (OEM) as continued progress is made in planning for potential terrorist incidents involving radiation.

The scope of the document covers the full range of radiological incidents, but its focus is predominantly on Radiological Dispersal Devices (RDDs), because RDDs are expected to occur in urban environments and present a radiological response challenge for OSCs. Any suspected terrorist incident could involve additional hazards, such as explosive, chemical, or biological contamination. Therefore, it is considered essential that responders follow normal hazardous material response protocols until the type and severity of the incident has been fully identified.

The document focuses mainly on:

- The early and intermediate phases of a response, including early activities that should be implemented to assist or mitigate long-term cleanup
- Eight radionuclides considered to be the most likely to be encountered during a radiological response (Cesium-137, Strontium-90, Cobalt-60, Americium-241, Radium-226, Iridium-192, Plutonium-238, and Plutonium-239/240)

In responding to a radiological emergency, the OSC and other EPA responders will be integrated into the local Incident Command System (ICS) for the response. The OSC's responsibilities will be consistent with those outlined under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and the National Response Plan (NRP). It is important that OSCs understand the federal plans under which they may be operating when responding to a radiological incident. Response to a radiological terrorist incident is likely to be conducted under the NRP and will involve numerous federal agencies. Procedures and processes are provided by which the OSC can fulfill his or her responsibilities under the applicable plan(s).

ACRONYMS

ACL	Administrative Control Level
AFRAT	Air Force Radiation Assessment Team
AFRRI	Armed Forces Radiobiology Research Institute
ALARA	As Low As Reasonably Achievable
ALI	Annual Limit on Intake
^{241}Am	Americium-241
AMS	Aerial Measuring System
ARAC	Atmospheric Release Advisory Capability
ARARs	Applicable or Relevant and Appropriate Requirements
ARG	Accident Response Group
ARL	Action Reference Level
BOAs	Basic Order Agreements
CBIRF	Chemical Biological Incident Response Force
CBRNE	Chemical, Biological, Radiological, Nuclear, or High Yield Explosive
CDC	Centers for Disease Control and Prevention
^{137}Cs	Cesium-137
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMAT	Consequence Management Advisory Team
CMRT	Consequence Management Response Team
^{60}Co	Cobalt-60
CONPLAN	Concept of Operations Plan
CPM	Counts per Minute
CRI	Center for Radiation Information
CZT	Cadmium/Zinc/Telluride
DEST	Domestic Emergency Support Team
DHS	Department of Homeland Security
DoD	Department of Defense
DOE	Department of Energy
DOELAP	Department of Energy Laboratory Accreditation Program
DOJ	Department of Justice
DOT	Department of Transportation
DPM	Disintegrations per Minute
DSCA	Defense Support for Civil Authorities
DTPA	Diethylenetriaminepentaacetic Acid
ECOT	Emergency Communications and Outreach Team
EDTA	Ethylenediamintetraacetic Acid
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
ERT	Environmental Response Team
ESF	Emergency Support Function
FBI	Federal Bureau of Investigation
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency

FRMAC	Federal Radiological Monitoring and Assessment Center
FRP	Federal Response Plan
GIS	Geographic Information System
GPHS	General Purpose Heat Source
GPS	Global Positioning System
HASP	Health and Safety Plan
HMRU	Hazardous Materials Response Unit
HRT	Health Response Team
HHS	Department of Health and Human Services
HPGe	High Purity Germanium Detector
HRS	Hazard Ranking System
IAC	Incident Advisory Council
IAEA	International Atomic Energy Agency
IAP	Incident Action Plan
IC	Incident Commander
ICP	Incident Command Post
ICS	Incident Command System
ICSD	Ionization Chamber Smoke Detectors
IDLH	Immediately Dangerous to Life or Health
IMAAC	Interagency Modeling and Atmospheric Assessment Center
IND	Improvised Nuclear Device
INS	Incident of National Significance
IO	Information Officer
^{192}Ir	Iridium-192
JFO	Joint Field Office
JIC	Joint Information Center
JNACC	Joint Nuclear Accident Coordinating Center
JOC	Joint Operations Center
JTF-CS	Joint Task Force Civil Support
KI	Potassium Iodide
MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	Minimum Detectable Activity
MOA	Memorandum of Agreement
MRAT	Medical Radiobiology Advisory Team
MRE	Meal Ready to Eat
NBC	Nuclear, Biological, Chemical
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEST	Nuclear Emergency Support Team
NIMS	National Incident Management System
NIRT	Nuclear Incident Response Team
NNSA	National Nuclear Security Administration
NPL	National Priorities List
NRC	National Response Center
NRC	Nuclear Regulatory Commission

NRP	National Response Plan
NVLAP	National Voluntary Laboratory Accreditation Program
OAR	Office of Air and Radiation
OEM	Office of Emergency Management
OPA	Oil Pollution Act
ORIA	Office of Radiation and Indoor Air
OSC	On-Scene Coordinator
OSHA	Occupational Safety and Health Administration
OSRTI	Office of Superfund Remediation and Technology Innovation
OSWER	Office of Solid Waste and Emergency Response
PA	Preliminary Assessment
PAGs	Protective Action Guides
PEL	Permissible Exposure Limits
PIAT	Public Information Assist Team
PIC	Pressurized Ion Chamber
PIO	Public Information Officer
^{214}Po	Radium-C
PPE	Personal Protective Equipment
^{238}Pu	Plutonium-238
$^{239/240}Pu$	Plutonium-239/240
QSGs	Quick Start Guides
^{226}Ra	Radium-226
RAMT	Radiological Advisory Medical Team
RAP	Radiological Assistance Program
RCRA	Resource Conservation and Recovery Act
RDD	Radiological Dispersal Device
REAC/TS	Radiation Emergency Assistance Center/Training Site
RED	Radiological Exposure Device
RERT	Radiological Emergency Response Team
RRSF	Radiological Response Survey Form
RSO	Regional Safety Officer
RTG	Radioisotope Thermoelectric Generator
SAC	Special Agent in Charge
SCBA	Self-Contained Breathing Apparatus
SHEM	Safety, Health, and Environmental Management
SHEMP	Safety, Health, and Environmental Management Program
SOG	Standard Operating Guidance
SOP	Standard Operating Procedure
^{90}Sr	Strontium-90
START	Superfund Technical Assistance and Response Team
TAT	Turn-Around Time
TEDE	Total Effective Dose Equivalent
TLD	Thermoluminescent Dosimetry
TSD	Treatment, Storage, and Disposal
UC	Unified Command
USACE	U.S. Army Corps of Engineers

USDA	U.S. Department of Agriculture
USCG	U.S. Coast Guard
WCO	Waste Certifying Official
WCS	Waste Control Specialist
WMD	Weapon of Mass Destruction
WMD-CST	Weapons of Mass Destruction Civil Support Team

1. PURPOSE AND SCOPE

1.1 BACKGROUND

The ruthlessness of the September 11 attacks has alerted the world to the potential for nuclear terrorism. The willingness of terrorists to sacrifice their lives to achieve their objectives creates a new dimension in the fight against terrorism. We face the potential of terrorists acquiring or building nuclear bombs or using radioactive sources to incite panic, contaminate property, and cause injury or death among civilian populations. While a nuclear bomb detonation would cause the greatest destruction, it is the least likely of the potential radiological incidents. More likely, due to the great number of orphaned radioactive sources, would be a “dirty bomb” incident in which a conventional explosive is used to disperse radioactive material. Although terrorists have not yet used a nuclear weapon or detonated a “dirty bomb,” reports that some terrorist groups, particularly al-Qaeda, have attempted to acquire nuclear material is a cause for concern.

According to the International Atomic Energy Agency (IAEA) Illicit Trafficking Database, there were 196 cases of trafficking in nuclear material and 400 cases of trafficking in other radioactive sources (medical, industrial) between 1993 and 2004. However, only 18 of these cases actually involved small amounts of highly enriched uranium or plutonium that is needed to produce a nuclear bomb. IAEA experts judge the quantities involved to be insufficient to construct a nuclear explosive device.

There also has been a six-fold increase in the inventory of nuclear and radioactive materials in peaceful programs worldwide since 1970. According to IAEA figures, there are 438 nuclear power reactors, 651 research reactors (of which 284 are in operation), and 250 fuel cycle plants around the world, including uranium mills and plants that convert, enrich, store, and reprocess nuclear material. Additionally, tens of thousands of radiation sources are used in medicine, industry, agriculture, and research. While the level of security at nuclear facilities is generally very high, the security of medical and industrial radiation sources is disturbingly weak in some countries.

The threats from nuclear terrorism are dependent upon the materials available and types of facilities involved, and fall into three main categories: nuclear and radioactive material facilities, nuclear material, and radioactive sources.

Nuclear and Radioactive Material Facilities

The primary risks associated with nuclear facilities involve the theft or diversion of nuclear material from the facility, or a physical attack or act of sabotage designed to cause an uncontrolled release of radioactivity to the surrounding environment. In urban areas that do not have nuclear reactors or fuel cycle facilities, other facilities with radioactive material inventories do exist, such as nuclear medicine facilities, hospitals, construction sites using radiography sources, and industrial sites using radioactive sources. Radioactive material could present risks if there is a physical attack or an accidental fire at such a facility. Radioactive materials also could be stolen from such a facility and fabricated into a Radiological Dispersal Device (RDD) to be used elsewhere.

Nuclear Materials

Terrorists obtaining or building nuclear weapons may be the least likely terrorism scenario, but by far would be the most devastating. While it cannot be discounted that terrorists could obtain some nuclear material, it is highly unlikely they could use it to manufacture and successfully detonate a nuclear bomb. But no scenario is impossible. Beyond the difficulty for terrorists to obtain weapons-grade material, actually producing a nuclear weapon is far from a trivial exercise. Scientific expertise and access to sophisticated equipment would be required. However, when the Cold War ended, thousands of highly knowledgeable scientists and engineers previously involved in the Soviet Union's weapons program were laid off or found their incomes drastically reduced. Another legacy of the Cold War is the disturbing reports, albeit unsubstantiated, of missing nuclear weapons.

Radioactive Sources

Terrorists could develop a crude RDD using radioactive sources commonly used in every day life. The number of radioactive sources in the world is vast. Sources used in radiotherapy alone are on the order of ten thousand. Many more are used in industry. For example, Cobalt-60 (^{60}Co) sources are used to check for welding errors or cracks in buildings, pipelines, and structures. Radionuclides also are used for food preservation. There are a large number of unwanted radioactive sources, many of which are simply abandoned and "orphaned" of any regulatory control. A dirty bomb could be made by combining conventional explosives with a radioactive source, although handling the source could be deadly.

Concern about radioactive sources and dirty bombs is high because the security of radioactive materials in many countries has been relatively lax. There are few security precautions on radiotherapy equipment and a large source could be removed quite easily, especially if those involved have no regard for their own health. Moreover, in many countries, the regulatory oversight of radiation sources is weak. As a result, an undetermined number of radioactive sources have become orphaned of regulatory control and their location is unknown, even in the United States.

The U.S. Nuclear Regulatory Commission (NRC) and state regulations require owners licensed to use or store radioactive material to secure this material from theft and unauthorized access. These measures have been greatly strengthened since the attacks of September 11, 2001. Licensees must promptly report lost or stolen high-risk radioactive material. Local authorities also assist in determined efforts to find and retrieve such sources. Most reports of lost or stolen material involve small or short-lived radioactive sources that are not useful for creating a RDD. The NRC has not detected a pattern of collecting such sources for the purpose of assembling an RDD. It is important to note that the radioactivity of the combined total of all unrecovered sources over the past five years (when corrected for radioactive decay) would not reach the threshold for one high-risk radioactive source. Unfortunately, the same cannot be said worldwide. The U.S. is working to strengthen controls on high-risk radioactive sources both at home and abroad (NRC 2005).

1.2 RADIOLOGICAL DISPERSAL DEVICE EVENTS

The principal type of RDD is a dirty bomb that combines a conventional explosive with radioactive material. In most instances, the conventional explosive device would have more immediate lethal effects than the radioactive material. At the levels created by most probable sources, not enough radioactivity would be present in a dirty bomb to kill people or cause severe illness. For example, most radioactive material employed in hospitals for diagnosis or treatment of cancer is sufficiently benign that approximately 100,000 patients are released every day with this material in their bodies. However, certain other radioactive materials, dispersed in the air, could contaminate up to several city blocks, creating fear and possibly panic and requiring potentially costly cleanup.

A second type of RDD might involve a radioactive material that is dispersed in air or water by mechanical means rather than through the use of an explosive. Methods to administer these materials might be a water spray truck, a crop duster, or manually spreading radioactive material.

Another type of RDD might involve a powerful radioactive source hidden in a public place, such as a trash receptacle in a busy train or subway station, where people passing close to the source might get a significant dose of radiation. By definition this would be considered a Radiological Exposure Device (RED).

RDDs would be used to spread radioactive contamination and are in no way similar to a nuclear weapon and its destructive effects. The presumed purpose of an RDD would be as a Weapon of Mass Disruption rather than a Weapon of Mass Destruction (WMD).

1.2.1 Impact of a Dirty Bomb

The extent of local contamination would depend on a number of factors, including the size of the explosive, the amount and type of radioactive material used, and weather conditions. Prompt detection of the kind of radioactive material employed would greatly assist local authorities in advising the community on protective measures, such as quickly leaving the immediate area or sheltering inside until further advised. Subsequent decontamination of the affected area could involve considerable time and expense. A dirty bomb, though not expected to result in significant radiological effects, could have significant psychological and economic effects.

Although not a terrorist incident, the accidental contamination of Goiânia, a major city in Brazil, with a medical radiation source exemplifies the potential for a terrorist group to wreak havoc on an urban center. In September, 1987, scrap scavengers broke into an abandoned radiological clinic, stole a highly radioactive Cesium-137 (^{137}Cs) source and moved it to a junkyard for sale as scrap. Workers broke open the encasement and cut up the 1,375 Curie capsule of cesium into pieces. The valuable-looking scrap was then distributed to friends and family of workers around the city. As a result, some 112,000 persons were eventually monitored, of whom 249 were found to be contaminated either internally or externally, fourteen suffered from severe internal radiation effects, and four subsequently died. Significant contamination was found in 85 homes, 50 vehicles, and 45 public locations where decontamination or removal was required. Seven homes where decontamination was not feasible were demolished and removed. Decontamination activities generated approximately 3,500 cubic meters of waste, encapsulated in about 12,500 drums and 1,470 boxes (IAEA 1988).

1.2.2 Cancer and Other Health Effects

Most injuries from a dirty bomb would probably occur from the heat, debris, radiological dust, and force of the conventional explosion used to disperse the radioactive material, affecting only individuals close to the site of the explosion. At the low radiation levels expected from an RDD, the immediate health effects from radiation exposure likely would be minimal (DHS 2004a).

Health effects of radiation exposure are determined by the amount of radiation absorbed by the body, type of radiation, means of exposure (external or internal), and length of time exposed. The health effects of radiation tend to be directly proportional to the radiation dose. Acute radiation syndrome (ARS) is a short-term health effect caused by exposure to a highly radioactive material over a relatively short amount of time. ARS is not likely to result from a dirty bomb. If a reasonable estimate can be made of a person's dose, much is known about the health effects of that dose.

Psychological effects from fear of being exposed may be one of the major consequences of a dirty bomb. Unless information about potential exposure is made available from a credible source, people unsure about their exposure might seek advice from medical centers, complicating the centers' ability to deal with acute injuries.

Just because a person is near a radioactive source for a short time or gets a small amount of radioactive dust on himself or herself does not mean he or she will get cancer later in life, especially if it is removed quickly. Studies have shown that radiation is a relatively weak carcinogen. Exposure at the low radiation doses expected from an RDD would increase the risk of cancer very slightly over naturally occurring rates. A long-term medical surveillance program may need to be established for victims of a significant radiological attack to monitor potential health effects (EPA 2005a).

It should be noted that potassium iodide (KI) would not be protective except in the very unlikely event that the dirty bomb contained radioactive iodine isotopes in large quantities. Radioactive iodine isotopes are not particularly attractive for use in an RDD for a variety of technical reasons, the most important of which is the short half-life (eight days) of the Iodine-131 radionuclide. KI only protects the thyroid from radioactive iodine, but offers no protection to other parts of the body or against other radioactive isotopes (NRC 2003).

1.3 PURPOSE OF OSC RADIOLOGICAL RESPONSE GUIDELINES

The purpose of this document is to provide EPA On-Scene Coordinators (OSCs) with up-to-date technical information on radiological emergency responses. Information in this document can be used:

- As a training tool to develop a better understanding of the potential challenges associated with a radiological emergency response
- As a technical reference during any radiological emergency response

Because the document has these two purposes, it contains information designed for access during both preparedness and response. As a result, some of the information in the document may not be of immediate assistance during an incident, while other sections (e.g., Entry/Egress Procedures) are designed to provide immediate assistance to OSCs during a response.

The document contains information that may be of interest to other federal, state, and local responders, but has been designed primarily for EPA OSCs and incorporates by reference existing EPA protocols, policies, and guidance.

This document will be updated on a periodic basis to reflect new knowledge, policy developments, and relevant research. Additional reference materials may be found at www.epaosc.net.

1.4 SCOPE

While the document was designed to cover the full range of radiological incidents, its focus is predominantly on RDDs, because of the likelihood that OSCs will be among the first federal responders on the scene of an RDD incident. RDDs are expected to occur in urban environments, triggering a host of issues that may also be involved (albeit to a lesser extent) in radiological incidents not involving terrorist activity. Incidents involving nuclear threats are outside the current scope of this document, although this may be included in future updates.

It should be noted that, while the scope of this document focuses on the radiological aspects of a potential incident, any suspected terrorist incident could involve additional hazards, such as explosives, chemical or biological contamination, or secondary devices. It is therefore essential that responders follow normal hazardous material response protocols until the type and severity of the incident has been fully identified.

1.5 ASSUMPTIONS

This document has been developed under the following assumptions:

- All EPA OSCs responding to radiological emergencies will be enrolled in an EPA Radiation Health and Safety Program consistent with current EPA requirements and guidance (including *EPA's Medical Surveillance Program Implementation Plan*; EPA 2005a), and will have been provided basic training by EPA's Environmental Response Team (ERT) on the use of EPA's standard radiological response equipment.

- The authors considered information regarding the early and intermediate phases of a response to be the most helpful to OSCs, so this document focuses on those phases. Information also is provided regarding early activities that should be implemented to assist or mitigate long-term cleanup (recovery).

- The OSC and other EPA responders will be integrated into the Incident Command System (ICS) for the response. The OSCs' responsibilities will be consistent with those outlined under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR Part 300) and the NRP (DHS 2004b).

- The document focuses on eight radionuclides that have unique chemistry, half-life, or radiation emissions that can represent the majority of radionuclides in commercial use and that might be encountered by OSCs: Cesium-137 (^{137}Cs), Strontium-90 (^{90}Sr), Cobalt-60 (^{60}Co), Americium-241 (^{241}Am), Radium-226 (^{226}Ra), Iridium-192 (^{192}Ir), Plutonium-238 (^{238}Pu), and Plutonium-239/240 ($^{239/240}$Pu).

1.6 DOCUMENT ORGANIZATION AND USE

Chapter 2. Federal Plans and Agency Roles: This chapter is designed primarily for preparedness use and provides a general overview of the federal plans governing a radiological response and an overview of the assumptions regarding a response that dictate the flow of the rest of this document.

Chapter 3. EPA Response: This chapter has an introduction designed for preparedness use, followed by operating guidance that should be used by OSCs in entering potentially contaminated areas.

Chapter 4. Health and Safety: This chapter provides general information for use by OSCs in both preparing for a radiological incident and in assessing what should be included in a site-specific Health and Safety Plan (HASP). It also provides references that may be helpful in developing a site-specific HASP.

Chapter 5. Radiological Standard Operating Procedures: This chapter consists of an overview of Standard Operating Procedures (SOPs) that can be used by OSCs in all phases of a response. The SOPs have been developed to be used with the nationally consistent equipment purchased by EPA for radiological emergency response. The SOPs are not included in this document, but will be available in a companion CD and via the Internet.

Chapter 6. Stabilization/Decontamination: This chapter provides a general overview of information needed to perform decontamination following a radiological release, prevent further spread of contamination, allow return of properties to use, and reduce the potential long-term cleanup requirements. It is organized by radionuclide and may be helpful to OSCs in preparedness (as a training tool) or in a response to help the OSCs understand the range of radionuclide-specific tools that may be used.

Chapter 7. Cleanup Planning: This chapter provides an overview of the cleanup considerations that the OSC should address during the early and intermediate phases of a response. It provides a review of the recommendations in the forthcoming Department of Homeland Security (DHS) guidance, *Application of Protective Action Guides for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents* (DHS 2006).

Chapter 8. Waste Disposition: This chapter is designed as a tool to assist the OSC in developing a waste management plan, including characterization, treatment, and disposal. The chapter provides a review of the waste acceptance criteria of existing commercial facilities that accept radiologically contaminated waste. It may be helpful to the OSC either in preparing for a potential incident or during a response to an incident.

Chapter 9. Community Outreach: This chapter is designed as a preparedness tool to assist the OSC in understanding the context of community outreach and introducing the OSC to communication issues specific to ionizing radiation (versus other hazardous substances).

1.7 DOCUMENT DEVELOPMENT

This document was developed by a team of EPA personnel from the Office of Solid Waste and Emergency Response (Offices of Emergency Management and Superfund Remediation and Technology Innovation/Environmental Response Team), the Office of Air and Radiation/Office of Radiation and Indoor Air (both Headquarters and the National Air and Radiation Environmental Laboratory), and regional OSCs, with support from several contracting firms.

2. FEDERAL PLANS AND AGENCY ROLES

OSCs should understand the federal response plans under which they may operate in response to a radiological incident, including terrorist incidents. Three major federal response plans (or systems) describe the roles and responsibilities of the agencies involved in radiological response and the mechanisms for coordination among these agencies.

Most of the "routine" radiological incidents to which EPA OSCs respond (such as orphan sources and abandoned facilities) are addressed under the NCP (40 CFR Part 300). A radiological terrorist incident response, however, is likely to be conducted under the National Response Plan (NRP) and will involve numerous federal agencies, including the Federal Bureau of Investigation (FBI) and DHS (DHS 2004b). As described later in this chapter, the NCP is considered an operational supplement to the NRP, so NCP authorities related to radiological responses remain relevant to an EPA response to a radiological terrorist incident under the NRP. The NRP is based upon the Incident Command System (ICS) response management structure set forth in the National Incident Management System (NIMS). Emergency responses under the NCP also follow the NIMS/ICS framework.

This chapter briefly describes these three major response plans—NCP, NRP, and NIMS—and how they relate to a radiological response, particularly a response to a radiological terrorist incident. More detailed training on these three systems is available to OSCs through other venues, including EPA's Incident Management Training, regional NRP training, and courses at OSC Readiness Training.

Section 2.1 provides a brief description of the NCP, with a focus on radiological response authorities. OSCs operate under the NCP on a day-to-day basis, and should be familiar with NCP requirements. Section 2.2 briefly describes the NIMS and the ICS under which OSCs conduct emergency responses. Section 2.3 provides an overview of the NRP, the NRP response framework for radiological incidents, and EPA's role in such incidents. It also explains how the NCP and NIMS/ICS fit into an NRP radiological response. Section 2.4 describes EPA's response to radiological terrorist incidents in particular. Section 2.5 describes the federal special teams that can assist the OSC in a radiological response.

OSCs should be aware that much of the federal planning for radiological terrorist incidents conducted to date has focused on radiological dispersal devices (RDDs). The Federal Government is in the process of undertaking additional planning to more fully prepare for a response to an improvised nuclear device (IND) incident. Additional details on the Federal Government's response and role in an IND incident, therefore, should be forthcoming in the NRP and other appropriate federal emergency planning documents.

2.1 EPA RESPONSE TO RADIOLOGICAL INCIDENTS UNDER THE NCP

The NCP, 40 CFR Part 300, implements the response authorities of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or "Superfund") and the Clean Water Act, as amended by the Oil Pollution Act (OPA). The NCP provides policy and protocols for cleaning up releases of oil, hazardous substances, pollutants, and contaminants, including accidental or deliberate releases of radiological contamination. Under the NCP, EPA OSCs respond to incidents in the inland zone while U.S. Coast Guard (USCG) OSCs respond to incidents in the coastal zone. Most “routine” radiological incidents to which OSCs respond are addressed under the NCP, but NCP authorities and federal roles also play a part in a NRP response to a radiological terrorist incident.

With respect to radiological emergency response, OSCs should be aware of two aspects of the following NCP authorities:

1. **Roles of Other Federal Agencies in Providing OSCs**: While EPA and USCG provide OSCs for most responses under the NCP, Executive Order 12580 and Section 300.120 of the NCP state that the Department of Defense (DoD) and Department of Energy (DOE), which frequently handle radioactive materials, also provide OSCs for emergency responses. DoD and DOE provide their own OSCs for responses involving releases from, or on, their facilities, materials, and weapons (which includes incidents involving their materials or weapons in transit). Their responsibilities include addressing any off-site releases. If DoD or DOE requests EPA assistance in the response, the Regional Removal Manager will make the decision to respond on a case-by-case basis depending upon resource availability, and should coordinate that decision with EPA’s Office of Emergency Management (OEM) Headquarters. These DoD and DOE roles carry over into the NRP, as will be described further in Section 2.3 of this chapter.

2. **CERCLA Limitations on Radiological Response Authoritie**s: The definition of “release” under CERCLA, codified in the NCP, excludes releases of source, byproduct, or special nuclear material from a nuclear incident at certain facilities licensed by the Nuclear Regulatory Commission, most notably, commercial nuclear power plants and fuels associated with these plants. This exclusion may preclude the use of Superfund monies for releases that are covered by this exclusion where, for example, it is known that no other hazardous substances, pollutants, or contaminants are or could be commingled with the source, byproduct, or special nuclear material covered by the CERCLA “release” definition. Again, as will be discussed in Section 2.3 of this chapter, this exclusion should be considered if EPA assistance is requested under the NRP for terrorist incidents at nuclear power plants.

2.2 NATIONAL INCIDENT MANAGEMENT SYSTEM / INCIDENT COMMAND SYSTEM

DHS issued NIMS in March 2004 to provide a consistent nationwide approach for federal, state, and local governments to work effectively and efficiently together to prepare for, respond to, and recover from domestic incidents, regardless of cause, size, or complexity (DHS 2004c). Federal policy requires federal departments and agencies to adopt NIMS. EPA has adopted NIMS for its emergency response program.

NIMS relies on the ICS, a system for managing incidents that integrates the facilities, equipment, personnel, procedures, and communications involved in a response within a common organizational structure. At the on-scene level, an Incident Command Post (ICP) is established. This is the location from which tactical response operations are directed. The NIMS ICS specifies how the ICP is organized. The organization has five major functions: command, operations, planning, logistics, and finance and administration (with a potential sixth function to cover intelligence). The ICP is led by the Incident Commander (IC), the senior individual with the authority to direct the response. Where multiple ICs have jurisdiction over the response, the ICP is led by a Unified Command (UC). Under Unified Command, ICs work together to establish common objectives and carry out tactical response activities, with each IC retaining his or her ultimate authority. A Joint Information Center (JIC) may be established to coordinate public information activities. (See Chapter 9 for more information on public information during a radiological emergency response.)

Under the NCP, the individual with the authority to direct and coordinate the response at the on-scene level is the OSC. Therefore, for a radiological response in which EPA is taking a leadership role, the OSC generally fulfills the role of the EPA IC at the ICP. When EPA is only providing support to another entity (e.g., local or federal agency) during a response, the OSC may instead provide that support through another location within the ICS, such as the Planning Section and/or Operations Section. For a radiological terrorist incident that occurs in a major urban area, it is likely that local officials (e.g., fire department) will establish an ICP prior to the OSC's arrival (assuming local response capabilities have not been overwhelmed or incapacitated), and the OSC would join the ICP in a location appropriate to EPA's role in the response. Other EPA and NCP response assets may fill other positions in the ICS as determined by the OSC.

As needed and in accordance with EPA's role in the response, the OSC may also request full or partial activation of an Incident Management Team (IMT) from the regional EPA office. The IMT consists of personnel who are trained and experienced in specific ICS positions. The OSC may request full activation of an IMT if the magnitude or complexity of the incident requires establishing and maintaining an ICS structure for a prolonged response. Normally, the EPA IC will continue to be the responding OSC who first established UC with the local responders at the ICP.

An Area Command may also be established if the incident is large enough to require more than one ICP, or if there are multiple incidents within the same geographic area. In this case, the EPA regional emergency response program would send an EPA representative to the Area Command.

One other aspect of NIMS/ICS will be particularly important for radiological responses, which typically require the management of significant volumes of environmental data. The NIMS states that for incidents involving large volumes of environmental data, an Environmental Unit (EU) may be established within the Planning Section of the ICP to facilitate interagency data coordination and management. For radiological incidents where EPA plays a leadership role, it is expected that EPA would work with local authorities to establish an EU (or its equivalent) to coordinate data within the ICP. Coordination of data also will be performed through the Federal Radiological Monitoring and Assessment Center (FRMAC) when a FRMAC is activated, which is discussed in more detail in Section 2.5 of this chapter. EPA's Radiological Emergency Response Team (RERT) Commander fulfills the role of Senior EPA Official in the FRMAC.

2.3 OVERVIEW OF RESPONSE TO RADIOLOGICAL INCIDENTS UNDER THE NATIONAL RESPONSE PLAN

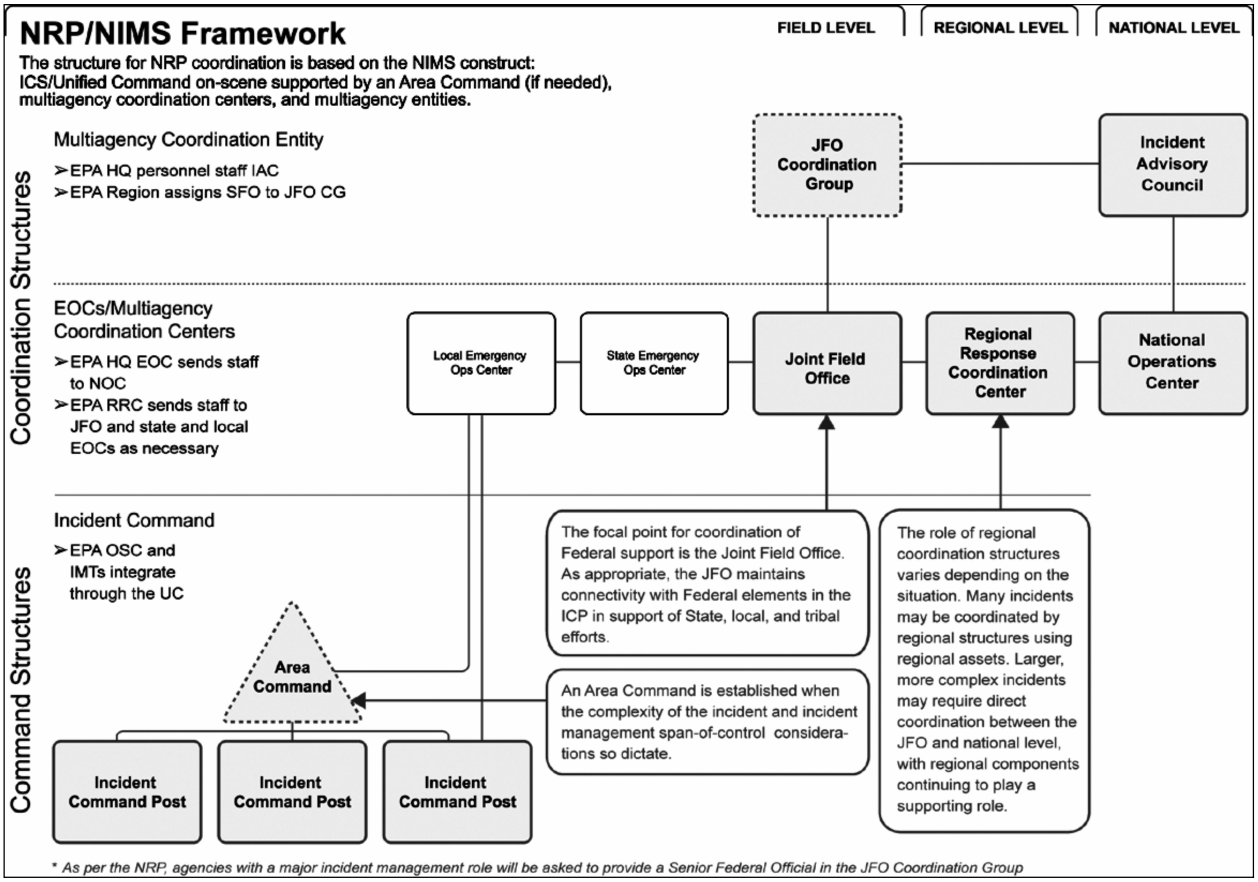
Under the NRP, DHS is responsible for overall federal coordination of all actual and potential Incidents of National Significance (INSs). The Secretary of DHS determines whether an incident should be designated an INS. The NRP establishes the protocols and procedures for the Federal Government to support state, local, and tribal agencies in responding to significant incidents. In general, the NRP is activated for INSs; however, several of its annexes may also be used for non-INSs (see text box). This section provides an overview of the NRP and several NRP annexes that are critical for radiological responses.

The NRP relies on NIMS, and thus recognizes that tactical management of an incident occurs at the ICP level. When an EPA OSC leads a NRP response, the EPA OSC fulfills the role of IC at the ICP level. However, during a NRP INS, DHS will activate additional response structures above the ICP level to coordinate with the federal agencies, states, locals, and private sector. Figure 2.1 presents an overview of the NRP/NIMS response structure for an INS (DHS 2004b). These additional structures include the Joint Field Office (JFO) and Incident Advisory Council (IAC), both managed by DHS. The EPA regional emergency response program sends an EPA representative(s) to the JFO, and EPA Headquarters sends a representative to the IAC. The JFO is led by a JFO Coordination Group, which is similar to and operates under the same principles as the UC at the ICP. Among other functions, the JFO Coordination Group and IAC may provide strategic direction for the response, guidance on allocation of federal resources, and assistance in resolving conflicts that arise at lower levels in the response structure. So, while an OSC continues to respond as the EPA IC at the ICP for an NRP INS, additional coordination will be needed with these other NRP response structures. In general, the ICP/UC communicates with the JFO/JFO Coordination Group, and the JFO Coordination Group communicates with the IAC.

Nuclear/Radiological Incident Annex to the NRP versus the NCP

The principal annex of the NRP that addresses interagency coordination for radiological response is the Nuclear/Radiological Incident Annex. It should be noted that the NRP's Nuclear/Radiological Incident Annex can be used for both INSs under the NRP, as well as incidents of lesser severity not under the NRP. For radiological incidents that are below the threshold of an INS but that still require federal participation in the response, however, the Annex states that the Coordinating Agency has the option of coordinating the Federal response using: 1) the procedures in the Nuclear/Radiological Incident Annex; 2) agency-specific plans; and/or 3) the NCP, as appropriate. Thus, since most "routine" radiological responses that EPA conducts do not rise to the level of an INS under the NRP, EPA will carry out most of its radiological responses solely under the NCP. Other departments/agencies may choose another option for "routine" incidents. A radiological terrorist incident, however, is expected to be declared an INS under the NRP.

Figure 2.1 NRP/NIMS Framework (adapted from NRP)



Whether EPA has a role in a radiological response under the NRP, and whether that role is a leadership or support role, is identified in the Nuclear/Radiological Incident Annex, a key component of the NRP for radiological responses. This Annex lists different possible scenarios of nuclear/radiological releases and assigns leadership to a Coordinating Agency, a specific federal agency responsible for each response scenario. The scenarios and Coordinating Agency designations are listed in Table 2.1.

DHS always assumes the role of overall federal coordinator for the incident, but the designated "Coordinating Agency," in consultation with DHS, has the primary responsibility for the federal nuclear/radiological aspects of the response for a given scenario. The Coordinating Agency should be part of the UC at the ICP (generally the OSC when EPA is the Coordinating Agency), and should also provide a Senior Federal Official to the JFO Coordination Group (assigned by the regional office when EPA is the Coordinating Agency).

Table 2.1 Coordinating Agencies

Type of Incident	Coordinating Agency
a. Radiological terrorism incidents (e.g., RDD/IND or radiological exposure device): (1) Material or facilities owned or operated by DoD or DOE (2) Material or facilities licensed by NRC or Agreement State (3) All others	 (1)DoD or DOE (2)NRC (3)DOE*
b. Nuclear facilities: (1) Owned or operated by DoD or DOE (2) Licensed by NRC or Agreement State (3) Not licensed, owned, or operated by a federal agency or an Agreement State, or currently or formerly licensed facilities for which the owner/operator is not financially viable or is otherwise unable to respond	 (1)DoD or DOE (2)NRC (3)EPA
c. Transportation of radioactive materials: (1) Materials shipped by or for DOE or DOE (2) Shipment of NRC or Agreement State-licensed materials (3) Shipment of materials in certain areas of the coastal zone that are not licensed or owned by a federal agency or Agreement State (see USCG list of responsibilities for further explanation of “certain areas”) (4) All others	 (1)DoD or DOE (2)NRC (3)DHS/USCG (4)EPA
d. Space vehicles containing radioactive materials: (1) Managed by NASA or DoD (2) Not managed by DoD or NASA impacting certain areas of the coastal zone (3) All others	 (1)NASA or DoD (2)DHS/USCG (3)EPA
e. Foreign, unknown, or unlicensed material: (1) Incidents involving foreign or unknown sources of radioactive material in certain areas of the coastal zone (2) All others	 (1)DHS/USCG (2)EPA
f. Nuclear weapon accident/incident (based on custody at time of event)	DoD or DOE
Other types of incidents not otherwise addressed above	DHS designates
* For category a(3), “all other” radiological terrorist incidents, DOE is designated as the Coordinating Agency in the table. For this category of incident, however, the annex states that the Coordinating Agency role transitions from DOE to EPA for environmental cleanup and site restoration at a mutually agreeable time, and after consultation with state, local, and tribal governments, the cooperating agencies, and the JFO Coordination Group.	

When EPA is the Coordinating Agency, an EPA OSC becomes the IC who, along with the EPA representatives on the JFO and IAC, need to understand their responsibilities as laid out in the NRP Nuclear/Radiological Incident Annex. The Annex describes the specific responsibilities of the Coordinating Agency with regard to the following:

- Coordination of the overall technical response
- Management of technical data
- Oversight of development of Protective Action Recommendations
- Incident security[1]

1 OSCs should be aware that DoD, DOE, and the National Aeronautics and Space Administration (NASA) have the authority to establish a National Defense Area (NDA) or National Security Area (NSA) for radiological incidents

- Demobilization
- Coordination of information with the public, Congress, and White House
- Coordination with the Department of State when incidents have international implications

When USCG is the designated Coordinating Agency, it does not assume that role for the entire coastal zone (as is the case for other incidents under the NCP), but only for incidents in certain coastal areas (i.e., vessels, areas seaward of the shoreline to the outer edge of the Exclusive Economic Zone, and within the boundaries of certain waterfront facilities). Those areas are described in more detail at the end of the Nuclear/Radiological Incident Annex in the description of USCG's responsibilities. Therefore, for radiological incidents, EPA assumes leadership for some types of incidents in the coastal zone as identified in Table 2.1.

The Coordinating Agency may request assistance from various Cooperating Agencies listed in the Annex. EPA may be called upon as a Cooperating Agency. It is important to be aware that even when EPA is not a designated Coordinating Agency for an incident, the assigned Coordinating Agency may request EPA's assistance. EPA may serve in either role for a radiological terrorist incident, though EPA is not designated as the *initial* Coordinating Agency for any radiological terrorist scenario. DOE transitions the Coordinating Agency role to EPA under radiological terrorist scenario a(3) in Table 2.1.

When EPA OSCs represent the Coordinating or Cooperating Agency during an INS, they generally respond using their NCP authorities, which are coordinated with the NRP. In addition to the NRP Nuclear/Radiological Incident Annex, two other NRP annexes that describe how EPA coordinates NCP activities with the NRP apply to EPA OSCs when both the NRP and NCP are activated:

- Emergency Support Function (ESF) #10 - Oil and Hazardous Materials Response[2]
- Oil and Hazardous Materials Incident Annex

ESF #10 is activated under the Stafford Act or as a result of a "federal-to-federal support" activation under the NRP. Federal-to-federal support under the NRP involves the transfer of resources from one federal agency to another to fund assistance in coordinating the response. DHS may transfer the funds to EPA to respond. Alternatively, EPA follows the procedures in the Oil and Hazardous Materials Incident Annex (in this case EPA is conducting the response using CERCLA/OPA funds). EPA and USCG are the two primary agencies that implement these annexes, and bring the resources of the NCP response system to an NRP INS response. Operationally, the two annexes are very similar, but the use of different statutory authorities/ funds may have an impact on the allowable scope of EPA's response. For example, as noted earlier, OSCs may be precluded from conducting a Superfund-funded response to a commercial

involving their weapons and special nuclear materials. NDAs and NSAs are established to safeguard classified and/or restricted information and place non-federal lands under federal control for the duration of the incident. If EPA assists, we would typically be addressing contamination outside the NDA/NSA.

[2] Under ESF #10, EPA also may be tasked to carry out activities under Stafford Act authority that are not typically conducted under the NCP. The Stafford Act is authorized when the President declares a "National Emergency." When responding under the Stafford Act, EPA receives a "mission statement" from the Federal Emergency Management Agency (FEMA)/DHS, and FEMA pays the cost.

nuclear power plant incident if the incident falls under the CERCLA exclusion, but would have the authority to assist if funded under a Stafford Act Mission Assignment from DHS/Federal Emergency Management Agency (FEMA). Another difference between the two annexes is that DHS's role, particularly DHS/FEMA's role, may be different depending upon whether or not they are implementing Stafford Act responsibilities or not.

Generally, the ESF#10 and Oil and Hazardous Materials Incident Annex describe how:

- EPA OSCs function as the EPA IC (if EPA has a leadership role)
- EPA staffs the other NRP response structures (e.g., JFO, DHS/FEMA Regional Response Coordination Center, IAC)
- Other NCP response mechanisms (e.g., the Regional Response Teams and National Response Team) are linked into the NRP structure

One other NRP annex that OSCs should be familiar with is the Catastrophic Incident Annex, which the Secretary of DHS may activate in response to a large-scale disaster or IND incident. Essentially, this Annex pre-authorizes certain federal agencies to deploy immediately without waiting for the normal NRP activation procedures to be completed. Thus, it allows a proactive federal response. EPA is one of those agencies authorized to deploy immediately when this Annex is activated. However, it does not change EPA's fundamental role in the response after initial deployment. This Annex is more relevant to federal agencies without response authority of their own than to EPA that has CERCLA/NCP authority to respond to any incident that meets the NCP criteria for a response. Thus, EPA would not necessarily have to wait for NRP activation to respond to a radiological incident, including a radiological terrorist incident. But any EPA response should be consistent with the identification of federal roles (in particular, the designation of the Coordinating Agency) in the Nuclear/Radiological Incident Annex.

2.4 OVERVIEW OF EPA RESPONSE TO RADIOLOGICAL TERRORIST INCIDENTS UNDER THE NRP

2.4.1 Terrorist Incident in Urban Area or Other Location for Which EPA is Pre-Designated as the Coordinating Agency for Environmental Cleanup Phase

If a radiological terrorist incident occurs in a likely terrorist target, such as a major city or other area that is covered by category a(3) in Table 2-1, and DHS declares the incident an INS, activates the NRP, and possibly activates the Catastrophic Incident Annex, the following occur:

- DHS is the overall federal coordinator of the response and provides oversight primarily from the JFO and Headquarters.
- DOE is the initial Coordinating Agency, providing technical leadership for the federal radiological aspects of the response, in consultation with DHS.
- EPA provides support to DOE, initially as a Cooperating Agency and later as the Coordinating Agency for the environmental cleanup.

- Department of Justice (DOJ)/FBI is the lead agency for criminal investigations of terrorist acts or threats (not for the overall federal response; DHS maintains that role).
- Other federal agencies may be activated under the NRP to assist as appropriate. Examples are the Department of Health and Human Services (HHS) for public health and medical assistance, U.S. Army Corps of Engineers (USACE or "the Corps") for emergency removal of contaminated debris to facilitate the response, and the Department of Labor's Occupational Safety and Health Administration (OSHA) for worker health and safety issues.

In a major city, the local fire department likely will establish one or more ICPs before federal resources arrive (assuming local response agencies are not overwhelmed or incapacitated). EPA's initial responders would most likely integrate into the UC and ICP. (Chapter 3 of this document addresses immediate response procedures for the OSC.) DOE, EPA, and FBI would provide representatives to the local ICP as appropriate, including IC representatives to the UC. (It is assumed in this scenario that locals/states would require significant federal assistance.)

EPA generally chooses an OSC to be the IC.[3] The OSC subsequently assigns other EPA response personnel to appropriate locations within the ICS as needed, and may request full or partial activation of an IMT, as needed. In some cases, to maintain a reasonably sized UC, EPA, DOE, and the local IC may prefer that within the UC, DOE represent all federal technical response assets during the emergency phase while DOE is the Coordinating Agency (with EPA filling other ICP positions). Later that responsibility transfers to EPA.

As noted earlier, EPA would likely work with the local authorities to establish an EU (or its equivalent) within the Planning Section to coordinate environmental data within the ICP. Procedures for sharing and managing radiological and non-radiological environmental data would have to be defined. DOE would deploy the advance elements of the FRMAC (see Section 2.5 for more details), which would be integrated with the ICS. The forthcoming *EPA Incident Management Handbook* will provide additional suggestions regarding FRMAC incorporation into the ICS. All three federal agencies would also send representatives to the JFO (and other NRP response structures as needed). Tactical operations should be planned and carried out at the ICP in accordance with NIMS, but the ICP also would need to provide information to, and coordinate with, the JFO.

Wherever possible, regional offices should conduct advance planning with local officials in high-risk areas on how federal response assets would integrate into the local incident management system for a large radiological incident.

EPA will integrate NCP activities with the NRP in accordance with either ESF #10 or the Oil and Hazardous Materials Incident Annex, depending on the source of funding for EPA's

[3] If the terrorist incident occurs in certain areas of the coastal zone (i.e., vessels, areas seaward of the shoreline to the outer edge of the Exclusive Economic Zone, and within the boundaries of certain waterfront facilities, as described in the Nuclear/Radiological Incident Annex under the description of USCG's responsibilities), DOE would still be the initial Coordinating Agency under the NRP for the emergency phase, but USCG would assist DOE and provide the OSC in the UC for the purposes of the NCP. It is expected that EPA would still be called upon to assist both USCG and DOE in the early response, and would provide representatives to the appropriate sections of the ICS. EPA would provide the OSC/IC in the UC when the Coordinating Agency role transitions to EPA.

activities. It is expected, however, that a radiological incident causing significant impacts will result in a Stafford Act declaration and activation of ESF #10. Supplemental appropriations may also be provided.

As noted above, under the NRP, DHS coordinates field-level activities from the JFO. It is not expected that DHS would assign an IC to the ICP, but DHS may instead decide to send a DHS liaison to the ICP.

With regard to FBI participation, the Terrorism Incident Law Enforcement and Investigation Annex to the NRP describes how the FBI should conduct its operations during the investigation phase (before an incident may be declared an INS under the NRP) and after an incident is declared an INS. The FBI is responsible for investigating the incident, as well as for locating any illegally diverted nuclear weapon, device, or material and for restoring nuclear facilities to their rightful custodians.

When an INS is declared, the FBI Special Agent in Charge (SAC) will join the JFO as a member of the JFO Coordination Group, and the FBI Joint Operations Center (JOC) will integrate into the JFO. The FBI also will send representatives to the ICP. The Terrorism Incident Law Enforcement and Investigation Annex identifies three potential FBI positions within the ICP:

- FBI representative to the UC
- Deputy Chief of the Operations Section
- Deputy Chief of the Planning Section

If conflicts arise at the ICP between law enforcement and emergency response activities that are not resolved by the UC (such as data sharing), issues should be raised to the JFO Coordination Group for resolution. EPA OSCs would raise these issues through the EPA Senior Federal Official in the JFO.

If the FBI is investigating a terrorist threat, it may ask EPA to assist in the investigation before the incident occurs. The FBI may set up a JOC to conduct an investigation involving a WMD or Chemical, Biological, Radiological, Nuclear, or high yield Explosive (CBRNE). EPA may be asked to participate in the Domestic Emergency Support Team (DEST), which provides guidance to the FBI SAC concerning WMD threats and actual incidents. Rostered DEST members represent EPA Headquarters, and may be deployed with the DEST to the JOC. Regional participation in the DEST may also be requested.

The EPA OSC’s initial role in a radiological terrorist incident is to coordinate EPA resources in the ICP to support DOE, FBI, and local authorities. Critical early tasks should include health and safety planning, site characterization, and site stabilization (Chapter 3 provides information on the initial assessment of the incident and other priorities, while Chapter 4 addresses health and safety requirements for a radiological emergency response and for radiological incident cleanup). Once adequate health and safety measures are in place, additional assessment may be initiated using the procedures outlined in Chapter 5.

As the emergency subsides, planning for decontamination and cleanup should begin (as outlined in Chapters 6, 7, and 8). DOE will transition the Coordinating Agency role to EPA for environmental cleanup and site restoration at a mutually agreeable time, and after consultation with state, local, and tribal governments, the Cooperating Agencies, and the JFO Coordination Group. When this transition occurs, however, EPA should work with DHS to ensure that DOE and other relevant Cooperating Agencies under the NRP Nuclear/Radiological Incident Annex will commit the required resources, personnel, and funds for the duration of the federal response. Table 2.2 provides an overview of the OSC's response activities during a radiological terrorist incident, and indicates the corresponding chapter of this document that addresses the activity.

It should be mentioned that, under the NRP, the lead federal agency for monitoring and decontamination of the affected public is HHS (under ESF #8 - Public Health and Medical Services Annex). HHS is charged with coordinating federal assistance (e.g., National Disaster Medical System) for public decontamination. DOE provides assistance to HHS for this activity during radiological incidents. The NRP notes that state and local governments retain primary responsibility for public screening and decontamination, and that federal assistance is limited.

USACE plays a key role as a Cooperating Agency to EPA during the environmental response to a RDD/IND incident, including management of waste and contaminated wastewaters. The areas in which USACE may provide assistance are listed at the end of the NRP Nuclear/Radiological Incident Annex under the description of USACE responsibilities. (If ESF #10 is activated, EPA may assign environmental activities to USACE. If not, the OSC should work with USACE in the same manner the OSC would with any other NRT member agency or special teams.) In addition, USACE has a primary role under ESF #3 - Public Works and Engineering Annex. Historically under the Stafford Act, USACE has been the federal agency with responsibility for assisting locals with the clearance of debris in a disaster. The NRP expanded the definition of the term "debris" to include contaminated debris. If a RDD/IND results in radioactively contaminated building debris and rubble, USACE is usually assigned to clear the debris from the "debris zone" for the purposes of facilitating the emergency response. The debris zone will be defined by representatives from USACE and ESF #10 (EPA), and USACE will coordinate their contaminated debris removal and management activities under ESF #3 with ESF #10.

USACE should provide staff to the ICP as appropriate to coordinate their debris removal activities. Ideally, EPA and USACE would co-locate in a joint ICP with the other onsite federal, state, and local agencies under the UC to ensure smooth coordination between ESF #3 and ESF #10 activities for a radiological terrorist incident. If unable to collocate all resources in the same command post, an agreement should be reached on how to ensure a UC and coordinated activities (e.g., sharing liaisons between ESF #10 and ESF #3 command post locations).

Table 2.2 Incident Response by an OSC and Applicable Chapter of Radiological Response Guidelines

Site Activity	OSC Response Activity	Chapter
Incident occurs (spread of contamination likely)	OSC response supports fire, EMS, and police	Chapter 3
Radiation detected	OSC calls RERT, ERT, NDT* as appropriate for advice, and implements entry/egress procedures	Chapter 3
Radionuclide identified (α, γ, β emission levels determined)	Set up health and safety zones to limit the spread of contamination, and implement initial activities	Chapters 3 and 4
Health and safety measures in place, health physicists arrive onsite	Implement appropriate survey, monitoring, and sampling procedures	Chapter 5
Contamination extent and hot spots determined	Initial site stabilization efforts and cleanup planning	Chapters 5 and 6
Cleanup planning	Implement process for setting site-specific levels	Chapter 7
Waste disposition	Determine disposition options	Chapter 8

* Radiological Emergency Response Team (RERT), Environmental Response Team (ERT), National Decontamination Team (NDT)

DHS has developed a federal interagency guidance document titled *Application of Protective Action Guides for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents*, which was published in the *Federal Register* for interim use and comment on January 3, 2006 (DHS 2006). This guidance recommends protective action guides (PAGs) to support decisions about actions that may need to be taken to protect the public during a RDD or IND incident. The PAGs address the early, intermediate, and late phases of the response. The document includes a process for establishing final cleanup levels for RDD/IND incidents. This guidance is described in more detail in Chapter 7.

2.4.2 Terrorist Incident for which DoD/DOE/NRC is Assigned as Coordinating Agency

DoD and DOE are the designated Coordinating Agencies under the NRP Nuclear/Radiological Incident Annex for radiological terrorist incidents involving their materials or facilities (see Table 2.1). The NRC is the Coordinating Agency for radiological terrorist incidents involving materials or facilities licensed by the NRC or an Agreement State.

In such incidents, the Coordinating Agency may request assistance from any Cooperating Agency, including EPA. The appropriate role for the EPA OSC (and other EPA response personnel) and placement in the ICP depends upon the type of assistance requested. For example, if EPA provides onsite technical assistance, EPA personnel may join the Operations and

Planning Sections. EPA may also provide representatives to the JFO and other NRP structures, if appropriate.

The initial Coordinating Agency may request a transition of that role to EPA or other Cooperating Agency to manage the long-term cleanup. If DoD, DOE, or NRC request such a transition, the Regional Removal Manager should coordinate the decision with EPA OEM Headquarters.

The funding source is a consideration in these scenarios. If EPA receives adequate Stafford Act funding and a Mission Assignment, providing assistance should be relatively straightforward. If a Stafford Act declaration is not made, or a Mission Assignment is not provided to EPA, a funding source will need to be identified. If the incident involves DoD or DOE materials or facilities, EPA may expect DoD or DOE to reimburse Superfund for EPA's assistance. If the terrorist incident involves a commercial nuclear power plant and the release is determined to be covered by the CERCLA release exclusion described earlier (i.e., source, byproduct, or special nuclear materials), funding from a source other than Superfund will be needed. This may occur in situations where, for example, it is known that no other hazardous substances, pollutants, or contaminants are or could be commingled with the source, byproduct, or special nuclear material covered by the CERCLA "release" definition. It is possible that the federal-to-federal support mechanisms in the NRP may be used to transfer funds from one agency to another, and/or that supplemental appropriations may be provided from Congress.

2.5 FEDERAL SPECIAL TEAMS ASSISTANCE AND ROLES

In addition to the Special Teams (listed in the NCP) that are available to assist the OSC, there are a number of other federal assets that may be called upon in a radiological response. Their placement within the ICP will vary depending upon the type of assistance they provide, but most will integrate into the Operations and/or Planning Sections.

2.5.1 Interagency Teams under the NRP

Nuclear Incident Response Team (NIRT)

The Homeland Security Act of 2002 authorized the Secretary of Homeland Security, in connection with an actual or threatened terrorist attack, major disaster, or other emergency, to call certain DOE and EPA elements into service as an organizational unit of DHS. The Act defines these assets as the "Nuclear Incident Response Team" (NIRT), which includes those (1) DOE entities that perform nuclear and/or radiological emergency support functions (including accident response, search response, advisory, and technical operations functions), radiation exposure functions at the medical assistance facility known as the Radiation Emergency Assistance Center/Training Site (REAC/TS), radiological assistance functions, and related functions; and (2) EPA entities "that perform such support functions (including radiological emergency response functions) and related functions."

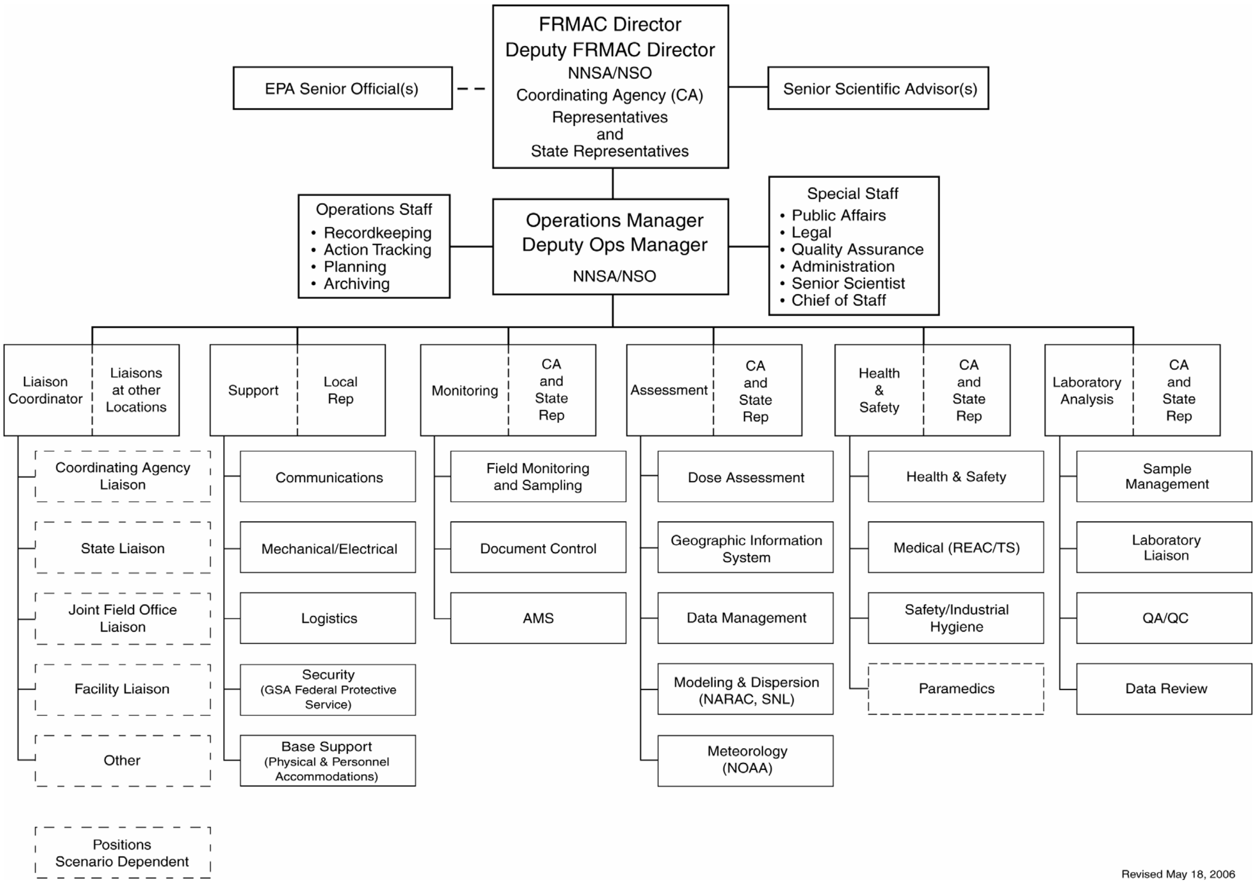
DOE has entered into a Memorandum of Agreement (MOA) with DHS regarding the specific assets that constitute the DOE component of the NIRT. In discussions with EPA, DHS has indicated that DOE does not foresee providing direct operational direction to EPA assets that might become part of the NIRT. Instead, it intends to rely on the structure of the NRP and its Nuclear/Radiological Incident Annex, and the mission assignment process where applicable, to provide overall coordination of a federal response. Therefore, EPA and DHS have not entered into an agreement regarding the NIRT. However, OSCs should be aware of the NIRT and its statutory background (see http://www.dhs.gov/dhspublic/display?theme=17&content=368).

Federal Radiological Monitoring and Assessment Center

The FRMAC is an interagency organization that coordinates federal off-site radiological monitoring and assessment activities for a nuclear or radiological accident or incident. For Incidents of National Significance, the FRMAC supports DHS and the designated Coordinating Agency under the NRP's Nuclear/Radiological Incident Annex. The FRMAC provides federal and state authorities with coordinated and quality-controlled evaluation and interpretation of radiological monitoring and assessment data. The size of the response is dependent on the magnitude of the incident. Although all federal, state, and local monitoring and assessment assets integrate into the FRMAC as part of a response under the Nuclear/Radiological Incident Annex, the FRMAC is frequently referred to as a DOE asset, because DOE leads the FRMAC for the emergency phase of the response and provides significant resources to the establishment of the FRMAC. The leadership of the FRMAC transitions to EPA during the intermediate phase of the response. The Nuclear/Radiological Incident Annex sets forth specific conditions that must be met before this transition may occur. (Additional information about DOE FRMAC assets and the deployment of the FRMAC may be found in Section 2.6.2, DOE Assets.) Discussions are currently ongoing with DOE, and specifically FRMAC management, regarding the integration of the FRMAC into a site-specific ICS. Additional details may be found in the forthcoming *EPA Incident Management Handbook*.

The FRMAC's expertise includes radiation monitoring, sampling, analysis, assessment, health and safety, and support and logistics functions. Figure 2.2 provides the organizational structure of the FRMAC (DOE 2005). EPA's Radiological Emergency Response Team (RERT), a Special Team under the NCP discussed later in this chapter, frequently exercises with the FRMAC. One of the RERT Commanders is expected to fulfill the role of the FRMAC's Senior EPA Official. This role should not be confused with the EPA Senior Federal Official (SFO) in the JFO. The FRMAC Senior EPA Official works under the overall direction of the EPA OSC serving as EPA's IC. During a response, it is expected that the FRMAC Director will work within the ICS organizational structure as appropriate, coordinating with both the Operations and Planning Sections, and specifically with the Environmental Unit Leader, if one is designated.

Figure 2.2 Full FRMAC Organizational Chart (adapted from DOE 2005)



Note: This organizational chart has not been updated to reflect the issuance of NIMS, and does not represent how those components will be integrated with the ICS in the field. EPA currently is working with DOE to clarify those issues, which will be addressed in the forthcoming EPA Incident Management Handbook and modified DOE FRMAC guidance.

Advisory Team for the Environment, Food, and Health

The Advisory Team for the Environment, Food, and Health (frequently referred to as the "A-Team") is an interagency team that develops Federal Protective Action Recommendations and provides them to the Coordinating Agency and, for INSs, DHS. Federal Protective Action Recommendations may include advice and assistance on measures to avoid or reduce exposure of the public to radiation from a release of radioactive material. This includes advice on emergency actions such as sheltering, evacuation, and prophylactic use of potassium iodide. Additionally, advice may be provided on long-term measures, such as restrictions on food, temporary relocation, or permanent resettlement, to avoid or minimize exposure to residual radioactivity or exposure through the ingestion pathway. The Advisory Team is chaired by the HHS Centers for Disease Control and Prevention (CDC) and includes members from EPA's Office of Radiation and Indoor Air (ORIA), U.S. Department of Agriculture (USDA), DHS, and the Food and Drug Administration (FDA). The Advisory Team typically co-locates with the FRMAC, but provides recommendations directly to the Coordinating Agency.

Interagency Modeling and Atmospheric Assessment Center

DHS established a multi-hazard Interagency Modeling and Atmospheric Assessment Center (IMAAC) to ensure that federal plume modeling efforts and communication are consistent across the government. While the IMAAC is a multi-hazard center, it was established specifically to address lessons learned from the TOPOFF2 dirty bomb exercise. In the event of an emergency, the IMAAC will provide atmospheric hazards predictions in support of the Coordinating Agency under the NRP for INSs. The IMAAC products will be recognized as the single source of federal hazards prediction and will be provided to federal, state, and local emergency responders and other government officials as necessary (DHS 2004c). The IMAAC will be responsible for providing accurate, reliable estimates of predicted hazard areas, with associated concentrations, which will serve as the foundation for decisions by the authorized emergency managers. It should be noted that the IMAAC is not intended to replace or supplant the atmospheric transport and diffusion modeling activities that are currently in place to meet agency-specific mission needs (DHS 2004c).

EPA currently is working with DHS and the IMAAC to develop an approach for sharing IMAAC models during an emergency. OSCs and the EPA Emergency Operations Center (EOC) currently are expected to have full access to IMAAC products during an emergency. The FRMAC also is coordinating with DHS/IMAAC regarding the coordination of data and modeling outputs during an emergency.

2.5.2 EPA Assets

Environmental Response Team

The Environmental Response Team (ERT) is a branch within EPA's OSRTI that provides technical support to regional OSCs and Remedial Project Managers (RPMs) in responding to oil spills, hazardous materials emergencies, potentially hazardous situations, long-term remedial activities, and the detection and analytical method development for radiological, biological, and chemical agents. In the radiological area, the ERT is staffed with two Health Physicists whose collective experience exceeds 50 years in emergency response, site characterization and assessment, measurement, verification, cleanup, and disposal of materials contaminated with radioactivity. The ERT also maintains contractor support which includes two full-time personnel who provide health physics and radiation technician services, and additional access to 31 contract Health Physicists. Equipment resources include alpha, beta, gamma, and neutron monitoring equipment, remote gamma surveillance systems, field gamma spectrometry equipment, large-area mobile gamma survey systems, air sampling and measurement systems, interdiction gamma detection systems, radon detection systems, radiation decontamination detectors, emergency response vehicles, and a mobile command post. The ERT stores and maintains radiation monitoring and evaluation equipment and supplies at its Cincinnati and Las Vegas facilities to support its own response activities, as well as to supplement regional equipment stores in the event of a major radiation release event. The ERT and its contractors provide technical and logistical health physics support to regional pre-deployments protecting major public events. The ERT also provides both basic and advanced radiation training to regional, state, and local response personnel. The ERT is prepared to respond to any incidents 24-hours-per-day, 365-days-per-year.

National Decontamination Team

The National Decontamination Team (NDT), in OSWER's OEM, is the federal technical resource that supports domestic and international decontamination actions to protect human health, the environment, and national security. NDT focuses on decontaminating the infrastructure from an INS, a specific mission that is not replicated by other EPA special teams under the NCP, such as the ERT, the RERT, or other elite response units from other federal agencies who may respond on-scene in the aftermath of an INS. Although NDT's mission does not duplicate functions currently served by other assets, it coordinates with and complements other efforts.

NDT's competencies, capabilities, and training includes:

- Advanced training in a variety of relevant disciplines including medical toxicology, biochemistry, risk assessment, health physics, industrial hygiene, and engineering that enables the team to tackle a broad range of complex, multi-disciplinary, problems
- Extensive individual training and meeting physical fitness requirements for emergency response operations, including HAZWOPER (Level A entries), the Incident Command System, proper use of a wide-range of personal protective equipment (PPE), and specialized instruments suitable for an all-hazards venue
- Maintaining security clearances as directed by OSWER's OEM
- Together with EPA's National Homeland Security Research Center (NHSRC) staff and others, assisting in bridging the gap between research and development and the delivery and vetting of products that enhance and improve field operations
- Managing and deploying ASPECT aircraft for chemical and radiological incidents.

The NDT is available 24 hours a day via pager at 800-329-1841.

Radiological Emergency Response Team (RERT)

EPA's RERT draws personnel from ORIA's national laboratories and headquarters. RERT provides OSCs with guidance and on-scene assistance at Superfund and emergency response sites and the FRMAC. RERT focuses on identifying and assessing potential impacts of low-level contamination. RERT assists federal, state, tribal, and local response efforts before, during, and following a radiological incident by:

- Providing technical advice and assistance to prevent or minimize threats to public health and the environment
- Providing advice on protective measures to ensure public health and safety
- Providing assessments of dose and impact of any release on public health and the environment
- Performing monitoring, sampling, laboratory analyses, and data assessments to assess and characterize environmental impacts
- Providing technical advice and assistance for containment, cleanup, restoration, and recovery following a radiological incident

In addition to trained personnel, RERT provides mobile emergency response equipment including the RadNet monitoring system, Mobile Emergency Response Laboratories (MERLs), Mobile Sample Prep Laboratories, a variety of scanning and sampling equipment, and general support equipment. The two RERT Commanders, located in Montgomery, Alabama, and Las Vegas, Nevada, rotate as the primary contact for the Teams. The RERT Commander on rotation can be accessed 24-hours-per-day through the National Response Center.

2.5.3 DOE Assets

DOE's emergency response programs provide the national technical response to all nuclear or radiological emergencies within the United States and abroad. DOE provides expert technical advice in response to nuclear weapon accidents and significant incidents, radiological accidents, lost or stolen radioactive materials, and acts of nuclear terrorism. These assets facilitate access to nuclear weapons design and production knowledge, as well as provide deployable capabilities that can be configured rapidly for a time-phased response to any specific nuclear incident. All DOE assets may be deployed by contacting the National Nuclear Security Administration (NNSA) at DOE Headquarters through the DOE Emergency Operations Center.

Radiological Assistance Program Teams

The Radiological Assistance Program (RAP) Teams are DOE's primary accident response element and are comprised of health physicists and support personnel with a primary mission to perform radiological assessment and monitoring at an accident. The RAP Team is usually the first NNSA team to deploy to the scene of an accident or incident. The RAP Teams provide the initial DOE radiological emergency response and assist in the following:

- Characterizing the radiation environment at the accident or incident scene
- Identifying the presence of radioactive contamination on personnel, equipment, and property at the accident or incident scene
- Determining the best methodology for personnel monitoring, decontamination, and material recovery

The RAP Teams typically possess portable radiation detectors, air samplers, personnel protective clothing and equipment, and communication equipment. The RAP Teams are located in eight regional coordinating offices across the United States, as shown in Figure 2.3. Table 2.3 provides contact information.

Figure 2.3 DOE RAP Team Locations (DOE 2005)

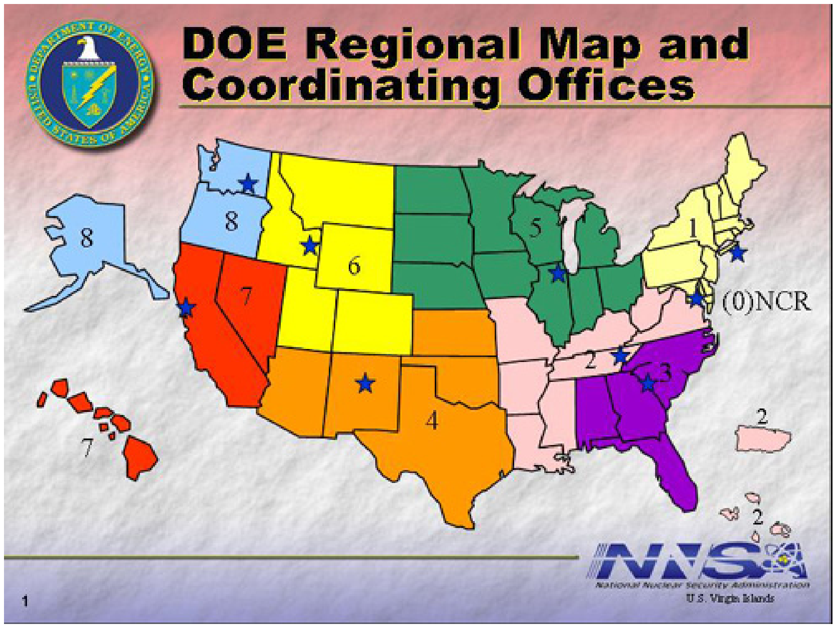


Table 2.3 DOE RAP Regional Contact Numbers (DOE 2005)

Region 1, Brookhaven Area Office	(631) 344-2200
Region 2, Oak Ridge Regional Operations Office	(865) 576-1005
Region 3, Savannah River Operations Office	(803) 725-3333
Region 4, NNSA Service Center	(505) 845-4667
Region 5, Chicago Operations Office	(630) 252-4800
Region 6, Idaho Operations Office	(208) 526-1515
Region 7, Livermore Site Office	(925) 422-8951
Region 8, Richlands Operations Office	(509) 373-3800
DOE HQ	(202) 586-8100

Accident Response Group

The Accident Response Group (ARG) responds in the event of an accident involving a U.S. nuclear weapon or a nuclear explosive device. The ARG, which is managed out of NNSA Albuquerque, New Mexico, brings expert personnel and specialized equipment for diagnosing, disabling, and rendering safe a damaged weapon or improvised device. ARG response is coordinated through the DOE Joint Nuclear [Weapon] Accident Coordinating Center (JNACC). The ARG first deploys an advance team–consisting of an Energy Senior Official, Senior Scientific Advisors, Weapon Recovery Director, Logistics Coordinator, Hazards Assessment Director, and Public Affairs Officer–to the scene, usually within a few hours after notification. The ARG advance team determines the type and number of personnel required and the equipment needed for the response. The RAP team provides radiological assessment and other information to the ARG. After this briefing, the RAP team works hand-in-hand with the ARG.

Aerial Measuring System

The Aerial Measuring System (AMS) is based and operated out of Nellis Air Force Base in Las Vegas, Nevada, with additional operational capability at Andrews Air Force Base near Washington, DC (DOE 2005). The AMS aircraft carry radiation detection systems that provide real-time measurements of extremely low levels of ground and airborne contamination. AMS also can provide detailed aerial photographs and multi-spectral imagery and analysis of an accident site. AMS maintains both fixed-wing aircraft (Beechcraft B-200 or Cessna Citation) and helicopters (Bell 412). Aircraft can arrive quickly at the emergency scene to provide rapid mapping of the extent and levels of contamination. Figure 2.4 shows the approximate time from notification until data is in the hands of decision makers, for the B-200. While helicopters are slower than fixed-wing aircraft, they are able to travel at lower altitudes, typically 150 feet above ground, and can therefore provide a more detailed and complete radiological picture than can fixed-wing aircraft. However, because helicopters fly more slowly, the time between notification and provision of data is longer. A four-wheel drive vehicle-based radiation detection system, named KIWI, also can be used to develop highly detailed maps of any ground contamination. NNSA is then able to rapidly develop maps of the airborne and ground hazards. This enables the scientists to determine ground deposition of radiological materials and to project the radiation dose to which people and the environment are exposed.

Atmospheric Release Advisory Capability

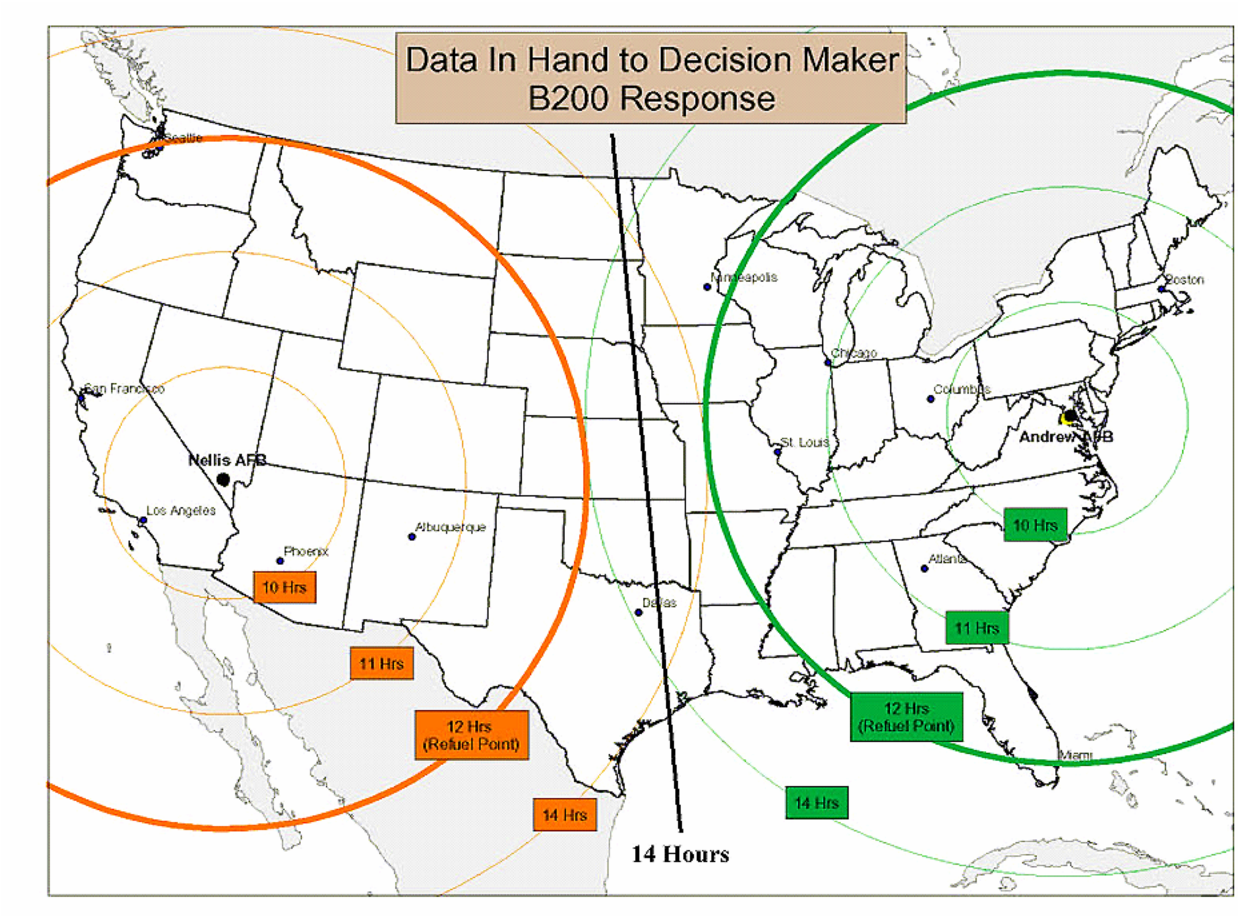
The Atmospheric Release Advisory Capability (ARAC) provides real-time computer predictions of the atmospheric transport of radioactivity from a nuclear incident. These predictions use topographical and real-time meteorological data in a 3-D radiological dispersion model. Maps are produced that contain accumulated integrated doses, airborne concentrations, and contamination distributions. The ARAC, also known as the National Atmospheric Release Advisory Capability (NARAC), supports the IMAAC.

Nuclear Emergency Support Team

The Nuclear Emergency Support Team's (NEST) mission is to provide specialized technical expertise to the federal response in resolving nuclear or radiological terrorist incidents (DOE 2002). All response team activations and deployments are directed by DOE Headquarters after coordination with other concerned agencies.

NEST capabilities include search and identification of nuclear materials, diagnostics and assessment of suspected nuclear devices, technical operations in support of render-safe procedures, and packaging for transport to final disposition. NEST capabilities are drawn from the nation's nuclear weapons complex. Response teams vary in size from a five-person technical advisory team to a seven-person Search Response Team to a tailored deployment of dozens of technical specialists from NNSA's nuclear weapons laboratories and facilities (including Los Alamos National Laboratory, Sandia National Laboratories, Lawrence Livermore National Laboratory, Bechtel Nevada's Remote Sensing Laboratory, and the Pantex Plant). The NEST specialized response teams include coordination and liaison, and advisory teams, search teams, technical operations teams, and planning support teams. The teams deploy with secure and non-secure communications packages and Geographic Information System (GIS) databases that provide electronic mapping and demographics.

Figure 2.4 DOE AMS B-200 Range Chart



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Radiation Emergency Assistance Center/Training Site

The REAC/TS, an emergency response team of health professionals and radiation medical support, provides 24-hour medical consultation on health problems associated with radiation accidents. In addition, REAC/TS has a central training and demonstration facility where national and foreign medical, nursing, paramedical, and health physics professionals receive intense training in the treatment of radiation exposure. REAC/TS has been designated as the World Health Organization Collaboration Center for radiation emergency assistance.

DOE FRMAC Assets

DOE provides the resources and assets to activate FRMAC, as discussed in Section 2.5.1. These resources are primarily based and operated out of Nellis Air Force Base in Las Vegas, Nevada (at the DOE/NNSA Nevada Site Office), with additional assets elsewhere within DOE. When a FRMAC response is required and authorized by DOE Headquarters, DOE designates a FRMAC Director and initiates a FRMAC deployment. The FRMAC deploys as a phased response (DOE 2005). Prior to the initiation of FRMAC operations, federal first responders coordinate radiological monitoring and assessment data with the DOE Consequence Management Home Team (CMHT), contacted through DOE's Emergency Operations Center. The CMHT operates within the Remote Sensing Laboratory in Las Vegas, Nevada, and integrates scientists from Sandia National Laboratories for nuclear effects modeling. This in-house component provides a reach-back capability to support the deploying FRMAC assets in the field. The FRMAC Phase I can be expected to deploy in approximately eight hours ("wheels up" time), followed by FRMAC Phase II in about 11 hours (again, "wheels up" time). The full-field FRMAC (pictured in Figure 2.2) should be operational within 24 to 36 hours. All phased response times may vary depending on the location of the incident, travel, and weather conditions.

The FRMAC Phase I (also known as the Consequence Management Response Team I, or CMRT I) is a 16-member rapid initial response capability (DOE 2005). This phase serves as a quick response element to augment the RAP Teams in U.S. responses. It also provides the core command and control for FRMAC contributions from other departments/agencies and state and local responders. The team will incorporate all the disciplines necessary to support operations (including radiation monitoring, sampling, analysis, assessment, health and safety, and support and logistics functions), but only on a limited scale. It is designed for rapid radiological data collection and assessment in order to provide early health effects advice and timely characterization of the radiological situation to the officials responsible for making and implementing protective actions for the public. In addition, CMRT I has the capability to provide escort services for emergency workers entering potentially contaminated areas for lifesaving and/or forensic purposes.

The FRMAC Phase II (also known as the CMRT II) is designed to dispatch as an augmentation team to CMRT I. The integrated CMRT II provides additional monitoring and assessment capability and 24-hour operations; establishes data, voice, and fax links with DOE offices; and establishes GIS support to the state and Coordinating Agency. If appropriate, the CMRT II will initiate preparations for the arrival of the FRMAC.

For deployments to remote areas, DOE has the resources and capability to establish technical operations centers in tents equipped with portable generator alternating current power, air conditioning/heating, satellite communications, radio communications, tables, chairs, and other support equipment. In addition, tents, sleeping bags, and food can be provided for several days (sufficient meals ready to eat [MREs] for 100 people for three days) for the housing and care of the phased responders.

The full field FRMAC organizational chart is shown as Figure 2.2. Figure 2.2 shows the basic and most common operational configuration for the FRMAC during a major radiological emergency, as exercised at nuclear power plant and weapons exercises. However, this chart may be modified for smaller radiological deployments. The full field FRMAC includes participation by the Coordinating Agency and state.

2.5.4 DoD Assets

For radiological responses conducted under the NCP alone, DoD assets must be accessed through DoD Headquarters. The National Response Team has recently issued guidance on how to access DoD resources, which can be found at www.nrt.org. For INSs under the NRP, initial requests for DoD Defense Support of Civil Authorities (DSCA) resources go to the Office of the Secretary of Defense, Executive Secretariat. Requests originating at the Joint Field Office go to the Defense Coordinating Officer (with limited exceptions, including USACE support, which can be accessed through ESF #3, and National Guard forces employed under State Active Duty or Title 32 status, who can be accessed through the state. Specific resources of potential interest to OSCs are listed below).

Medical Radiobiology Advisory Team

The Medical Radiobiology Advisory Team (MRAT) can be deployed from the Armed Forces Radiobiology Research Institute (AFRRI), a tri-service facility in Bethesda, Maryland, that conducts research in the field of radiobiology and related matters essential to the operational and medical support of the DoD and the Military Services (DoD 2005). MRAT provides expertise in radiation risk communication, personnel dose estimation, hand-held nuclide identification, and radiation medicine (including chelation therapy, emetics and/or cathartics, protectants, and psychological awareness). MRAT also can provide technical advice regarding (but not perform) external personnel decon, perform internal and wound personnel decon, use site restoration software and models for both plume prediction and health physics interpretation, and provide waste disposal advice.

Air Force Radiation Assessment Team

The Air Force Radiation Assessment Team (AFRAT) is a field-qualified 37-person team of deployable health physicists, industrial hygienists, and laboratory technicians stationed at the Air Force Institute for Environmental, Safety, and Occupational Health Risk Analysis (DoD 2005). Assets include a forward-deployed field laboratory, supplemented by reach-back radioanalytical capability at Brooks Air Force Base, Texas. The AFRAT may deploy to any location, worldwide, within 24 to 48 hours (time to arrive). It may provide a full range of equipment, force protection dosimetry, and consultation about health physics, industrial hygiene, and environmental quality.

The capability is comprised of five teams: Nuclear Incident Response Force I, Nuclear Incident Response Force II, Radiological Reconnaissance Laboratory I, Radiological Reconnaissance Laboratory II, and Field Laboratory for Assessment of Radiation Exposure. During an emergency, these teams may provide:

- Onsite detection, identification, and quantification of ionizing radiation hazards
- External dosimetry support for force protection of up to 1,000 measurements a day
- Twenty-eight extra-duty personnel that include occupational health physicians, health physicists, bioenvironmental engineers, bioenvironmental engineering technicians, radioanalytical laboratory technicians, radiochemists, and laboratory technicians with expertise in industrial hygiene and environmental quality

Radiological Advisory Medical Team

The Radiological Advisory Medical Team (RAMT) is a U.S. Army rapid-response team specifically designed to provide timely expert guidance and services to the Combatant Commander, the DoD Senior Federal Official, and/or local medical authorities. It can provide limited medical support to response teams in controlled areas (DoD 2005). In peacetime or war, the RAMT is capable of responding to a wide variety of events involving limited or mass nuclear casualties, radiologically contaminated patients, or exposed populations from events, such as reactor accidents, radiological terrorism, or nuclear war. The RAMT may deploy within four hours of notification. During an emergency, the RAMT may provide:

- Guidance relative to the potential health hazards to personnel from radiological contamination or exposure to ionizing radiation
- Evaluation of survey data to provide technical guidance to the responsible officials using radiologically contaminated areas
- Monitoring of medical facilities and equipment where contaminated patients have been evacuated
- Advice on the potential health hazards from exposure to sources of ionizing radiation and the decontamination of personnel, medical treatment facilities, and medical equipment
- Advice on early and follow-up laboratory and clinical procedures
- Assistance with a bioassay program

Consequence Management Advisory Team

The Consequence Management Advisory Team (CMAT), which is coordinated from DoD's U.S. NORTHCOM Joint Task Force Civil Support (JTF-CS), is trained and equipped to help a DoD lead responder to assess and predict contamination after a nuclear incident (DoD 2005). A CMAT advance party may deploy to assess the onsite situation and may be followed by additional personnel depending on the situation. The CMAT advises the DoD lead official on overall federal response procedures and requirements associated with a nuclear weapon accident response. The MRAT also deploys as part of the CMAT. The CMAT's deployment time depends on aircraft availability. During an emergency, the CMAT may provide:

- Hazard prediction and modeling capability
- Secure and non-secure satellite voice, data, and fax communications
- Public affairs personnel
- Legal counselors
- An extensive technical publications library on nuclear weapons and materials
- Guidance and advice on current techniques for radiation injury treatment and internal decontamination
- Casualty estimates (Biodosimetry Assessment Tool)
- Guidance and advice about the potential health hazards and performance decrement effects from exposure to various doses of ionizing radiation
- Advice on appropriate bioassay and clinical procedures
- MRAT physicians who have access to, and expertise in, the use of pharmaceutical agents for treating radiation injury, including internal contamination

U.S. Marine Corps Chemical Biological Incident Response Force

Despite its name, the Chemical Biological Incident Response Force (CBIRF) responds to radiological and nuclear incidents (USCG 2005). The CBIRF, located in Indian Head, Maryland, is designed to deploy immediately in the event of a credible threat of a CBRNE incident in order to assist local, state, or federal agencies. CBIRF assistance includes coordinating initial relief efforts, security, detection, identification, expert medical advice, and limited decontamination of personnel and equipment. CBIRF consists of specially trained personnel and specialized equipment suited for a wide range of operational contingencies. Through detection, decontamination, and emergency medical services, the CBIRF capabilities are intended to minimize the effects of a chemical, biological, or radiological incident. CBIRF is prepared to respond on short notice to incidents worldwide in assisting the on-scene commander in providing initial post-incident consequence management. There are five functional elements within CBIRF that deploy in an emergency situation to assist in the response:

- The Nuclear, Biological, Chemical (NBC) reconnaissance element, responsible for detecting the location of an incident site
- The Decontamination element, which decontaminates personnel and equipment exposed to any contamination
- The Medical element, which is capable of providing triage support to casualties during and after decontamination
- The Security element, which provides security for the contaminated site as well as assets operating within the area
- The Service support operations element, which provides shelter, food, and water so CBIRF can operate in a contaminated site

U.S. National Guard Weapons of Mass Destruction Civil Support Teams

The Weapons of Mass Destruction Civil Support Teams (WMD-CSTs) are designed to augment terrorism response capabilities in events known or suspected to involve WMD (USCG 2005). The WMD-CST mission is to support civil authorities at a domestic CBRNE incident site by identifying CBRNE agents/substances, assessing current and projected consequences, advising on response measures, and assisting with appropriate requests for state support to facilitate additional resources. Each unit is made up of 22 full-time National Guard members, and consists of six sections: command, operations, communications, administration/ logistics, medical, and survey. Members have been specially trained and equipped to provide a technical reach-back capability to other experts. The team integrates into the ICS in support of the local IC. Each WMD-CST has the capability to provide rapid detection and analysis of chemical, biological, and radiological hazard agents at WMD incident scenes, and is equipped with a mobile Analytical Laboratory System.

WMD-CSTs are currently based in Alaska, Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Hawaii, Idaho, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Missouri, New York, New Mexico, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, and West Virginia. By 2007, there will be one team in every state and territory.

2.5.5 Department of Labor/OSHA Health Response Team (HRT)

The HRT, based in Utah, is available to provide technical assistance in the areas of industrial hygiene and specialized engineering (USCG 2005). The HRT is organized into four specialized response teams in the areas of chemical, biological, radiological, and structural collapse, which are supplemented by additional team members located throughout the country in OSHA field offices. The HRT is designed for, and serves to conduct, the following:

- Respond to occupationally related emergencies that may involve potentially catastrophic releases of hazardous materials
- Provide technical expertise in recognizing and evaluating health and safety hazards associated with a wide range of complex industrial operations
- Evaluate and recommend appropriate engineering controls, and provide onsite technical expertise for complex, unusual, and high-priority occupational hazard investigations
- Work with the Directorates of Health and Safety Standards in developing new standards, and design and conduct studies to obtain data that the standards development organizations can use to form the basis for making decisions
- Maintain current national and international safety and health awareness and technological advances involving industry practices and specific work processes to advise OSHA program offices of their potential impact on existing OSHA programs
- Provide national technical experts for hazardous waste site activities
- Provide testimony as needed during contested cases or in the standards-setting process.

FBI, Laboratory Division, Hazardous Materials Response Unit (HMRU)

Located in Quantico, Virginia, the FBI’s Hazardous Materials Response Unit (HMRU) responds to criminal acts and incidents involving the use of hazardous materials, including radiological devices. HMRU also develops the FBI’s technical proficiency and readiness for crime scene and evidence-related operations in cases involving chemical, biological, and radiological materials and wastes (USCG 2005). While the HMRU is unlikely to be called upon to assist the OSC, OSCs should be aware of their role in investigating a crime scene involving radiological devices.

3. EPA RESPONSE

Several different surreptitious mechanisms exist for the introduction of radioactive materials as part of a terrorist attack. Some of these mechanisms are:

- Radiological Dispersal Device (RDD)
- Improvised Nuclear Device (IND)
- Soluble radionuclides introduced into a large drinking water supply
- Consumer product tampering at a factory or production site
- Crop sprayers being used to spread aerosols over large surface areas

All of these mechanisms present their own special circumstances requiring the deployment of EPA radiological monitoring assets/resources. In the initial phase of all but the RDD/IND type scenario, OSCs would have a more focused effort on the radioactive contamination problem and less on loss of life and immediate life threatening conditions. Additionally, the OSC would have credible information that a radiological event occurred, and environmental monitoring for a specific (and likely already known) radiological substance will be required.

In the RDD/IND scenario, first responders and OSC personnel will be concerned with life saving activities first and contamination/radiation issues second. For such an event there will be scant details about the radioactive materials present and the OSC will have minimal resources at their disposal for detailed measurements of these materials.

For these reasons, this chapter focuses on an event where there is insufficient lead time to deploy these assets. The chapter is intended to provide OSCs with radiological response guidance when the Health Physicist and significant radiation monitoring assets are not yet onsite.

The first on-scene responders to a potential terrorist threat are local officials—fire and police departments. Unless a terrorist attack involving radioactive material is targeted on a nuclear facility, it is possible that radiological aspects of the event may not be recognized by first responders to the scene (NCRP 2001). Because of EPA's statutory responsibilities under the NCP to respond to releases of oil, hazardous substances, pollutants, or contaminants, local officials often call EPA to assist them in responding to these types of releases. It is likely that EPA OSCs and Superfund Technical Assistance and Response Team (START) contractors will be on scene during the first few hours after an incident. Therefore, it is critical that OSCs be equipped with the proper radiation/radioactivity detection and dosimetry instrumentation and understand the role they can play to support the local response effort.

To understand the role they can play, OSCs must first understand the actions they can take with limited resources to provide key information that can be acted upon. A full radiological characterization of the incident will not happen until additional resources arrive; however, some general protective actions can be implemented based on limited survey data to help the local emergency responders maintain control of the scene and keep their radiation exposure as low as is practicable. The magnitude of the initiating event will determine the quantity and type of response assets (e.g., personnel, air monitoring equipment) that OSCs will mobilize to respond.

Immediate response assets will vary from region to region, but one to two OSCs and two to five START contractors are typical during the first few hours of an event.

Most likely, significant state and federal radiological resources will not be on scene during the initial emergency response phase of an incident. Even after these resources arrive, it will still take some time before the magnitude of a terrorist attack involving radioactive material is understood. Local emergency responders plan for and respond to transportation incidents involving hazardous materials all the time. Protective actions that are implemented by local responders for hazardous materials incidents are essentially no different than actions taken for an incident involving the intentional dispersal of radioactive material. Local responders generally follow the protective actions found in the Department of Transportation's (DOT's) *Emergency Response Guidebook* when responding to hazardous materials incidents (DOT 2004). However, the implementation of these protective measures cannot occur until the radiological aspects of the site are recognized.

Depending on the nature of the incident, local responders may be inundated with fire fighting and life-saving operations, so air monitoring may not occur initially. In this situation, air monitoring both inside and outside the exclusion zone is justified to support the implementation of protective actions. Radiological monitoring data should be collected to answer the following questions: 1) has radioactive material been detected and at what level? and 2) can it be transported from one area to another? This basic information will allow the Incident Commander (IC) to take actions that will protect the public and help the local responders control the spread of radioactive material before information is obtained on the nature and extent of contamination.

Performing air monitoring in urban environments is more complicated than in rural environments. The presence of large buildings or structures creates complex wind patterns that emergency responders should become familiar with. The following section presents some of the common patterns of plume transport in urban environments.

3.1 COMMON PATTERNS OF PLUME TRANSPORT IN URBAN ENVIRONMENTS

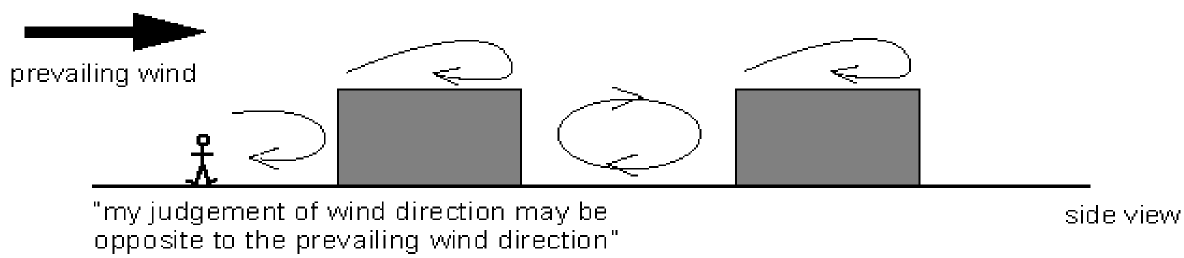
Although not an everyday phenomenon, releases of hazardous gases and aerosols that pose a potential threat to human life do occur in populated urban environments. These releases may stem from onsite accidents, as in the case of industrial chemical releases during transport of hazardous chemicals (tanker truck or railroad spills), or from predetermined acts, as in the case of a chemical, biological, or radiological agent terrorist attack (LANL undated).

At accident sites, emergency responders typically are responsible for maintaining order, determining safe zones, and performing rescue and evacuation. In the event of a toxic cloud release in an urban area, emergency responders need to be cognizant of the complicated transport and dispersion processes that occur around building structures in order to make sound decisions.

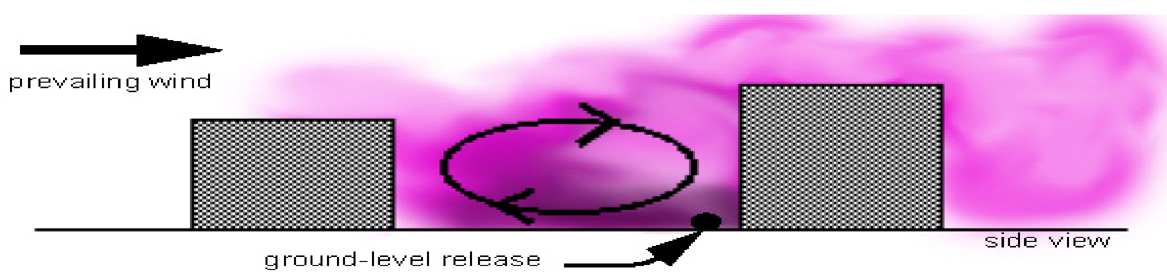
This subsection is meant to help emergency responders, managers, and training personnel become familiar with some of the more common patterns of plume transport and dispersion that develop in built-up urban areas. The example list that follows describes common situations that may occur in an urban environment and gives warnings about potentially fatal consequences if the situation is misinterpreted. These examples are not meant to tell the emergency responder what to do, but rather to warn the emergency responder that sometimes unexpected or counter-intuitive flow phenomena may occur. The objective of the examples that follow is to give the emergency responder more knowledge so that he or she is better able to anticipate problems.

It is very important to understand that, because of the complexities of urban built-up areas, it is difficult to generalize rules for plume transport and dispersion that work for every case. Evidence suggests that transport and dispersion around buildings or other structures is very complicated and transport and dispersion patterns may be very different depending on building shape, relative heights, and other factors. These examples were developed to give emergency responders a general idea of some of the complexities of plume transport and dispersion in built-up areas. Caution should be used in applying “go/no go” decisions based on the following examples.

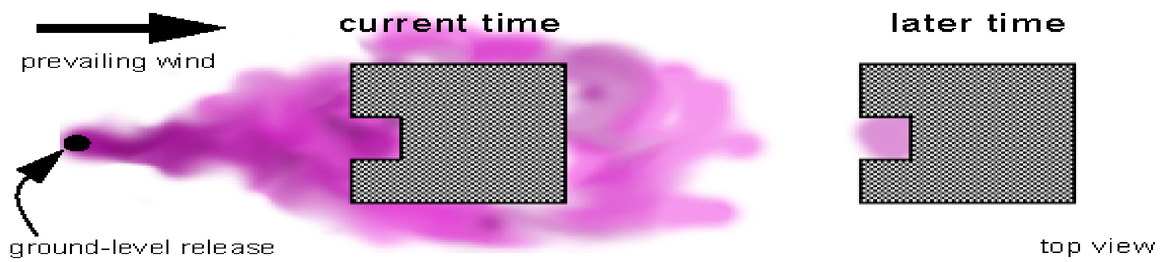
Apparent Wind Anomalies. The locally measured wind may not match the large-scale wind direction due to building-induced circulations. Because of the complicated flows that develop around buildings, a measurement of wind made at ground-level may not be indicative of the upper-level prevailing wind. Evacuation zones far downwind must be determined by the larger-scale plume transport that follows the prevailing wind, not the local wind.



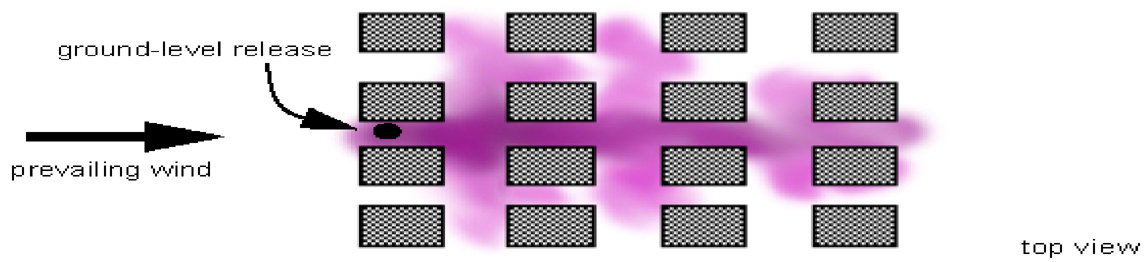
Agent Trapping in Vortices. For winds traveling approaching a building face-on, concentrations of hazardous material can build up in between the buildings and take a relatively long time to flush out. Air contaminants can become trapped between buildings in slow moving vortices, thus taking longer to flush out with clean air. In most cases, wider buildings and narrower streets will trap the pollutant longer.



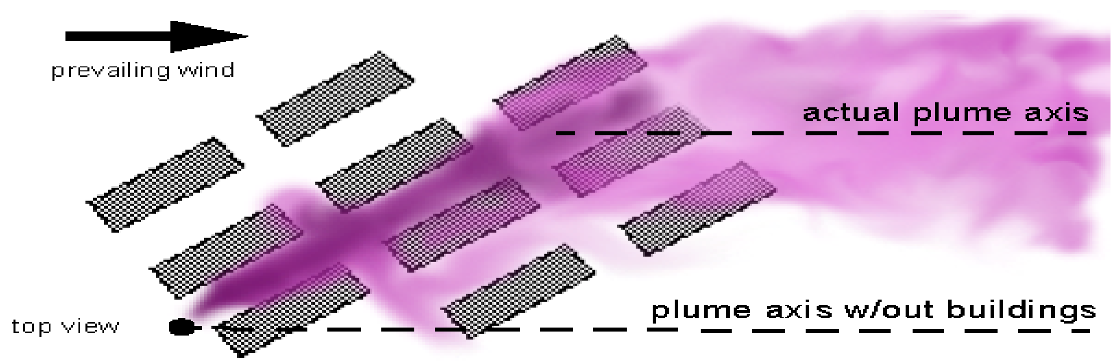
Agent Entrapment. Recessed entryways or architectural alcoves may trap and hold air contaminants for some time after the plume has passed. Even after the main portion of the plume has disappeared, some of the air contamination may have collected in alcoves and other zones of stagnation.



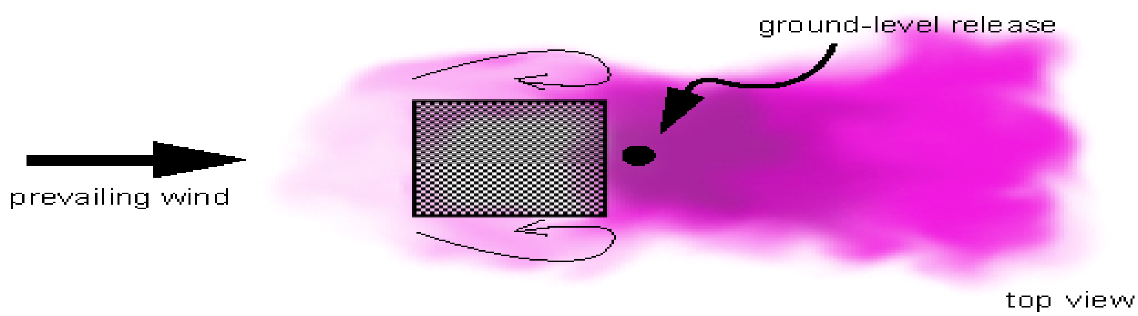
On-Axis Channeling Effects. For winds parallel to the street, the plume can become contained within the street canyon; however, the plume can travel up side streets. If the prevailing wind direction is parallel to the street containing the release, contaminated air is likely to travel several blocks in each direction along site streets.



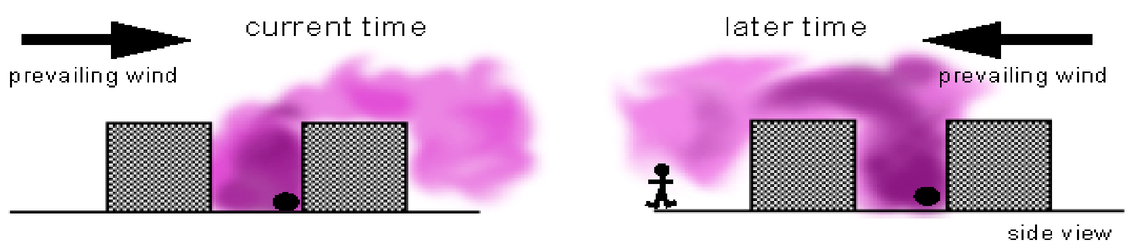
Off-Axis Channeling Effects. The plumes can get channeled by streets near the source and end up traveling off the prevailing wind direction axis. For determining larger-scale evacuation zones, the plume initially may be transported in a direction off-angle from the prevailing wind. Once the plume gets dispersed above the buildings, it will then travel with the prevailing wind, but the plume's center will be offset from the release point.



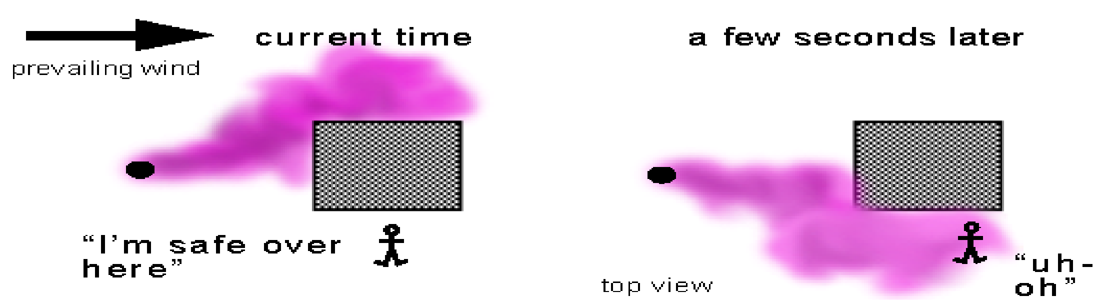
Eddy Transport of Agent. The air contaminant can move short distances against the prevailing wind direction in recirculation zones along the sides and top of buildings. Even if the source is determined to be downwind, contaminated air may be found at locations near the building upstream of the source, as the plume can travel short distances in the direction opposite the prevailing wind.



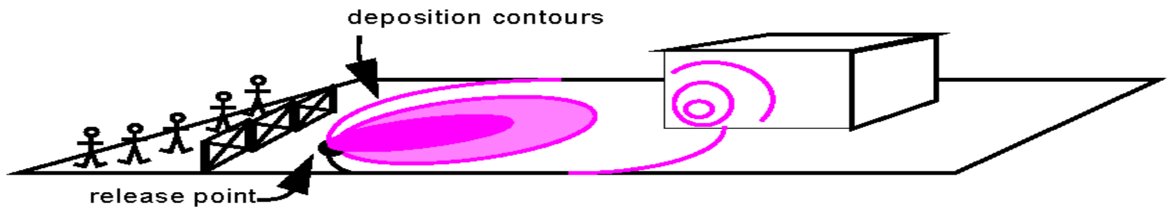
Large-Scale Wind Variability. The prevailing wind switches direction occasionally, so the upwind safe zone may now be downwind. The prevailing wind is not fixed and under some circumstances can change direction quickly. Thus, monitor the prevailing wind direction so that safe zones can be maintained.



Small-Scale Wind Variability. The local wind can switch directions very rapidly, causing the plume to switch from one side of a building to the other side in a matter of seconds. Due to the turbulent nature of the wind, it is very common for a plume to bounce from one side of a building to the other. Therefore, it may not be safe on one side of a building just because the plume is currently on the other side.



Agent Deposition. After the plume has left the area of release, the ground and building surfaces may still be contaminated due to deposition of the toxic agent. Because the contaminant may stick to surfaces, touching surfaces in the vicinity of the release point is not recommended until decontamination is complete.



Indoor Effects. When the plume is passing over, it is probably safer to remain indoors. After the plume has passed by, it may be safer to move outdoors. For an outdoor release, modeling studies show that concentrations can initially be lower indoors, but then later the concentrations become lower outside. These relationships, however, depend upon the details of the building ventilation.

3.2 INITIAL RESPONSE ASSETS

The following is a bulleted list of air monitoring equipment that OSCs should have available to them while on primary response. Detailed description and operational readiness guidelines can be found in the Quick Start Guides (QSGs). The QSGs can be found on the OSC website at www.epaosc.org.

- Micro-R meter
- GM pancake detector probe
- Ion chamber
- Alpha scintillation probe
- Alpha/beta/gamma/neutron detector
- SAM-935 multi-channel analyzer
- Multi-Rae 5 gas monitor
- Data-ram particulate monitor
- Radeco air sampler (LB 5211 glass fiber filters)
- Siemens EPD Mk2 real time dosimeter
- Plastic wrapping materials to prevent contamination of equipments

- EPD Mk2 Dosimeters
- Glassine envelopes

3.3 RESPONSE PROCEDURES

All OSC responses to releases of hazardous material must include an assessment for the presence of radioactive material. Prior to any initial response to a hazardous material incident, each OSC should ensure that they are responding with the response assets listed in Section 3.2. Prior to deployment, operational checks of the radiation instruments should be performed. Follow the QSGs specific to each instrument. Note the background readings in your log book. The Micro-R and GM pancake survey meters should be placed in the front seat of the vehicle with the audible turned on. The survey meters should be on the lowest multiplication scale (i.e., the most sensitive). Arrive upwind if there is a visible smoke plume. As you arrive on scene, be sure that the meters are still reading background. Listen for a change in the audible tone or look at the meter face. If the levels are greater than twice background, wrap all meters in plastic to protect them from getting contaminated. Wrap only the non-detector surfaces on the pancake detector.

Upon arrival at the scene, the OSC should obtain a situational briefing by the IC or his or her representative. Offer EPA air monitoring and response assets to the local response effort and establish EPA's role in the incident action plan. If the response notification guidelines have been exceeded and the IC is not aware of the presence of radioactive material, inform the IC of these readings and follow the Radiological Entry/Egress procedures that follow and those that are presented in the Radiological Response Standard Operating Procedure 402 (RRSOP-402) *Scoping Survey Approaches and Strategies*. Remember, the scene also must be screened for chemical and biological agents as well as radioactive material. All EPA radiological survey data should be recorded on Radiological Response Survey Form 900 (RRSF-900). This form can be found in RRSOP-402 (available on companion CD or at www.epaosc.org).

At any time during the response, if you encounter exposure rate levels (micro-R meter) and/or count rate levels (GM pancake detector) greater than the response guideline values, additional notifications must be made. The OSC should start the notification chain by informing the IC. Next the OSC should notify the Radiological Emergency Response Team (RERT) Commander, the DOE Radiological Assistance Program (RAP) Team covering your region, and the State Radiation Program. Radiation technical and response support can be obtained from these entities. These additional notifications can be made by the Regional Duty Officer. The response notification guidelines are ***100 micro-Roentgens per hour (µR/hr)*** with the micro-R meter and a continuous deflection greater than ***330 counts per minute (cpm)*** with the pancake detector. These levels refer to an ambient (i.e., a general area) reading, not a reading on a few objects or in small areas (i.e., contact readings). This means that as you are surveying the scene, 100 µR/hr or 330 cpm is an ambient, continuous reading and above your previously established background reading.

3.4 RADIOLOGICAL RESPONSE STANDARD OPERATING GUIDANCE (SOG)

3.4.1 Pre-Deployment & Arrival Procedures

As described in Chapter 2, DOE is the Coordinating Agency for certain radiological terrorism incidents under the NRP Nuclear/Radiological Incident Annex. This Coordinating Agency role transitions from DOE to EPA for cleanup and site restoration at a mutually agreeable time. One of the responsibilities of the Coordinating Agency is to ensure the coordination of technical data which includes analysis, storage and dissemination. The first DOE asset to arrive on-scene will typically be the Regional Radiological Assistance Program (RAP) team(s). The RAP teams do not have the capability to set up an electronic database. While the FRMAC has this capability, the EPA OSC may arrive on scene prior to the FRMAC. In this case, the EPA OSC can assist DOE by setting up an electronic database, i.e., SCRIBE, to store all onsite air monitoring data including any available EPA, DOE RAP, and state and local radiological monitoring data. Access to SCRIBE will be provided to DOE assets (the DOE Consequence Management Response Team) and the DHS IMAAC, so they can access the data remotely prior to the FRMAC's on-scene arrival. Once the DOE FRMAC personnel arrive and establish their own database capabilities, the FRMAC database will become the official Federal repository for radiological data. EPA will continue to store its own radiological and non-radiological data in SCRIBE, and continue to make the SCRIBE data available to the FRMAC.

Pre-Deployment Operational Checks

a. Perform operational checks on Micro-R meters (i.e., model 192, 19) and pancake detectors (2241-2 coupled to model 44-9 pancake detector) in accordance with QSGs.
b. Place radiation meters in front seat of vehicle or dashboard with audible ‘on.’

Arrival Procedures

a. If there is a visible smoke plume, arrive up-wind of the scene.
b. Check radiation meters against notification guidelines. The notification guidelines are an ambient reading of 100 μR/hr with the Micro-R meter and/or 330 cpm with pancake detector. (These are equivalent readings when calibrated to a ^{137}Cs source.)
c. If first responders have set up an exclusion zone for the public, drive outside the perimeter of the exclusion zone, one to two kilometers downwind, recording any readings above background (see Figure 3-1). Record these readings on RRSF-900. If guidelines are exceeded, make notifications to EPA, the RERT Commander, DOE RAP, and state and local radiological response programs. Notifications can be made through the National Response Center. Radiation data also must be reported to IMAAC for accurate, reliable estimates of predicted hazard areas, with associated concentrations. These models will serve as the foundation to support protective action decisions by the authorized emergency managers.

Figure 3.1 Sampling locations for a hypothetical incident at the Chicago Board of Trade.

d. Collect wipe samples of any visible dust in areas where notification guidelines were exceeded. Follow contamination assessment procedures in section 4 of this SOG.
e. If removable contamination exists, recommendations should be made to the IC that the exclusion zone be expanded and radiological protective actions implemented. Removable contamination is contamination deposited on the surface of structures, areas, objects, or personnel that can be readily spread or removed by physical means. (Any recommendations should be made in consultation with DOE and the RERT.)
f. Follow radiological perimeter, reconnaissance, and exclusion zone monitoring procedures

3.4.2 Pre-Entry Procedures

Planning

a. Synchronize the EPA and the IC's action objectives.
b. Establish the EPA role in the incident response plan.
c. Collect all first responder radiation data and record as "first responder data" on form RRSF-900.

Organize Assets and Brief Personnel

a. Establish an initial-entry team.
b. Establish a backup team.
c. Establish a decontamination team (exclusion zone exit self-surveys may have to be performed until additional assets arrive; see Chapter 6).
d. Brief all personnel on the required tasks to accomplish during the entry.
e. Communicate situation, objectives, control measures, access restrictions, and turnback criteria (Chapter 4).

Safety Planning and Medical Screening

a. Develop site-specific Health and Safety Plan (HASP) (see Appendix 2).
b. Perform medical screening on entry team, backup team, and if available, decontamination team.
c. Radiological health and safety requirements include thermoluminescent dosimetry (TLD) badges, EPD Mk2 real-time dosimeters, and briefing on radiological turn-back levels (1.5 Roentgens/hour).

Equipment Calibration and Operational Checks

a. Inspect the personal protective equipment (PPE) for signs of cracks, rips, tears, or other defects.
b. Follow QSG for chemical agent detectors.
c. Follow the QSG for the SAM-935, Ludlum Model 43-90 alpha scintillator, and Eberline RO20 ion chamber.
d. Verify that your staging area is free of contamination.
e. Conduct communication checks between entry team, backup team, Lead OSC, and decontamination team.

Don PPE (Level C is appropriate for radiological hazards; unknown conditions require a minimum of Level B.)

a. Use the buddy-team method to don PPE.
b. Inspect and verify the proper PPE fit and function.

Entry Clearance

a. Request permission from the Lead OSC and IC to enter the exclusion zone.
b. Record time on air, entry team personnel names, and equipment taken into exclusion zone.
c. Entry team verifies required tasks and plan of action for entry to the Lead OSC.
d. Confirm decontamination line is established and the backup team is ready.
e. Receive clearance and permit entry team to enter the exclusion zone.

3.4.3 Entry Procedures

Reconnaissance

a. Adjust the reconnaissance plan, as required, to meet the needs of the IC and OSC to ensure there is a mission justification for all entries.
b. In developing the reconnaissance plan consider the following objectives:
   1) Locations and types of hazards;
   2) Physical layouts and descriptions;
   3) Casualty status or information;
   4) Additional requirements; and
   5) Video and/or still camera pictures .

Monitoring Initial Entry Procedure

a. Conduct non-radiological air monitoring (Multi-Rae 5 gas monitor) throughout operations to identify any atmospheres that are corrosive, combustible, or oxygen-deficient; toxic substances that are immediately dangerous to life or health (IDLH); and exposures over Permissible Exposure Limits (PELs).
b. Approach the center of the incident scene from the downwind direction. Place Radeco air sampler at 100 μR/hr point (follow the QSG). Place small "x" on the exterior surface of the filter paper. Record flow rate and start time on form RRSF-900.
c. Continue to walk in a line and record dose rate (micro-R) measurements at 100 μR/hr, 500 μR/hr, and 1 milli-Roentgen per hour (mR/hr) level on form RRSF-900. Measurements should be collected at waist level.
d. With the SAM-935, collect one-minute spectrum at the 100 μR/hr location. This is a high enough exposure rate to identify the isotope(s). Record the identified isotope(s) and spectrum number on RRSF-900. The SAM-935 should be in MCA mode with the following isotopes enabled; ^{137}Cs, ^{60}Co, ^{226}Ra, ^{192}Ir, ^{241}Am, and ^{239}Pu.
e. Collect a wipe sample at each monitoring point location in an area that is likely to contain loose surface contamination. With moderate pressure, swipe an area approximately 3 inches by 6 inches and place wipe in a glassine envelope.
f. Mark radiological monitoring location with pin flags, marking paint, or duct tape.
g. Record all readings including Global Positioning System (GPS) locations of measurement points on form RRSF-900.

3.4.4 Egress Procedures

a. Exit exclusion zone through the Contamination Reduction Corridor (CRC or decontamination line).
b. Place hand tools and monitoring instruments taken into the exclusion zone at a table or inside a bucket provided in the designated equipment/instrument drop station .
c. Position the tools and monitoring equipment so that the incoming Entry Team can easily acquire them.
d. Remove the outer gloves and place them in a designated container.
e. Follow standard PPE doffing protocols. The order of PPE removal will depend on the level of protection. Step-by-step doffing and personnel decontamination procedures can be found in RRDSOP 601 (*currently under development*).

f. Personal contamination surveys must take place in a low background environment Perspiration should be removed from hands and face using paper towel or other absorbent material.
g. If the Entry Team is using a self-frisking technique, set up the GM pancake detector with the window facing up and move finger tips and the palms of each hand across the detector. Speed is about 1 to 2 inches per second. Count rates with the GM pancake greater than *100 counts per minute above background reading* (as a continuous deflection) should be considered contaminated and personal decontamination is recommended.
h. If no contamination is found on the hands, pick up the unit and scan the bottom of the feet and underside of the neck where the respirator was worn.
i. If contamination is detected on hands, feet or the underside of the neck, decontamination of these areas should be performed and a full body scan should follow.
j. If no contamination is found on the hands, feet and neck, a full body scan is not warranted.

3.4.5 Contamination Assessment

Contamination Swipe Surveys

a. Survey/count the swipe samples in an area where the ambient radiation level is at normal (pre-event) background levels.
b. Place the filter paper on a flat non-contaminated surface and count for 15 seconds with a Ludlum Model 2241 on the "det 2" setting with the Ludlum Model Probe 43-90 to determine if **alpha** contamination is present. Record the result on form RRSF-900.
c. If the reading is greater than 5 times background, contamination exists.
d. To determine if loose **beta/gamma** contamination is present, change the Probe to the Ludlum Model 44-9 and switch to the "det 1" setting on the Ludlum Model 2241. Record the result on form RRSF-900.
e. If the reading is greater than 2 times background, contamination exists.

Filter Paper Alpha Airborne Radioactivity Determination

a. Count the filter paper for 10 minutes with a Ludlum Model 2241 on the "det 2" setting using the Ludlum Probe model 43-90. Record results form RRSF-900.
b. Wait for 30 minutes and count again. If the filter paper count rate decreases by approximately one-half, then the radioactivity is most likely due to radon decay products. If the count rate does not decrease, then the radioactivity most likely exists and Level B, or greater, respiratory protection should continue to be worn in this area.

Filter Paper Beta Radioactivity Determination

a. Count the filter paper for 10 minutes with a Ludlum Model 2241 on the "det 1" setting with the Ludlum Probe model 44-9. Record results on form RRSF-900.
b. Wait for 30 minutes and count again. If the filter paper count rate decreases by approximately one-half, then the radioactivity is most likely due to radon decay products. If the count rate does not decrease, then the radioactivity is due to some other beta activity. This indicates that a radioactive airborne condition exists and Level C respiratory, or greater, protection should continue to be worn in this area.

3.4.6 Sample Shipping/Analysis and Reporting

Shipping

a. Prepare the sample for transport. Transfer sample collection media to appropriate containers and label in accordance with the chain-of-custody procedures. Record any pertinent information on a separate Chain-of-Custody Form for group sample transfer
b. Ship airborne radioactivity samples that are greater than twice background after 30-minute decay to a certified lab (a list of certified labs is in development by EPA working in conjunction with DOE; once available, it will be posted to www.epaosc.org) and request the following analyses: Alpha spectroscopy for the actinides (i.e., ^{234}U, ^{235}U, ^{238}U, ^{230}Th, ^{232}Th, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Am), total strontium, and gamma spectrometry.
c. Report all survey and contamination assessment data to the IC as well as to the RERT, DOE RAP, and state/local radiological response programs.

3.5 ENTRY/EGRESS FOLLOW-UP

3.5.1 Confirming or Negating the Presence of Removable Contamination

It is essential for responders to confirm or negate the presence of removable contamination at the scene. Information about removable contamination can be used by the IC to make decisions about implementing protective actions in order to protect the public and maintain control of the incident scene. Based on early local and EPA monitoring data, the OSC can provide guidelines to the IC, who can then make the decision to implement predetermined protective actions to protect the responders and the public.

3.5.2 Implementation of Immediate Actions

If removable radioactive material is confirmed at the scene, the following additional protective actions should be considered: 1) evaluation of responder personal protection equipment; 2) restriction of contaminated vehicles and equipment to the exclusion zone; 3) sheltering and isolation of potentially contaminated victims until radiation screening is completed; 4) implementation of personnel radiation surveys for victims and responders from the exclusion zone; 5) decontamination of contaminated victims and equipment; and 6) release of protective action information to the public. While an OSC may not be responsible for implementing each of these actions, he or she should work with the local IC to ensure that these steps are taken as soon as possible.

Immediate Actions to Consider

- Protect emergency responders health and safety
- Evaluate responder personal protection equipment
- Rotate teams to decrease individual exposure
- Avoid contact with debris
- Restrict contaminated vehicles and equipment to the exclusion zone
- Shelter and isolate potentially contaminated victims
- Implement personnel radiation surveys for victims and responders from the exclusion zone
- Decontaminate contaminated victims and equipment

Emergency Responder Health and Safety

In the event of a RDD explosion, emergency responders (i.e., police and fire departments) carry the greatest risk of radiation exposure. The safety of response personnel is of the highest priority; therefore, responders should follow standard measures to keep their radiation exposures to As Low As Reasonably Achievable (ALARA) levels. These actions include wearing a self-contained breathing apparatus (SCBA) at all times while in a controlled area. This action should be strictly enforced by the local command staff. The responders also should limit the amount of time they risk exposure to the radiation sources by rotating teams to different areas of the exclusion zone. Most importantly, the response personnel should *avoid moving or touching visible pieces of debris*, which may be radioactively contaminated, and may be critical evidence of criminal activity. If at all possible, victims should be removed to a triage area and not treated in an area where debris is visible.

Restriction of Contaminated Vehicles and Equipment

Restricting potentially contaminated emergency response vehicles and equipment to the exclusion zone will help limit the spread of radioactive material contamination and help maintain control of the incident scene. Vehicle and personnel traffic should have one specific entry and egress point. Criteria for release will depend on circumstances. Only personnel and equipment that are surveyed should be released. If practical, any vehicles or equipment already in the exclusion zone should remain dedicated to the exclusion zone until it is appropriate to decontaminate the vehicles and equipment.

Sheltering and Isolating Potentially Contaminated Victims

If the presence of removable radioactive material is confirmed, the IC should coordinate with local authorities in considering sheltering the public for a short duration until the release is secured and visible dust has settled to the ground. Immediate evacuation of the public is not appropriate for an urban RDD scenario, because evacuating members of the public would be directly exposed to the airborne plume. The DOT *Emergency Response Guidebook* recommends that for large quantities of radioactive material involved in a fire (Guide 164-166), evacuate 1,000 feet in all directions (DOT 2004). With a RDD in a major metropolitan city, this order could involve thousands of people, which could make this decision impracticable. In addition, once the RDD has occurred, the opportunity to avoid exposure by evacuation has largely passed. Keeping the public inside buildings will provide adequate protection against internal and external exposure from the plume until an orderly exit plan can be implemented.

Implementation of Victim Radiation Surveys

Victims will be classified according to their injuries and urgency for hospital care. The levels of severity for a victim's injury are classified by first responders. The following is an example of a first responder classification protocol developed for the City of Chicago:

- **Black:** Victim does not have vital signs and will be left at the scene until after other victims in critical condition are addressed

- **Red:** Victim is in serious condition and needs immediate transport to hospital
- **Yellow:** Victim is injured and able to move but still needs transport to hospital
- **Green:** Victim does not have any injuries and does not need transport to hospital

Transportation and treatment of injured victims should not be delayed for radiological surveys or decontamination. Life threatening injuries always take precedence over potential radioactive material contamination. If it does not delay transportation or treatment, victims should receive a personal radiation survey. Radiological monitoring of victims is the responsibility of the local responders. If a request is made for radiation monitoring and decontamination of victims, the OSC can request support from State Radiation Programs and HHS which, under Emergency Support Function #8 of the National Response Plan, is responsible for radiation monitoring and decontamination of victims. HHS coordinates limited federal resources to assist, as DOE provides support to HHS for monitoring and decontaminating victims for radiological incidents.

Release of Information Fact Sheets to the Public

The OSC should request the immediate deployment of a public information officer (PIO) and a community relations specialist to advise the OSC and integrate into the ICS. Any questions regarding public safety should be directed to the incident's PIO. The PIO will provide information with recommendations such as bagging clothes and taking a thorough but tepid shower to remove any potential radiation contamination. Updated information will be provided via local media outlets.

4. HEALTH AND SAFETY

This chapter assumes that all EPA OSCs responding to radiological incidents have been or are enrolled in a Radiation Health and Safety Program consistent with the following:

- EPA's Safety, Health, and Environmental Management (SHEM) 38 (SHEM Guidance No. 38) (EPA 2006)
- EPA's Medical Surveillance Program Implementation Plan (EPA 2005a)
- EPA's Radiation Health and Safety Implementation Plan (EPA 2005b)
- Nuclear Regulatory Commission (NRC) regulations in 10 CFR Part 20 standards for radiation protection.

Many aspects of health and safety are common to every response to a hazardous materials incident. However, the response to ionizing radiation poses a few additional unique or uncommon health and safety concerns that the National Response Plan's (NRP's) Worker Safety and Health Annex addresses. For instance, special considerations should be made for female workers that declare they are pregnant (EPA 2006).

The NRP's Worker Safety and Health Annex is always activated for Incidents of National Significance (INSs) and other situations involving significant worker safety and health issues. This Annex likely will be activated for a large-scale radiological incident, including a terrorist incident.

OSHA is the Coordinating Agency for this annex, and several agencies, including EPA, are Cooperating Agencies. OSHA and the Cooperating Agencies provide staff to support the (Incident Command Post (ICP) Safety Officer. Their assistance may be provided in, but is not limited to, the following areas:

- Ensuring that site-specific occupational safety and health plans are coordinated and consistent
- Identifying and assessing hazards
- Conducting responder personal exposure monitoring
- Providing responder medical surveillance and medical monitoring
- Coordinating and managing exposure data
- Developing and implementing personal protective equipment (PPE) programs
- Resolving conflicts regarding worker safety and health

4.1 DOSE LIMITING SYSTEMS

4.1.1 Rationale

EPA's dose limitation system is based on three principles:

- ***Justification***. There should not be any planned occupational exposure of workers to ionizing radiation without the expectation of an overall benefit from the activity causing the exposure and an analysis of the available options and alternatives.

- ***Optimization***. A sustained effort should be made to ensure that collective doses, as well as annual, committed, and cumulative lifetime individual doses, are maintained As Low

As Reasonably Achievable (ALARA), economic and social factors being taken into account.

- ***Limitation.*** Radiation doses received as a result of routine and/or emergency occupational exposure should not exceed the Administrative Control Level (ACL) established under EPA's Health and Safety Program (EPA 2006).

4.1.2 EPA's Usual Practices

EPA has established an ACL and an Action Reference Level (ARL) that are based upon the premise that EPA employees, as a usual practice, are not radiation workers. Thus, their annual exposure should be controlled to levels well below those allowed to radiation workers (i.e., 5 rem annual dose) and more in line with those levels considered acceptable to the general public.

- EPA's ACL is 500 mrem committed effective dose equivalent (CEDE) from intake plus external whole-body dose (the combination is the total effective dose equivalent (TEDE)) in any period of twelve consecutive months. The ACL is the maximum acceptable dose for an individual worker during any twelve consecutive months. If a worker has reached the ACL, work assignments with a potential for additional radiation exposure should be restricted until the ACL is again satisfied. The ACL may be exceeded with a waiver. SHEM 38 contains the rules regarding waivers (EPA 2006).

- EPA's ARL has been set to alert supervisors and workers to the constant need for maintaining good radiological protection practices, and to help ensure that long-term worker exposure does not exceed the ACL. The ARL has been set to 50 mrem/quarter whole-body external exposure or internal effective dose equivalent. Any worker's exposure that exceeds this ARL will immediately trigger a supervisor notification and documented review of the circumstances relating to the excursion. The ARL may be exceeded with a waiver. Rules regarding waivers are detailed in SHEM 38 (EPA 2006).

4.1.3 EPA's Emergency Practices

Emergency responders may be exposed to radiation while assuring protection of others and of valuable property. These exposures could be justified if the benefit for those protected outweighs the detriment to the worker. However, lower administrative levels should be used whenever possible. EPA's OSCs are considered emergency workers, and thus the recommendations provided by EPA for emergency worker dose limitations issued in EPA-400 "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents," also known as the "PAGs" (EPA 1992a), are applicable. Table 4.1 shows the emergency worker dose levels.

Table 4.1 EPA Emergency Responder Dose Guidance from EPA-400

Dose Limit TEDE[a] (rem*)	Activity	Condition
5	all	None
10	protecting valuable property	Voluntary; lower dose not practicable
25	lifesaving or protection of large populations	Voluntary; lower dose not practicable
>25	lifesaving or protection of large populations	**Only on a voluntary basis to persons fully aware of the risks involved**
[a] Sum of external effective dose equivalent and committed effective dose equivalent, or TEDE, to nonpregnant adults from exposure and intake during an emergency situation. These limits apply to all doses from an incident, except those received in unrestricted areas as members of the public. * For x and gamma radiation, Rad ~ rem ~ Roentgen (R).		
Exceeding the administrative control level requires concurrence of the senior EPA official onsite, the Incident Commander, the Health and Safety Officer, or the Radiation Safety Officer.		

Table 4.2 provides EPA-specific gamma exposure rates (Turnback Levels) at which emergency responders should seek further guidance before proceeding. Responders using handheld gamma radiation instruments can compare their readings to the levels in the table. If the responder's activities are deemed mission-justified, going into areas with levels higher than the turnbacks may be allowed. Exceeding EPA's ACL **requires concurrence of the senior EPA official onsite, the Incident Commander, the Health and Safety Officer, or the Radiation Safety Officer**. Lower levels should be used whenever possible.

Table 4.2 EPA Emergency Responder Gamma Exposure Rate Turnback Levels

Time Period	Employee Type	Turnback Level	Condition
Early Phase: (Release ONGOING)	OSCs, initial EPA responders	**10 R/hr**	Voluntary, with supervisor review, for lifesaving or critical actions ONLY – evaluate anticipated doses against dose limits above
Early Phase: (Release terminated)	OSCs, RERT-Forward, ERT and initial EPA responders		
Intermediate Phase: (Some data available)	OSCs, RERT-Forward, ERT	**1.5 R/hr**	Dose management imperative
Late Phase: Cleanup	Any EPA employees, RERT-Support and Home Teams	Site specific according to site health and safety plan	EPA Action Reference Level: 50 mrem/quarter *and* Administrative Control Level: 500 mrem/year
Important: DOSE MANAGEMENT should begin at 1 millirem per hour			

Table 4.3 provides guidance specific to detecting and protecting responders in the presence of loose alpha or beta contamination. Alpha and beta contamination pose an internal hazard which may complicate the responder's work. Additional personal protective equipment and detection instruments must be used. The Turnback Level of ≈ 400 cpm on the "National Buy" instruments are a rough approximation based on assumptions noted in the table. Caution should be exercised in any situation involving loose or airborne alpha or beta contamination above natural background.

Table 4.3 Respiratory Protection and Alpha/Beta

Personal protective equipment (tyvek, boots, gloves) should be worn in the presence of *any* alpha or beta contamination above natural background.	
Appropriate respiratory protection should be worn in the presence of *loose* alpha or beta contamination above natural background.	
Incidents involving airborne alpha or beta emitters require proper instrumentation as noted below.	
At all times, worker exposures should be As Low As Reasonably Achievable.	
Alpha on the ground turnback level	**Beta** on the ground turnback level
2,000 dpm/100 cm^2 { ≈ 400 cpm with National Buy instrument Ludlum model 2241-2 (or comparable) coupled with alpha probe model 43-90**}**	**10,000 dpm/100 cm^2 { ≈ 400 cpm** with National Buy instrument Ludlum 2241-2 (or comparable) coupled with pancake probe model 44-9**}**
Leave the area until you have protective clothing and respiratory protection - evaluate actions against dose limits	**Leave the area** until you have protective clothing and respiratory protection - evaluate actions against dose limits
Informed safety decisions regarding subsequent site activities should be made based on air sample analysis and nuclide identification. These values assume a static measurement on the ground (or a flat surface) at a distance of 1cm. Alpha-only or beta-only instruments may respond erroneously in a high gamma rate field – be aware!	

Informed safety decisions regarding subsequent site activities should be made based on air sample analysis and nuclide identification. These values assume a static measurement on the ground (or a flat surface) at a distance of one centimeter. *Alpha-only or beta-only instruments may respond erroneously in a high gamma rate field (readings persist after the probe has been moved away from surface).*

People who are not trained in radiation response may serve as PIOs, headquarters liaisons, or emergency operations center personnel at the Joint Field Office or Emergency Operations Centers. If such personnel must be deployed to forward locations (*not* including field work), they should be issued thermoluminescent dosimetry (TLD) badges, but EPA's ACL of 500 mrem/year should not be waived.

4.1.4 EPA's Radiation Site Practices

Once the emergency response is over and site cleanup activities are ongoing, under the newly revised SHEM 38 guide, normal administrative dose levels and criteria apply to EPA employees.

It should be noted that OSHA's regulations differ in subtle but significant ways (especially pertaining to dose levels) from the NRC's regulations that apply to sites with licensed material. Thus, the OSCs should ensure that the site-specific Health and Safety Plan is consistent with 29 CFR 1910.1096.

The OSHA regulations include several areas that must be addressed by the Health and Safety Manager, including:

- Exposure of individuals to radiation in restricted areas
- Exposure to airborne radioactive material
- Precautionary procedures and personal monitoring
- Immediate evacuation warning signals
- Posting requirements and exceptions from posting requirements
- Shipping issues with radioactive materials
- Storage of radioactive materials
- Waste disposal
- Notification of any incidents and overexposures
- Employee records

For example, under 29 CFR 1910.1096, a radiation worker is required to take radiation safety training as well as site-specific health and safety training. Environmental surveillance programs, such as air monitoring, may be required depending on the nature of the work. Internal contamination surveillance programs, such as bioassays, may be required depending on the nature of the work. External whole body radiation monitoring, such as using a TLD badge, will be required for workers expected to exceed 10% of their gamma whole body exposure limit.

Note that the START contracts beginning in FY 2006 require the contractor to maintain a radiation program that is consistent with the 10 CFR Part 20 requirements.

4.2 DOSIMETRY

4.2.1 External Dosimetry Requirements

All OSCs are issued a TLD badge as well as an electronic dosimeter. OSCs are expected to wear both when responding to sites. In addition, if OSCs integrate with a Federal Radiological Monitoring and Assessment Center (FRMAC) response, they may be asked to wear an additional TLD badge processed by a Department of Energy Laboratory Accreditation Program (DOELAP) or National Voluntary Laboratory Accreditation Program (NVLAP) accredited processor. FRMAC may provide a dose report to each participant's home organization after the conclusion of the individual's activities. However, FRMAC dosimetry does **not** replace the TLD and electronic dosimeters issued by EPA. The EPA dosimetry record serves as the dose of legal record. Electronic dosimeters are useful for monitoring dose to an individual on a daily basis, thereby providing greater assurance that exposures are ALARA. Electronic dosimeters may not, however, be used as a legal dose of record. Guidance for wearing external dosimeters (including TLD and electronic dosimeters) includes the following:

- The dosimeter must be worn on the chest area on or between the waist and the neck unless otherwise instructed by health and safety personnel.
- The dosimeter is to be worn only by the individual to whom it was issued. Lost, damaged, or contaminated dosimeters must be reported immediately to the Health and Safety staff.
- If a participant discovers that his/her dosimeter is missing while in a radiological area, he/she should immediately leave the area, then notify the team leader and report the missing dosimeter to the Health and Safety Manager. A new TLD or electronic dosimeter will be issued by Health and Safety as appropriate.
- Dosimeters must be returned or exchanged at the time designated by the Health and Safety Manager, upon request, or at the end of the operation.

4.2.2 Internal Dosimetry

Participants exposed to loose (i.e., removable) radioactive material or who work in areas where radioactive material may be inhaled may be asked to submit bioassay samples and participate in whole-body, lung, or wound counting. The term bioassay refers to the assessment of the quantity of radioactive material present in the body. A bioassay may be used to verify the performance of a respirator and to ensure that the appropriate protection factor is applied. The evaluation of an individual's CEDE is based on bioassay data rather than air concentration values unless bioassay data are unavailable or inadequate, or internal dose estimates based on representative air concentration values are demonstrated to be as, or more, accurate.

If necessary, EPA's Office of Radiation and Indoor Air (ORIA) and Safety, Health, and Environmental Management Program (SHEMP), working with REAC/TS, develop a site-specific Bioassay Plan for inclusion in the site-specific Health and Safety Plan. The Health and Safety Manager is responsible for performing preliminary CEDE estimates based on air sampling results. Dose assessments, based on bioassay results, are assigned after samples have been collected and analyzed. Personnel should be notified promptly of a confirmed positive bioassay result and dose assessments with subsequent refinements.

Bioassays may be required during general operations initiated in response to an occurrence to determine if there has been an intake of radioactive material. Bioassay sampling may also be requested as a follow up to a known intake in order to quantify the intake and monitor the status of the radioactivity. The data are used to refine the dose assessment, depending on the radio-nuclide, method of ingestion/inhalation, and biological half-life.

Whether or not bioassay is warranted is usually based on the following considerations, but bioassays may be requested as a precautionary measure at the discretion of Health and Safety Manager in the field:

- Amount of material released and the respirable fraction
- Amount of time the person was in an airborne radioactivity area
- Whether respiratory protection and anti-contamination measures were employed
- Level of the resuspension factor

The internal dose assessment program involves tracking and reviewing air monitoring results to determine trends, and collecting nasal smears or nose blow samples, urine samples, or fecal samples to monitor intakes of transportable radionuclides. Additionally, *in vivo* measurements are used to monitor the deposition of non-transportable radionuclides. The internal dose assessment program should be designed to rapidly detect a release of radioactive material and/or a breach of respiratory protection.

Two types of bioassays are used. There is the *in vivo* bioassay, which involves counting living tissue, and there is the *in vitro* bioassay, which involves counting samples, such as urine, blood, phlegm, and nasal smears.

In Vivo Bioassay Measurements

In vivo techniques consist of direct measurements of gamma or X-radiation emanating from the body from contamination that has been ingested, inhaled, or injected into the body. Even without a baseline measurement, this method is very useful for any radionuclide that emits or has daughters that emit photons of sufficient energy to escape the body. The photon flux must be large enough for measurement in a reasonable time period, even though the quantity of material in the organ is very small. *In vivo* measurements may also be useful for thyroid, wound, or post-intake whole-body counting. Whole body counts, lung counts, thyroid counts, and biological sampling should be performed as soon as practical after a suspected intake of a photon emitter. Some examples of appropriate non-routine *in vivo* bioassays are:

- Lung counts following a suspected intake of thorium, uranium, or any of the transuranics (lung counts are not as sensitive as analysis of bioassay samples)
- Whole body counts for detecting most gamma-emitting fission and activation products
- Thyroid counts for suspected radioiodine uptakes
- Urine and feces sampling and whole body counting to detect and assess intakes of the actinides

In Vitro Bioassay Measurements

The amount of material present in the body is estimated using the amount of materials present in excretions or secretions from the body, such as urine, blood, breath, sputum, sweat, saliva, hair, nasal discharges, tissue, and feces. Laboratory personnel may need training, vaccinations, and equipment appropriate for working with potential blood-borne pathogens, such as hepatitis. Fecal bioassays typically are used for alpha-emitting radionuclides if a lower minimum detectable activity is required. However, during a rapid deployment, acquiring fecal samples may be impractical; therefore, urine bioassays may be the method of choice for most applications. As a default, a one-liter (or 24-hour) sample should be collected prior to exposure to contaminants (as practical), and then every two weeks during exposure, and once again at the conclusion of activities. Sampling frequencies can be adjusted, based upon the unique circumstances. A urine bioassay may be required for detection of pure beta-emitters, such as ^{90}Sr and ^{89}Sr. Calculation requires knowledge and use of metabolic models that allow sample activity to be related to activity present in the body. The resulting dose calculations used to quantify committed and effective dose equivalents are estimates, representing an average. This is due partly to the use of default values for measurements that cannot be made readily, such as mass of particular organs, volumes of particular fluids, metabolic rate, in lieu of actual values for each individual involved.

4.3 RECORDING OCCUPATIONAL EXPOSURES

In addition to participating in an EPA Radiation Health and Safety Program (consistent with EPA's *Medical Surveillance Program Implementation Plan)* and any site-specific medical monitoring/dosimetry program, EPA workers who receive any type of known occupational exposure above the ARL or ACL (or local control limit) must report the exposure immediately to their direct supervisor. All known radiation exposure above the ARL or ACL (or local control limit) should be reported to the Regional Safety Officer (RSO)/SHEMP Manager or designee as soon as possible so that further exposure monitoring or dose assessments can be completed. The worker also must submit the following two forms to their supervisors:

- Cover Memo to EPA Form 1440-9, *Supervisor's Report of Accident/Illness*
- EPA Form 1440-9, *Supervisor's Report of Accident/Illness*

The worker's supervisor should complete the forms and provide copies to the RSO/SHEMP Manager or designee, who in turn ensures that any other required forms are completed and any other necessary parties are notified of the occupational exposure, as required.

If a worker reports an accident or illness, it is that worker's responsibility to consult the RSO/SHEMP Manager or designee for advice and to inform the supervisor if he or she wants or needs follow-up medical evaluation, treatment, or time off from work. The RSO/SHEMP Manager shall begin procedures for follow-up care or worker's compensation as warranted. The worker's supervisor shall retain approval authority in worker's compensation and follow-up medical care cases. In an emergency situation in which immediate medical care is warranted, the appropriate forms may be submitted after the emergency medical care has been provided.

4.4 RADIATION AREA LIMITS

4.4.1 Usual Work Practices

Under normal situations, any area in which radiation levels exceed those in Table 4.4 will be considered a radiation area and controlled accordingly. Any area in which contamination levels exceed those in Table 4.4 will be considered a contamination area and controlled accordingly. During a response to a significant uncontrolled release (e.g., RDD) other (higher) criteria may be appropriate, particularly during the early and intermediate phases of a response.

Table 4.4 Radiation Area Limits*

Area	Level	Distance from Ground
Radiation Area	5 mrem < X > 100 mrem in one hour	30 centimeters
High Radiation Area	100 mrem < X > 500 rad in one hour	30 centimeters
Very High Radiation Area	X > 500 rad in one hour	1 meter

*based upon 10 CFR 20 and 10 CFR 835

4.4.2 Emergency Practices

ALARA should be maintained during emergencies. No exposure should be permitted without a mission justification. However, during an emergency, as noted above in Section 4.1.3, allowable dose levels may be increased. Zoning the event scene into hot, warm, and cold zones will help reduce radiation exposures and aid in controlling the spread of contamination. The size of the event scene determines the size of the zones and the control points needed. Because site-specific conditions may vary widely, responders should choose reasonable exposure rate (gamma) or activity concentration (alpha/beta) levels for the zone boundaries. The turnback levels, provided in Table 4.2, may be helpful in evaluating these boundaries. When possible, the outer perimeter of the warm zone should be established. This is where contamination levels are at or near background when measured with a count rate instrument. If establishing an outer perimeter is not practical because of the size of the event, adjustments can be made. The warm zone can be utilized for decontamination efforts. The cold zone barrier should be established at a location where all access to and from the warm zone will be continuously monitored and all personnel are accounted for (logged in and out).

4.5 HOTLINE AND DECONTAMINATION

In an incident involving radioactive materials or radioactivity, as in any event where contamination is present, a clear demarcation line must be established. This line establishes the controlled area. It is across this control line where field responders must don and doff PPE and exposure monitoring devices. It also is across this line where field samples are accepted through the sample control mechanism. The hotline and sample control structure ensures that contamination is not transferred from the controlled areas to the greatest extent possible, and provides a first opportunity to perform quality assurance and quality control measures on samples coming in from the field. Procedures and processes consistent with EPA's Standard Operating Safety Guides should be followed (EPA 1992b). Similarly, responders and equipment should be monitored and decontaminated prior to removal from contaminated zones.

Personnel and equipment surveys must be performed in a low-background environment with the appropriate survey instrument. Surface contamination can usually be detected by direct monitoring methods; however certain situations require the use of indirect methods, such as swiping. The monitoring method must have sufficient sensitivity to detect the contaminant of concern at the level needed. (See Chapter 5 for equipment selection and relevant procedures). Currently, there are no specific “clearance” levels set for EPA’s release of previously contaminated materials. However, EPA is currently participating in the development of an interagency MARSAME (Multi-Agency Radiation Survey and Assessment of Materials and Equipment) supplement to the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM; EPA 2000a), which will include an appendix that summarizes disposition criteria from five federal agencies for various materials (e.g., scrap metals, building debris, dispersible bulk materials, furniture). Public review of the draft MARSAME is expected in 2006.

4.6 DEVELOPMENT OF THE HASP

EPA has developed a tool called the Environmental Response Team Chemical/Biological/ Nuclear Health and Safety Plan (ERT CBN-HASP) Wizard (available at www.epaosc.net) to assist OSCs or their designees in developing a Health and Safety Plan for radiation emergency responses. In addition, OSHA, with EPA support, has developed EHASP, available at www.dol.osha.gov. Although the current version of this document is intended for use at longer-term sites, an emergency response version is under development. Appendix 2 contains an example HASP.

5. RADIOLOGICAL STANDARD OPERATING PROCEDURES

The procedures described in this chapter were developed to provide uniformity of actions by all EPA regions and their contractors in response to a significant radiological incident. This discussion assumes that a full response is necessary and that the Incident Command System (ICS) is in place. Personnel are expected to be trained in and follow these procedures, or obtain permission from the OSC prior to deviating from them. Compliance with these procedures provides assurance that information collected in the field will be consistent, of good quality, and compatible for integration into the FRMAC (Federal Radiological Monitoring and Assessment Center).

Specific procedures for implementing the instrumentation setup, collection of samples, and monitoring of various media are in a companion compact disc (CD) that will be posted on www.epaosc.gov.

Radiological monitoring is conducted with standardized instrumentation to determine the actual and potential hazards from radiation and contamination. Generally speaking, the same instruments are used in the early, intermediate, and late phases of a response to a radiological incident. However, the critical information requirements vary by phase. As a result, the use of radiological monitoring instruments and reporting of radiological monitoring data may vary depending on a number of factors, including time available, controls in place, and significance of the release. Guidance on which instruments may be required in various phases of the response can be found in Chapter 3.

The instrumentation used to collect monitoring data must meet quality assurance requirements in order to provide with certainty that the data are valid for the intended purpose. The purpose for monitoring is defined by the OSC.

An approach for defining the type, quantity, and quality of data is described by the Data Quality Objective (DQO) process (Section 5.5 Data Quality Objectives). The DQO process is recommended for each phase of a response to define the monitoring tasks that are to be conducted by field monitors.

5.1 RADIATION FIELD SURVEYS

During an emergency response, one of the first tasks is to determine if radioactive material is present. If radioactive material is present, data collection is initiated to (1) determine the type of radiation; (2) identify the specific radionuclide(s); and (3) determine the relative abundance of the radionuclide(s). Once this information is obtained, a more thorough survey can be performed by sampling and taking direct measurements. The survey design should delineate the location and concentration of the radioactive material. This information provides the basis for determining the risk associated with the radioactive material, and guides further remedial action decisions.

A field survey should assure the effectiveness, efficiency, and defensibility of the data collected. The type, quantity, and quality of the data collected should support the decision-making process, and therefore promote the efficient use of resources by eliminating unnecessary or overly precise survey data. However, before an instrument is put to use in the field, DQOs must be established to assure that the proper instrument is selected for the appropriate field survey. The data quality requirements for each type of survey are different because the end use of the data is different. (Section 5.3 Data Quality Levels)

Field surveys fall into four broad categories:

- Operational surveys
- Release surveys
- Remediation surveys
- Special surveys

5.1.1 Operational Survey

Operational surveys include routine investigation of areas with established quantities of radioactive materials, as well as surveys conducted to determine the potential presence of unknown quantities of radioactive materials. Boundaries, postings, and controls are based on operational surveys. To determine the relative quantity of radiation, operational surveys require a functional instrument that is not necessarily qualified to provide precise measurements. Data collected during operational surveys requires instrument quality control and checks that correspond to data quality levels (DQL) 1-3, depending on the expected use of the survey data (Section 5.3 Data Quality Levels).

5.1.2 Release Survey

Release surveys are conducted to allow materials that have been in a contamination or airborne radioactivity area to be unconditionally released or cleared. Because release limits are precisely defined and generally close to background, a calibrated instrument with a current determination of the detection limit is required. Data collected during release surveys require instrument quality control and checks that correspond to DQL 1.

5.1.3 Remediation Survey

Remediation surveys include: (1) scoping surveys that are used to confirm the presence of radioactive materials; (2) characterization surveys that are used to minimize the uncertainty in remediation plans; (3) remedial action surveys that quantify the progress of the remedial actions; and (4) final or release surveys to confirm that the remediation effort was effective. Data collected during remediation surveys requires instrument quality control and checks that correspond to DQLs 1 and 2 depending on the expected use of the data.

5.1.4 Special Survey

Examples of special surveys include source leak tests, transportation surveys, and preoperational surveys to develop the area background. Data collected during special surveys requires instrument quality control and checks that correspond to DQLs 1 and 2, depending on the expected use of the data.

5.2 PROCEDURES

The companion CD, which will be posted on the Internet, contains Radiological Response Standard Operating Procedures (RRSOPs) and associated forms for use in supporting radiological field activities. The RRSOPs are consistent with the radiological procedures and data reporting formats used by FRMAC. They were developed with the intention of using the National Incident Management System concepts and principles that will enable responders at all levels to work together effectively to manage domestic incidents.

The procedures have been organized into the following Series to allow for the addition of new Standard Operating Procedures (SOPs) and to provide a method for keeping similar SOPs together:

- 100 Series Instrument Management
- 200 Series Alpha scintillation, gas proportional, and Geiger Mueller detectors operation and quality control
- 300 Series Exposure rate instruments operation and quality control
- 400 Series General survey techniques and approaches
- 500 Series Sampling methods (air, water, soil, subsurface, and sediment)
- 600 Series Entry and egress area controls

Quick Start Guides and the Radiological SOPs augment each other. Quick Start Guides have been developed to describe how to put an instrument into operation. The RRSOPs describe how to use the instrument to collect data that meets the DQLs described in Section 5.3. The SOPs are more specific and directive than the Quick Start Guides in regard to setting up and using instruments. The data acquired from the use of the SOPs are quantitative in nature and provide defensible records.

The Quick Start Guides typically discuss putting monitoring instruments into field use. They are useful tools for a field worker, who must initialize the appropriate instrument as expeditiously as possible to rapidly screen an area for radiological hazards within defined limits. The field worker may then be directed to conduct a brief survey. The survey results allow the OSC to prioritize work efforts. If the area does not have elevated radiation levels, other potential hazards may be addressed. Conversely, if elevated radiation is detected, then the OSC knows that the area must be adequately controlled and managed.

One Quick Start Guide deals with Air Sampling, which should be included in the preliminary evaluation of an area since airborne concentrations of radioactive material are seldom detectable with radiation survey instruments. Other types of sampling, including water sampling, may be required on a case-by-case basis as directed by the OSC.

A number of the SOPs refer to the Radiological Point of Contact, who is the senior or designated Health Physicist for the response. This person may be the OSC or a Health Physicist from the Office of Radiation and Indoor Air (ORIA) or another organization within EPA. The Radiological Point of Contact may be the Region Radiation Safety Officer. The Radiological Point of Contact is designated by the OSC.

In 2004, EPA's Office of Solid Waste and Emergency Response (OSWER) approved the National Buy strategy, a program that standardizes the procurement of radiological monitoring instrumentation for EPA's Office of Emergency Management (OEM). This innovative procurement program has provided a realistic means to uniformly train personnel, exchange or augment equipment from region to region as necessary, and effectively minimize maintenance and calibration costs. The standardized instruments provide consistent data if used in a prescribed manner. These SOPs provide that uniformity.

The following SOPs will be updated regularly based on a number of sources:

- Lessons learned
- Equipment modifications
- Input from parallel organizations
- Review comments from users

Ongoing training is necessary to maintain familiarity with the SOPs. It is too late to learn the content of applicable SOPs at the scene of an incident. Effective training requires a walkthrough of the procedures using the actual equipment and forms. This training is reinforced by field exercises using developed scenarios that test certain SOPs.

5.3 DATA QUALITY LEVELS

For planning purposes, this guide establishes DQLs 1-3 for monitoring with radiation detection instrumentation. These DQLs apply a graded approach for collecting radiation data. Level 1 represents the highest quality of data, while Level 3 represents the lowest. Table 5.1 defines each level, and describes instrument use, DQO data requirements, field surveys, and appropriate quality controls and checks.

Table 5.1 Data Quality Levels and Instrument Quality Checks

Data Quality Level	Data Quality Objectives- Data Requirement	Instrument Use	Instrument quality controls and checks
1	• Data is used for risk assessment • Data is used for inter-agency comparability • Data is generated for regulatory compliance	• Measurement • Operational surveys • Release surveys • Remediation surveys • Special surveys	• Instrument is calibrated annually or has a technical basis document • Representative background is established where the instrument control checks are performed • Prior to use, a control chart is developed with a reproducible geometry and quality control (QC) source at the field logistics center or instrument storage • A QC source check is performed before and after field use • A source response check is performed and documented at scheduled times during field use.

Data Quality Level	Data Quality Objectives-Data Requirement	Instrument Use	Instrument quality controls and checks
2	• Data is used to monitor changing conditions within defined boundaries • Data is specific to an operation or activity • Data is comparable to other data collected at this scene • Data is used to provide immediate recognition of unexpected changes in radiation levels or quality	• Measurement • Operational surveys • Remediation surveys • Special surveys	• Instrument is calibrated annually or has a technical basis document • Representative background is established where the instrument control checks are performed. • A source response check is performed and documented before and after field use and at scheduled times during the use of the instrument in the field.
3	• Data is obtained quickly • Data is used to determine if controls for radioactive materials are necessary • Data is comparable only to other data collected by this instrument during this use	• Detection • Operational surveys	• Instrument is calibrated annually or has a technical basis document • Prior to use, a background value is determined • Prior to use, a source response check is performed to verify that the instrument responds to the radiation of interest

From Table 5.1, it can be concluded that DQL 1 qualified instruments are used to release items following decontamination procedures. DQL 3 instruments are used early on to determine if there is a radiological hazard, and if so, the general areas of the most concern. DQL 2 instruments are used for most monitoring operations, pre-job and post-job surveys, and other support.

5.4 DATA QUALITY ASSESSMENT

When radiological data collection is required, a Data Quality Assessment (DQA) should be performed after the data collection is complete. DQA is the scientific and statistical process of evaluating: (1) whether the results of an environmental data collection effort are of the right type, quality, and quantity to support their intended use; and (2) whether DQOs established for the data have been met. Data quality, as a concept, is meaningful only when it relates to the intended use of the data. Therefore, the context for using the data set must be established as a yardstick for judging whether or not the data are adequate.

DQA can answer two fundamental questions:

1. Can the decision (or estimate) be made with the desired confidence, given the quality of the data set?

2. How well can the sampling design be expected to perform over a wide range of possible outcomes? If the same sampling design strategy is used again for a similar study, will the data support the same intended use with the desired level of confidence, particularly if the measurement results turn out to be higher or lower than those observed in the current study?

The DQA process involves first verifying that the assumptions under which the data collection design and DQOs that were developed have been met, and then taking appropriate corrective action if the assumptions have not been met. The DQA process evaluates how well the data collected support the type of decision that must be made and whether scientifically valid and meaningful conclusions can be drawn from the data.

To the extent possible, the DQA methods and procedures outlined in EPA's *Guidance for Data Quality Assessment, Practical Methods for Data Analysis (EPA QA/G-9)* should be followed (EPA 2000b). Forms associated with the procedures provide a means for documenting the data that will be reviewed in the DQA. Forms should be controlled to prevent loss or alteration.

The OSC typically assigns the DQA role to a knowledgeable support person who maintains the data that has been collected, evaluates its quality, and recommends additional sampling needs.

5.5 DATA QUALITY OBJECTIVES

Establishing DQOs is a major part of the planning process for work assignments that require the collection or use of environmental measurements, samples, and data. EPA's DQO process, described in *Guidance for the Data Quality Objectives Process (EPA QA/G-4)*, should be followed to ensure that the type, quantity, and quality of data are sufficient to meet overall work assignment objectives (EPA 1994).

The DQO process includes: (1) clarifying study objectives and decisions to be made based on the data collected; (2) defining the most appropriate type of data to collect; (3) determining the most appropriate conditions for collecting the data; and (4) specifying acceptable decision error limits based on the consequences of making an incorrect decision. The DQO process consists of seven steps:

- Step 1—State the problem
- Step 2—Identify the decision
- Step 3—Identify inputs to the decision
- Step 4—Define the boundaries of the study
- Step 5—Develop a decision rule
- Step 6—Specify tolerable limits on decision errors
- Step 7—Optimize the design for obtaining data

The DQO process offers a systematic approach to planning. All seven steps of the DQO process may not be applicable to all radiological data collection activities. Examples include activities where specific decisions cannot be identified or studies that are exploratory in nature. In these situations, the steps of the DQO process that are applicable to help plan the data collection effort should be used.

The following is an example of the DQO process applied to the release of a piece of equipment from a contaminated area following decontamination:

Step 1—State the problem

Determine if a piece of potentially contaminated equipment can be unconditionally released from a contamination area.

Step 2—Identify the decision

If the contamination on the item is less than published standards, the item can be unconditionally released from the contamination area.

Step 3—Identify inputs to the decision

Removable contamination and total contamination values must be less than published values.

Step 4—Define the boundaries of the study (what to survey)

Removable alpha and beta contamination over representative portions of the equipment.

Total alpha and beta contamination over the entire surface of the piece of equipment.

Only the surfaces that could potentially be exposed to airborne radioactivity require survey.

Step 5—Develop a decision rule

The piece of equipment can be unconditionally released if no 100 cm^2 sampled area exceeds the removable contamination criteria for either alpha or beta contamination and the average total contamination is less than the release criteria (with no individual reading exceeding three times the release criteria for total contamination when averaged over one square meter).

If either of these criteria is not met, the equipment will be returned for further decontamination, continue to be used in the contamination area, or disposed as radioactive waste as determined by the OSC.

Step 6—Specify tolerable limits on decision errors

The measurements are to be within 95% confidence that contamination will not be present above the release criteria if the measurement indicates that contamination does not exceed the release criteria (Type I error).

The measurements are to be within 95% confidence that contamination does exceed the release criteria if the measurement indicates that the release criteria has been exceeded (Type II error).

Step 7—Optimize the design for obtaining data

Develop one square meter survey grid on the equipment.

Collect one swipe from each square meter of surface area potentially exposed to the atmosphere.

Record the highest total contamination measurement in each survey grid.

Document the survey grid on the item with pictures or sketches in accordance with survey procedures.

5.6 QUALITY ASSURANCE

Data quality is based on the accuracy and precision of a particular instrument, the geometry of a source, the activity concentration of the source, and the methods used to collect the data. Methods used to collect data are typically described in formally documented monitoring procedures and provide the basis for personnel training. Such procedures are included in the companion CD.

Instrument accuracy and precision is evaluated by the ability of the instrument to respond to radioactive material in a predictable manner specific to the location (environment), concentration, geometry, and other factors that can affect the response of the particular instrument. Background can change from one geographical location to another, and can change over relatively short distances, primarily due to differences in the exposed geological strata. The area of the response needs to be evaluated for background before meaningful data can be collected. This process is documented in Procedure RRSOP-401.

Checks are performed on instrumentation prior to its use, then periodic function checks are performed to ensure the equipment remains in a ready state. The level of effort given to these checks varies with the DQL. DQL 3 checks are simple and quick, while DQL 1 checks are much more demanding.

5.6.1 Quality Control Procedures

Instrument-specific quality control procedures involve calibration, maintenance, functional checks, etc. Quality control requirements have been incorporated into the procedures found in the companion CD. Terms, such as “calibration,” that are used in the procedures have specific meanings as described in the following sections.

5.6.2 Calibration

Instrument calibration involves exposing an instrument to a radiation field of known intensity while adjusting the controls on the instrument to match the intensity. The radiation characteristics of the source should be traceable to an official standards laboratory, such as the National Institute of Standards and Technology (NIST).

The objective of calibration is to adjust or determine the response or reading of an instrument relative to a series of conventionally true values for radiation sources or to determine the activity of a radiation source relative to a standard or conventionally true value.

Radiological monitoring instrument calibration is usually required annually (or more frequently if recommended by the manufacturer's specifications). A technical basis is required for any instrument whose calibration is scheduled at a frequency greater than annually. In addition, calibration may be necessary following maintenance or adjustment of parameters that affect an instrument's operation. More frequent instrument calibration may be required when the instrument is used under harsh field conditions.

Radiological instrument calibration is normally performed at two points on each scale. If a scaler instrument is not calibrated on each scale, a Special Use Tag should be placed on the instrument indicating which scales are not calibrated. However, if the instrument does not have scales, it should be calibrated at (1) a point above the maximum expected reading, (2) a point near the detection limit, and (3) a point near the expected routine operating region. Before using an instrument, check the calibration tag for any use restrictions.

Instruments are calibrated with a specific cable and detector combination. The instrument, cable, and detector combination should not be changed unless specifically documented by the instrument manual or calibration certificate. It is generally permissible to change a cable in the field without recalibration provided the replacement cable is the same type AND length of the original.

Equipment is marked to indicate calibration status. Equipment that is out of calibration is tagged or segregated until repaired, recalibrated, or replaced. A record of calibration history should be documented and available to the user of the instrument.

Calibration is normally not performed in the field for survey instruments. Calibration may be performed for laboratory-based measurement equipment after the equipment has been relocated to the field, often in a mobile laboratory. However, functional checks are performed in the field to verify that the instrument is performing within prescribed tolerances.

5.6.3 Manufacturer's Instructions and Procedures

Quality operations should be performed in accordance with the manufacturer's published instructions or procedures. Manufacturer instrument manuals normally accompany a radiological monitoring instrument from the warehouse to the field location, especially if the instrument may be transferred to another person for use.

5.7 RADIOACTIVE SOURCES

5.7.1 Source Response

Each operational instrument should be checked with a source at least daily or prior to use. In ratemeter mode, instruments should exhibit a response within 20% of the expected reading when exposed to a source in a constant and reproducible manner. Sources that are used in scaler mode, including instruments used to count smear and air samples such as the Ludlum 3030, should exhibit a response within three standard deviations of the mean value.

Sources used for quality control measurements should have energies similar to those of the expected radionuclides. Ideal sources should have a long half-life (on the order of years), be physically stable (fixed or encapsulated within an appropriate material), have a unique serial number or marking, and be in the same or similar geometry as the measurements collected.

Once the instrument has been shown to respond within tolerance, it is permissible to obtain generic reference readings for a specific source in a specified geometry. This is accomplished by collecting a statistically significant number of background readings and source readings using a jig to provide reproducible results. The average source reading and control limits can then be placed on a chart (Section 5.8.6 Control Charts). Any future checks with that source in the specific jig (or an equivalent jig) are then recorded on the chart and compared with the control limits. Net counts are used in these determinations to minimize the influence of background.

Sources used for instrument functional checks, including check sources, should be maintained on a source inventory. Sources should be tracked by radionuclide, activity, and serial number, if applicable. Sources should be stored only in approved locations. Instruments with affixed sources should be included in the source control program. Sources should only be used by personnel with appropriate training so that exposures are minimized and the source is not damaged by improper handling. Sources that are lost should be reported to the OSC, and an effort made to locate the missing source. Radioactive sources used for quality assurance measurements are defined in Table 5.2.

Table 5.2 Radioactive Sources

Source Type	Definition	Handling Procedures	Use
Calibration sources (e.g., ^{137}Cs, ^{60}Co, ^{230}Th, ^{90}Sr)	• Source traceable to NIST or another recognized standard • Unique serial number • Calibration certificate	Handled with gloves or Teflon tipped tweezers to avoid accidentally removing radioactive material as well as to avoid depositing foreign material such as grease, dirt, etc., on the surface of the source	• In defined, uncontaminated areas • Used for QC of DQL 1
QC source (e.g., ^{137}Cs, ^{60}Co button sources, ^{90}Sr, ^{230}Th or other plated sources)	• Radiation emission rate and quality are well known • Unique serial number • May or may not have calibration certificates	Handled with gloves or Teflon tipped tweezers. Small (microCi) sealed sources (other than plated or otherwise exposed radioactive surface) can be handled by hand without gloves.	• Can be used in contaminated areas if they are checked for removable contamination before being put back into service. • Used for QC of DQL 2
Check source (e.g., lantern mantle or piece of orange Fiesta-ware)	• Source used to confirm the satisfactory operation of a radiological monitoring instrument • May have serial numbers • Typically do not have calibration certificates	May be handled with hands, although plated sources should be handled with gloves if possible.	• In contaminated areas • Used for QC of DQL 3

5.7.2 Source Positioning Jigs

Source positioning jigs, or source jigs, are instrument-specific calibration devices that provide a constant and reproducible geometry for performing a source response check. The instrument or probe is placed on a jig that has a particular radioactive source in a fixed location. The use of a source jig eliminates the source-instrument variability factor in the determination of instrument response to a certain radiation type.

Multiple readings of an instrument/probe are taken in a jig with a given source to provide statistically valid instrument readings. From these readings, a control chart is developed.

The source and the jig (or an equivalent jig) that was used to develop the control chart should accompany the instrument to the field for the performance of quality control checks for the appropriate DQL.

5.8 INSTRUMENT TESTS

A test is a procedure whereby an instrument, component, or circuit is evaluated against certain criteria for satisfactory operation. Tests that are performed on instruments include performance tests, source response checks, functional checks, and "as found readings." Specific test control measures are defined in the instrument-specific quality control procedures.

5.8.1 Performance Test

A performance test is an evaluation of the performance of an instrument in response to a given influence quantity.

5.8.2 Source Response Check

A source response check compares the instrument response to a source to determine whether or not the instrument is still functional within an acceptable range.

5.8.3 Functional Check

A functional check is performed to determine that an instrument is operational and capable of performing its intended function. Such checks may be qualitative, and may include a battery check, zero setting, or a source response check. Functional check requirements for specific instruments are documented in procedures or as instructions on forms or logs.

5.8.4 As Found Readings

After an instrument has been in the field, it is returned to the organization that owns the instrument. "As found readings" are performed by the organization upon the return of an instrument that has been in field use to provide assurance that the instrument performance did not change during use. "As found readings" are taken using the same source and geometry that were used to develop control charts, perform routine functional tests, etc., prior to the use of the instrument. As found readings for instruments used in ratemeter mode should be within 20% of the expected reading. If the as found reading exceeds +20%, the data collected by that instrument since its last source response check are to be evaluated for validity. Readings/measurements taken by this instrument may need to be taken again. If measurements need to be retaken, maintain the initial set of readings, as well as follow-up or repeat readings/measurements, making appropriate notations on the data.

As-found readings also are performed when an instrument is submitted for recalibration. The Calibration Facility conducts as found readings using certified sources prior to making any adjustments to the instrument. Recalibration as found readings for instruments used in the ratemeter mode should be 10% of the conventionally true value.

5.8.5 Detection limit

The detection limit is defined as the smallest concentration of radioactivity in a sample that can be detected with a 5% probability of not detecting radioactivity, when in fact it is present (Type 1 error) and also a 5% probability of erroneously detecting radioactivity, when in fact none was present (Type 2 error). The detection limit is defined by a statistically valid instrument response after appropriate calibration factors have been applied. The detection limit should be calculated for instruments that are used to measure low levels of radiation.

The detection limit may be calculated and expressed as Minimum Detectable Activity (MDA). MDA is defined as the smallest quantity of radioactivity that can be measured under specific conditions. It depends on the lower limit of detection and on the counting efficiency of a counting system. MDA is often used interchangeably with the minimum detectable concentration (MDC), which is the minimum detectable activity measured in concentration units. Calculations for MDA and MDC should be provided in technical basis documents. A number of the forms in the procedures require the determination of MDA. The calculated MDA should be compared to the data requirements to assure that the instrument is appropriate for its intended use prior to the survey.

Some procedures require the determination of an instrument MDA based on the background, instrument efficiency (from the calibration certificates), count time, and probe, or measurement size. MDAs are typically determined for instruments that will be used to measure contamination, but they are generally not determined for instruments that will measure gamma or neutron radiation levels.

5.8.6 Control Charts

Control charts should be developed for each instrument used to make measurements corresponding to DQL 1 or 2. The control chart is typically based on an average instrument reading of a quality control source that is counted in a reproducible geometry. When an instrument is put into service and will be used to take DQL-1 or DQL-2 measurements, a control reading should be taken with the instrument, the appropriate QC source, and jig. The results of the check are then plotted on the control chart. For DQL-1 measurements, another check is performed at the conclusion of the readings, and that value is plotted on the control chart as well. For instruments that are in routine use, control charts typically have a one-week duration.

Controls are based on percent variation from the average for ratemeter mode instruments. An instrument used in ratemeter mode is operational if it meets the criteria defined in Table 5.3.

Table 5.3 Control Chart Criteria for Ratemeter Mode

Criteria	Action
≤ 10% of the average	Instrument can be used
> 10 to ≤ 20% of the average ≤ 10% of the average for both subsequent readings > 10% to ≤ 20% of the average for both subsequent readings	Two more readings should be taken Instrument can be used Should be evaluated by a Health Physicist
> 20% of the average	Instrument fails and should be returned for maintenance or recalibration

Controls are based on an evaluation of standard deviation from the norm for scaler mode instruments. Typically, an instrument is operational if it meets the criteria defined in Table 5.4. If the quality control check is outside the acceptable limits, additional data may need to be collected.

Table 5.4 Control Chart Criteria for Scaler Mode

Criteria	Action
≤ 2 standard deviations	Instrument can be used
> 2 to ≤ 3 standard deviations ≤ 2 standard deviations for both subsequent readings > 2 to ≤ 3 standard deviations for both subsequent readings	Two more readings should be taken Instrument can be used Should be evaluated by a Health Physicist
> 3 standard deviations	Instrument fails and should returned for maintenance or recalibration

6. STABILIZATION/DECONTAMINATION

6.1 INTRODUCTION

Stabilization and decontamination usually begin when:

- Emergency response functions for lifesaving or rescue are complete
- The event site has been secured and there is assurance that the site is stable
- The incident involves a radiological dispersal device (RDD) or improvised nuclear device (IND) that activates the National Response Plan (NRP)[4]
- Entry and egress locations are specifically designated
- Personnel decontamination stations have been set up
- Vector/animal control has been established to minimize inadvertent transport of radioactive materials from the contamination reduction zone to the support zone

The following information, which comes from various quantitative and qualitative sources, should be available to the OSC to plan and implement stabilization and decontamination:

- Identity of the radionuclide(s)
- Matrices that are affected (e.g., concrete building surfaces, epoxy-coated floors)
- Proposed methods of disposal of contaminated material
- Types of containers available for disposal
- Work completed to immediately identify or stabilize hot spots or easily dispersible radioactive materials
- Radiation survey maps of the various zones

Because they are most likely to be part of a RDD, the radionuclides specifically addressed in this chapter are ^{137}Cs, ^{90}Sr, ^{60}Co, ^{241}Am, ^{226}Ra, ^{192}Ir, ^{238}Pu, and $^{240+239}Pu$. Their chemical properties, related field detection techniques, relevant environmental factors, and decontamination approaches are described. The techniques for stabilization, decontamination, or mitigation of fixed contamination of materials to be left in place fall into two distinct categories with various subgroups as shown in Table 6.1 (EPA undated).

The planning processes for decontamination, mitigation, or stabilization should include long-term as well as immediate requirements, costs, and infrastructure needs. A list of topics to consider is shown in Table 6.2. Information about the distribution, mass concentration, surface activity, and exact types of radionuclides present can be obtained from quantitative instruments. Much of this type of information comes from samples sent to analytical laboratories.

[4] When events do not activate the NRP, the OSC takes responsibility for decisions regarding access, decontamination, disposal, and ultimately, the release of the area for normal use.

Table 6.1 Chemical and Physical Decontamination/Mitigation Techniques

Techniques	Brief Description of the Techniques
Chemical	
Chelation and Organic Acids	Chelating agents like EDTA, oxalic acid, or DTPA are applied to complex/solubilize the radionuclides deposited on a surface.
Strong Mineral Acids	Acids like nitric or hydrochloric are used to oxidize and complex radionuclides by dissolution of the surface layer of the substrate.
Chemical Foams, Surfactants, or Gels	These materials are used to change the primary adsorbed film of material on the substrate so that it can be removed by wiping, dissolution, or vacuuming.
Oxidizing/Reducing Agents	Depending upon the particular radionuclide, this is an application of a specific reagent that changes the chemical oxidation state of the radionuclide, making it soluble.
TechXtract	A proprietary three-step process that involves a liquid application that penetrates the surface of the substrate and then is worked into the surface with an abrasive material. A rinse material is sprayed onto the surface and then vacuumed off.
Physical/Mechanical	
Strippable Coatings	These are latex type materials that are sprayed onto a surface. The material is allowed to dry and then peeled off in a single sheet. The radionuclides that were on the surface become incorporated into the sprayed on coating and are removed when the coating is peeled off.
Centrifugal Shot Blasting	The technique uses metallic or ceramic shot to remove the outer surface of a substrate. The shot is recycled to a container for reuse.
Concrete Grinding	High integrity materials are used to remove the outer surface of concrete for all three of these techniques. The idea is to remove those radionuclides that are only embedded on the outermost surface.
Concrete Shaving/ Cutting	
Concrete Spalling	
Dry Ice Blasting	Tiny pellets of solid carbon dioxide are impinged on the surface of a substrate to mechanically remove a thin film of material. The carbon dioxide evaporates to reduce the total waste volume.
Dry Vacuuming or Wiping	High-suction vacuum cleaning to remove loose debris or loosely adhered material; dry wiping to remove materials in the same way.
Scabbling	Metallic pins are used to mechanically erode the outermost surface of hard materials like concrete.
Grit Blasting	Sand or iron shot the same size as sand is used to mechanically erode a hard surface.
High Pressure Water	Water is directed at impervious surfaces at up to 20,000 psig (pounds per square inch gauge) to mechanically dislodge materials. This technique can be used with or without chemical additives for complexation/desorption.
Steam Cleaning/ Vacuuming	High temperature and slight pressure mechanically dislodge particulates from impervious surfaces.
Sponge (Soft Media) Blasting	Soft, polymeric spheres of very small diameter are impinged on a surface of a substrate that would be destroyed by harsher physical means such as shot blasting or grinding.

Table 6.2 Additional Decontamination Response Issues

If Emergency Support Function (ESF) 3 has been activated under the NRP, define EPA and USACE roles for debris management.
Identify contractors and Basic Order Agreements (BOAs) for decontamination contractors.
Discuss removal strategy for radioactive waste materials. Consider the increased rate of exposure to workers as the wastes are co-located, and how rapidly these waste concentration areas need to be removed for final disposal.
Minimize the spread of contamination.
Evaluate the potential re-contamination of areas that were decontaminated during the emergency phases.
Establish awareness of EPA policies on: population monitoring, human decontamination, Protective Action Guides (PAG) determination, and personal property monitoring and decontamination (cars, computers, lawn mowers, etc.).
Evaluate clean-up of locations or materials required for critical infrastructure, and establish a priority list.
Familiarize personnel in the organization with the generic decontamination technologies available and the limitations or advantages of each. Form consensus on the best technology to use for each application.
Identify staging areas for storage or decontamination of cars and equipment.

6.2 CESIUM-137 (^{137}CS)

6.2.1 Chemical Properties/Form

Cesium is a silvery white metal that melts at 82°°F. It is very chemically reactive and rapidly oxidizes from the metal (zero oxidation state) to the +1 oxidation state when exposed to air or moisture. Metallic cesium is preserved usually by storing it in an inert atmosphere or in an inert liquid (like mineral oil) because exposure of metallic cesium to air can cause a significant conflagration that is typically treated as a Class D fire. It is unlikely that metallic cesium, as a source, will be encountered.

The chemical properties of cesium are analogous to those of sodium. It is present only as the +1 cation in aqueous solution. Cesium salts, including the oxide, are soluble in water. The most commonly encountered form of cesium is CsCl, which is deliquescent; it dissolves in the moisture that it absorbs when exposed to moist air. Ion exchange resins have a higher selectivity for cesium than for the other cations in the Group I series of elements. Thus, one effective method of cesium removal from water is through ion exchange.

The two most radiation dose significant radioisotopes of cesium are ^{134}Cs (half-life 2.1 years) and ^{137}Cs (half-life 30 years). Generally speaking, ^{134}Cs is unlikely to be present at a RDD incident due to its relatively short half-life, and the fact that only a very small amount of it is used for commercial purposes.

The concentration of ^{137}Cs in surface soil samples (less than 15 cm below the topsoil) in the continental United States is on average about 0.6 pCi/g. The source for this terrestrial ^{137}Cs is from atmospheric fallout originating from above-ground nuclear weapons testing between 1950 and 1978. Exterior building surfaces can be expected to contain small quantities of this cesium source based on continued fallout and re-suspension of surface soils.

Devices that contain ^{137}Cs, such as a medical irradiator or a cesium source from a liquid scintillation counter, have CsCl powder in a sealed container. Most cesium sources encountered are in this form, which is easily dispersible when the container is breached. The particle size that might be experienced depends to a large extent on the size of the explosive device and the heat it generates during detonation. High temperature detonation causes cesium to volatilize, vaporize, and then re-condense when it passes through its phase transition temperature upon expanding into the atmosphere. The majority of the particle sizes are likely be 0.5 to 100 microns.

6.2.2 Field Detection Techniques

Cs-137 is a long-lived (half-life 30 years), pure beta emitting nuclide (0.511 MeV βmax of principle beta) that decays to short-lived ^{137}Ba (half-life 2.6 minutes) that emits a 662 keV gamma ray. For most general area surveys, detectors that respond to the 662 keV gamma ray of ^{137}Ba are used. For surface area contamination surveys, detectors that respond to the ^{137}Cs beta particle or to the 662 keV gamma ray of ^{137}Ba are used.

Without knowledge of the radioactive source, a general area gamma survey (refer to RRSOP-402) can be conducted with Ludlum Models 192 and 19 Micro-R Meter for gamma exposure rates between 1 and 5,000 μR/hr or 0.001 to 5 mR/hr. Terrestrial gamma background exposure rates vary according to soil type and geographical area but are normally between 3 and 9 μR/hr. The upper range (1,000 to 5,000 μR/hr) of the Model 192 Micro-R Meter responds to exposures that are approximately 100 to 1,000 times typical terrestrial background levels. If the upper response range of this instrument is exceeded, the Eberline Model RO20 should be used. This unit has a gamma response of 5 to 50,000 mR/hr. General surveys with either meter should be conducted holding the unit at waist height and slowly walking through the potentially contaminated area.

For gamma-emitting, nuclide-identifying scoping surveys of potentially contaminated ground (refer to RRSOP-402), the SAM-935 with the NaI detector will typically be the instrument of choice. The survey meter-probe should be calibrated with an extended ^{137}Cs source prior to use. The SAM-935 unit has software that performs nuclide identification and spectral analysis. As recommended in the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), the detector should be held close to the ground surface (~6 cm or 2.5 inches) and moved in a serpentine pattern while walking at a slow speed (i.e., typically 0.5 m/s (~1.5 ft/s) or slow enough to detect the desired investigation level).

For surveying of potentially contaminated surfaces (refer to RRSOP-402), the Ludlum 2241 with 44-9 alpha/beta probe can be used. Use of this survey meter-probe combination will facilitate converting the observed count rate to surface activity (units of Bq/cm^2). The meter response conversion to surface activity should take into account the 12 cm^2 active surface area of the 44-9 probe. The probe should be held less than 2 cm (~1 inch) from the surface under investigation and moved slowly (<5 cm/s or <2 in/s). It should be noted that the open 44-9 probe (1.7 mg/cm^2 thick window) will respond to both alpha and beta particles. A thin plastic (or mylar) covering (~8 mg/cm^2) of the probe face will absorb alpha particles, thus rendering the probe a beta-only detector. The unit should be calibrated using a ^{137}Cs source whose dimensions match the area to be surveyed using this instrument.

6.2.3 Contract Laboratory Turn-Around-Time

The analysis for ^{137}Cs normally does not require sample preparation, as it is a high energy gamma emitter. It can be detected to about 5 pCi/g of solid material when a 1 kg sample is counted for about 100 minutes on a high-purity germanium detector. There may be minor sample self-shielding concerns with large concrete or steel samples. However, all other matrices do not significantly diminish the 661 keV gamma rays.

This detector counting time represents only a portion of the radiological holding time (i.e., no sample preparation or data reduction times are included). The laboratory turn-around time (TAT), which includes the radiological holding time, is the summation of the times for sample logging at the laboratory, sample preparation, counting of the prepared sample, data processing, final data review by lab technical personnel, and transmittal of a data report. The time taken to ship the sample to the laboratory is not normally included in the laboratory TAT but should be considered as part of the overall TAT (i.e., from field shipping to receipt of data report). The time required for these ancillary functions are dictated by the data quality objectives for the event.

6.2.4 Environmental Factors

Decontamination processes for ^{137}Cs may be thwarted by the environmental conditions that follow the RDD event. Much of what is known about the decontamination of surfaces involves studies of dry deposition resulting from a detonation. The subsequent environmental conditions, such as wind, rain, snow, freezing rain, or high humidity, affect how the radionuclides adhere or incorporate into the material. These environmental factors affect the decontamination process. Thus, stabilization should be performed as soon as practicable to surfaces that are susceptible to these environmental factors, making subsequent decontamination easier. As an example, consider a RDD that has been detonated outdoors adjacent to buildings comprised of limestone surfaces. The force of the detonation drives the radioactive cesium into the building surface, but it only penetrates a few tenths of a millimeter. This surface is susceptible to continued degradation by acid rain. If the surface is allowed to become wet, the cesium becomes fixed in the limestone matrix and penetrates it more deeply. This causes cesium to bind to the material, likely increasing the time and cost of decontamination.

6.2.5 Decontamination Approaches

The solubility of cesium is a very important factor when cesium is the only contaminant (Table 6.3). Hot water can effectively decontaminate a surface with low porosity (i.e., one that water will not penetrate). Surfaces, such as polished non-porous marble and epoxy-coated walls or floors, fall into this category. Expeditious cleanup of these surfaces and collection of the liquid used for cleanup mitigates the spread of contamination to storm sewers and sanitary systems.

Materials that are porous, such as concrete, unpainted plaster, limestone, and cement, should not be treated with any liquid solutions because they are able to draw water into the medium's interior via capillary action. Porous materials provide a conduit for soluble ions like cesium to penetrate the medium to much greater depths. Thus, decontaminating with water solutions only confounds the cleanup. When scabbling is used initially, less building material has to be removed, thereby minimizing waste and saving time and money.

Table 6.3 Potential Techniques for Cesium Decontamination

Matrix	Concrete or Cement	Stone (non-porous marble or granite)	Stone (lime)	Macadam	Plaster or Dry Wall	Steel (uncoated)	Painted Surfaces
Primary Decon Technique	Scabbling	Hot Water	Sponge Blasting	Hot Water with Surfactant	Sponge Blasting	Mild Abrasive (Roto Peening)	Hot Water
Secondary Decon Technique	TechXTract®	Strippable Coating	Cement Cutting	Sponge Blasting	Mild Abrasive	Strippable Coating	Sponge Blasting

6.3 STRONTIUM-90 (^{90}SR)

6.3.1 Chemical Properties/Form

Strontium is a silver-white metal that reacts in air and water to form the oxide. Its two valence states are zero and +2, and it is chemically similar to calcium, magnesium, barium, and radium. Ionic strontium forms compounds in the environment that tend to make it slightly insoluble to very insoluble. Specifically, carbonates, sulfates, and phosphates are insoluble but are easily dissolved using dilute acids. The subsequent solution can have the strontium removed by exchange onto a cation resin.

Strontium's has two principal isotopes of concern are ^{89}Sr (half-life 50 days) and ^{90}Sr (half-life 29 years). Sr-89 can be produced via an accelerator and also is a prominent fission product. Its short half-life usually excludes it from the scenarios that an OSC might encounter. The current environmental concentration of ^{90}Sr in soil due to atmospheric deposition from the weapons testing era is about 0.05 pCi/g. Sr-90 decays to ^{90}Y, which has a half-life of 64 hours. Within two weeks after the production of ^{90}Sr, the activity due to the ^{90}Y increases to equal that of the ^{90}Sr if no chemical speciation occurs.

Sr-90 has many industrial uses, including a General Purpose Heat Source (GPHS)-Radioisotope Thermoelectric Generator (RTG). These devices contain thousands of curies of ^{90}Sr, and an equivalent amount of ^{90}Y due to secular equilibrium. The chemical composition of strontium in these sources is the oxide, which is usually in the form of pellets or discs. If strontium in this form were to be part of a RDD, the initial aerosol color following the explosion might be crimson as a result of the strontium excitation.

6.3.2 Field Detection Techniques

Sr-90 is a long-lived (half-life 28.6 years) pure beta emitter (0.55 MeV βmax) that has a short-lived ^{90}Y decay product (half-life 64 hours) that is also a pure beta emitter (2.3 MeV βmax). The high energy of the ^{90}Y beta particle allows the ^{90}Sr to be detected using an open window GM tube or a pancake probe. Self-shielding will be of little concern when performing surface evaluations for this contaminant. Since ^{90}Sr does not emit a gamma ray, gamma detectors, such as a Micro-R meter or survey meter with a gamma probe, are ineffective in measuring ^{90}Sr contamination unless the contamination is extremely high. Under this circumstance, the decay of ^{90}Y may create sufficient Bremstrahlung photon radiation from the interaction of the high-energy 2.3 Mev beta particle with the matrix under investigation.

When surveying small general areas or potentially ^{90}Sr contaminated surfaces, the Ludlum 2241with 44-9 alpha/beta probe can be used (refer to RRSOP-402). Use of this survey meter-probe combination facilitates converting the observed count rate to surface activity (units of Bq/cm^2). The meter response conversion to surface activity should take into account the 12 cm^2 active surface area of the 44-9 probe. The probe should be held less than 2 cm (~1 inch) from the surface under investigation and moved slowly at a speed of ~1.5 ft/s for small area surveys and < 5 cm/s or < 2 in/s for objects. The probe should be held less than 2 cm (~1 inch) from the surface under investigation and moved slowly at a speed of ~1.5 ft/s. It should be noted that the open 44-9 probe (1.7 mg/cm^2 thick window) will respond to both alpha and beta particles. A thin plastic (or Mylar) covering (~8 mg/cm^2) of the probe face will absorb alpha particles, thus rendering the probe a beta-only detector. The unit should be calibrated using a ^{90}Sr source whose dimensions match the area to be surveyed using this instrument.

6.3.3 Contract Laboratory Turn-Around-Time

Sr-90 is a pure beta emitter. As such, it requires chemical separation from its matrix, as well as any other beta emitters (like naturally occurring radionuclides of radium, lead, and bismuth), to provide the most accurate assessment of the ^{90}Sr contamination. Matrix dissolution for ^{90}Sr should take from one-half to two hours depending on the size of the sample and the matrix. Analytical separations may take up to several hours using either precipitation or ion exchange. In order to achieve detectable concentrations as low as 300 pCi/g using a 1 kg sample size, count times will take on the order of 5 hours using liquid scintillation (this assumes that the technique requiring the in-growth of ^{90}Y is not used and only ^{90}Sr is present). Thus, a reasonable estimate of total radiostrontium concentration could be made in about 2 days.

This detector counting time represents only a portion of the radiological holding time; no sample preparation or data reduction times are included. The laboratory TAT, which includes the radiological holding time, is the summation of the times for sample logging at the laboratory, sample preparation, counting of the prepared sample, data processing, final data review by lab technical personnel, and transmittal of a data report. The time taken to ship the sample to the laboratory is not normally included in the laboratory TAT but should be considered as part of the overall

TAT, from field shipping to receipt of data report. The time required for these ancillary functions is dictated by the data quality objectives for the event.

6.3.4 Environmental Factors

The presence of ^{90}Sr means that ^{90}Y also will be present. Thus, any environmental conditions that can cause chemical speciation of these radionuclides will cause them to "separate." For example, ^{90}Sr deposited on a non-porous marble surface that is affected by acid rainwater allows the strontium to remain deposited (as the insoluble carbonate), but the yttrium would be mobile enough to cause an apparent decontamination. Since the ^{90}Sr then reestablishes secular equilibrium with ^{90}Y, the total activity, hours to days later, appears to increase. This kind of increase/decrease in activity can cause considerable confusion unless the strontium and yttrium are fixed on the surface and not susceptible to migration.

6.3.5 Decontamination Approaches

Strontium forms complexes with several different chelating agents, such as ethylenediamintetra-acetic acid (EDTA). However chelating techniques on porous or calcium- or magnesium-based materials may simply drive the contamination deeper into the material. Thus, caution should be used on porous surfaces, such as limestone and wood, or building materials containing calcium or magnesium. When chelating agents are not applicable, a solid shaving technique should remove contamination effectively while minimizing the structural impact to the building. Table 6.4 presents several approaches for decontaminating various surface materials.

Table 6.4 Potential Techniques for Strontium Decontamination

Matrix	Concrete or Cement	Stone (non-porous marble or granite)	Stone (lime)	Macadam	Plaster or Dry Wall	Steel (uncoated)	Painted Surfaces
Primary Decon Technique	Scabbling	Chemical Decon (complexing agent)	Sponge Blasting	Chemical Decon (complexing agent)	Sponge Blasting	Mild Abrasive (Roto Peening)	Chemical Decon (complexing agent)
Secondary Decon Technique	TechXTract®	Strippable Coating	Concrete Shaving	Sponge Blasting	Concrete Shaving	Strippable Coating	Sponge Blasting

6.4 COBALT-60 (^{60}CO)

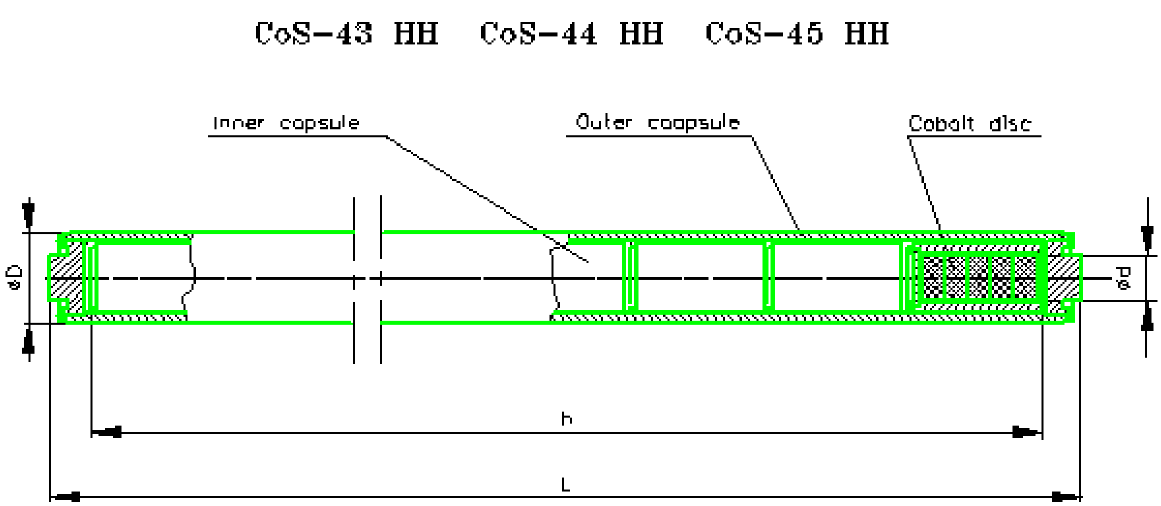
6.4.1 Chemical Properties/Form

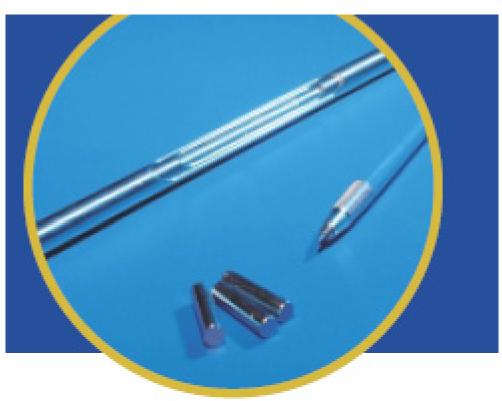
Cobalt is a grey-white metal that has two stable oxidation states: zero and +2. Oxidation state +3 is unstable and easily reduced in the natural environment to +2. Cobalt changes state easily in acidic solutions containing cation resins. It also complexes with organic acids like EDTA that can be used to remove cobalt from contaminated surfaces.

Chemical forms of cobalt that might be encountered as a result of a RDD are the metal (as solid discs or pins) or the oxide (as a powder or compressed disc). A diagram that identifies a pin configuration is shown in Figure 6.2. Cobalt metal is double-encapsulated in stainless steel (KO-33 or KO-36) and sealed by argon arc welding. Table 6.5 shows three different capsule sizes. The small diameter of these encapsulated sources makes them easily transportable. The high specific activity means that only a small quantity can create widespread contamination.

Cobalt has two principal radioisotopes of concern, ^{58}Co (half-life 71 days) and ^{60}Co (half-life 5.27 years). As with the other radionuclides, the short-lived ^{58}Co is an unlikely contaminant resulting from a RDD. Co-60 is a beta-gamma emitter that emits two high-energy gamma rays for 100% of the decays. For this reason, ^{60}Co is easily detectable. However, these emitted gamma rays present a problem (in terms of required shielding) when attempting to stabilize contaminated areas or collect contaminated material and centrally locate the contaminated material.

Figure 6.1 Example of an Encapsulated Radioactive Source





Recommended working life: 20 years
Quality control: Ultrasonic test "A" Vacuum bubble test

Table 6.5 Capsule Sizes

	Overall dimensions		**Active dimensions**		**Maximum equivalent activity**	
	D [mm]	**L** [mm]	**d** [mm]	**h** [mm]	TBq	Ci
CoS-43 HH	11	451	7	437	130	3510
CoS-44 HH	11	220	7	207	60	1622
CoS-45 HH	11	81.5	7	69	17	459

6.4.2 Field Detection Techniques

Co-60 is a long-lived (half-life 5.27 years) beta emitting nuclide (0.318 MeV βmax of principal beta) that also emits several gamma rays (1173 keV and 1332 keV). For the general area surveys, detector probes that respond to the 1173 keV and 1332 keV gamma rays are used. For surface area contamination surveys, detector probes that respond to either beta particles or to the 1173 keV and 1332 keV gamma rays are used.

Without knowledge of the radioactive source, a general area gamma survey can be conducted with a Ludlum Model 192 Micro-R Meter for gamma exposure rates between 1 and 5,000 µR/hr or 0.001 to 5 mR/hr. Terrestrial gamma background exposure rates vary according to soil type and geographical area but are normally between 3 and 9 µR/hr. The upper range (1,000 to 5,000 µR/hr) of the Model 192 Micro-R Meter responds to exposures that are approximately 100 to 1,000 times typical terrestrial background levels. If the upper response range of this instrument is exceeded, the Eberline Model RO20 should be used. This unit has a gamma response of 5 to 50,000 mR/hr. General surveys (refer to RRSOP-402) with either meter should be conducted holding the unit at waist height and slowly walking through the potentially contaminated area.

For gamma-emitting, nuclide-identifying scoping surveys of potentially contaminated ground, the SAM-935 with the NaI detector is typically the instrument of choice. The survey meter-probe should be calibrated with an extended ^{60}Co source prior to use. The SAM-935 unit has software that performs nuclide identification and spectral analysis. As recommended in MARSSIM (EPA 2000a), the detector should be held close to the ground surface (~6 cm or 2.5 inches) and moved in a serpentine pattern while walking at a slow speed (i.e., typically 0.5 m/s (~1.5 ft/s) or slow enough to detect the desired investigation level).

The Ludlum 2241with 44-9 alpha/beta probe may be used to survey potentially contaminated surfaces. Use of this survey meter-probe combination facilitates converting the observed count rate to surface activity (units of Bq/cm^2). The meter response conversion to surface activity should take into account the 12 cm^2 active surface area of the 44-9 probe. The probe should be held less than 2 cm (~1 inch) from the surface under investigation and moved slowly (<5 cm/s or <2 in/s). It should be noted that the open 44-9 probe (1.7 mg/cm^2 thick window) responds to both alpha and beta particles. The thin plastic (or Mylar) covering (~8 mg/cm^2) of the probe face absorbs alpha particles, thus rendering the probe a beta only detector. The unit should be calibrated using a ^{60}Co source with dimensions that match the area to be surveyed.

6.4.3 Contract Laboratory Turn-Around-Time

Analysis of ^{60}Co is routinely performed via gamma ray spectrometry. Samples that follow the decontamination may be analyzed without any chemical separation to concentrations of ~10 pCi/g using a 1 kg sample and counting for approximately 1 hour using a HPGe. There may be minor sample self-shielding concerns with large concrete or steel samples. However all other matrices do not significantly diminish the 1173 and 1332 keV gamma rays.

This detector counting time represents only a portion of the radiological holding time (i.e., no sample preparation or data reduction times are included). The laboratory TAT, which includes the radiological holding time, is the summation of the times for sample logging at the laboratory, sample preparation, counting of the prepared sample, data processing, final data review by lab technical personnel, and transmittal of a data report. The time taken to ship the sample to the laboratory is not normally included in the laboratory TAT but should be considered as part of the overall TAT, from field shipping to receipt of data report. The time required for these ancillary functions are dictated by the data quality objectives for the event.

6.4.4 Environmental Factors

The most likely fate of cobalt in the environment is its oxide state, which can be difficult to dissolve. Generally, the most effective methods for dissolving the oxide are nitric or hydrochloric acid, or ammoniacal EDTA.

6.4.5 Decontamination Approaches

Removal of cobalt with aqueous solutions that lack a complexing agent or a strong acid causes the formation of colloidal cobalt that cannot be filtered easily, ion exchanged, or concentrated into a waste form.

Cobalt is easily solubilized by mineral acids and chelating agents that are readily available. The resultant solution also may be reduced in volume via ion exchange onto either a cation or anion resin (depending on the chemical used). The use of acids for chemical decontamination of metal surfaces also dissolves at least part of the metal surface. While this aids in the removal of the radionuclide, it also creates an additional mass of waste from the dissolved metal. Table 6.6 presents cobalt decontamination techniques.

Table 6.6 Potential Techniques for Cobalt Decontamination

Matrix	Concrete or Cement	Stone (non-porous marble or granite)	Stone (lime)	Macadam	Plaster or Dry Wall	Steel (uncoated)	Painted Surfaces
Primary Decon Technique	Scabbling	Strippable Paint	Sponge Blasting	Chemical Decon (complexing agent)	Sponge Blasting	Strippable Paint	Strippable Paint
Secondary Decon Technique	Concrete Cutting	Sponge Blasting	Concrete Cutting	Grit Blasting	Concrete Cutting	Chemical Decon (concentrated mineral acid)	Sponge Blasting

6.5 AMERICIUM-241 (^{241}AM)

6.5.1 Chemical Properties/Form

Americium is a silvery white metal that exists in the +3 oxidation state when found in environmental samples. It generally is not very soluble in surface or ground water and its chemistry is quite unique. It does not form many complexes with organic chelating agents and is not easily ion-exchanged using ordinary cation exchange resins.

Am-241 is a manmade metal that is produced from the decay of ^{241}Pu. Am-241 in the environment came from the atmospheric suspension of the radionuclide following weapons testing from the 1950s to 1978. As such, it is in the form of microscopic dust.

Am-241 is used in some medical diagnostic devices and in a variety of industrial and commercial devices that measure density and thickness. Am-241 is also used commercially in mixtures with beryllium metal as low-flux neutron sources. The alpha emission from the americium yields a nuclear reaction with the beryllium to yield a neutron. If used as a RDD, such a source would have the added hazard of finely divided beryllium. The approximate size of a single such source is a cylinder about 3 inches in diameter and about 6 inches long. Am-241 sources (approximately 100 pCi) are also present in smoke detectors that are sold over-the-counter.

Am-241 may be electroplated onto a nickel metal disc as either an alpha or gamma source. Am-241 used in industrial, medical, or commercial devices is generally electroplated onto a coin-sized metal or plastic disc. The ^{241}Am source present in a smoke detector is inside a metal cylinder that is about the size of a pencil eraser. Most Ionization Chamber Smoke Detectors (ICSD) sold today use an oxide of ^{241}Am as the radioactive source (see Figure 6.3). The typical activity for a modern residential ICSD is approximately 1 μCi, while the activity in one used in public and commercial buildings might be as high as 50 μCi.

Figure 6.2 Am-241 Smoke Detector Source

The size of the enclosed source is about equal to a U.S. penny.

6.5.2 Field Detection Techniques

Am-241 is a long-lived (half-life 433 years), alpha particle emitting (5.2 MeV) nuclide that also emits a low-energy photon (59.5 keV) of low abundance (~36 %). Since ^{241}Am is a weak photon emitter, it may be possible to detect higher-level activities of this radionuclide using the Berkley Nucleonic SAM 935 coupled with a portable "thin-windowed" sodium iodide detector. However, gamma detectors, such as a Micro-R meter, are inefficient and ineffective in measuring ^{241}Am contamination unless the contamination is extremely high. General surveys (refer to RRSOP-402) with this instrument and detector should be conducted holding the unit at 15 inches above the surface to be surveyed and slowly walking through the potentially contaminated area.

Alpha surveys (refer to RRSOP-402) can be made on surfaces that americium has not penetrated. Generally, this technique is not applicable to those situations (like soil) where even minor penetration of the radionuclide into the matrix has occurred. In most cases, porous (e.g., wood) and volumetric (e.g., soil and water) contamination cannot be detected by scanning for alpha activity. When surveying potentially smooth, non-porous contaminated surfaces (e.g., painted concrete, metal, glass), the Ludlum 2241 with the 43-90 alpha scintillation probe or the 44-9 alpha/beta probe can be used. Use of these survey meter-probe combinations facilitates converting the observed count rate to surface activity (units of Bq/cm^2). The meter response conversion to surface activity should take into account the active surface area of the 43-90 scintillation probe of 100 cm^2 and the 44-9 probe of 12 cm^2. For alpha surveys, the probes should be held within 1 cm (<½ inch) from the surface under investigation and moved slowly (<5 cm/s or <2 in/s). The 43-90 probe detects only alphas, whereas the open 44-9 probe (1.7 mg/cm^2 thick window) responds to both alpha and beta particles. The thin plastic (or Mylar) covering (~8 mg/cm^2) of the 44-9 probe face absorbs alpha particles, thus rendering the 44-9 probe a beta-only detector. The differential reading between the total response of the open window and the covered window is due to alpha contamination. Both probes should be calibrated using a matching area calibrated ^{241}Am source. Corrections for surface roughness should be applied to the calibrations and field readings (EPA 2000a). For volumetric materials, samples are collected in the field and sent to a laboratory for analysis (EPA 2000a).

6.5.3 Contract Laboratory Turn-Around-Time

Gross alpha survey of samples indicating positive activity needs to be assessed for americium. Although americium emits a gamma ray a small percentage of the time, it is of low energy. Thus, it is unlikely that gamma survey field instruments (like an RO-020) will be used to detect americium in samples for cleanup levels.

If an alpha survey indicates positive activity and subsequent analysis is required to confirm the presence of americium, gamma spectrometric analysis is the most expeditious method to use since no sample preparation is required, and the ^{241}Am gamma ray is distinctive. However, depending upon the density of the medium and the concentration, gamma spectrometry may not accurately assess the concentration levels needed. Additionally, most high purity germanium detectors (HPGe) do not have thin, low Z detector covers that also reduce the ability to detect a 59 keV gamma ray. A 1 kg sample of soil counted for 100 minutes on a HPGe detector with normal aluminum housing can detect about 100 pCi/g of ^{241}Am.

Alpha spectrometry requires chemical separation of the americium from all other transuranic elements. Acid or base dissolution and several chemical separation steps are necessary to achieve that separation. The counting interval required for analysis to a level of 50 pCi/g using a 5 g sample is about 20 hours. Thus, the total chemical and radiological analysis time is on the order of 2 days. This represents only the sample processing and detector time. The total TAT needs to include the shipping time, sample logging at the laboratory count time, data processing, and final data review by lab technical personnel. The time required for these ancillary functions is dictated by the data quality objectives for the event.

6.5.4 Environmental Factors

Americium has a very low solubility. If dispersed in the environment, it forms small particulate material that can be easily dispersed into the air if the particulate material dries out. Because ^{241}Am is an alpha emitter, it is a serious concern. Drying out ^{241}Am deposits should be avoided when possible.

6.5.5 Decontamination Approaches

Americium has a low solubility in water, and few chelating agents form strong complexes with isotopes of that radionuclide. If water is used as the medium for decontamination, solutions containing phosphates or oxalates should be avoided, as both of these can cause americium to precipitate.

Americium forms insoluble compounds in environmental media. Because of the limited number of chelating agents or strong acids that can successfully solubilize americium, physical methods of removal are more practicable. Table 6.7 presents several decontamination approaches.

Table 6.7 Potential Techniques for Americium Decontamination

Matrix	Concrete or Cement	Stone (non-porous marble or granite)	Stone (lime)	Macadam	Plaster or Dry Wall	Steel (uncoated)	Painted Surfaces
Primary Decon Technique	Scabbling	Sponge Blasting	Cement Cutting	Hot Water Wash	Concrete Shaving	Hot Water Wash	Hot Water Wash
Secondary Decon Technique	TechXtract®	Hot Water Wash	TechXtract®	Scabbling	TechXtract®	Chemical Decon with Acid	Sponge Blasting

6.6 RADIUM-226 (^{226}RA)

6.6.1 Chemical Properties/Form

Radium's two oxidation states are zero and +2, and it is chemically similar to calcium, magnesium, and strontium. The metal is silvery-white, which darkens to black upon exposure to air. If exposed to high temperatures, such as during a RDD event, the initial color observed from the conflagration might be crimson due to the excitation of radium atoms. Radium solubility will depend on the presence and the concentration of the chemically similar elements. Thus, the carbonates and sulfates of radium will be very insoluble. The presence of other elements in the radium group, like calcium or magnesium, also will have a significant effect on its solubility. If these materials are present, radium will coprecipitate with them. Cation resin materials exchange radium in acidic solution, and this reaction can be a significant factor in the treatment of aqueous wastes contaminated with radium. Although radium may be complexed with EDTA, it is more readily complexed with diethylenetriaminepentaacetic acid (DTPA).

Radium has three radioisotopes that have the potential for being detected during a radiological incident: ^{226}Ra, ^{228}Ra, and ^{224}Ra. Although the isotope of concern, radiologically, is ^{226}Ra because of its long half-life (the other two are short-lived and could not amass a significant quantity), the presence of the other two isotopes and their radioactive progeny can cause significant interference when evaluating contamination levels of ^{226}Ra.

Ra-226's first decay product is ^{222}Rn, a noble gas that has a short half-life (3.8 days). The subsequent decay products are non-volatile alpha and beta emitters. If ^{226}Ra is present from a RDD, it would also contain all the decay products of ^{226}Ra at the same concentration due to the establishment of secular equilibrium in the source material. The volatility of the radon will cause redeposition of the other decay products based on temperature and meteorological conditions. This can occur over short periods (hours to days).

Ra-228 and ^{224}Ra are decay products of ^{232}Th and are naturally occurring (as are ^{226}Ra and its decay products). Ra-224 decays to ^{220}Rn, which behaves similarly to ^{222}Rn. Rn-220 also has short-lived decay products that are both alpha and beta emitters.

For these three radionuclides of radium, it is important not only to assess the changing activity due to the delayed build-in based on the parent-daughter relationships of the radionuclides, but also the absolute amount of each. The time delay to build-in activity will be the same whether or not the source is a natural effect or the result of a RDD. The critical factor will be the total concentration of each.

6.6.2 Field Detection Techniques

Ra-226 is a long-lived (half-life 1,600 years), alpha particle emitting (4.784 MeV, 94.4% abundance) nuclide that also emits a low-energy photon (186 keV) of low abundance (~3.3 %). The short-lived decay products, which reach some level of secular equilibrium with ^{226}Ra within weeks, emit numerous easily detected alpha and beta particles and gamma rays. The short-lived decay product nuclides include ^{222}Rn, ^{218}Po, ^{218}Bi, and ^{218}Pb. For general area surveys and surface contamination surveys, instruments with detector probes that respond to either gamma rays (principally 352, 609 and 1764 keV) or beta particles (numerous betas having βmax greater than 0.60 MeV) are used.

Without knowledge of the radioactive source, a general-area gamma survey (refer to RRSOP-402) can be conducted with a Ludlum Model 192 Micro-R Meter for gamma exposure rates between 1 and 5,000 μR/hr or 0.001 to 5 mR/hr. Terrestrial gamma background exposure rates vary according soil type and geographical area but are normally between 3 and 9 μR/hr. The upper range (1,000 to 5,000 μR/hr) of the Model 192 Micro-R Meter responds to exposures that are approximately 100 to 1,000 times typical terrestrial background levels. If the upper response range of this instrument is exceeded, the Eberline Model RO20 should be used. This unit has a gamma response of 5 to 50,000 mR/hr. General surveys (refer to RRSOP-402) with either meter should be conducted holding the unit at waist height and slowly walking through the potentially contaminated area.

For gamma-emitting, nuclide-identifying scoping surveys of potentially contaminated ground (refer to RRSOP-402), the SAM-935 with the NaI detector is typically the instrument of choice. The survey meter-probe should be calibrated with an extended ^{226}Ra source prior to use. The SAM-935 unit has software that performs nuclide identification and spectral analysis. As recommended in MARSSIM (EPA 2000a), the detector is held close to the ground surface (~6 cm or 2.5 inches) and moved in a serpentine pattern while walking at a slow speed (i.e., typically 0.5 m/s (~1.5 ft/s) or slow enough to detect the desired investigation level).

When surveying potentially contaminated surfaces, the Ludlum 2241with 44-9 alpha/beta probe can be used to detect the ^{226}Ra alpha particle and the beta and alpha particles from the short-lived decay products. Use of this survey meter-probe combination facilitates converting the observed count rate to surface activity (units of Bq/cm^2). The meter response conversion to surface activity should take into account the 12 cm^2 active surface area of the 44-9 probe. The probe should be held less than 2 cm (~1 inch) from the surface under investigation and moved slowly (<5 cm/s or <2 in/s). It should be noted that the open 44-9 probe (1.7 mg/cm^2 thick window) responds to both alpha and beta particles. The thin plastic (or Mylar) covering (~8 mg/cm^2) of the probe face absorbs alpha particles, thus rendering the probe a beta-only detector. The unit should be calibrated using a ^{226}Ra source whose dimensions match the area to be surveyed with this instrument.

Alpha surveys may be conducted on surfaces where ^{226}Ra or decay products do not penetrate the matrix (refer to RRSOP-402). Generally, this technique is not applicable to those situations (like soil) where even minor penetration of the radionuclide into the matrix has occurred. In most cases, porous (e.g., wood) and volumetric (e.g., soil and water) contamination cannot be detected by scanning for alpha activity. For surveying potentially smooth, non-porous contaminated surfaces (e.g., concrete, metal, drywall), the Ludlum 2241 with the 43-90 alpha scintillation probe or the 44-9 alpha/beta probe may be used. Use of these survey meter-probe combinations facilitates converting the observed count rate to surface activity (units of Bq/cm^2). The meter response conversion to surface activity should take into account the active surface area of the 43-90 scintillation probe of 100 cm^2 and the 44-9 probe of 12 cm^2. For alpha surveys, the probes should be held within 1 cm (<½ inch) from the surface under investigation and moved slowly. The 43-90 probe detects alphas only, whereas the open 44-9 probe (1.7 mg/cm^2 thick window) responds to both alpha and beta particles. The thin plastic (or Mylar) covering (~ 8 mg/cm^2) of the 44-9 probe face absorbs alpha particles, thus rendering the probe as a beta only detector. The differential reading between the total response of the open window and the covered window indicates alpha contamination. Both probes should be calibrated using a matching area calibrated ^{226}Ra source with the short-lived decay products in equilibrium. Corrections for surface roughness should be applied to the calibrations and field readings (EPA 2000a). For volumetric materials, samples are collected in the field and sent to a laboratory for analysis (EPA 2000a).

6.6.3 Contract Laboratory Turn-Around-Time

Analysis for ^{226}Ra in environmental samples is most often performed using the "Deemanation" method. This method involves chemical isolation and precipitation of radium followed by the 5-21 day in-growth of the ^{222}Rn daughter. The sample is counted using a special scintillation detector. It takes at least 7 days to complete the analytical separations and counting. However, for levels that are much higher than those normally experienced (factor of at least 20), ^{226}Ra can be analyzed directly using gamma ray spectrometry. With a HPGe detector, a 10-hour count, and a sample size of about 200 g, concentrations of 2 pCi/g should be achievable.

The analysis represents only the sample processing and detector time. The total TAT needs to include the shipping time, sample logging at the laboratory, count time, data processing, final data review, and data reporting by lab technical personnel. The time required for these ancillary functions is dictated by the data quality objectives for the event.

6.6.4 Environmental Factors

The environmental factors that affect radium are similar to those affecting strontium. By the time decontamination efforts start, radium will be in equilibrium with its decay products (a total of five stopping at radium-C (^{214}Po)). Thus, the measurement of decontamination should take into account all of the radionuclides that may be present in the decay chain, not just radium (an alpha emitter) or its decay products (both alpha and beta emitters).

Allowing surfaces that contain radium contamination to be affected by environmental factors, such as acid rain, will exacerbate cleanup efforts since acid rain tends to drive radium and its decay products deeper into most surfaces.

6.6.5 Decontamination Approaches

Solutions containing carbonates, sulfates, or phosphates should be avoided, as these precipitate radium and potentially 'fix' the radionuclide on the surface that is to be decontaminated. Potential techniques for decontaminating surfaces with radium are summarized in Table 6.8.

Table 6.8 Potential Techniques for Radium Decontamination

Matrix	Concrete or Cement	Stone (non-porous marble or granite)	Stone (lime)	Macadam	Plaster or Dry Wall	Steel (uncoated)	Painted Surfaces
Primary Decon Technique	Scabbling	Hot Water with DTPA	Concrete Cutting	Hot Water with EDTA	Sponge Blasting	Hot Water Rinse	Hot Water Rinse
Secondary Decon Technique	N/A	N/A	N/A	TechXtract®	TechXtract®	Strippable Paint	N/A

6.7 IRIDIUM-192 (^{192}IR)

6.7.1 Chemical Properties/Form

Iridium is a shiny, silvery-white, very dense metal that does not rust/react when exposed to normal environmental conditions. Iridium can exist in several different oxidation states but only under strongly oxidizing conditions. Iridium radioisotopes are always present in the elemental form if detected in the environment. Ir-192 used in medicine is in the form of tiny seeds, each about the size of a grain of rice. Industrial gauges hold pencil-like metal sticks of solid ^{192}Ir or small pencil-like tubes that contain pellets of ^{192}Ir. Ir-192 sources are made of iridium in the elemental state.

Iridium has a very high melting point and tensile strength that cause the iridium source to be very inert. This means that it will not disperse into fine particulates. The size of these sources is similar to that of the sealed ^{60}Co sources seen in Figure 6.2. The iridium surface may become black following a conflagration, but iridium most likely will remain as discrete particles, visible without magnification.

6.7.2 Field Detection Techniques

Ir-192 has a half-life of 74 days and decays by electron capture 4.7% of the time with the emission of numerous gamma rays of low abundance and by a beta particle emission, and 95.3% of the time with principal gamma rays of 296, 308, 317, and 468 keV. For most general-area surveys, detectors that respond to the gamma rays are used. For surface area contamination surveys, detector probes that respond to the ^{192}Ir beta particles 0.536 MeV (41.4% abundance) βmax and 0.672 MeV (48.3% abundance) βmax are used.

Without knowledge of the radioactive source, a general area gamma survey (refer to RRSOP-402) can be conducted with a Ludlum Model 192 Micro-R Meter for gamma exposure rates between 1 and 5,000 μR/hr or 0.001 to 5 mR/hr. Terrestrial gamma background exposure rates vary according soil type and geographical area but normally are between 3 and 9 μR/hr. The upper range (1,000 to 5,000 μR/hr) of the Model 192 Micro-R Meter responds to exposures that are approximately 100 to 1,000 times typical terrestrial background levels. If the upper response range of this instrument is exceeded, the Eberline Model RO20 should be used. This unit has a gamma response of 5 to 50,000 mR/hr. General surveys with either meter should be conducted holding the unit at waist height and slowly walking through the potentially contaminated area.

For gamma-emitting, nuclide-identifying scoping surveys of potentially contaminated ground (refer to RRSOP-402), the SAM-935 with the NaI detector is typically the instrument of choice. The survey meter-probe should be calibrated with a ^{192}Ir source prior to use. The SAM-935 unit has software that performs nuclide identification and spectral analysis. As recommended in MARSSIM, the detector is held close to the ground surface (~6 cm or 2.5 inches) and moved in a serpentine pattern while walking at a slow speed, typically 0.5 m/s (~1.5 ft/s) or slow enough to detect the desired investigation level.

For surveying of potentially contaminated surfaces (refer to RRSOP-402), the Ludlum 2241with 44-9 alpha/beta probe can be used. Use of this survey meter-probe combination facilitates converting the observed count rate to surface activity (units of Bq/cm^2). The meter response conversion to surface activity should take into account the 12 cm^2 active surface area of the 44-9 probe. The probe should be held less than 2 cm (~1 inch) from the surface under investigation and moved slowly (<5 cm/s or <2 in/s). It should be noted that the open 44-9 probe (1.7 mg/cm^2 thick window) responds to both alpha and beta particles. The thin plastic (or Mylar) covering (~8 mg/cm^2) of the probe face absorbs alpha particles, thus rendering the probe a beta-only detector. The unit should be calibrated using a ^{192}Ir source whose dimensions match the area to be surveyed using this instrument.

6.7.3 Contract Laboratory Turn-Around-Time

The most effective method of analysis for iridium is by gamma ray detection. The likelihood of finding low concentrations of this radionuclide are minimal because the metallic state is the only readily available form. The only sample preparation involves putting the sample in a calibrated geometry before counting. A two-hour count time on a HPGe detector will identify the presence of ^{192}Ir at about 25 pCi/g for a 1 kg sample.

This detector counting time represents only a portion of the radiological holding time (i.e., no sample preparation or data reduction times are included). The laboratory TAT, which includes the radiological holding time, is the summation of the times for sample logging at the laboratory, sample preparation, counting of the prepared sample, data processing, final data review by lab technical personnel, and transmittal of a data report. The time taken to ship the sample to the laboratory from the field to receipt of the data report is not normally included in the laboratory

TAT but should be considered as part of the overall TAT. The time required for these ancillary functions is dictated by the data quality objectives for the event.

6.7.4 Environmental Factors

The inert nature of the iridium, and its high-density, make it unlikely that any environmental parameters will alter its spread or affect its removal.

6.7.5 Decontamination Approaches

If iridium were dispersed as a result of a RDD, the material would be fine insoluble particulate matter. The most serious condition to avoid is the rapid surveying of such an area. ‘Hot’ particles like this could easily be overlooked if the scan speed is too rapid.

The inert nature of iridium metal makes decontamination procedures involving wash solutions impracticable. Its physical form causes the material to impinge onto a surface and potentially become deeply imbedded. This generally means that the most successful decontamination techniques use physical removal of discrete masses. Although methods like scabbling or roto-peening may be considered, they create a large amount of solid waste, most of which is not contaminated. Potentially, the best method of decontamination would be to use a survey instrument to locate the hot spots and confine decontamination efforts to these localized areas. This approach saves time and money on waste disposal. It is likely that simple mechanical techniques, like using forceps on an extension arm, will provide the most effective decontamination technique for ^{192}Ir contamination.

Chemical techniques are not expected to be effective on removing ^{192}Ir, since ^{192}Ir is very inert. For smooth, non-porous surfaces where the radionuclide is not embedded, the most effective cleanup technique is either high-pressure hot water or dry vacuuming.

A technique to remove iridium that should also be considered is decay in place. Since iridium’s half-life is short, 1-2 years might be sufficient for radioactive decay to be effective. Table 6.9 presents various iridium decontamination techniques.

Table 6.9 Potential Techniques for Iridium Decontamination

Matrix	Concrete or Cement	Stone (non-porous marble or granite)	Stone (lime)	Macadam	Plaster or Dry Wall	Steel (uncoated)	Painted Surfaces
Primary Decon Technique	Concrete Grinding	Concrete Grinding	Concrete Grinding	Concrete Grinding	Concrete Grinding	Hot Water	Hot Water
Secondary Decon Technique	Hot Water	Hot Water	Hot Water	Hot Water	Hot Water	Hot Water	Concrete Grinding

6.8 PLUTONIUM-238 AND -239 (^{238}PU AND $^{(239+240)}$PU)

6.8.1 Chemical Properties/Form

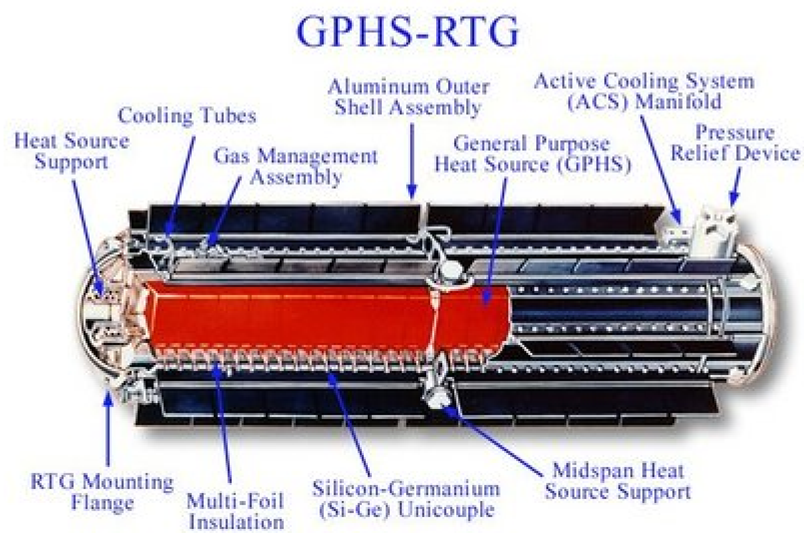
Plutonium is a highly reactive gray metal that exists in the +3, +4, +5, and +6 oxidation states in addition to the metallic state. The oxidized metal surface takes on a yellow appearance. In dilute aqueous solution, all four oxidation states of plutonium exist. Its chemistry, as with those of the other transuranics, is unique. It may be ion exchanged by both cation and anion resins, dependent upon its oxidation state and the presence of complexing agents. The radionuclides of principal concern are ^{238}Pu (half-life 88 years) and $^{239+240}$Pu (half-lives of 24,000 and 6,600 years, respectively). The isotopes of 239 and 240 are routinely analyzed as the total of activity of the two radionuclides because their alpha particle energies are so close that they cannot be distinguished using normal counting techniques. The isotope ^{238}Pu is very commonly used in radioisotope thermoelectric generators, such as the one seen in Figure 6.2. Both isotopes may be found in environmental samples at very low concentrations due to the atmospheric testing that took place in the 1950s through 1978.

6.8.2 Field Detection Techniques

Pu-238 and 239/240 are relatively long-lived alpha particles emitting (> 5.1 MeV) nuclides. Although ^{239}Pu also emits a low-energy X-ray (13.6 keV) of low abundance (~4 %), the low energy photon can only be detected in the field with special low-energy photon detectors not available to routine field survey teams. Therefore, general area surveys cannot be conducted for these plutonium isotopes unless specialized equipment and specially trained personnel are available.

Alpha surveys can be made on surfaces where there is no depth of penetration of the plutonium into the matrix (refer to RRSOP-402). Most likely, this technique will not be applicable to those situations (like soil) where even minor radionuclide depth penetration occurs. In most cases, porous (e.g., wood) and volumetric (e.g., soil and water) contamination cannot be detected by scanning for alpha activity. When surveying potentially smooth, non-porous contaminated surfaces (e.g., concrete, metal, drywall), the Ludlum 2241 with the 43-90 alpha scintillation

Figure 6.3 General Purpose Heat Source (GPHS) Radioisotope Thermoelectric Generator (RTG)



probe or the 44-9 alpha/beta probe can be used. These survey meter-probe combinations facilitate converting the observed count rate to surface activity (units of Bq/cm^2). The meter response conversion to surface activity should take into account the active surface area of the 43-90 scintillation probe of 100 cm^2 and the 44-9 probe of 12 cm^2. For alpha surveys, the probes should be held within 1 cm (<½ inch) from the surface under investigation and moved slowly (<5 cm/s or <2 in/s). The 43-90 probe detects alphas only, whereas the open 44-9 probe (1.7 mg/cm^2 thick window) responds to both alpha and beta particles. The thin plastic (or Mylar) covering (~8 mg/cm^2) of the 44-9 probe face absorbs alpha particles, thus rendering the probe a beta-only detector. The differential reading between the total response of the open window and the covered window is from alpha contamination. The unit should be calibrated using a ^{238}Pu, or $^{239+240}Pu$ source whose dimensions match the area to be surveyed with this instrument.

Corrections for surface roughness should be applied to the calibrations and field readings (EPA 2000a). For volumetric materials, samples are collected in the field and sent to a laboratory for analyses (EPA 2000a).

6.8.3 Contract Laboratory Turn-Around-Time

The chemistry of plutonium is quite complex. A solution of plutonium initially of one oxidation state undergoes several different disproportionation and oxidation-reduction reactions until all four of the above oxidation states are present. This peculiar chemistry for plutonium requires sample storage and analytical separations with significant types of chemical additives to ensure that plutonium maintains the proper oxidation state for analysis and separation. The anticipated laboratory time using chemical separations and alpha spectrometry on a one-gram sample is one day to achieve detectable levels of 100 pCi/g of the plutonium isotopes.

Chemical separation and detector counting time represents only a portion of the radiological holding time (i.e., no sample preparation or data reduction times are included). The laboratory

TAT, which includes the radiological holding time, is the summation of the time required for sample logging at the laboratory, sample preparation, counting of the prepared sample, data processing, final data review by lab technical personnel, and transmittal of a data report. The time taken to ship the sample to the laboratory is not normally included in the laboratory TAT but should be considered as part of the overall TAT. The time required for these ancillary functions is dictated by the data quality objectives for the event.

6.8.4 Environmental Factors

Plutonium is not only a multivalent metal, but depending upon environmental conditions, it may change oxidation state. Thus, the decontamination technique used must take into account its several potential states and is the reason for the selection of physical techniques as the primary decontamination method in the Table 6.10 below.

6.8.5 Decontamination Approaches

Dry deposition of plutonium is most likely to result in surface contamination. Because of its ability to change oxidation states, chemical means of decontamination may drive the plutonium further into the matrix. Therefore chemical decontamination techniques should be avoided. In most cases, physical removal techniques are likely to be the most effective methods. Physical removal requires significant planning for the use of respiratory protection because of the high dose that can be caused by alpha deposition inside the body.

Table 6.10 Potential Techniques for Plutonium Decontamination

Matrix	Concrete or cement	Stone (non-porous marble or granite)	Stone (lime)	Macadam	Plaster or Dry Wall	Steel (uncoated)	Painted Surfaces
Primary Decon Technique	Concrete Cutting	Hot Water with Complexing Agent	Concrete Cutting	Scabbling	Concrete Cutting	Hot Water with Complexing Agent	Strippable Coating
Secondary Decon Technique	Scabbling	Strippable Coating	Sponge Blasting	Hot Water with Com-plexing Agent	Sponge Blasting	Strippable Coating	Grit Blasting

7. CLEANUP PLANNING

This chapter describes cleanup planning aspects that should be considered throughout the early and intermediate phases of incident response. It does not include a complete cleanup how-to process, but rather references documents that provide such information.

Planning for site cleanup and restoration should begin as soon as possible after an incident, because activities undertaken as part of the initial and intermediate response will be vital to the successful recovery of the contaminated area and will have an impact on the eventual cleanup. Recovery and site restoration become the dominant tasks once the initial protective measures are in place, the incident is stabilized, and the initial site characterization is complete. Conversely, if actions are taken in early phases without consideration of the cleanup, those actions could seriously complicate cleanup and the eventual disposition of waste. Therefore, it is important to have some initial plan for site cleanup and restoration early in the process. Generally, development of a detailed recovery strategy begins during the intermediate phase of the radiological incident response.

7.1 RECOMMENDATION FOR RECOVERY AFTER RDD/IND INCIDENTS

For Radiological Dispersal Device (RDD) or Improvised Nuclear Device (IND) incidents, the guidance for cleanup and recovery contained in the document titled *Application of Protective Action Guides for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents* (RDD/IND PAG Application) should be used (DHS 2006). The RDD/IND PAG Application guidance provides an optimization process for establishing recovery and cleanup exposure levels. As described in the guidance, optimized exposure levels should be established for a site on an incident-specific basis.

The RDD/IND PAG Application guidance does not include a pre-established numeric guideline for cleanup, such as a cancer risk range or a millirem dose limit. Instead, the DHS has proposed the use of an optimization process that considers the overall welfare of the public while establishing cleanup levels consistent with social, economic, and health protection factors. EPA participated in the development of the guidance and has committed to using it for RDD/IND planning. In developing the guidance, the Federal Government recognized that experience from existing programs, such as the EPA Superfund program, NRC standards for decontamination and decommissions to terminate a plant license, and other national and international recommendations, will be useful in planning the recovery and restoration efforts following a RDD or IND incident. This guidance allows the consideration and incorporation, as appropriate, of any or all of the existing programs.

The RDD/IND PAG Application guidance addresses the extremely broad range of situations that can occur under various RDD and IND scenarios. This range of situations may be from light contamination of a single street or building to the widespread destruction of a major metropolitan area that could be potentially worse than the bombings of Hiroshima or Nagasaki. This range of situations is larger than those addressed by most existing programs or recommendations. Ultimately, the RDD/IND guidance will be incorporated by EPA into a revised PAG Manual that currently is under development.

The *optimized exposure level* is the exposure level at which the risks from radiation exposure are offset by the benefits of the activities associated with the exposure, such as allowing people to return to their homes and offices. Optimization is a decision-making process that seeks to consider and balance many factors. Most existing state and federal site cleanup programs that address either radionuclides or chemicals use some type of optimization approach, although it is not always referred to as such. For example, EPA's Superfund remedial program uses nine remedy selection criteria when evaluating remediation options for National Priorities List (NPL) sites. The Nuclear Regulatory Commission (NRC) uses an As Low As Reasonably Achievable (ALARA) approach for decommissioning of licensed facilities. Both of these are optimization approaches. Additionally, the *Framework for Environmental Health Risk Management* (Framework) written by the Presidential/Congressional Commission on Risk Assessment and Risk Management (PC-97) served as the philosophical base for the optimization process described in the RDD/IND PAG Application document (PCC 1997).

Under a recovery phase optimization approach, the evaluation of cleanup alternatives should consider and factor in all relevant variables, such as the areas impacted (e.g., size, location relative to population), the types of contamination (e.g., chemical, biological, radiological), human health, public welfare, technical feasibility, costs, and available resources to implement and maintain remedial options, long-term effectiveness, timeliness, public acceptability, and economic effects (e.g., on residents, tourism, business, and industry).

During the optimization process, standards from existing cleanup programs, such as EPA's Superfund and NRC's decommissioning programs, should be considered as benchmarks (see Table 7.1). The optimization process allows stakeholders to help decision makers choose from a variety of dose and/or risk benchmarks identified from state, federal, or other sources (e.g., national and international advisory organizations) as goals or starting points in the analysis of remediation options. The benchmarks that may be useful for analysis of remediation options and cleanup levels may increase or decrease depending on site-specific circumstances and balancing of other relevant factors.

If the chosen benchmark has an optimization process built into it, then the optimization process associated with the benchmark being used to determine final cleanup levels should be used. For example, if the CERCLA criteria are used as a benchmark, then the nine remedy selection criteria should be used in the optimization process. If the NRC or DOE dose criteria are used as a benchmark, then the ALARA process should be used in the optimization process.

Table 7.1 Selected Examples of U.S. Benchmarks for Potential Use in Evaluating Long-Term Cleanup Exposure Level Options During the Late Phase[1, 2]

Example Organizations or Cleanup Programs	**Summary of selected program-specific human health protection goals or concepts as applied to the cleanup of radiological contamination**
NRC Agreement State Decommissioning Programs	Varies across states. Usually, decommissioning programs seek to achieve: – 25 mrem/yr primary dose limit – 100 mrem/yr allowable exemption – Lower levels based on the ALARA concept. Some states have more stringent dose limits (e.g., 19, 15, or 10 mrem/yr)
State Environmental Department Contaminated Site Cleanup Programs	Varies across states. Usually, programs seek to achieve risk-based goals or a range of acceptable risk outcomes. Goals typically: – fall within a risk range of 10^{-4} to 10^{-6} excess lifetime cancer risk – rely on a hazard index of one (or less) for non-cancer effects – include meeting existing applicable or relevant environmental regulations/standards. Some states have single risk-based standards or goals (e.g., 10^{-4}, 10^{-5}, or 10^{-6}).
NRC and DOE Decommissioning and Site Remediation Programs	Site cleanups seek to achieve: – 25 mrem/yr primary dose limit – 100 mrem/yr allowable exemption – Lower levels based on the ALARA concept. (For further information, see 10 CFR 20 Subpart E; and DOE Order 5400.5)
EPA Superfund Remedial Site Cleanup Program[3]	Generally, remedial actions achieve human exposures that meet: – 10^{-4} to 10^{-6} excess cancer risk – Hazard Index of one or less for non-cancer toxicity – All Applicable or Relevant and Appropriate Requirements (ARARs). These may be waived under specific circumstances. (For further information see: 40 CFR 300.430)

[1]Table presents examples only. Final cleanup goals and/or actual cleanup outcomes for a particular incident may vary depending on the circumstances of the incident. **No single cleanup target is recommended for all possible incidents.**

[2]Although many response programs often articulate target cleanup goals or limits in planning guidance, whether or not these levels are met or exceeded on a response-specific basis generally depends on the program context and the site-specific circumstances. Levels and concepts in this table are presented for illustration only and should not be applied to a specific incident cleanup without a thorough understanding of their derivation and application in the originating programs. **Users should be aware that EPA has determined that most of these other benchmarks should not be used to establish cleanup levels at Superfund Remedial sites** [EPA OSWER Directive 9200.4-18, NTIS Order Number (PB97 963210), Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," August 22, 1997 (EPA 1997)].

[3]Under CERCLA's remedial program requirement, section 105(d) provides that, if a petition for assessment is filed, and no preliminary assessment (PA) of the release has been conducted within 12 months of the petition's receipt, then EPA must either complete a preliminary assessment, or explain why an assessment is not appropriate. (See also 40 CFR 300.42(b)(5).) Similarly, section 105(d) requires an evaluation of a release or threatened release under the Hazard Ranking System (HRS) if the preliminary assessment indicated it may pose a threat to human health or the environment.

Optimization activities are quantitative and qualitative assessments applied at each stage of site recovery decision making—from evaluation of remedial options to implementation of the chosen alternative. Evaluation of options for the late phase of recovery after a radiological incident should balance all of the relevant factors. Some factors to consider include the following (all may not be relevant in all circumstances):

- Areas impacted (e.g., size, location relative to population)
- Types of contamination (including chemical and biological, if relevant, in addition to radiological)
- Other hazards present
- Human health
- Public welfare
- Ecological risks
- Actions already taken during the early and intermediate phases
- Projected land use
- Preservation or destruction of places of historical, national, or regional significance
- Technical feasibility
- Wastes generated
- Waste disposal options and costs
- Available resources (and costs) to implement and maintain cleanup options
- Potential adverse impacts (e.g., to human health, the environment, and the economy) of cleanup options
- Long-term effectiveness
- Timeliness
- Public acceptability, including local cultural sensitivities
- Economic effects (e.g., tourism, business, and industry)

Determining the optimized exposure level for recovery requires consideration of the net health benefits of reducing radiation exposure to selected levels and the burdens that the dose reduction places upon society. It is important to involve technical experts, representatives of the affected population, and other stakeholders in this process. As appropriate for the site-specific circumstances, technical and stakeholder working groups may be formed to focus on recovery and site restoration issues. The designated OSC may or may not be a part of these groups, although other experts in EPA may participate. Workgroup membership should be determined on a case-by-case basis.

Smaller incidents may not require the establishment of formal working groups, but appropriate stakeholders should be involved in the optimization process. The working groups should draw upon the expertise of various technical disciplines, members of the affected areas, government agencies, and public interest groups. At a minimum, people with the following expertise should be included:

- Health physics and radiation protection
- Environmental fate and transport sciences
- Decontamination technologies

- Radiation measurements
- Site-specific demographics, land uses, and local public works
- Local community needs, wants, and wishes (e.g., strategic planning)
- Government

The working groups should be organizationally and functionally flexible, as the needs of the specific situation dictate. State and local public officials also need to be included in the process. In some cases it may be feasible to have a single group that includes all the relevant skills and knowledge. Under other circumstances, it may be desirable to have separate groups of technical experts, local community members, other stakeholders, and government officials. Suggested organizational structures can be found in the *Framework for Environmental Health Risk Management* (PCC 1997).

7.2 RECOMMENDATIONS FOR RECOVERY AFTER RADIOLOGICAL INCIDENTS OTHER THAN RDDs AND INDs

Radiological incidents that are not RDDs or INDs may be cleaned up like any other EPA cleanup site. Existing EPA cleanup processes should be used for non-RDD incidents addressed under EPA's NCP authorities.

For non-RDD/IND incident recovery, no nationwide standards currently exist for removal actions at radiologically contaminated sites. Removal and cleanup programs, depending on the site-specific circumstances and regional policies, have the flexibility to select cleanup levels based on a number of processes:

- The same method recommended above for RDD/IND
- Previous EPA Removal Actions
- A streamlined version of the process delineated in the RDD/IND PAG Application guidance
- Applicable or Relevant and Appropriate Requirements (ARARs) or other levels known as To Be Considered (TBCs)
- Methods used by the NRC in their decommissioning program
- Methods used by the DOE in the cleanup of their sites
- The optimization processes that are inherent in some of the benchmarks provided in Table 7.1

Any of these methods allow an optimized exposure level or levels to be selected that best suit the characteristics of the radiological incident and the particular needs of the affected community.

There may be issues beyond the radiological contamination situation that need to be considered. For example, the presence, nature, type, and size of non-radiological hazards may have an impact that must be considered. In some circumstances, these non-radiological problems could be larger or more significant than the radiation exposure hazard. These issues will vary from incident to incident.

Several EPA publications provide information that may be relevant to EPA OSCs as they begin the cleanup process. Potentially relevant guidance for making Superfund remedy decisions in general may be found at: http://www.epa.gov/superfund/action/guidance/remedy/index.htm.

EPA CERCLA guidance documents for addressing radionuclides under the removal and/or remedial program may be found at:
http://www.epa.gov/superfund/resources/radiation/index.htm.

7.3 THINGS TO KEEP IN MIND DURING THE RESPONSE

- Cleanup after a nationally significant event is likely to be a politically driven process and the choice of a waste disposal site may be politically driven.
- Start developing a waste disposition plan early in the response (see Chapter 8).
- Starting with local priorities, the cleanup can be broken into manageable units. Refer to the Defense Nuclear Agency's 1993, *On-Scene Commander's Guide to Site Restoration* for more information.
- Public perception and media attention will affect decision making in all stages of the response.
- Get input early in the stabilization and characterization process from the waste facility that takes the waste. Use this input to plan for sampling, surveys, removal, and packaging. Avoid double and triple handling of waste materials to reduce worker exposures.
- Cleanup levels may vary depending on occupancy factors and the nature of contamination throughout an incident site (e.g., an outside building surface 30 feet above ground may not have to be decontaminated to the same degree as the same building's surface at three feet above ground).
- Chemical, biological, and hazardous materials characterization must be done simultaneously with radiological characterization.
- Site characterization should be informed by waste acceptance criteria (see Chapter 8).
- Materials moved during stabilization may be kept temporarily in a waste staging area.
- For an onsite waste staging area, radiation shine may affect site surveys.
- For an off-site waste staging area, perimeter monitoring and security will be required.
- Strippable coatings should all have been tested for chemical/hazardous material content to ensure they can be disposed of along with radioactive waste.
- Water decontamination methods require collection of water, storage, and treatment/solidification before disposal. Radioactive waste facilities do not accept water or any liquid forms of radioactive waste. In the emergency phase of a large response, decontamination water should only be collected to the extent practical.
- If low-level or cleared materials are going to solid waste landfills, plan on doing at least as much characterization for these materials as for the radioactive waste.
- Transuranics (such as ^{241}Am) are not allowed in any commercial radioactive waste facilities. Special disposal through DOE facilities must be arranged.
- Waste characterization can be set up creatively with specialized equipment (e.g., running truckloads of material through large plastic scintillation detectors and using Monte Carlo and MicroShield calculations to ensure accurate reporting).

8. WASTE DISPOSITION

8.1 PURPOSE AND SCOPE

This chapter is intended as an advanced planning guide for the management of radioactive waste and debris generated during the cleanup and decontamination of a major radiological incident. It addresses the key topics and elements to consider when planning for the disposition of the radioactive and mixed waste generated from cleanup and decontamination activities in the aftermath of a Radiological Dispersal Device/Improvised Nuclear Device (RDD/IND) incident (as discussed in Chapter 2). The RDD/IND scenario assumes that: 1) states and local governments have requested significant federal assistance; and 2) DOE is the initial Coordinating Agency under the National Response Plan (NRP), with EPA assisting DOE before becoming the Coordinating Agency for environmental cleanup and site restoration. This chapter assumes that decisions have not been made about where to dispose of the radioactively contaminated waste from a RDD scenario.

The extent of such a terrorism-related event can only be characterized after it has unfolded. Therefore, this chapter, by necessity, is general in nature and is intended as a guide for future discussions and planning between government agencies involved in the response to a RDD event. It briefly identifies key government agencies' roles and responsibilities with regard to waste management.

By law, radiological waste is differentiated into different types and classes based on its source (or activity). For some types of waste, there may be no commercial disposal facility available. This chapter assumes that both commercial and DOE sites may take the waste and therefore addresses planning considerations for disposal at both commercial and DOE facilities.

8.2 KEY GOVERNMENT RESPONSIBILITIES RELATED TO WASTE MANAGEMENT

- **State and Local Officials.** State and local officials in the affected jurisdiction should participate in the Incident Command Post (ICP), provide a representative to the Unified Command (UC), and take part in waste management decision making. In addition, state and local officials in the jurisdiction that will be receiving the waste for interim management or final disposition need to be consulted.
- **EPA.** EPA initially assists the Coordinating Agency before the Coordinating Agency responsibility transitions to EPA. The OSC should join the UC in the Incident Command Post (ICP) before transitioning to the Coordinating Agency role for the cleanup phase. As explained in Chapter 2, a Stafford Act declaration is likely in response to a RDD/IND scenario. Under the Stafford Act, the Emergency Support Function (ESF) #10–Oil and Hazardous Materials Response Annex likely will be activated, giving EPA the lead for decontamination activities, environmental cleanup, and site restoration. EPA becomes the federal agency responsible for waste management associated with these activities (first in a support role to DOE and later as the Coordinating Agency).
- **DOE.** During a RDD/IND incident, DOE is the initial Coordinating Agency and participates in the UC in the ICP. Therefore, DOE has a role in waste management

decision making through the UC. DOE may have additional personnel assisting in other sections of the ICP, as appropriate, including sections that may be assigned responsibility for waste management. DOE participation in the ICP is expected to continue as a supporting agency after the Coordinating Agency role transitions to EPA. If a decision is made to use DOE facilities for interim or permanent waste disposition, appropriate DOE personnel must be involved. DOE personnel assigned to the Operations and Planning Sections of the ICP are responsible for waste management to facilitate proper waste characterization and ensure that the packaging meets DOE facility waste acceptance criteria.

- **USACE.** During a RDD/IND incident, USACE is the primary federal agency designated to handle emergency removal of contaminated debris within the “debris zone,” under ESF #3–Public Works and Engineering Annex. USACE coordinates with ESF #10/EPA to define the “debris zone” and manage the contaminated debris. In addition (and separate from ESF #3), USACE supports EPA under ESF #10 for RDD/IND responses, and plays a key role in managing waste and debris generated as a result of ESF #10 decontamination, environmental cleanup, and site restoration activities.

8.3 KEY PERSONNEL

Because waste management activities during a RDD/IND are significant, they likely will be managed under a separate Disposal Unit or similar group in the Operations Section of the ICP. Technical specialists in the Environmental Unit of the Planning Section provide support to the Disposal Unit.

8.3.1 Unified Command/OSC/Site Project Manager

Depending on the cleanup phase, the UC/OSC/Site Project Manager is responsible for providing overall direction of the cleanup effort.

8.3.2 Waste Management Manager

The Waste Management Manager is responsible for establishing a program that demonstrates control of waste processes and for maintaining waste traceability documentation. The Waste Management Manager works with:

- Radiological Characterization Personnel who are responsible for developing waste stream characterization methods and defining radiological quantification requirements
- Chemical Characterization Personnel who are responsible for identifying and characterizing hazardous waste materials/items
- Waste Packaging and Transportation Personnel who are responsible for ensuring that waste items are appropriately packaged and meet the requirements for transportation
- Sampling Crew who are responsible for developing data quality objectives, sampling plans, sample acquisition, sample preparation and shipment, and defining requirements for data validation

8.3.3 Health and Safety Officer

The Health and Safety Officer or designee has overall responsibility for ensuring a safe work zone for personnel involved with the cleanup effort, members of the public, and the environment. He or she works with:

- Health Physicists who are responsible for defining health and safety aspects associated with ionizing radiation
- Radiological Survey Technicians who are responsible for performing radiation surveys in association with radioactive waste generation, management, characterization, packaging, certification, and shipment
- Hazardous Material and Control Personnel who are responsible for identifying and defining health and safety aspects associated with hazardous materials

8.3.4 Waste Management Quality Assurance Officer

The Waste Management Quality Assurance Officer oversees quality assurance of the waste management processes, ensures that personnel are appropriately trained, and ensures that items and services are appropriately procured. The Quality Assurance Officer works with:

- Data Validation Personnel who are responsible for ensuring that radiological and chemical sampling data are appropriate for waste characterization purposes
- Waste Package Certifier, for DOE disposal only
- Waste Certification Official, for DOE disposal only

The Waste Package Certifier and Certification Official are responsible for ensuring that the waste meets the requirements for disposal at a selected DOE disposal site. As required by DOE Order 435.1, all DOE disposal sites must have written and approved waste acceptance requirements. Also, wastes disposed of at DOE sites must be certified, by signature, as being compliant with these requirements.

8.3.5 Local, State, and Federal Assistance/Oversight Personnel

Local, state, and federal assistance and oversight personnel are responsible for providing general oversight with regard to requirements instituted by local, state, and other federal bodies.

8.4 WASTE DISPOSITION PROCESS

8.4.1 Overview of Cleanup Activities

Cleanup involves the discovery, initial scoping, and cleanup of potential waste material related to the waste stream generation process.

8.4.2 Interface Requirements and Chain of Command

Critical to a successful response is the integration of the waste disposition process into the Planning and Operations Sections of the Incident Command System (ICS) and coordination with site personnel and the Treatment, Storage, and Disposal (TSD) facility.

8.4.3 Prerequisites to Waste Disposal

Documentation

Prior to the commencement of cleanup activities, a considerable quantity of investigative and radiological/chemical survey information has to be generated. Thus, a waste management plan that addresses how radioactive, hazardous, and mixed wastes will be handled, packaged, and characterized during the waste removal and characterization process is a prerequisite to waste disposal.

If the waste is disposed of at a commercial or DOE facility, sufficient information and documentation must be available to demonstrate that the waste will not be considered hazardous under the Resource Conservation and Recovery Act (RCRA) or by the state where it was generated. In some cases, not enough information is available to begin the preliminary disposition process. In this case, a comprehensive characterization plan may be required and implemented as a prerequisite to the disposition process. Other prerequisite documentation may involve waste packaging strategies, health and safety plans, contingency plans, quality assurance, and waste certification plans.

Approvals

Approvals related to health and safety will be needed from local, state, and federal agencies. Approvals and signatures are required as prerequisites in order to acknowledge the involvement of the appropriate government agencies.

8.4.4 Implementing Procedures

Health and Safety

Several health and safety procedures should be followed during the cleanup. They include the operation, calibration, and maintenance of radiation and chemical survey instrumentation; internal and external dosimetry; personal protective equipment; radiation work permits; and industrial work permits.

Waste Characterization

Procedures need to be developed to define how the chemical, physical, and radiological properties of the waste will be determined and to document and specify how radiological quantification will be performed on a per package basis.

Waste Packaging

Procedures need to be developed to specify how waste will be packaged using acceptable types of packaging materials, how prohibited items will be segregated, and which documents are required to demonstrate traceability of waste from the point of generation through package certification.

Waste Certification (DOE Disposal Only)

Procedures specifying the roles, responsibilities, and controls in place are required to ensure that radioactive waste is generated, packaged, characterized, and certified in a manner that preserves the requirements for off-site DOE disposal.

Waste Transportation

Procedures that demonstrate controls are in place to ensure that DOT requirements are met for radioactive waste transported over public roads and/or railways are required.

Quality Assurance

Procedures that demonstrate implementation of an effective quality assurance/quality control program, including personnel training and qualification, document control, records management, work processes, design control, procurement, inspection and acceptance testing, and management and independent assessments are required.

8.4.5 Application of MARSSIM (graded approach for waste characterization purposes)

Process Knowledge

The *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM; EPA 2000a) was developed through the interaction of four federal agencies: DOE, DoD, NRC, and EPA. Many of the terms and guidance in MARSSIM are appropriate for RDD/IND incidents. MARSSIM is most appropriate for use in determining if a remediated site has met the cleanup standards that show the site is safe for public/industrial reuse and for identifying and characterizing contaminated media. In a simplistic sense, MARSSIM provides a roadmap that begins with historical, qualitative information and allows personnel to determine data gaps that may be filled with more quantitative information through scoping and characterization surveys.

Historical information or process knowledge should be applied to characterizing radioactively contaminated materials. Data acquired from first responders and other personnel initially present at an event provide the necessary information to determine 1) if nuclear materials are present or were used in the event; and 2) from a qualitative sense, if radiation exposure and/or airborne activity levels are safe for more intrusive testing.

Scoping Surveys

Information gained from historical data [process knowledge] allows identification of data gaps that can be further assessed through scoping surveys. During the scoping phase, a more refined radiological assessment is conducted to determine the nature and extent of contamination (e.g., application of probes, such as field alpha and gamma spectroscopy, tritium monitors). Scoping surveys also may be used to provide semi-quantitative information that is useful when making preliminary disposition and packaging determinations. For example, assume that a site has been identified as having very low alpha contamination and no RCRA hazardous materials, and a field gamma spectrometer (e.g., NaI counter) indicates the presence of ^{137}Cs at the 660 keV peak. This information may be sufficient to determine that the waste may be packaged as low-level waste, meeting the requirements of either Envirocare of Utah (provided it is Class A waste) or the Nevada Test Site. The following types of tools and/or steps may all be used in performing a scoping survey:

- Alpha and Beta/Gamma Surveys
- Field Gamma and Alpha Spectroscopy
- Hazardous Material Screening
- Identification and Segregation of Prohibited Items
- Visual Examination

Characterization Surveys

In association with, or in addition to, the scoping surveys, characterization surveys provide even more rigorous information that allows identification of isotopic abundances and provides a means for quantifying nuclide content in a given package or waste lot. Here, nuclide abundances may be determined through laboratory analyses involving various radioanalytical methods (e.g., isotopic uranium (U), Pu, Am, curium (Cm), neptunium (Np), gamma spectroscopy, liquid scintillation counting). Package activities may also be determined in this phase through the application of one or more quantifycation methods (e.g., swipe to curie, nondestructive assay, gross radiation measurement). As an example, assume that the same scenario as that used above for scoping surveys applies, and the laboratory analysis of the samples indicates the presence of ^{137}Cs with minor impurities of ^{238}Pu, ^{241}Am, and hydrogen-3 (^{3}H) greater than 1% of the total activity. Then the analytical data could be used to establish an isotopic distribution with ^{137}Cs scaling factors relating all other nuclide contributions. Waste packages could then be nondestructively assayed using a high purity germanium detector in which ^{137}Cs concentrations are estimated. Scaling factors may be applied to estimate concentrations of ^{238}Pu, ^{241}Am, and ^{3}H.

8.4.6 TSD Selection

Disposition of waste articles requires an in-depth knowledge of the waste material and knowledge of various TSD facility acceptance criteria. For CERCLA sites, the NCP's "Off-Site Rule" (40 CFR 300.440) also applies, although OSCs may determine during an emergency action that it is necessary to transfer waste off-site without following the Off-Site Rule. In many cases, preliminary disposition may be determined during or at the conclusion of the scoping surveys. In other cases, more in-depth knowledge or investigation (e.g., sampling) may be warranted to characterize the waste prior to disposing of it. OSCs should initiate communication with potential TSD facilities during the planning phase. The waste management plan should identify the documentation needed for the disposition and include any initial agreements with TSD facilities. Selecting a TSD should include the following:

- Evaluation of characterization data against TSD acceptance criteria—use of preliminary/ screening data from process knowledge and/or scoping surveys (radiological, chemical, physical)
- Coordination with TSD facility
- Cost and time considerations

The costs associated with packaging, transportation, and disposal at the selected TSD facility should be evaluated to determine the most effective disposal path. If, for instance, the Nevada Test Site and Envirocare of Utah are possible disposition sites for the waste, a cost analysis should be conducted for these sites.

8.4.7 Packaging, Characterization, and Shipment

The waste disposition plan should address the logistics, personnel, and responsibilities associated with characterizing, packaging, and shipping radioactive waste materials. Disposition planning should include waste sent to temporary storage (an interim storage location) while awaiting final characterization data and preparation of the final characterization documents that verify compliance with the acceptance criteria of the TSD (for commercial TSD facilities). Planning should include the following tasks:

- Preparation of the documentation for shipping
- Package selection
- Preliminary certification (for shipment only)
- Ship waste to TSD

8.4.8 Waste Certification (for DOE TSD only)

As discussed previously, wastes destined for a DOE facility must be certified in accordance with DOE Order 435.1. Compliance with this order involves preparing the final characterization data and certification paperwork and coordinating with the Waste Certifying Official who accepts waste for disposal.

8.5 SELECTED TSD FACILITY ACCEPTANCE REQUIREMENTS

Waste acceptance criteria can vary widely depending on the TSD facility to be used. The waste management plan should include the criteria and the steps needed to meet them. It is critical that OSCs select a waste disposition expert early in the response to take the responsibility for determining the availability of TSD facilities and meeting the facility's acceptance criteria. Example TSD facilities and some general information regarding their operation is provided below:

Barnwell, South Carolina

State-owned & licensed, contractor-operated. Accepts LLW Classes A-C from all U.S. generators except those in Rocky Mountain and Northwest Compacts. After June 30, 2008 it will only accept from Atlantic compact states. For further information and assistance contact:

Corporate Office
Chem-Nuclear Systems
140 Stoneridge Drive
Columbia, SC 29210
(803) 256-0450
Barnwell Waste Brokers List:
http://www.energy.sc.gov/PDFs/broker_list_03.pdf

Hanford, Washington

Facility resides on DOE Hanford property, operated by U.S. Ecology, licensed by State of Washington. Accepts waste from the Northwest and Rocky Mountain compacts; LLW Classes A-C; NARM and Exempt wastes; Prohibited wastes include mixed waste, unprocessed liquids, limits on oils and SNM, etc. (check with site). For further information and assistance contact:

Mike Ault - Facility Manager
mault@americanecology.com
(509) 377-2411 Phone
(509) 377-2244 Fax
US Ecology Inc.
1777 Terminal Drive
Richland, WA 99352

Envirocare - Clive, Utah

Private facility licensed and permitted by Utah and NRC. Accepts Class A LLW & NORM/NARM; PCB radioactive waste; asbestos-contaminated waste; 11e.(2) byproduct material. Receives, treats, and disposes of mixed waste, designed to receive both bulk (e.g., intermodals, gondolas, etc.) and non-bulk (e.g., drums, boxes, etc.) containers. For further information and assistance contact:

Envirocare Govt. Programs
605 North 5600 West
Salt Lake City, Utah 84116
Client Service Managers:
Chris Lee: (801) 649-2079
Jose Jerez: (801) 649-2053

Waste Control Specialists (WCS) - Andrews, Texas

Private facility licensed and permitted by State of Texas. Accepts for storage, treatment and/or disposal: Class A, B, C and Greater-than-Class-C (GTCC) LLW; 11e.(2) byproduct material; NORM/NARM; Special Nuclear Material; TSCA wastes; RCRA hazardous and solid wastes; Mixed low-level waste.

WCS can receive and treat the following wastes: Hazardous and non-hazardous wastes mixed with Class A, B, C, and Greater than Class C (GTCC) LLW, and transuranic radioactive waste (TRUW); MLLW with a high volatile organic compound content can be treated on a case-by-case basis; inorganic waste streams including acids, bases, and wastes contaminated with metals; organic waste streams (with concentration limitations); water-reactive inorganic materials, such as elemental lithium, sodium, etc., and shredded debris that can be treated by methods other than encapsulation. For further information and assistance contact:

Waste Control Specialists, LLC
Three Lincoln Center
5430 LBJ Freeway
Suite 1700
Dallas, TX 75240
Contact: Michael Lauer
Phone: (972) 450-4284
E-Mail: mlauer@valhi.net

Nevada Test Site

DOE's National Nuclear Security Administration Nevada Site Office manages operations at the Nevada Test Site (NTS), which include disposal operations. NTS disposal operations include disposal of low-level, mixed, and transuranic waste generated at approved DOE and defense industry sites across the United States. For more information contact;

DOE
National Nuclear Security Administration
Nevada Test Site Office

9. COMMUNITY OUTREACH

The initial focus during a radiological emergency response is to eliminate immediate and potential threats to the public. Equally important is providing the news media, public officials, and the impacted community with updated information on potential hazards (radiological and non-radiological), evacuation plans, health concerns, and the status of the response. Terrorism poses special concerns by creating additional fear and anxiety throughout a community.

A Joint Information Center (JIC) is a facility established to coordinate all incident-related public information activities. Public Information Officers (PIOs) or Public Affairs Officials from all of the responding agencies and organizations co-locate at the JIC. In some cases, a JIC may be a virtual network between responding agencies and organizations. The PIOs work closely with elected officials, community leaders, health care community members, social and support groups, advocacy groups, the news media, and other stakeholders during an emergency situation. The JIC provides rumor control and prepares and disseminates accurate and validated information to the public.

This chapter provides suggestions and tools for consideration by people handling communications and outreach during a response to a radiological incident. These include:

- Overview of the National Incident Management System (NIMS)/National Response Plan (NRP) JIC
- JIC roles and responsibilities
- JIC checklists
- Suggestions for communicating risk
- Assistance from special teams

9.1 OVERVIEW OF THE NIMS/NRP JOINT INFORMATION CENTER

As described in Chapter 2, the National Response Plan provides a framework for managing Incidents of National Significance (INSs). During an incident, federal, state, local, and tribal authorities share responsibility for communicating information regarding the incident to the public. These actions are a critical component of incident management and must be fully integrated with all other operational actions to ensure that the public is kept abreast of the situation and any protective measures that they should consider taking. All public and media questions should be routed to the incident JIC.

During the early phase of a response, state and local officials are responsible for communicating with the public. If asked for assistance or if an incident is declared an INS, federal agencies work with state and local officials to set up a JIC. During an INS, DHS becomes the lead federal agency; however, the state, local, and tribal officials retain primary responsibility for communicating health and safety instructions to their citizens.

During the initial stages of an incident, a virtual JIC may be established to coordinate information among local responders and federal agencies. Communication would be through technological means, such as conference calls and e-mail, thereby allowing communication activities to be organized across the country, if necessary.

A radiological emergency is likely to involve a complex, multi-agency response. For an INS, which a RDD is likely to be deemed, it is possible that a federal JIC will be established by DHS with the Joint Field Office where public affairs officials from all involved organizations work together to develop and disseminate information to the public and media. It also is possible that local officials will decide to establish a separate JIC. In that case, it will be imperative that the JICs communicate in order to provide consistent, timely messages to the public.

9.2 JOINT INFORMATION CENTER ROLES AND RESPONSIBILITIES

The JIC structure is designed to work equally well for large or small situations and can expand or contract to meet the needs of the incident. Under NIMS, the JIC is led by the PIO, who has the following responsibilities:

- **Staff the JIC**. Under the NIMS, the PIO will be responsible for all JIC activities unless the JIC staff is expanded and assigned responsibilities accordingly. At the top of the JIC structure are the PIO, then the Assistant PIO/JIC Manager, then Assistant PIO for Internal Affairs, and Assistant PIO for External Affairs. Personnel can be added in roles such as data gathering, production, and dissemination assistants. The National Response Team's JIC Manual (NRT 2000) includes models showing how to staff a JIC.

- **Gather Incident Data**. JIC personnel must develop an effective method for obtaining up-to-date information from appropriate Incident Command System (ICS)/Unified Command (UC) personnel while staying within the ICS structure. Communications between JIC members is imperative. Since cell phone and land-line service circuits can become quickly overloaded in a crisis, the use of satellite and two-way radio communications should be arranged. Gathering information also involves capturing video and photographs that can be used by the response organization as well as the media.

- **Know the Audience**. Understanding the demographics of the impacted community will help overcome communications barriers and ensure information from the JIC is received and understood. Look for factors such as non-English speakers, cultural differences, and age range to help determine communications methods. GIS software and demographic databases may be helpful for this analysis. Community leaders are another source of demographic and community data.

- **Inform the Public**. The main role of the JIC is to provide quick, accurate, and consistent information about the incident to the public and media. This involves gaining and maintaining public trust and confidence by involving community leaders and media to ensure timely and coordinated release of information. The media is the best source of reaching the public. Make your messages clear, concise, and honest. Admit when mistakes have been made or when information is not known. Promise to seek out the answers as soon as possible. Be aware of the various deadlines for different media, such as print, television, and radio. Use all channels of information to distribute your messages, including the Internet.

- **Receive Feedback**. Obtaining community feedback will provide response agencies with insight into community information needs and expectations. Actively seeking feedback will inform the JIC of rumors and misinformation. Correcting erroneous perceptions is essential to staying credible and in control during a crisis. This feedback also will keep the Incident Commander (IC) and Command Staff informed of public affairs issues that could negatively impact the response.

9.3 JOINT INFORMATION CENTER CHECKLISTS

Effective emergency communications requires that communicators be prepared, available, and credible. Use the following checklists or similar organizational tools to help prepare for handling emergency situations.

Personal Needs

	Resources
	Credentials and Forms
	Bank Card
	Cell Phone/Satellite Phone/Blackberry/Pager
	Medication (if applicable)
	Family Contact Information
	Change of Clothes
	Snacks

General Logistics

	Resources
	Location (set up by state)
	Chairs
	Desks
	Phones
	Hotline/1-800 line
	Cell Phone/Blackberry/Pager
	Satellite Phone
	Computers
	Internet
	E-mail

	Printers
	Paper (printers, photocopier, note taker)
	Ink
	Pens/Pencils
	Fax Machine
	Photocopier
	Whiteboard/Large Post-it Note Pads
	Thick Markers
	JIC Inquiry Form (used to track media and public questions and comments)
	Debris Notification Form
	Relevant Fact Sheets (those already generated)
	Local Phone Book
	Maps and/or Mapping Software
	Camera (digital is preferable for easy dissemination)
	Video Camera (digital is preferable for easy dissemination)
	Film
	Batteries
	Extension Cords/Power Cords
	Media Contact List
	JIC Contact List (how to contact field PIOs)
	Emergency Operations Center (EOC) Contact List (phone and fax for specific individuals)
	Area Command/Unified Command Contact List (phone and fax for specific individuals)

Press Conference Logistics

	Resources
	Location
	Podium
	Microphone
	Banner (EPA and/or other)
	Chairs
	Media Sign-in Sheet

JIC Personnel

Name	Role	Contact Information	Security Clearance-Y/N
	Information Officer		
	Assistant Information Officer		
	Assistant Information Officer for External		
	Assistant Information Officer for Internal		
	Field PIO for Site #1		
	Field PIO for Site #2		
	Field PIO for Site #3		
	Data Gathering Assistant		
	Product Assistant (writing press releases)		
	Support Assistant #1		
	Support Assistant #2		
	Webmaster		
	Scientific/Technical Expert		

9.4 SUGGESTIONS FOR COMMUNICATING RISK

Risk communications is based on the concept that “perception is reality.” Perceived risks must be taken seriously, and risk communicators must be sympathetic, honest, and accessible to inquirers. Keeping messages clear and concise is the best way to communicate with a concerned audience.

When communicating during a crisis, you should:

- Show compassion
- Tell the audience what you know and do not know about the incident
- Inform them of the actions being taken to remedy the situation
- Explain protective actions that they should consider taking
- Set a timeframe for getting the audience more information

It is important to know your audience because different audiences (e.g., employees, reporters, local politicians) may need different types of information. Anticipate what information people need and research the most effective method to get it to them. Use the media, town hall meetings, and press conferences, and hand out flyers door-to-door if that is what will be most successful.

Remember that a local official often will have more credibility within a community. Therefore, it may be helpful to enlist such individuals to serve as spokespersons for various issues. For example, involve a local medical professional in communicating risk about public health concerns. It also is important to remember that, although individual spokespersons are helpful in communicating particular risks, it is critical that the JIC present a consistent message.

Avoid jargon and technical terms that may be confusing to the general public. For example, to scientists, using a conservative model to estimate risk provides an extra measure of caution to ensure safety. To many people, a conservative model might imply a limited effort or a desire to preserve the status quo. To scientists, contaminant levels well below standards are considered to be safe. To the general public, the term “below standards” means low quality or unacceptable. Respond to people’s concerns about their personal risk.

The term “risk” poses inherent communication issues between the public and responders. Most importantly, “risk” means different things to different people. The public’s concern is personal risk. They want an answer to: “What is going to happen to me and my loved ones?” The public looks to responders to provide them that answer. The responders evaluate risk as a conservative estimate of the probability of cancer incidence. The perceived difference between personal risk and population risk makes putting risk into perspective a difficult job for responders. The following are suggestions for helping the public understand risk:

- Respond to people’s concerns about their personal risk.
- Emphasize that risk estimates are conservative and protective, not predictive.
- Put data in perspective and try to express risk in different ways.
- Use comparisons to put risk in perspective.

To assist in developing communications tools, a variety of fact sheets are included in Appendix 3. The fact sheets cover both general guidance topics (protection action guides, sheltering-in-place) and information on specific radionuclides of concern.

Myths about Radiation

Radiation is an unfamiliar subject for a large portion of the general public. Popular culture has taught people that radiation can turn a man into "The Hulk" and, in sludge form, can turn a turtle into a ninja. Many people know that radiation causes cancer, and since the events of 9/11, the news media have kept nuclear weaponry at the forefront of the public's mind. Many people view radiation as an invisible killer.

A large portion of the public carries the misconception that small amounts of radiation are known to cause cancer. Responders act under the assumption that there is no level of exposure that carries no risk of health effects. Even though there is continuing debate in the scientific community on the topic, we work under this assumption for the protection of the public. Communicating cancer risk to the public, while working under the assumption that no level of exposure is "safe" and that the science has not confirmed radiation risk from small exposures, will be a difficult challenge during any radiological emergency.

People fear what they do not understand. This is why it is so important to be conscientious when creating and delivering messages about radiation. The public's concerns are real whether or not they are warranted. Treat them with respect by answering their questions with honest, easy-to-understand answers.

The Psychosocial Effects of a Radiological Terror Incident

In dealing with the public after a terrorist incident involving radioactive material, such as a Radiological Dispersal Device (RDD), it is important to note that the effects of such an incident may be more widespread than they appear. Because a RDD involves dispersal of an invisible agent and is the result of an intentional act, the potential exists for a great deal of psychosocial stress to occur in the wake of such an attack. Research indicates that the long-term psychological effects from a RDD could be more widely damaging than the physical effects of low-level radiation exposures resulting from the actual incident. The range of psychological effects produced by a RDD could extend from common, transient stress reactions caused by natural and human-made disasters to chronic stress induced by the invisible nature of radiation (NCRP 2001).

9.5 ASSISTANCE FROM SPECIAL TEAMS

Special Teams are available to assist federal agencies in emergency communications, community involvement, and outreach. In addition to those Special Teams specifically included in the NCP, other federal assets are available to assist with conducting outreach. This section describes who they are and how to reach them for assistance.

Superfund Emergency Communications and Outreach Team

EPA has developed an Emergency Communications and Outreach Team (ECOT) that is available to support EPA regional emergency responses, specifically during national disasters and other significant events that require public outreach for extended periods of time. ECOT is a resource for building trust and credibility in the community. Its members are experienced Superfund community involvement and public affairs specialists. ECOT members can travel to an incident and support or lead communications efforts on-scene, or they may consult by phone or email to suggest strategies for effective community interaction. For additional information, contact Virginia Narsete, EPA Region 5, at 312-886-4359 or narsete.virginia@epa.gov.

EPA Radiation Protection Division's Center for Radiation Information

The Center for Radiation Information (CRI), located in the Office of Radiation and Indoor Air (ORIA) in the Office of Air and Radiation (OAR), is a headquarters-based team of communications and outreach specialists responsible for supporting the Radiation Program's public information and communications efforts. During a radiological emergency, CRI also provides public outreach support to ORIA's Radiological Emergency Response Team. For additional information contact Jessica Wieder at (202) 343-9201 or wieder.jessica@epa.gov.

USCG Public Information Assist Team

The Public Information Assist Team (PIAT) consists of four emergency communications professionals who are available to federal OSCs during incidents receiving high media or public attention. Their primary function is to support emergency communications during accidents or premeditated release of oil or hazardous materials. This specialized team also is deployed to airplane crashes, floods, hurricanes, and incidents involving weapons of mass destruction.

PIAT members are qualified to set up a JIC and fill the PIO, Assistant PIO, and JIC Coordinators positions during a major event. The team can be deployed on two hours notice and will bring all equipment needed to establish and fully operate a JIC. They provide Incident Commanders with public information strategies, skills, and risk communications tools to help inform the public and media. For more information, contact the National Strike Force Coordination Center at (252) 331-6000.

DOE Radiation Emergency Assistance Center/Training Site

DOE's Radiation Emergency Assistance Center/Training Site (REAC/TS) provides 24-hour direct or consultative assistance with medical and health physics problems for local, national, and international accidents. The REAC/TS program provides a radiological emergency response team, which consists of physicians, nurses, health physicists, coordinators, and support personnel, to provide first-line responders with consultative or direct medical assistance and radiological assistance at the REAC/TS facility or at the accident site. Specifically, the team has expertise in and is equipped to conduct:

- Medical and radiological triage
- Decontamination procedures for external contamination and internally deposited radionuclides, including chelation therapy
- Diagnostic and prognostic assessments of radiation-induced injuries
- Radiation dose estimates by methods that include cytogenetic analysis, bioassay, and in vivo counting

For additional information, review the REAC/TS web site at http://www.orau.gov/reacts/ or contact Pat Cooley at (865) 576-3131 or cooleyp@orau.gov.

10. REFERENCES

CDC. 2006. Radiation Emergencies: Info for the General Public. Center for Disease Control and Prevention. http://www.bt.cdc.gov/radiation/#public

10 CFR Part 20. Standards for Protection Against Radiation. Nuclear Regulatory Commission. http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/

29 CFR 1910.1096. Occupational Exposure to Ionizing Radiation. Occupational Safety and Health Administration. *Federal Register* vol. 70, No. 84. May 3, 2005. http://a257.g.akamaitech.net/7/257/2422/01jan20051800/edocket.access.gpo.gov/2005/pdf/05-8805.pdf

40 CFR Part 300. National Oil and Hazardous Substances Pollution Contingency Plan. U.S. Environmental Protection Agency. *Federal Register* vol. 53:51394. December 21, 1988. http://www.access.gpo.gov/nara/cfr/waisidx_03/40cfr300_03.html

DHS. 2004a. Radiological Attack: Dirty Bombs and Other Devices. U.S. Department of Homeland Security and National Academy of Engineering. http://www.nae.edu/NAE/pubundcom.nsf/weblinks/CGOZ46NVG/$file/radiological%20attack%2006.pdf

DHS. 2004b. National Response Plan. U.S. Department of Homeland Security. http://www.dhs.gov/interweb/assetlibrary/NRP_FullText.pdf

DHS. 2004c. National Incident Management System. U.S. Department of Homeland Security. http://www.fema.gov/pdf/nims/nims_doc_full.pdf

DHS. 2004d. Memorandum of Agreement Among the Interagency Modeling and Atmospheric Assessment Center of the Department of Homeland Security and the Department of Commerce, National Oceanic and Atmospheric Administration, Department of Defense, Department of Energy, Environmental Protection Agency, National Aeronautics and Space Administration, Nuclear Regulatory Commission, Department of Interior, U.S. Forestry Service. U.S. Department of Homeland Security. http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2004/secy2004-0221/attachment.pdf

DHS. 2006. Application of Protective Action Guides for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents. Department of Homeland Security. *Federal Register* January 3, 2006. http://www.dhs.gov/dhspublic/display?theme=43&content=5327&print=true

DNA. 2006. On-Scene Commanders Guide to Site Restoration. Pamphlet 5200.xx-P. Defense Nuclear Agency. September 30, 2006.

DoD. 2003. Final Report on the Discrete Fury Test Program. Prepared by Applied Research Associates Inc., for Defense Threat Reduction Agency (Contract No. DSWA01-98-D-0076). Project Officers Report 7652. August 2003.

DoD. 2005. Department of Defense Nuclear Accident Response Manual. DoD 3150.8-M. (accessed August 28, 2005). February 22, 2005. http://www.dtic.mil/whs/directives/corres/pdf/p31508m_0205/p31508m.pdf

DOE. 2002. Nuclear Emergency Support Team Fact Sheet. U.S. Department of Energy, Office of Emergency Response. http://www.nv.doe.gov/library/FactSheets/NEST.pdf

DOE. 2005. Federal Radiological Monitoring and Assessment Center (FRMAC) Operations Manual. DOE/NV/11718-080-Rev.2. U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. http://www.nv.doe.gov/library/publications/frmac/DOENV_11718_080_Rev2.pdf

DOT. 2004. Emergency Response Guidebook. U.S. Department of Transportation. http://hazmat.dot.gov/pubs/erg/gydebook.htm

EPA. undated. Technology Reference Guide for Radioactively Contaminated Surfaces (to be issued) (Order No. 4W-2324-WTSX) being prepared by EnDyna Inc for U.S. Environmental Protection Agency, Office of Air and Radiation.

EPA. 1992a. Manual of Protective Action Guides and Protective Actions for Nuclear Incidents (also known as the "PAGs"). EPA 400-R-92-001. www.epa.gov/radiation/rert/pags.htm.

EPA. 1992b. Standard Operating Safety Guides, U.S. Environmental Protection Agency Publication 9285.1-03, June 1992. http://www.ert.org/mainContent.asp?section=Products&subsection=List

EPA. 1994. Guidance for the Data Quality Objectives Process, EPA QA/G-4. EPA 600-R-96-065. U.S. Environmental Protection Agency.

EPA. 1997. Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination. OSWER Directive 9200.4-18, NTIS PB97 963210. August 22. http://www.epa.gov/superfund/resources/radiation/radarars.htm

EPA. 2000a. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Revision 1. NUREG-1575 Rev 1, EPA 402-R-97-016 Rev 1, DOE/EH-0624 Rev 1. (GPO Stock Number for Revision 1 is 052-020-00814-1). U.S. Environmental Protection Agency, U.S. Nuclear Regulatory Commission, et al. http://www.epa.gov/radiation/marssim/ or from http://bookstore.gpo.gov/index.html.

EPA. 2000b. Guidance for Data Quality Assessment: Practical Methods for Data Analysis, EPA QA/G-9, QA00 Version. EPA 600-R-96-084. U.S. Environmental Protection Agency, Quality Assurance Management Staff. http://www.epa.gov/quality/qa_docs.html.

EPA. 2000c. EPA Radiological Emergency Response Plan. U.S. Environmental Protection Agency. http://www.epa.gov/radiation/rert/plans.htm#rerp

EPA. 2004. Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP). Volumes 1-3. EPA 402-B-04-001A-C, NUREG 1576, NTIS PB2004-105421. U.S. Environmental Protection Agency. http://www.epa.gov/radiation/marlap/manual.htm

EPA. 2005a. EPA Medical Surveillance Program Implementation Plan. Draft. www.epaosc.org

EPA. 2005b. Emergency Response Health and Safety Manual, Chapter 2: Radiation Health and Safety Implementation Plan. U.S. Environmental Protection Agency.

EPA. 2006. Safety, Health, and Environmental Management (SHEM) Guidance No. 38. U.S. Environmental Protection Agency.

IAEA. 1988. The Radiological Accident in Goiânia 1988. International Atomic Energy Agency. http://www-pub.iaea.org/MTCD/publications/PDF/Pub815_web.pdf

LANL. Undated. Emergency Responders' "Rules of Thumb" for Air Toxics Releases in Urban Environments, Los Alamos National Laboratory. Technical Report LA-UR-4539. http://www.mipt.org/pdf/la-ur-98-4539.pdf

NCRP. 2001. Management of Terrorist Events Involving Radioactive Material. NCRP Report No. 138. National Council on Radiation Protection and Measurements, Bethesda, MD. www.ncrponline.org/ncrprpts.html

NRC. 2003. Fact Sheet on Dirty Bombs. U.S. Nuclear Regulatory Commission. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/dirty-bombs.html

NRC. 2005. Backgrounder on Dirty Bombs. U.S. Nuclear Regulatory Commission. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/dirty-bombs-bg.html

NRT. 2000. Joint Information Center Model: Collaborative Communications During Emergency Response. The National Response Team. http://www.nrt.org/production/NRT/NRTWeb.nsf/AllAttachmentsByTitle/A-55JIC/$File/JIC.pdf?OpenElement

PCC. 1997. Framework for Environmental Health Risk Management. Final Report, Vol. 1. (PC-97). The Presidential/Congressional Commission on Risk Assessment and Risk Management. http://www.riskworld.com/Nreports/1997/risk-rpt/pdf/EPAJAN.P

USCG. 2005. Hazardous Materials Response Special Teams Capabilities and Contact Handbook. U.S. Coast Guard. http://www.uscg.mil/hq/g-m/2005SpecialTeamsHandbook.pdf

APPENDIX 1. DEFINITIONS

ALARA stands for "as low as reasonably achievable." It is a safety concept indicating that every reasonable effort must be made to maintain exposures as far below the applicable limits as practical.

Alpha Particle. A particle with a +2 charge made up of two neutrons and two protons emitted by certain radioactive nuclei. Alpha particles can be stopped by thin layers of light materials, such as a sheet of paper, and pose no direct or external radiation threat; however, they can pose a serious health threat if ingested or inhaled.

Beta Particle. A particle emitted by certain radioactive nuclei, which can have a +1 charge (positron) or a –1 charge (negatron). Both particles have the mass equivalent to that of an electron. Beta particles can be stopped by thick pieces of aluminum. They can pose a serious direct or external radiation threat and can be lethal depending on the amount received. They also pose a serious internal radiation threat if inhaled or ingested.

Contamination Reduction Zone (or Warm Zone). The transition area between the exclusion and support zones. This area is where responders enter and exit the exclusion zone and where decontamination activities take place. See also exclusion zone and support zone.

Decay, Radioactive. The decrease in the amount of any radioactive isotope with the passage of time due to the spontaneous emission of radiation from the atomic nuclei (either alpha or beta particles, often accompanied by gamma radiation) and consequent transformation to a different chemical form.

Dirty Bomb. Commonly refers to a device that spreads radioactive material by exploding a conventional (non-nuclear) explosive, such as dynamite. Because they do not involve the sophisticated technology required to create a nuclear explosion, dirty bombs are much simpler to make than a true nuclear bomb.

Dosimeter. A small portable instrument (such as a film badge, thermoluminescent, or pocket dosimeter) for measuring and recording the total accumulated personal dose of ionizing radiation.

Exclusion Zone (or Hot Zone). The area with actual or potential contamination and the highest potential for exposure to hazardous substances. See also support zone and contamination reduction zone.

FRP (Federal Response Plan). The FRP established the basic mechanisms and structures for provision of federal assistance to a state and its affected local governments impacted by a catastrophic disaster or emergency situation. The FRP has been superseded by the issuance of the National Response Plan.

FRMAC (Federal Radiological Monitoring and Assessment Center). An operations center usually established near the scene of a radiological emergency from which federal field monitoring and assessment assistance is directed and coordinated.

Gamma Rays. High-energy electromagnetic radiation emitted by certain radionuclides when their nuclei transition from a higher to a lower energy state. These rays have high energy and a short wave length. A radionuclide which emits gamma rays can be qualitatively and quantitatively identified because the energy of the gamma radiation is defined by the radionuclide present.

Half-life. The time in which one half of the atoms of a radioactive isotope disintegrate into another nuclear form. Half-lives vary from billionths of a billionth of a second to billions of years. Also called physical or radiological half-life.

Health Physics. A scientific field that focuses on radiation protection of humans and the environment. Health Physics uses physics, biology, chemistry, statistics and electronic instrumentation to help protect individuals from any damaging effects of radiation.

Improvised Nuclear Device (IND) Incident. DHS defines an IND as an illicit nuclear weapon bought, stolen, or otherwise originating from a nuclear state, or a weapon fabricated by a terrorist group from illegally obtained fissile nuclear weapons material that produces a nuclear explosion.

National Incident Management System. A system that provides a consistent nationwide approach for federal, state, and local governments to work effectively and efficiently together to prepare for, respond to, and recover from domestic incidents, regardless of cause, size, or complexity.

National Response Plan. The National Response Plan (NRP) establishes the basic mechanisms and structures for provision of federal assistance to a state and its affected local governments impacted by a catastrophic disaster or emergency situation. Issued by DHS in December 2004, it supersedes the Federal Response Plan and several other federal emergency response plans, including the Federal Radiological Emergency Response Plan.

Photon. A discrete “packet” of pure electromagnetic energy. Photons have no mass and travel at the speed of light. The term “photon” was developed to describe energy when it acts like a particle (causing interactions at the molecular or atomic level), rather than a wave. Gamma and X-rays are photons.

Protective Action Guide. A protective action guide tells state and local authorities at what projected dose they should take action to protect people from exposure to unplanned releases of radioactive material into the environment.

Radiation Sickness (Syndrome). The set of symptoms that result when the whole body (or a large part of it) has received an exposure of greater than 50 rads of ionizing radiation. The earliest symptoms are nausea, fatigue, vomiting, and diarrhea. Hair loss, hemorrhaging, inflammation of the mouth and throat, and general loss of energy may follow. If the exposure has been approximately 1,000 rad or more, death may occur within two to four weeks.

RDD (Radiological Dispersal Devices). A RDD is any device that causes the purposeful dissemination of radioactive material across an area without a nuclear detonation. The mode of dispersal typically described as a RDD is an explosive device coupled with radioactive material (also known as a “dirty bomb”).

Roentgen (R). A unit of exposure to ionizing radiation. It is an indication of the strength of the ionizing radiation. One Roentgen is the amount of gamma or x-rays needed to produce ions carrying 1 electrostatic unit of electrical charge in 1 cubic centimeter of dry air under standard conditions.

RAD (Roentgen Absorbed Dose). A basic unit of absorbed radiation dose. It is being replaced by the 'gray,' which is equivalent to 100 rad. One rad equals the dose delivered to an object of 100 ergs of energy, per gram of material.

REM (Roentgen Equivalent Man). A unit of equivalent dose. Rem relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose.

Stafford Act. The Robert T. Stafford Disaster Relief and Emergency Assistance Act provides authority for the Federal Government to respond to disasters and emergencies in order to provide assistance to save lives and protect public health, safety, and property.

Support Zone (or Cold Zone). The area of the site that is free from contamination and that may be safely used as a planning and staging area. See also exclusion zone and contamination reduction zone.

Transuranic. Elements with atomic numbers higher than uranium (92). For example, plutonium and americium are transuranics.

X-rays. High-energy electromagnetic radiation emitted by atoms when electrons fall from a higher energy shell to a lower energy shell. These rays have high energy and a short wave length. X-rays are very similar to gamma rays.

APPENDIX 2. SAMPLE HEALTH AND SAFETY PLAN

HEALTH AND SAFETY PLAN (HASP) FOR Chicago Radiological Response

CHEMICAL AGENTS

Unknown

BIOLOGICAL AGENTS

Unknown

RADIOLOGICAL ISOTOPES

cesium-137, cobalt 60 (unconfirmed)

Response Name: Chicago Loop Emergency Response

NRC Spill Report No. 798567

Location: Chicago and Clark Street

Date of Operations: 7-14-06 through ?

Prepared by: U.S.EPA

Title: OSC

Date Prepared: 5/19/2006

Organization: U.S EPA Region 5 Emergency Response

Approved by: Mark Colvin

Title: Region 5 SHEMP Manager

Organization: U.S. EPA Region 5

Date Approved: 5-19-06

1. POLICY, ORGANIZATION AND RESPONSIBILITIES, AND SCOPE OF WORK

1.1 POLICY

This health and safety plan (HASP) establishes the procedures and requirements to ensure the health and safety of response team members for the above-referenced location. This plan must and will be updated as conditions and events change. It is the response team's responsibility to ensure the health and safety of its members, the public, and the environment during the performance of work it conducts.

After reading this plan, applicable team members shall read and sign the Health and Safety Plan Acceptance. This HASP has been developed for use by those agencies and team members who have signed the acceptance form, and is not intended for use by firms not associated with the response teams efforts. Subcontractors are responsible for developing and providing their own safety plans.

This HASP has been prepared to meet the following applicable regulatory requirements and guidance:

Applicable Regulation/Guidance
GENERAL DUTY CLAUSE (OSHA Act, Section 5(a)(1)): Under the 'General Duty' clause of the Occupational Safety and Health Act of 1970, section 5(a)(1) states that each employer 'shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees.'
LOG AND SUMMARY OF OCCUPATIONAL INJURIES AND ILLNESSES (29 CFR 1904.24): This regulation requires that each employer maintain a log of all recordable occupational injuries and illnesses and that the information be recorded in the log within six working days of the receipt of the information. Form OSHA No. 200 or its equivalent is to be used for this purpose.
ACCESS TO EMPLOYEE EXPOSURE AND MEDICAL RECORDS (29 CFR 1910.20): An employer must provide exposure and medical records to an employee or designated representative within fifteen days after the request for access to records. If the employee requests copies of this information, the employer must make the copies available to the employee at no cost. All employee medical records must be maintained for the duration of employment plus 30 years by the employer.
EMPLOYEE EMERGENCY PLANS AND FIRE PREVENTION PLANS (29 CFR 1910.38): This regulation applies to all emergency action plans and fire prevention plans required by particular OSHA standards. With the exception of employers with 10 or fewer employees, both the emergency action plan and the fire prevention plan are required in writing. The required elements of each of these plans are provided in the regulation. If the employer has 10 or fewer employees, the elements of both types of plan must be provided orally to employees. The employer shall also perform housekeeping and maintenance of equipment and systems as part of the fire prevention plan.
OCCUPATIONAL NOISE EXPOSURE (29 CFR 1910.95): On many sites, different site activities (e.g., drilling operations, heavy equipment operations) may result in appreciable noise levels. It is important that area and personal noise surveys be conducted to categorize noise levels appropriately. A sound level meter that has the capability to integrate and average sound levels over the course of a work day is required. Currently, the OSHA-Permissible Exposure Limit for an eight-hour workday, forty-hour work week, is 90 dBA, as recorded on a sound level meter on the A weighted scale. An employer shall implement a hearing conservation program if 8-hour time weighted average noise exposures equal or exceed 85 decibels on the A scale. Continuous intermittent and impulsive sound levels of 80 dBA or greater shall be integrated into the time weighted average.

EYE AND FACE PROTECTION (29 CFR 1910.133): Eye and face protection is required when there is the potential for on-site injury. Particular information on goggles, spectacles, and face protection is included in this regulation. Design, construction, testing, and use of such devices must be in accordance with ANSI Z87.1-1968 specifications.

RESPIRATORY PROTECTION (29 CFR 1910.134): Prior to wearing a respirator, an employee should be certified as medically able to wear one. Each employer should have a written respiratory protection plan for selection and use of respirators. All employees must be trained regarding the appropriate use of a respirator.

OCCUPATIONAL HEAD PROTECTION (29 CFR 1910.135): On-site situations requiring head protection include: presence of overhead objects, on-site operation of heavy equipment, potential for flying objects in the work area, and possible electrical shock hazard. In addition to protecting workers from falling or flying objects, head protection affords limited protection from electric shock and burn. Head protection must meet ANSI Z89.1-1969 specifications.

HAZARDOUS LOCATIONS (29 CFR 1910.307): Electrical equipment used in hazardous locations must be intrinsically safe and suitable for use in the appropriate classified environment. Specified definitions of classifications and further information can be found in Section 1910.307 and 1910.399.

TOXIC AND HAZARDOUS SUBSTANCES (Subpart Z, 29 CFR 1910.1000): There are other applicable OSHA standards that refer to particular air sampling procedures for chemical contaminants, PPE requirements, and record keeping for a variety of compounds.

Asbestos	29 CFR 1910.1001	Coal tar pitch volatiles	29 CFR 1910.1002
4-nitrobiphenyl	29 CFR 1910.1003	Alpha-Naphthylamine	29 CFR 1910.1004
Methyl chloromethyl ether	29 CFR 1910.1006		
3,3'-dichlorobenzidine	29 CFR 1910.1007		
bis-chloromethyl ether	29 CFR 1910.1008		
Benzidine	29 CFR 1910.1010		
4-aminodiphenyl	29 CFR 1910.1011		
Ethyleneimine	29 CFR 1910.1012		
beta-propiolactone	29 CFR 1910.1013		
2-acetylaminofluorene	29 CFR 1910.1014		
4-dimethylaminoazobenzene	29 CFR 1910.1015		
N-nitrosodimethylamine	29 CFR 1910.1016		
Vinyl chloride	29 CFR 1910.1017		
Inorganic arsenic	29 CFR 1910.1018		
Lead	29 CFR 1910.1025		
Benzene	29 CFR 1910.1028		
Coke oven emissions	29 CFR 1910.1029		
1,2-dibromo-3-chloropropane	29 CFR 1910.1044		
Acrylonitrile	29 CFR 1910.1045		
Ethylene oxide	29 CFR 1910.1047		
Formaldehyde	29 CFR 1910.1048		

HAZARD COMMUNICATION (29 CFR 1910.1200): The employer will establish a hazard communication program to ensure that hazards associated with chemical usage are communicated to employees. The hazard communication program does not apply to hazardous wastes. There are training, labeling, and material safety data sheet (MSDS) requirements for known chemicals. Employers are required to develop a written hazard communication program that will include:

List of known hazardous chemicals on-site; *unknown*

Method for informing employee of chemical hazards associated with non-routine tasks; and

Methods for informing both employees and subcontractors about chemical hazards (e.g., chemical hazard training, distribution of MSDSs).

2. ORGANIZATION AND RESPONSIBILITIES

The HASP must include key personnel as well as their alternates. The HASP must also identify the communication procedures and provide for briefings to be held before site activity is initiated, and daily thereafter. These meeting should be held at any time they appear necessary to ensure that employees are adequately apprised of the health and safety procedures being followed at the site.

Primary team member's roles and responsibilities are listed below. *As applicable*, team members should read the work plan, sampling and analysis plan, and/or quality assurance plan prior to the completion of their assigned tasks.

Organization and Responsibilities (Primary Team Members)

Name	Organization	Responsibility
Mark Durno	USEPA Region 5	EPA OSC Incident Commander
Steve Renninger	U.S.EPA Region 5	EPA Field Ops Leader

NOTE: Refer to Section 4 of this SHASP for Training Requirements.

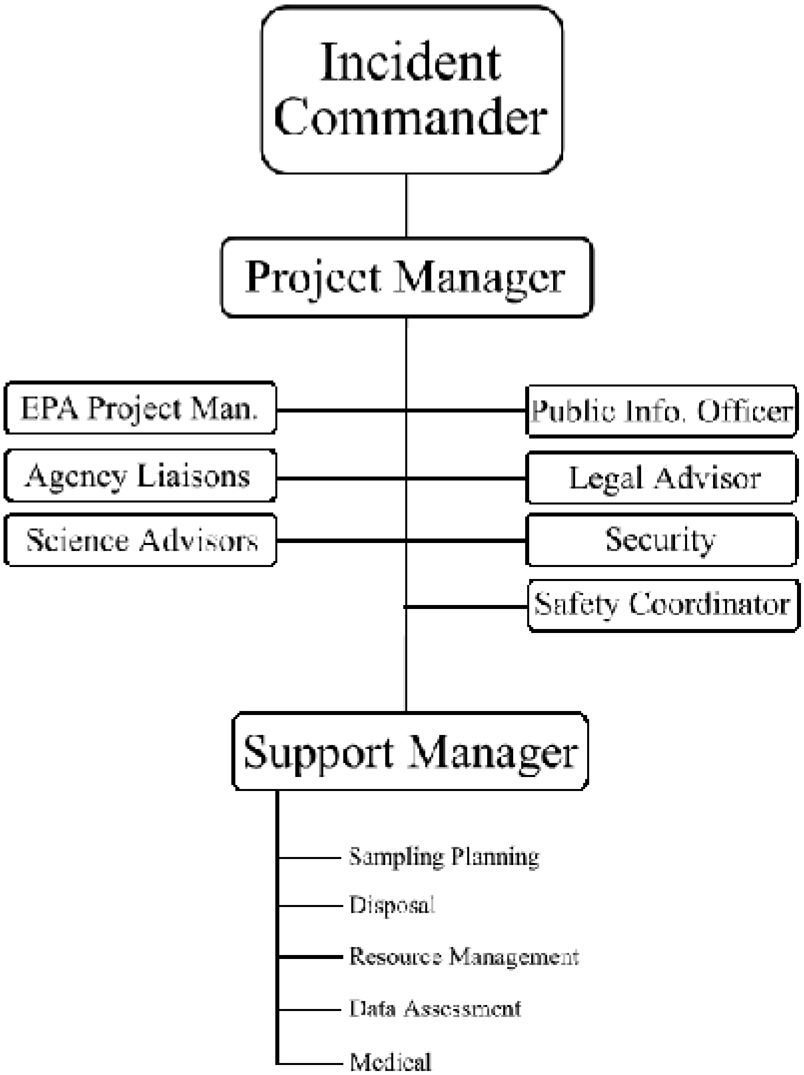
Alternate team member's roles and responsibilities are listed below. *As applicable*, team members should read the work plan, sampling and analysis plan, and/or quality assurance plan prior to the completion of their assigned tasks.

Organization and Responsibilities (Alternate Team Members)

Name	Organization	Responsibility
Michelle Cullerton	Region 5 START	Team Member - Air Sampling
Steve Jacobs	Region 5 START	Team Member - AirSampling
Ellery Savage	USEPA ERT	Team Member -Air Sampling
Doug Draper	USEPA ERT Contractor	Team Member - Air Sampling
Ben Markadel	Region 5 START	Health and Safety
Jodi McCardy	Region 5 START	Data Management

NOTE: Refer to Section 4 of this SHASP for Training Requirements.

ORGANIZATIONAL CHART SHOWING LINES OF AUTHORITY



1.3 COMMUNICATIONS

1.3.1 Radio Communications:

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Radio Communications		
Name	**Job/Team**	**Channel/Frequency**
EPA Response Team	Support Local Response	Channel 5 Freq 165.5

1.3.2 Phone Communications:

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Phone Communications		
Name	**Voice/Cellular/Pager**	**FAX**
EPA IC Mark Durno	513 456-9878 / 513 -281-7654/NA	312-353-9176

1.3.3 General signals for personnel in PPE:

Signal	Meaning
Thumbs Up	I'm OK / I agree
Thumbs Down	Don't Agree
Hands Across Throat	Out of air / Trouble breathing
Grab Hand / Arm	Come with me.
Hands on head	I need assistance.

1.4 SCOPE OF WORK
Description of Work:

General Tasks

1. Set up electronic database using SCRIBE, collect state and local air moinitoring data.
2. Perform site reconnisance around local perimeter for chem, rad and bio.
3. Monitor outside of perimeter for chemical, rad and particulate materials (multi-Rae, NaI detector, Ion chamber and Data Ram 4 particulate monitor).

4. Deploy RADeCO particulate air monitors (1) downwind (1) upwind and (1) > 100 uR/hr.

5. Prepare for Level B entry into restricted zone.

6. Follow Radiation Entry/Egress, Sample Analysis and Reporting Procedures identified below.

7. Record Data on RRSF-900 and enter into Scribe database.

8. Report data to IC, HQ, RERT, DOE and State and Local Officials.

9. Wear TLDs, report exposue from EPD Mk2 dosimeters every hour to EPA Health & Safety Officer.

10. Dose Management starts at 1 mR/hr.

Specific Tasks

11.1 Pre-Deployment Operational Checks

a. Perform operational checks on Micro-R meters (i.e., model 192, 19) and pancake detectors (2241-2 coupled to model 44-9 pancake detector) in accordance with QSGs.
b. Place radiation meters in front seat of vehicle or dashboard with audible 'on.'

11.2 *Arrival Procedures*

a. If there is a visible smoke plume, arrive up-wind of the scene.
b. Check radiation meters against notification guidelines. The notification guidelines are an ambient reading of 100 μR/hr with the micro-R meter and/or 330 cpm with pancake detector. (These are equivalent readings when calibrated to a cesium-137 source).
c. If first responders have set up an exclusion zone for the public, drive outside the perimeter of the exclusion zone, recording any readings at or above notification guidelines. Record these readings on RRSF-900. If guidelines are exceeded, make notifications to EPA, RERT Commander, DOE RAP, and State and local radiological response programs. Notifications can be made through the National Response Center.
d. Collect wipe samples of any visible dust in areas where notification guidelines were exceeded. Follow contamination assessment procedures in section 4 of this SOG.
e. If removable contamination exists, recommendations should be made to the IC that the exclusion zone be expanded and radiological protective actions implemented. (Any recommendations should be made in consultation with DOE and the RERT).
f. Follow radiological perimeter, reconnaissance, and hot zone monitoring procedures.

12.0 Pre-Entry Procedures

12.1 *Planning*

a. Synchronize the EPA and the incident commander's action objectives.
b. Establish the EPA role in the incident response plan.
c. Collect all first responder radiation data and record as "first responder data" on form RRSF-900.

12.2 *Organize Assets and Brief Personnel*

a. Establish an initial-entry team.
b. Establish a backup team.
c. Establish a decontamination team (hot zone exit self-surveys may have to be performed until additional assets arrive).
d. Brief all personnel on the required tasks to accomplish during the entry.
e. Communicate situation, objectives, control measures, access restrictions, and turn-back criteria.

12.3 *Safety Planning and Medical Screening*

a. Develop site-specific HASP.
b. Perform medical screening on entry team, backup team, and if available, decontamination team.
c. Radiological health and safety requirements include thermoluminescent dosimetry (TLD) badges, EPD Mk2 real-time dosimeters, and briefing on radiological turn-back levels, 10 Roentgens/hour, however dose management starts at 1 mR/hr.

12.4 *Equipment Calibration and Operational Checks*

a. Inspect the personal protective equipment (PPE) for signs of cracks, rips, tears, or other defects.
b. Follow QSG for chemical agent detectors.

c. Follow the QSG for the SAM-935, Ludlum Model 43-90 alpha scintillator, and Eberline RO20 ion chamber.
d. Verify that your staging area is free of contamination.
e. Conduct communication checks between entry team, backup team, Lead OSC, and decontamination team.

12.5 *Don PPE (Level C is appropriate for radiological hazards; unknown conditions require a minimum of Level B.*

a. Use the buddy-team method to don PPE.
b. Inspect and verify the proper PPE fit and function.

12.6 *Entry Clearance*

a. Request permission from the Lead OSC and IC to enter the hot zone.
b. Record time on air, entry team personnel names, and equipment taken into hot zone.
c. Entry team verifies required tasks and plan of action for entry to the Lead OSC.
d. Confirm decontamination line is established and the backup team is ready.
e. Receive clearance and permit entry team to enter the hot zone.

13.0 Entry Procedures

13.1 *Reconnaissance*

a. Adjust the reconnaissance plan, as required, to meet the needs of the IC and OSC to ensure there is a mission justification for all entries
b. In developing the reconnaissance plan consider the following objectives:
   1) Locations and types of hazards.
   2) Physical layouts and descriptions.
   3) Casualty status or information.
   4) Additional requirements.
   5) Video and/or still camera pictures.

13.2 *Monitoring Initial Entry Procedure*

a. Conduct non-radiological air monitoring (Multirae®) throughout operations to identify any atmospheres that are corrosive, combustible, or oxygen-deficient; toxic substances that are immediately dangerous to life or health (IDLH); and exposures over Permissible Exposure Limits (PELs).
b. Approach the center of the incident scene from the downwind direction. Place RADeCO Air Sampler at 100 µR/hr point (follow the QSG). Place small "x" on the exterior surface of the filter paper. Record flow rate and start time on form RRSF-900.
c. Continue to walk in a line and record dose rate (micro-R) measurements at100 μR/hr, 500 μR/hr, and 1 milli-Roentgen per hour (mR/hr) level on form RRSF-900. Measurements should be collected at waist level.
d. With the SAM-935, collect one-minute spectrum at the 100 u/R hr location. This is a high enough exposure rate to identify the isotope(s). Record the identified isotope(s) and spectrum # on RRSF-900. The SAM-935 should be in MCA mode with the following isotopes enabled; Cs-137, Co-60, Ra-226, Ir-192, Am-241, and Pu-239.)
e. Collect a wipe sample at each monitoring point location in an area that is likely to contain loose surface contamination. With moderate pressure, swipe an area approximately 3 inches by 6 inches and place wipe in a glassine envelope.
f. Mark radiological monitoring location with pin flags, marking paint, or duct tape.
g. Record all readings including Global Positioning System (GPS) locations of measurement points on form RRSF-900.

14.0 Egress Procedures

a. Exit hot/exclusion zone through the Contamination Reduction Corridor (CRC)
b. Place hand tools and monitoring instruments taken into the hot zone at a table or inside a bucket provided in the designated equipment/instrument drop station.
c. Position the tools and monitoring equipment so that the incoming Entry Team can easily acquire them.
d. Remove the outer gloves and place them in a designated container.
e. Follow standard PPE doffing protocols. The order of PPE removal will depend on the level of protection. Step by step doffing and personnel decontamination procedures can be found in RRDSOP 601(*currently under development*).
f. Personal contamination surveys must take place in a low background environment. Perspiration should be removed from hands and face using paper towel or other absorbent material.
g. If the Entry Team is using a self-frisking technique, set up the pancake GM detector with the window facing up and

move finger tips and the palms of each hand across the detector. Speed is about 1 to 2 inches per second. Count rates with the pancake GM greater than *100 counts per minute above background reading* (as a continuous deflection) should be considered contaminated and personnel personal decontamination is recommended.

e. If no contamination is found on the hands, pick up the unit and scan the bottom of the feet and underside of the neck where the respirator was worn.
f. If contamination is detected on hands, feet or the underside of the neck decontamination of these areas should be performed and a full body scan should follow.
g. If no contamination is found on the hands, feet and neck, a full body scan is not warranted.

15.0 Contamination Assessment

15.1 *Contamination Swipe Surveys*

a. Survey/count the swipe samples in an area where the ambient radiation level is at normal (pre-event) background levels.
b. Place the filter paper on a flat non-contaminated surface and count for 15 seconds with a Ludlum Model 2241 on the "det 2" setting with the Ludlum Model Probe 43-90 to determine if **alpha** contamination is present. Record the result on form RRSF-900.
c. If the reading is greater than 5x background, contamination exists.
d. To determine if loose **beta/gamma** contamination is present, change the Probe to the Ludlum Model 44-9 and switch to the "det 1" setting on the Ludlum Model 2241. Record the result on form RRSF-900.
e. If the reading is greater than 2x background, contamination exists.

15.2 *Filter Paper Alpha Airborne Radioactivity Determination*

a. Count the filter paper for 10 minutes with a Ludlum Model 2241 on the "det 2" setting using the Ludlum Probe model 43-90. Record results on the appropriate form.
b. Wait for 30 minutes and count again. If the filter paper count rate decreases by approximately one-half, then the radioactivity is most likely due to radon decay products. If the count rate does not decrease, then the radioactivity most likely exists and level B, or greater, respiratory protection should continue to be worn in this area.

15.3 *Filter Paper Beta Radioactivity Determination*

a. Count the filter paper for 10 minutes with a Ludlum Model 2241 on the "det 1" setting with the Ludlum Probe model 44-9. Record results on form RRSF-900.
b. Wait for 30 minutes and count again. If the filter paper count rate decreases by approximately one-half, then the radioactivity is most likely due to radon decay products. If the count rate does not decrease, then the radioactivity is due to some other beta activity. This indicates that a radioactive airborne condition exists and level C respiratory, or greater, protection should continue to be worn in this area.

16. Sample Shipping/Analysis and Reporting

16.1 *Shipping*

a. Prepare the sample for transport. Transfer sample collection media to appropriate containers and label in accordance with the chain-of-custody procedures. Record any pertinent information on a separate Chain-of-Custody Form for group sample transfer.
b. Ship airborne radioactivity samples that are greater than twice background after 30-minute decay to a certified lab (a list of certified labs is in development by EPA working with DOE, once available, it will be posted to www.epaosc.org) and request the following analyses: Alpha spectroscopy for the actinides (i.e. U-234, U-235, U-238, Th-230, Th-232, Pu-238, Pu-239, Pu-240, Am-241), total strontium, and gamma spectrometry.
c. Report all survey and contamination assessment data to the IC as well as to the RERT, DOE RAP, and State/local radiological response programs.

Individual operations required to complete the above scope of work are divided into numbered tasks (i.e., Task #1 - Perform site reconnaissance: Task #2 Collect samples of spilled material: etc).

Task Descriptions

Task #	
#1	Set Up electronic database using SCRIBE. Collect State and Local air monitoring data.
#2	Monitor outside of perimeter for chemical, rad and particulate materials (multi-Rae, NaI detector, Ion chamber and Data Ram 4 particulate monitor).
#3	Deploy RADeCO particulate air monitors (1) downwind (1) upwind and (1) > 100 uR/hr.
#4	Prepare for Level B entry into restricted zone.
#5	Follow Radiation Entry/Egress, Sample Analysis and Reporting Procedures identified above.
#6	Record Data on RRSF-900 and enter into Scribe database.
#7	Report data to IC, HQ, RERT, DOE and State and Local Officials.
#8	Wear TLDs, report exposue from EPD Mk2 dosimeters every hour to EPA Health & Safety Officer.
# 9	Dose Management starts at 1 mR/hr.

2. HEALTH AND SAFETY RISK ANALYSIS (SITE DESCRIPTION, HAZARD EVALUATION, INITIAL AND PERIODIC MONITORING, AND CONTROL)

Health and Safety Risk Analysis should be established for each task and operation identified in the site-specific work plan. Discussion of these analyses should include identification of the chemical, radiological and/or biological contaminants, affected media, concentrations, and potential routes of exposure for use in risk analysis. The Safety Risk Analysis should also address anticipated on-site operations and safety problems.

2.1 SITE DESCRIPTION

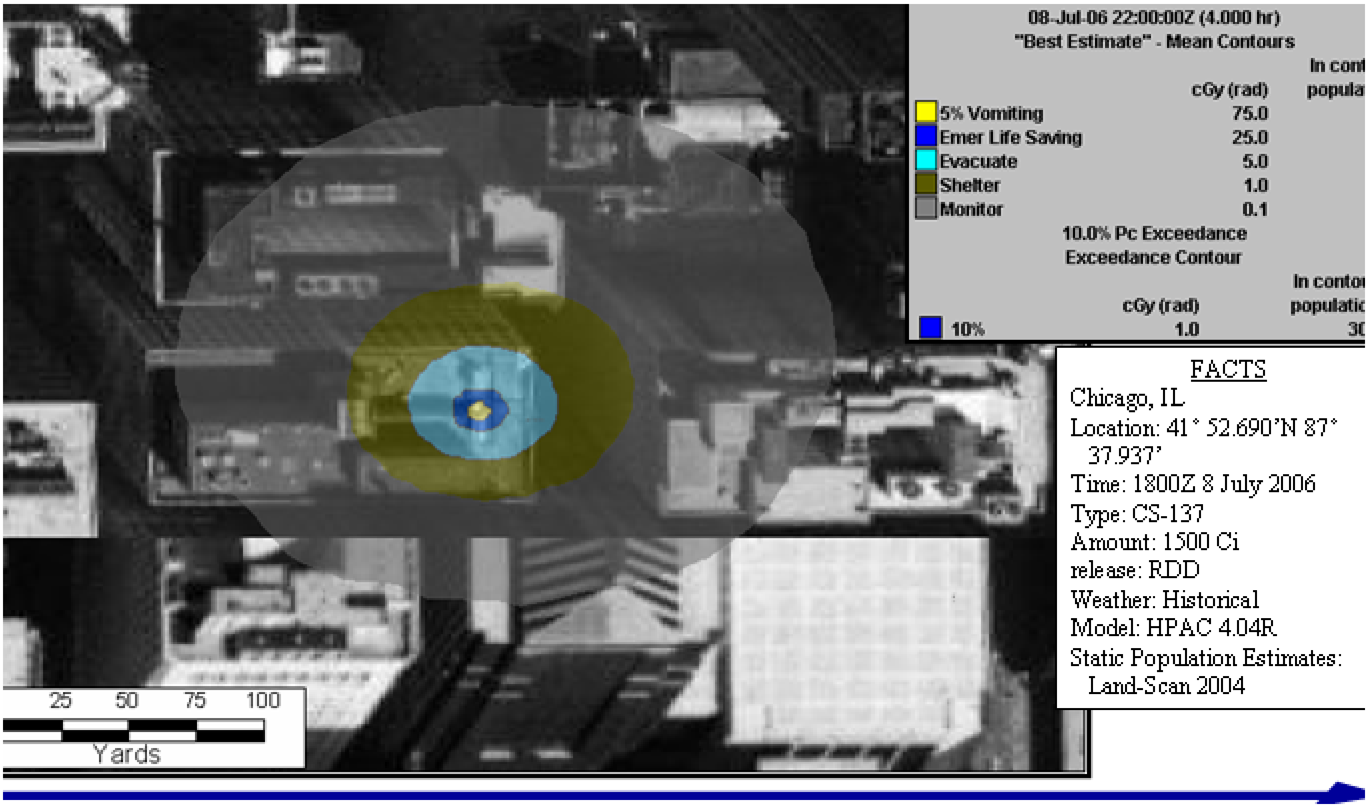
Is the site currently in operation? ☐ Yes ☑ No

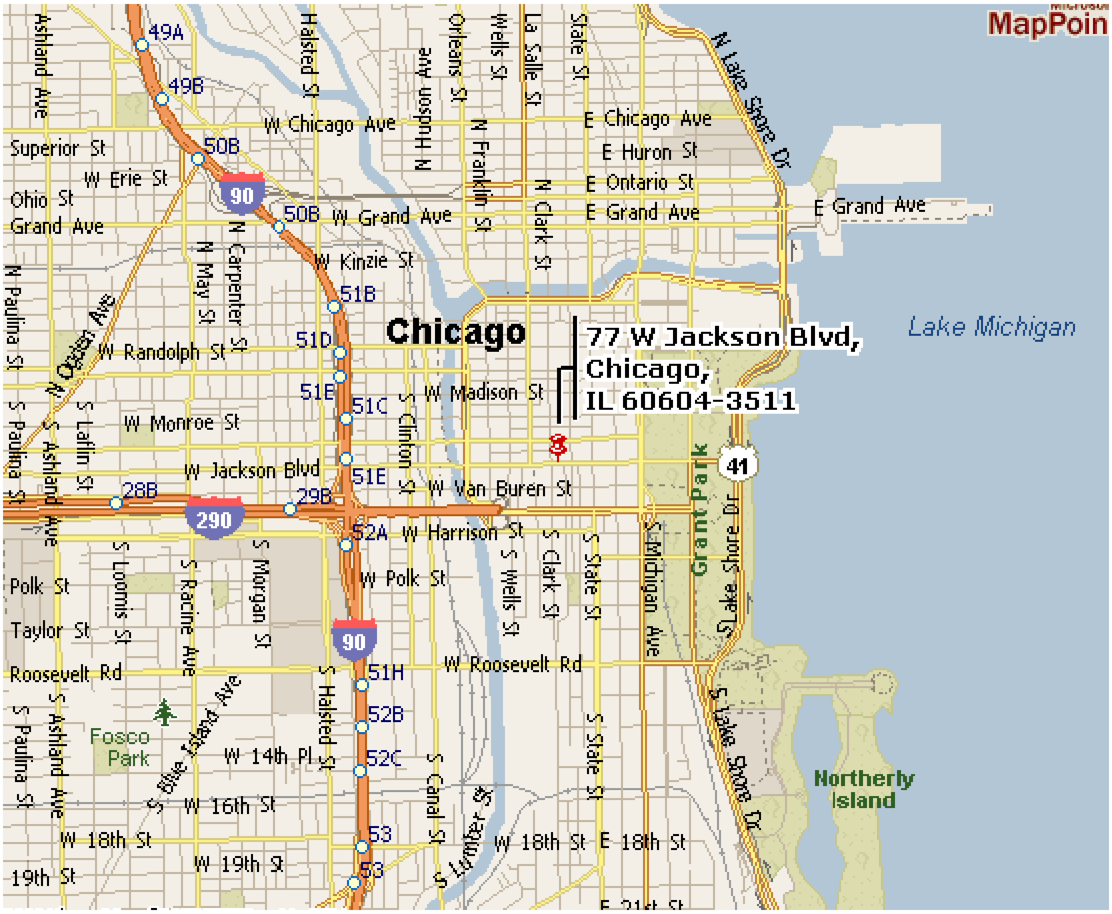
Site History- Description:

Explosion at the Chicago Board of Trade Building. Local Fire Department responding to contain the fire and prerform rescue operations. Chicago's 511 Hazmat Team reported reading of 5 milli-roentgens per hour 200 feet from explosion site, In addition The GR-130 Exploranium detector identified the presence of cesium-137 and cobalt-60.The Chicago Department of the Environment requested EPA assistance to perform air monitoring for radiological and chemical parameters.

Site Map

<see attached map>




77 W Jackson Blvd,
Chicago,
IL 60604-3511
Chicago
Lake Michigan
Northerly Island
Grant Park
Fosco Park
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Halsted St
Orleans St
Wells St
La Salle St
State St
Ashland Ave
Superior St
W Erie St
Ohio St
Grand Ave
Polk St
Taylor St
19th St
90
290
41
MapPoin

2.2 Hazard Evaluation

Responses to a Chemical, Radiological and/or Biological incident poses additional concerns and potential stresses not typically present at a hazardous material incident. There will probably be considerable public interest and an unusual amount of news media attention; the operations will be subject to public scrutiny. Also, there may have been deaths and injuries stemming from the incident. The cause of the incident may be unknown, and there may be conflicting or uncertain theories, observations, and information available to responders. There may be damaged structures, fires and explosions, and missing persons. Additionally, the site may be viewed as a potential crime scene, necessitating consideration of evidence collection and preservation procedures. Most likely, the circumstances will be unusual. The situation may present serious physical and psychological threats that cause stress in the workers. Team members should be aware of the unusual aspects of the response and potential effects on team members.

NOTE: Secondary hazards (devices) may be present and pose a significant risk to response personnel. CAUTION must be taken by all personnel. Should a secondary device be suspected and/or identified, contact and removal of the device from the site will be performed by properly trained Explosive Ordnance Disposal (EOD) or similarly trained personnel, prior to team entry. Items (boxes, packages, etc.) which have not been monitored by EOD personnel will not be approached or handled in any manner.

2.2.1 Hazard Evaluation

Radioactive Isotope	cesium-137 (unconfirmed)
DAC (uCi/mL)	0.00000006
Half-Life	30y
Surface Activity Level (dpm/100cm)	unknown at this time
Exposure Rate (mR/hr)	Ranges from background to 5 milli-roentgens per hour with Exploranium
Counts Per Minute	Several locations greater than 20,000 cpm.
Energy(s) in (MeV)	.662 MeV
Routes Of Exposure	inhalation ingestion external
Major Radiation(s)	gamma beta
Location	200 ft from explosion

Radioactive	cobalt-60 (unconfirmed)

Isotope	
DAC (uCi/mL)	0.00000007
Half-Life	5.3y
Surface Activity Level (dpm/100cm)	unknown at this time
Exposure Rate (mR/hr)	5 mR/hr
Counts Per Minute	0
Energy(s) in (MeV)	1.1 MeV 1.2 Mev
Routes Of Exposure	Ingestion, Inhalation, External
Major Radiation(s)	beta/gamma
Location	200 ft from explosion site.

2.2.2 Physical Hazard Evaluation (Extract Physical Hazards From File and Add Any Others To List)

Debris, hazardous conditions, electrical, heavy particulate and heat.

2.2 Hazard Control

An appropriate combination of engineering/administrative controls, work practices, and PPE shall be used to reduce and maintain team members exposures to a level at or below applicable exposure criteria.

Applicable Engineering And Administrative Control Measures:	The exclusion zone will be clearly marked and access restricted to those personnel directly involved with the response operations. Prior to entering the area, personnel will know their specific task assignments and responsibilities while within the contaminated area. Remote sensing devices will be used whenever feasible. Site entry and egress will be accomplished following pre-established procedures. Entry and exit corridors leading to the decontamination stations will be clearly marked. Emergency exits for personnel within the contaminated facility will have means of transporting personnel to the decontamination stations without contaminating the surrounding environment, other personnel, and/or the transportation vehicle. Personnel will enter and exit the contaminated areas only through the designated corridors. All personnel entering the exclusion zone will be 'logged in and out' for their entry and exit times, level of protection (LOP), and task to be performed. Personnel will follow any pre-established routes within the facility to preclude contamination of additional areas. Each team member will be provided with a map/plan of the facility that indicates the route to be taken and the location of emergency exits to be used. All personnel and equipment exiting the contaminated area will require decontamination prior to entering the support zone as described in the decontamination section of this plan.

PPE: Refer to PPE Section for assigned levels of protection and required PPE for this site.

Task Descriptions

Task #	Description	Contaminant	Risk
1	Set Up electronic database using SCRIBE. Collect State and Local air monitoring data.	N/A	N/A
2	Monitor outside of perimeter (in vehicle)for chemical, rad and particulate materials (multi-Rae, NaI detector, Ion chamber and Data Ram 4 particulate monitor).	Confirm presence of radioactive material i.e., Cs-137 and Co-60	particulates, low visibility, debris, rescue vihicles
3	Deploy RADeCO particulate air monitors (1) downwind (1) upwind and (1) > 100 uR/hr.	Radioactive material, particulates, monitor for chem materials	particulates, low visibility, debris rescue vehicles
4	Prepare for Level B entry into restricted zone.	Radioactive material, particulates, monitor for chem materials	Heat stress, low visibility, particulates, debris, rescue vehicles
5	Follow Radiation Entry/Egress, Sample Analysis and Reporting Procedures identified above.	Radioactive material, particulates, monitor for chem materials	Heat stress, low visibility, particulates, debris, rescue vehicles
6	Record Data on RRSF-900 and enter into Scribe database.	N/A	N/A/
7	Report data to IC, HQ, RERT, DOE and State and Local Officials.	N/A	N/A
	Wear TLDs, report exposue from		N/A

8	EPD Mk2 dosimeters every hour to EPA Health & Safety Officer.		
9	Dose Management starts at 1 mR/hr.		Maintain ALARA

2.3 RADIOLOGICAL HAZARD? ☑ Yes ☐ No

2.3.1 RADIOLOGICAL HAZARD EVALUATION AND CONTROL

Thermoluminescent dosimeters and Siemens EPD Mk2 real -time sosimeters should be worn at all times. Hourly Hp10 cummulative exposures should be recorded on exposure record forms and manitained by the Health and Safety Officer. Dose management starts at 1 mill-roentgen per hour. Emergency exposures should be maintained below 5 REM total effective dose equivalent (TEDE).

In addition, if OSCs integrate with a FRMAC response, they may be asked to wear an additional TLD badge processed by a Department of Energy Laboratory Accreditation Program (DOELAP) or National Voluntary Laboratory Accreditation Program (NVLAP) accredited processor. FRMAC may provide a dose report to each participant's home organization after the conclusion of the individual's activities. However, FRMAC dosimetry does **not** replace the TLD and dosimeters issued by EPA. The EPA dosimetry record will serve as the dose of record. Guidance for wearing external dosimeters includes:

> *The dosimeter must be worn on the chest area on or between the waist and the neck unless otherwise instructed by Health and Safety (H&S) personnel. The dosimeter is to be worn only by the individual to whom it was issued. Lost, damaged, or contaminated dosimeters must be reported immediately to the H&S staff. If a participant discovers that his/her dosimeter is missing while in a radiological area, he/she shall immediately leave the area, then notify the team leader and report the missing dosimeter to the H&S Manager. A new dosimeter will be issued by H&S. Dosimeters must be returned or exchanged at the time designated by the H&S Manager, upon request, or at the end of the operation.*

For emergencies, EPA has issued draft guidance that provides exposure *rates* that are based upon the understanding that, during emergencies, OSCs may receive doses that exceed the ACL of 500 mRem (TEDE). This guidance has been incorporated into the revised SHEM 38 guidance. These guidance include "Turn-back Levels" (shown in Table 2) that may be used at sites to ensure that these exposure limitations are not exceeded. Under this new guidance, EPA's On-Scene Coordinators are considered emergency workers, and thus the recommendations provided by EPA for emergency worker dose limitations, which are issued under EPA's *Protective Action Guidelines Manual* [EPA 3], are applicable.

> *People who are not trained in radiation should not be expected to serve in roles that will require them to be exposed to radiation levels that would exceed 100 mrem/year. Thus, these personnel (who may serve in roles as PIOs, headquarters liaisons, or emergency operations center personnel, at locations such as the FRMAC, Joint Field Office, or Emergency Operations Centers) should not be exposed to ionizing radiation that would increase their TEDE to greater than 100 mrem/year (limits considered acceptable to the general public). If such personnel must be deployed to forward locations (not including field work), they should be issued TLDs but the Agency's Administrative Control Level of 500 mrem/year should not be waived.*

Turnback Guidance for U.S. E.P.A. Personnel Responding To Radiological Emergencies

Table 1

Table 1: EPA Emergency Responder Dose Guidance from EPA-400		
Dose Limit TEDE[a] (rem*)	**Activity**	**Condition**
5	all	None
10	protecting valuable property	Voluntary; lower dose not practicable
25	lifesaving or protection of large populations	Voluntary; lower dose not practicable
>25	lifesaving or protection of large populations	**Only on a voluntary basis to persons fully aware of the risks involved**
[a] Sum of external effective dose equivalent and committed effective dose equivalent, or TEDE, to nonpregnant adults from exposure and intake during an emergency situation. These limits apply to all doses from an incident, except those received in unrestricted areas as members of the public. * For x and gamma radiation, Rad ~ rem ~ Roentgen (R).		
Exceeding the administrative control level requires concurrence of the senior EPA official onsite, the Incident Commander, the Health and Safety Officer, or the Radiation Safety Officer.		

Table 2

Table 2: EPA Emergency Responder Gamma Exposure Rate Turnback Levels			
Time Period	Employee Type	Turnback Level	Condition
Early Phase: (Release ONGOING)	OSCs, initial EPA responders	**10 R/hr**	Voluntary, with supervisor review, for lifesaving or critical actions ONLY – evaluate anticipated doses against dose limits above
Early Phase: (Release terminated)	OSCs, RERT-Forward, ERT and initial EPA responders		
Intermediate Phase: (Some data available)	OSCs, RERT-Forward, ERT	**1.5 R/hr**	Dose management imperative
Late Phase: Cleanup	Any EPA employees, RERT-Support and Home Teams	Site specific according to site health and safety plan	EPA Action Reference Level: 50 mrem/quarter *and* Administrative Control Level: 500 mrem/year
Important: DOSE MANAGEMENT should begin at 1 millirem per hour			

Table 3

Table 3: Respiratory Protection and Alpha/Beta	
Level D personal protective equipment (tyvek, boots, gloves) should be worn in the presence of *any* alpha or beta contamination above natural background.	
Appropriate respiratory protection should be worn in the presence of *loose* alpha or beta contamination above natural background.	
Incidents involving airborne alpha or beta emitters require proper instrumentation as noted below.	
At all times, worker exposures should be As Low As Reasonably Achievable.	
Alpha on the ground turnback level	**Beta** on ground turnback level
2000 dpm/100 cm² {≈ **400 cpm** with National Buy instrument Ludlum model 2241-2 (or comparable) coupled with alpha probe model 43-90}	**10,000 dpm/100 cm²** {≈ **400 cpm** with National Buy instrument Ludlum 2241-2 (or comparable) coupled with pancake probe model 44-9}
Leave the area until you have protective clothing and respiratory protection - evaluate actions against dose limits	**Leave the area** until you have protective clothing and respiratory protection - evaluate actions against dose limits
Informed safety decisions regarding subsequent site activities should be made based on air sample analysis and nuclide identification. These values assume a static measurement on the ground (or a flat surface) at distance of 1cm. Alpha-only or beta-only instruments may respond erroneously in a high gamma rate field – be aware!	

Table 4

Table 4: EARLY and INTERMEDIATE PHASE *EXAMPLE* STAY TIMES			
Exposure rates ↓	Up to **5 rem** TEDE limit for emergency operations	Up to **10 rem** TEDE when lower dose not practicable, only for protecting valuable property or infrastructure	Up to **25 rem** TEDE when lower dose not practicable, only for lifesaving or protecting large populations
0.1 R/hr	50 hours	100 hours	250 hours
1 R/hr	5 hours	10 hours	25 hours
5 R/hr	1 hour	2 hours	5 hours
10 R/hr	30 min.	1 hour	2.5 hours
25 R/hr	12 min.	24 min.	1 hour
50 R/hr	6 min.	12 min.	30 min.
100 R/hr	3 min.	6 min.	15 min.
Exposure rates or total doses in the shaded areas exceed guidance levels and are to be used only when critical actions or lifesaving are warranted. Gamma only – if airborne alpha or beta are present, appropriate respiratory protection must be used.			

2.3.1.1 Radiological Hazard Evaluation

Potential radiological hazards are described below by task number. Hazard Evaluation Sheets for major known contaminants are attached at the end of this plan.

Task Number	Radionuclide	DAC (mCi/ml)	Route(s) of Exposure	Major Radiation(s)	Energy(s) (MeV)	Half-Life
1-9	Cesium-137	6.0 x10^{-8}	External, Ingestion, Inhalation	Gamma Beta	.662 .173	30 yr
	Cobalt-60	7.0 x10^{-8}	External, Ingestion, Inhalation	Gamma Beta	1.1 1.3	5.3

The daughter product of Cesium -137 is Barium-137m, a radionuclide with a half-life of 2.552 minutes. Due to secular equilibrium, Ba-137m builds up in C-137 sources to an activity essentilly equal to that of Cs-137.

2.3.1.2 Radiological Hazard Control

Engineering/administrative controls and work practices shall be instituted to reduce and maintain employee exposures to a level at or below the permissible exposure/dose limits (see sections 4.2.3 and 5.5.1). Whenever engineering/administrative controls and work practices are not feasible or effective, any reasonable combination of engineering/administrative controls, work practices, and PPE shall be used to reduce and maintain employee exposures to a level at or below permissible exposure/dose limits.

Applicable Engineering/Administrative Control Measures:

Time, distance, shielding, PPE, monitor exposure with real-time dosimters.

3. EMPLOYEE TRAINING

Personnel will not be assigned to perform response tasks, use assigned levels of PPE or site specific monitoring equipment, or be assigned leadership roles unless they have been trained and have demonstrated competence in each specific area.

Prior to work, team members shall have received training as indicated below. (Indicate with "X")

Required Training
Radiation Basic Training (as described in EPA's Report 38)
Radiation Advanced Training (as described in EPA's Report 38)
Annual Radiation Refresher (as described in EPA's Report 38)
40-Hour OSHA HAZWOPER Initial Training and Annual Refresher (29 CFR 1910.120)
Annual First Aid / CPR
8-Hour General Radiation Health & Safety
DOT and Biannual Refresher (for handling and transportation of samples)
40-60 Hours of advanced NBC (domestic preparedness) response training beyond the 29 CFR 1910.120

NOTE:

1. Personnel functioning independently of an immediate supervisor must have a minimum of 3 days of actual field experience

under a skilled supervisor.

2. All employees must have had training to recognize the symptoms and signs of over-exposure to the chemical, biological, and/or radiation hazards present.

3. If there is no medical facility in proximity to the site, training records in the HASP must indicate at least one individual on-site is adequately trained to render first aid.

If any training above has been waved for any member, explain:

4. LEVEL OF PROTECTION (LOP) AND PERSONAL PROTECTIVE EQUIPMENT

4.1 LEVEL OF PROTECTION

The Table below indicates the levels of protection (LOPs) which have been selected for each work task based on an evaluation of the potential or known hazards, the routes of potential hazard, and the performance specifications of the PPE. On-site monitoring results and other information obtained from on-site activities will be used to modify these LOPs and the PPE, as necessary, to ensure sufficient personnel protection. The authorized LOP and PPE shall only be changed with the approval of the site SHSO.

Levels of Protection Table 1

Task #	**A**	**B X**	**C(X)**	**D**	**Modifications Allowed (*None*)**

Note: Use "X" for initial levels of protection. Use "(X)" to indicate levels of protection that may be used as site conditions warrant. Refer to Section 3 of this SHASP for Training Requirements.

4.2 PERSONAL PROTECTIVE EQUIPMENT

The PPE selected for each task is indicated in the Tables below. Refer to 29 CFR 1910.120 for the minimum PPE required for each LOP.

5. MEDICAL SURVEILLANCE

5.1 MEDICAL SURVEILLANCE PROGRAM

Team members shall actively participate in their applicable medical surveillance program and shall have received, within the past year, an appropriate physical examination and health rating.

Team members should inform the Site Health and Safety Officer of any allergies, medical conditions, or similar situations that are relevant to the safe conduct of the work to which this SHASP applies.

Site personnel who may be exposed at or above the OSHA-PELs or other published exposure levels must wear a respirator. If the individual wears a respirator 30 or more days each year the individual must be enrolled in a comprehensive medical monitoring program before working on site.

5.1.1 OTHER MEDICAL SURVEILLANCE PROCEDURES

5.2 RADIATION EXPOSURE

Is there a concern for radiation at the site? ☑ Yes ☐ No

5.2.1 External Dosimetry

Thermoluminescent Dosimeter (TLD) Badges: TLD

Pocket Dosimeters: No

Other: Siemens EPD real time. Dose Management at 1 mR/hr

5.2.2 Internal Dosimetry

☐ Whole body count ☐ Bioassay ☐ Other:

Requirements: *Based on site conditions Internal dosimetry may be required.*

Participants who are exposed to loose (i.e., removable) radioactive material or who work in areas where radioactive material may be inhaled may be asked to submit bioassay samples and participate in whole-body, lung, or wound counting. (Bioassay is the term that is used to describe the assessment of the quantity of radioactive material present in the body.) The NRC requirements state that “a bioassay is required to verify the performance of a respirator, if intake would have exceeded 10% of an ALI [Annual Limit on Intake] before credit was taken for a protection factor” [add reference]. The evaluation of an individual’s CEDE will be based on bioassay data rather than air concentration values unless bioassay data are unavailable or inadequate, or internal dose estimates based on representative air concentration values are demonstrated to be as, or more, accurate. If necessary, EPA’s ORIA and SHEMP, working with REAC/TS, will develop a site-specific Bioassay Plan for inclusion in the site-specific H&S Plan. Preliminary CEDE estimates, based upon air sampling results, will be performed under the responsibility of the Health and Safety Manager. Dose assessments, based on bioassay results, will be assigned after samples have been collected and analyzed. Personnel shall be notified promptly of a confirmed positive bioassay result and the results of dose assessments and subsequent refinements.

The internal dose assessment program will involve the tracking and review of air monitoring results to determine trends, and collecting nasal smears or nose blow samples, urine samples, or fecal samples to monitor intakes of transportable radionuclides. Additionally in vivo measurements are used to monitor the deposition of non-transportable radionuclides. The internal dose assessment program should be designed to rapidly detect a release of radioactive material and/or a breach of respiratory protection.

There are two types of bioassays:

In vivo bioassay involves counting the living tissue.
In vitro involves counting samples, such as urine, blood, phlegm, nasal smears, etc.

Bioassays may be required during general operations or may be initiated in response to an occurrence to determine if there has been an intake of radioactive material. Bioassay sampling may be requested to provide follow up to a known intake in order to quantify the intake and to monitor the status of the radioactivity to refine the dose assessment, depending on the radionuclide, method of ingestion/inhalation, and biological half life.

5.2.3 Radiation Dose

Emergency Response Dose Limits: Implementation of these dose limits may be designated on a site-specific basis. 5 REM TEDE During Emergenct Response Phase.

Site-Specific Dose Limits: Once ER Phase is over 500 mRem ACL should be used.

ALARA Policy: Radiation doses to site personnel shall be maintained as low as reasonably achievable (ALARA), taking into account the work objective, state of technology available, economics of improvements in dose reduction with respect to overall health and safety, and other societal and socioeconomic considerations.

6. AIR AND PERSONNEL MONITORING

Health and safety monitoring will be conducted to ensure proper selection of engineering/administrative controls, work practices, and/or PPE so that employees are not exposed to hazardous substances at levels that exceed permissible exposure/dose limits or published exposure levels. Health and safety monitoring will be conducted using the instruments, frequency, and action levels for the hazard present. Health and safety monitoring instruments shall have been appropriately calibrated and/or performance. Monitoring must also be performed for high risk employees.

6.1 Oxygen, Combustible Gases, Toxic Gases, and Radiation Hazard Evaluation

Upon initial entry all chemical, biological, and radioactive materials will be characterized. Oxygen, combustible gases, toxic gases and radiation will be monitored.

6.2 Hazard Monitoring

Oxygen Contentration	☑ Continuous ☐ Intermediate ☐ Other:
Combustible Gaes	☑ Continuous ☐ Intermediate ☐ Other:
Toxic Gases	☑ Continuous ☐ Intermediate ☐ Other:
Radiation	☑ Gamma Decay ☑ Beta Decay ☑ Alpha Decay
Other:_________________________	☐ Continuous ☐ Intermediate ☐ Other:________________________________
Other:_________________________	☐ Continuous ☐ Intermediate ☐ Other:________________________________
Other:_________________________	☐ Continuous ☐ Intermediate ☐ Other:________________________________
Other _________________________	☐ Continuous ☐ Intermediate ☐ Other:________________________________

Instrumentation Equipment Checklist

Equipment	No	Equipment	No
Multi-gas monito6 Type:__Multi-Rae Plus/Draeger Multi-warn	3	Calibration Gas	X
O₂/Explosimeter with Cal. Kit		Single Gas Monitor Type:____	
Wipe Samples	X	Total Station	
Glassine envelopes	X	Noise Dosimeter	
NaI Detector	4	Draeger Pump, Tubes _________________________	
Accuro Pump, Tubes __________________________		Real-time Aerosol Monitor Data RAM 4	2
Personal Real-time Aerosol Monitor		XRF, Portable	
Hazard Categorization Kit, with Gas		Infrared Monitor	
Ion Chamber	1	Ground Penetrating Radar	
TLDs	8	SAM-935 MCA	1
Siemens EPD Mk2 Dosimeters	8	Terrain Resistivity Meter with ACC's	
___EM-31 ___EM-34		Generator	2
Weather Station;___Datalogger		Heat Stress Monitor	
Wind Guage, Hand Held		pH: ___Paper;___Pen;___Meter	
Conductivity Probe/Pen		Water Quality Tester	
Dissolved Oxygen Meter		Relative Humidity: ___Probe; ___Pen	
H₂S Test Strips		RADeCO Air Samplers	3
2241-2 + Pancake GM	2	Sling Psychfrometer	
Interscan __SO<sub2</sub> __H₂S		LB5211 47mm filter paper	X
2241-2 + 43-90 alpha scintillation	2	Chlor-n-soil Kit	
Batteries for Equipment	X		

Sampling Equipment Checklist

Equipment	No	Equipment	No
Glass Bottles (sizes ___________________)		Glass Bottles, Wide Mouth (________________)	
VOA Bottles (40mL)		Polyethylene Bottles (size_______)	
Sample Preservatives: ___HNO₃, ___NaOH, ___H₂SO₄, ___HCL		Hand Bailers	
String and/or Rope		Personal Air Sampling Pumps with Calibrator, Chargers, Supplies	
Air Flow Calibrator		Generator(s), Portable	
High-Volume Air Samplers with Calibrators: ___PM-10; ___PS-1; ___PM-2.5		High-Flow Air Sampler	
Analytical Balance		Water level Indicator	
Well Pump		Cat Head/Motpr/Pulley	
Sampling Platform (Boat)		Kemmerer Water Sampler	
Eckman Dredge		Trowels and/or Spoons	
Shovel and/or Post-Hole Digger		Mixing Plates and/or Bowls	
Sieves		Hand Auger (size ________________)	
Sleeves/Caps/Extensions		Split Spoon Sampler	
Geoprobe		Soil Gas Tile Probe with Accessories	
Slam Bar (Size __________)		Extensions/Sleeves/Caps	
Soil Probe		Knives and/or Scissors	
Plastic Sample Bags	X	Plastic Sheeting	
Surveying: ___Flags; ___Tape		Auto Level; ___Tripod	
Field Transit; ___Tripod		Brunton Compas; ___Rod, 25ft.	
Chain or Tape (200ft.) and/or Rolatape		Hand-held GPS (_______________)	
Non-Sparking Tools		Thieving Rods with Bulbs	
Coliwasa Samplers with Tubes		Sudge Judge	

Spray Paint/ Marker		pH Paper	

7. SITE CONTROL

7.1 SITE LAYOUT AND WORK ZONES

Site Work Zones:	Work zones will be established and clearly marked prior to beginning operations. All personnel will be made aware of the zone boundaries and the operations permitted in each. **ATTACH A MAP OR SITE SKETCH TO THIS PLAN, INDICATING THE DESIGNATED SITE WORK ZONES.**
Site Access Requirements and Special Considerations	Only those personnel directly involved with the operations will be allowed on site. All personnel entering the exclusion zone will be “logged” in and out. Site-specific access requirements will be followed.
Illumination Requirements:	Intrinsically safe lighting will be used as needed. Lighting should be of such power and be so positioned that a minimum amount of shadows are created within the working area. Team members will use intrinsically safe flashlights.
Sanitary Facilities (toilet, shower, potable water):	Available nearby or local sanitary facilities will be identified. If additional facilities are needed, the team will make those arrangements. **FACILITIES LOCATED WITHIN THE EXCLUSION ZONE WILL NOT BE USED BY TEAM MEMBERS.**
On-Site Communications:	Communication methods and procedures will be selected that are appropriate for the tasks, needs, and PPE. Only intrinsically safe communication devices shall be used within the exclusion zone. If two-way radios are to be utilized on site, prior to beginning operations, frequency assignments will be given and made known to all team members.
Other Site-Control Requirements:	

7.2 SAFE WORK PRACTICES

Daily Safety Meeting:	A daily safety meeting will be conducted for all team members and documented on the Daily Safety Meeting Record form or in the field logbook. The information and data obtained from applicable site characterization and analysis will be addressed in the safety meetings and also used to update this SHASP, as necessary.
Work Limitations:	Site work will be limited to 12 hours per day for 12 consecutive days, except for emergency responses. Work will be performed only during daylight hours unless appropriate lighting is available. Work - rest cycles will be determined as site conditions allow.
Weather Limitations:	Outdoor operations will cease during electrical storms. The Site Health and Safety Officer will determine if other inclement weather conditions pose a safety threat to team members.
Buddy System:	At all times, field work will be conducted according to the buddy system, using no fewer than 2 members per team.
Line of Sight:	Each team member shall remain in the line of sight and within verbal/signal communication of at least one other team member, who is in the line of sight or communications (radio) with the team leader, Site Health and Safety Officer or other personnel having the means to effect/call rescue or EMS services.
Eating, Drinking, and Smoking:	Eating, drinking, smoking, and the use of tobacco products shall be prohibited in the exclusion and contamination reduction zone, at a minimum, and shall only be permitted in designated (clearly marked) areas of the support zone.
Contamination Avoidance:	Team members shall avoid unnecessary contamination of personnel, equipment, and materials to the extent practicable. Personnel will avoid all contact with potential contamination at all times. While in the exclusion zone, personnel will not sit, kneel or otherwise come in contact with potentially contaminated surfaces. Equipment will not be placed on unprotected surfaces. All personnel and equipment in the exclusion zone will require decontamination prior to leaving the site. Contact with any potential contamination will be brought to the attention of the Site Health and Safety Officer and decontamination personnel.
Sample Handling:	Protective gloves, of a type designated in section 6 will be worn when containerized samples are handled for labeling, packaging, transportation, and other purposes. Samples will not be handled prior to decontamination. Decontamination of sample containers will follow the procedures outlined for equipment decontamination. Samples will be stored in a secure area at all times in order to follow custody requirements.
Vermiculite Handling:	Respiratory protection (i.e., high-efficiency particulate air filtration) is recommended when vermiculite is used to package samples into shipping containers (some vermiculite contains low concentrations of asbestos).
Equipment and Supplies:	A checklist of equipment and supplies that may be needed for this work has been established. Additionally required equipment may be added to the list. Use of this list assists in the procurement, packaging and field availability of needed equipment.
Nearest Medical	:

Assistance and Phone Number:

Other Safe Work Practices: Secondary hazards (devices) should be identified and removed from the site by properly trained Explosive Ordnance Disposal (EOD) or similarly trained personnel, prior to team entry. Items (boxes, packages, etc.) which have not been monitored by EOD personnel will not be approached or handled in any manner.

8. GENERAL DECONTAMINATION PROCEDURES

All equipment, materials, and personnel will be evaluated for contamination upon leaving the exclusion zone. Equipment and materials will be decontaminated and/or disposed and personnel will be decontaminated as necessary. Decontamination will be performed in the contamination reduction corridor or any designated area such that the exposure of uncontaminated employees, equipment, and materials will be minimized. General decontamination procedures and decontamination solutions are described below.

Personnel Decontamination Procedures:	Personnel decontamination will follow pre-established and rehearsed procedures as outlined in Attachment 3 – Decontamination Procedures. All personnel who have entered the contaminated area will require decontamination. Depending on the level of protection (LOP) used (A; B; C), personnel will be required to go through multiple steps within the decontamination stations. Specific descriptions of the decontamination station steps and appropriate decontamination solutions are located in Attachment 3. Depending on the situation and available information, dry decontamination methods will be used whenever feasible to avoid potential cross-contamination of personnel and equipment and to preclude the creation of large amounts of decontamination and rinsing liquids.
PPE Requirements for Personnel Performing Decontamination:	Personnel performing decontamination procedures will be outfitted in personal protective equipment (PPE) at the same or no more than one level lower than team members. EXAMPLE: Team members are in Level A – Decontamination Personnel will be in Level B. Personnel operating stations where fluids (neutralization and rinsing) are used will require splash protection.
General Personnel Decontamination:	Following appropriate decontamination procedures, all team members will wash their hands and face with soap and water. Team members should shower at the end of each work shift, regardless of their activities on-site.
Disposable PPE:	Disposable PPE will be rendered unusable when removed. Disposable PPE will be treated with an appropriate decontamination solution, double bagged, labeled, and stored in a secure area. PPE will be disposed of as hazardous waste, in accordance with applicable regulatory requirements.
Equipment & Material Decontamination Procedures:	When feasible, all equipment taken into the contaminated area will be protected with plastic. Care should be taken to avoid obstructing intake and exhaust vents/ports on equipment. Equipment should not be placed on unprotected surfaces while in the exclusion zone. Equipment will be placed at the pre-established equipment drop station prior to entry in the contamination reduction corridor. **NO EQUIPMENT WILL BE BROUGHT DIRECTLY INTO THE CONTAMINATION REDUCTION CORRIDOR FROM THE EXCLUSION ZONE**. The plastic protection wrap on the equipment will be misted as needed with a decontamination solution, wiped clean, double bagged, labeled and disposed of with other hazardous wastes. After the outer wrapping has been removed, the equipment will be wiped again and placed in a clean area for re-use or calibration.
Disposal of Decontamination Wastes (e.g., dry wastes, decontamination fluids, etc.):	Dry wastes will be treated if needed with a decontamination solution, double bagged, labeled and stored in a secure area until disposal. Decontamination and rinsing solutions will be drummed, labeled and stored in a secure area. Disposal of both dry and liquid wastes will be arranged according to applicable regulatory requirements. Stored wastes will be kept in a secure area at all times.

Ventilation: All decontamination procedures will be conducted in a well-ventilated area, preferably outdoors and downwind of the support zone. If decontamination must be performed indoors, adequate mechanical ventilation will be provided for the decontamination work.

Additional information can be found in *Nuclear, Biological, and Chemical (NBC) Site Entry and Egress Draft Standard Operating Procedure*.

Decontamination Equipment Checklist

Equipment	No	Equipment	No
Wash tubs	1	Bucket	1
Scub Brushes	2	Pressurized Sprayer	1
Detergent (Type:______________)		Solvent (Type: __RADCON____________)	2
Household Bleach Solution		Distilled Water	
Deinonized Water		Disposable Facepiece Sanitizer Wipes	
Face Mask Sanitizer Powder		Wire Brush	2
Spray Bottle		Banner/Barrier Tape	
Plastic Sheeting		Tarps and Poles	
Trash Bags		Trash Cans	1
Masking Tape		Duct Tape	X
Paper Towels		Folding Chairs	
Step Ladders		5-Gallon Water Jugs	
Tables		Steam Cleaner with Generator	

9. SPILL CONTAINMENT PROGRAM

N/A

10. CONFINED SPACE ENTRY PROCEDURES

N/A

11. EMERGENCY RESPONSE

This section contains additional information pertaining to on-site emergency response and does not duplicate pertinent emergency response information contained in earlier sections of this plan (e.g., site layout, monitoring equipment, etc.). Emergency response procedures will be rehearsed regularly, as applicable, during all response site activities.

11.1 EMERGENCY RESPONSIBILITIES

All Personnel: All team members shall be alert to the possibility of an on-site emergency; report potential or actual emergency situations to the team leader and SSO; and notify appropriate emergency resources, as necessary.

Personnel will be made aware of their roles and responsibilities for emergency situations. Emergency response procedures, evacuation routes, and assigned responsibilities will be reviewed prior to beginning response operations.

Team Leaders: The team leaders will determine the emergency actions to be performed by team members and will direct these actions. The team leader also will ensure that applicable incidents are reported to the SSO. During emergency situations, team leaders will follow pre-established procedures and take direction from the SSO.

SHS: The SHS will recommend health/safety and protective measures appropriate to the emergency.

Other:

11.2 LOCAL AND SITE RESOURCES

Local Ambulance & Phone:	**Primary**	**Alternate**
	Name: Superior **Phone:** 312-555-1212	**Name: Critical Mass** **Phone: 312-555-1212**

Hospital Name & Phone:	**Primary**	**Alternate**
	Name: Northwestern Memorial **Phone:** 312-555-1212	**Name:** Rush Presbeterian **Phone:** 312-555-1212

Directions to Primary Hospital

Take Jackson to Michigan Avenue, go 2 Miles North and make a right on Superior street. Emergency Room enterance on left.

Police Dept.	**Primary**	**Alternate**
	Name: Mike Gierczek **Phone:** 312-555-1212 **Radio Frequency:** Cha. 6 Freq. 173.2 **Call Sign: P2**	**Name:** **Phone:** **Radio Frequency:** **Call Sign:**

Fire Dept.	**Primary**	**Alternate**
	Name: Terry Sheehan **Phone:** 312-555 1212 **Radio Frequency:** Chan 6 Freq 173.2 **Call Sign:** DOE 1	**Name:** **Phone:** **Radio Frequency:** **Call Sign:**

Poison Control Hotline:	**Name:** John Emerald **Phone:** 312-555-1212
DOE REAC/TS: (Radiation Emergency Assistance Center / Training Site)	REAC/TS is an emergency response team of Health & Safety Professionals and Radiation Medical Support that provides 24-hour medical consultation on health problems associated with radiation acidents. **Emergency Phone Number: +1 865 576 1005** *(ask for REAC/TS)*
Potentionally Responsible Party Contact:	**Name: N/A** **Phone:**
Site Contacts:	**Name: N/A** **Phone:** **Name:** **Phone:**

	Name: **Phone:**

On-Site Phone:	**Name:** **Phone: Unavailable** **Fax:** **Other:**	**Name:** **Phone:** **Fax:** **Other:**	**Name:** **Phone:** **Fax:** **Other:**

Other Resource Information:

Incident Reporting Procedures:

11.3 OTHER EMERGENCY RESPONSE PROCEDURES

On-Site Evacuation Signal/Alarm	**Primary**	**Alternate**
* Audible alarms must be perceptible above ambient noise. If visible (light) alarms are used, they must be distinguishable from ambient light levels and sources.	3 Blows on air horn	Repeated 3 blows on car horn

On-Site Assembly Area	**Primary**	**Alternate**
	Clark and Harrison Command Post	Federal Building 536 S. Jackson

Emergency Egress Route	**Primary**	**Alternate**
	Adams and LaSalle Street	Clark and Jackson

Off-Site Assembly Area	**Primary**	**Alternate**
	Chicago Fire Academy	None

Emergency Reporting:

Site Security and Control: In an emergency situation, team members will leave the area as per the pre-established routes and not re-enter the area until the emergency situation has been terminated. During an emergency situation, routine operations will stop until the emergency is over. Personnel will attempt to control site access.

Emergency Decontamination Procedures: Personnel will be decontaminated sufficiently so they are no longer a threat to those performing decontamination. Gross visible contamination will be removed. Outer PPE will be removed, the contaminant neutralized, and the PPE will be held for possible testing. Emergency first aid (to save life or limb) will be conducted to the extent available on site. The victim will be wrapped in such a manner as to avoid contamination of the transportation vehicle and taken to the nearest medical treatment facility. The facility will be contacted and informed of the victim's scheduled arrival and possible exposure.

PPE: Team members will don appropriate PPE when responding to an emergency situation. The SHSO and Section 6 of this plan will provide guidance regarding appropriate PPE. Unless it is obvious that a victim suffered a physical injury, personnel will don a level of PPE one higher than the victim. Emergency response personnel will undergo decontamination prior to leaving the site. This can be accomplished at the same time the victim is undergoing emergency decontamination .

Emergency Equipment: Adequate supplies of equipment shall be maintained in the support zone or other approved work locations. Emergency equipment should not be taken into the exclusion zone unless protected from contamination. Unprotected emergency equipment may require disposal unless decontamination can be accomplished or the equipment is disposable.

12. SUPPORTING DOCUMENTATION

Radioactive Material Safety Data Sheet

This data sheet presents information on radioisotopes only.
For information on chemical compounds incorporating this radionuclide, see the relevant Material Safety Data Sheet.

Cesium-137

Part 1 – Radioactive Material Identification

Common Names:	Cesium-137	**Chemical Symbol:**	Cs-137 or ^{137}Cs
Atomic Number:	55	**Mass Number:**	137 (82 neutrons)
Chemical Form:	Cesium chloride	**Physical Form:**	A pellet of cesium ceramic housed in a welded stainless steel capsule

Part 2 – Radiation Characteristics

Physical half-life: 30.22 years **Specific Activity (GBq/g):** 3,220

Principle Emissions	EMax (keV)	Eeff (keV)	Dose Rate (mSv/h/GBq at 1m)	Shielding Required
Beta* (*B*)	511 (94.6%)	157	-	-
Gamma (*y*) / X-Rays	662 (89.9%)	-	103[a]	HVL Lead: 0.65 cm
Alpha (*a*)	**-**	**-**	**-**	**-**
Neutron (*n*)	**-**	**-**	**-**	**-**

* Where Beta radiation is present, Bremsstrahlung radiation will be produced. Shielding may be required.
Note: Only emissions with abundance greater than 10% are shown.
a *The Health Physics and Radiological Health Handbook,* Scintra, Inc., Revised Edition, 1992

Progeny: Barium-137m (Ba-137m)

Part 3 – Detection and Measurement

Methods of detection (in order of preference)

1. A radiation survey meter equipped with an energy-compensated Geiger Mueller detector.
2. Ion chamber survey meter – tends to be less sensitive than a Geiger Mueller survey meter but is able to respond more precisely in higher radiation fields.
3. Gamma scintillation detector – very sensitive but is also energy dependent. Must be calibrated for Cs-137 before it can be used for dose assessment surveys.

Dosimetry

Whole Body ☑	Skin ☐	Extremity ☐	Neutron ☐

Internal:	Sealed sources pose no internal radiation hazard. However, in the event of loss of containment by the sealed source, all precautions should be taken to prevent inhalation or ingestion of the material.	
Critical Organ(s):	None known at this time.	
Annual dose limits:	*Non-nuclear energy workers:* *Nuclear energy workers:*	1mSv per year a) 50 mSv in one year b) 100 mSv total over five years
	Pregnant nuclear energy workers:	4 mSv over the balance of the pregnancy

Part 4 – Preventive Measures

Always use the principles of time, distance and shielding to minimize dose

Engineering Controls:	Sealed radioactive sources used in industrial applications should always be within a protective source housing to minimize radiation dose and to protect the source capsule from damage.
Personal Protective Equipment (*for normal handling of unsealed sources only. Always wear disposable gloves, safety glasses, personal protective equipment and clothing as appropriate to the material handled).*	No special PPE required.

Special Storage Requirements:	None

Part 5 – Control Levels

Oral Ingestion	Inhalation	
ALI (kBq)	ALI (kBq)	DAC (Bq/ml)
3700	7400	2.2×10^{-3}
Exemption Quantity (EQ):	10,000 Bq	

Part 6 – Non-Radiological Hazards

No potential health effects are known regarding non-radiological hazards associated with cesium. However, large oral doses of the material may cause gastrointestinal disturbances. Chronic effects are not known at this time.
OSHA Permissible Exposure Limit (PEL):
15 mg/m^3 total dust, 5 mg/m^3 respirable fraction for nuisance dusts

Part 7 - Emergency Procedures

*The following is a guide for first responders. The following actions, including remediation, should be carried out by qualified individuals. In cases where life-threatening injury has resulted, **first** treat the injury, **second** deal with personal decontamination.*

Personal Decontamination Techniques
· Wash well with soap and water and monitor skin
· Do not abrade skin, only blot dry
· Decontamination of clothing and surfaces are covered under operating and emergency procedures

Spill and Leak Control
· Alert everyone in the area
· Confine the problem or emergency (includes the use of absorbent material)
· Clear area
· Summon Aid

Damage to Sealed Radioactive Source Holder
· Evacuate the immediate vicinity around the source holder

· Place a barrier at a safe distance from the source holder (min. 5 meters)
· Identify area as a radiation hazard
· Contact emergency number posted on local warning sign

Suggested Emergency Protective Equipment
· Gloves
· Footwear Covers
· Safety Glasses
· Outer layer or easily removed protective clothing (as situation requires)

Revision Date:	December 17, 2001
This information was prepared by:	DOE ANL

Human Health Fact Sheet *ANL, October 2001*

Cesium

What Is It? Cesium is a soft, silvery white-gray metal that occurs in nature as cesium-133. The natural source yielding the greatest quantity of cesium is the rare mineral pollucite. American ores of pollucite, found in Maine and South Dakota, contain about 13% cesium oxide. Although it is a metal, cesium melts at the relatively low temperature of 28^o C (82^o F), so like mercury it is liquid at moderate temperatures. This most alkaline of metals reacts explosively when it comes in contact with cold water. There are 11 major radioactive isotopes of cesium. (Isotopes are different forms of an element that have the same number of protons in the nucleus but a different number of neutrons.) Only three have half-lives long enough to warrant concern: cesium-134, cesium-135 and cesium-137. Each of these decays by emitting a beta particle, and their half-lives range from about 2 to 2 million years. The half-lives of the other cesium isotopes are less than two weeks. Of these three, the isotope of most concern for Department of Energy (DOE) environmental management sites such as Hanford is cesium-137 which has a half lifeof 30 years. Its decay product, barium-137m (the"m" means metastable) stabilizes itself by emitting an energetic gamma ray with a half-life of about 2.6 minutes. It is this decay product that makes cesium an external hazard (that is, a hazard without being taken into the body). Cesium-135 and cesium-134 are typically of less concern because of their radiological decay characteristics. The very long half-life of cesium-135 means it has a very low specific activity, and the slow decay rate combined with its low decay energy contribute to its low hazard. Cesium-134 has a half-life of 2.1 years and decays by emitting a beta particle. The relatively small amount of cesium-134 produced more than 20 years ago would essentially all be gone today due to radioactive decay.

Where Does It Come From? Cesium is naturally present as the isotope 133 in various ores and to a lesser extent in soil. The three radioactive cesium isotopes identified above are produced by nuclear fission. When an atom of uranium-235 (or other fissile nuclide) fissions, it generally splits asymmetrically into two large fragments – fission products with mass numbers in the range of about 90 and 140 – and two or three neutrons. (The mass number is the sum of the number of protons and neutrons in the nucleus of the atom.) Cesium radionuclides are such fission products, with cesium-135 and cesium-137 being produced with relatively high yields of about 7% and 6%, respectively. That is, about 7 atoms of cesium-135 and 6 atoms of cesium-137 are produced per 100 fissions. Cesium-137 is a major radionuclide in spent nuclear fuel, highlevel radioactive wastes resulting from the processing of spent nuclear fuel, and radioactive wastes associated with the operation of nuclear reactors and fuel reprocessing plants.

How Is It Used? Cesium metal is used in photoelectric cells and various optical instruments, and cesium compounds are used in the production of glass and ceramics. Cesium-137 is also used in brachytherapy to treat various types of cancer. (Brachytherapy is a method of radiation treatment in which sealed sources are used to deliver a radiation dose at a distance of up to a few centimeters by surface, intracavitary, or interstitial application.)

What's in the Environment? Cesium-133 exists naturally as a stable isotope. The concentration of cesium in the earth's crust is 1.9 milligrams per kilogram (mg/kg), and the concentration in sea water is about 0.5 micrograms/kg. Cesium has been shown to biomagnify in aquatic food chains. Radioactive cesium is present in soil around the world largely as a result of fallout from past atmospheric nuclear weapons tests. The concentration of cesium-137 in surface soil from fallout ranges from about 0.1 to 1 picocurie (pCi)/g, averaging less than 0.4 pCi/g (or 0.3 billionth of a milligram per kilogram soil). Cesium is present as a contaminant at certain facilities, such as nuclear reactors and facilities that process spent nuclear fuel.

Cesium is generally one of the less mobile radioactive metals in the environment. It preferentially adheres quite well to soil, and the concentration associated with sandy soil particles is estimated to be 280 times higher than in interstitial water (water in the pore space between soil particles); concentration ratios are much higher (about 2,000 to more than 4,000) in clay and loam soils. Thus, cesium is generally not a major contaminant in groundwater at DOE sites. At Hanford, the highest concentrations of cesium-137 are in areas that contain waste from processing irradiated fuel, such as in the tanks in the central portion of the site and to a lesser degree in the former liquid disposal areas along the Columbia River.

What Happens to It in the Body? Cesium can be taken into the body by eating food, drinking water, or breathing air. After being taken in, cesium behaves in a manner similar to potassium and distributes uniformly throughout the body. Gastrointestinal absorption from food or water is the principal source of internally deposited cesium in the general population. Essentially all cesium that is ingested is absorbed into the bloodstream through the intestines. Cesium tends to concentrate in muscles because of their relatively large mass. Like potassium, cesium is excreted from the body fairly quickly. Ten percent is excreted with a biological half-life of 2 days, and the rest leaves the body with a biological half-life of about 110 days. This means that if someone is exposed to radioactive cesium and the source of exposure is removed, much of the cesium will readily clear the body along the normal pathways for potassium excretion within several months.

What Are the Primary Health Effects? Cesium-137 presents an external as well as internal health hazard. The strong external gamma radiation associated with its short-lived decay product barium-137m makes external exposure a concern, and shielding is often needed to handle materials containing large concentrations of cesium. While in the body, cesium poses a health hazard from both beta and gamma radiation, and the main health concern is associated with the increased likelihood for inducing cancer.

What Is the Risk? Lifetime cancer mortality risk coefficients have been calculated for nearly all radionuclides, including cesium *(see box at right).*While the coefficients for ingestion are somewhat lower than for inhalation, ingestion is generally the most common means of entry into the body. Similar to other radionuclides, the risk coefficients for tap water are about 80% of those for dietary ingestion.

In addition to risks from internal exposures, there is a risk from external gamma exposure. Using the external gamma risk coefficient to estimate a lifetime cancer mortality risk, if it is assumed that 100,000 people were continuously exposed to a thick layer of
soil with an initial average concentration of 1 pCi/g cesium-137, then 6 of these 100,000 people would be predicted to incur a fatal cancer. (This is in comparison to the 25,000 people from the group predicted to die of cancer from all other causes per the U.S. average.) This risk is largely associated with the gamma ray from barium-137m.

Radioactive Material Safety Data Sheet

This data sheet presents information on radioisotopes only.
For information on chemical compounds incorporating this radionuclide, see the relevant Material Safety Data Sheet.

Cobalt-60

Part 1 – Radioactive Material Identification

Common Names:	Cobalt-60	**Chemical Symbol:**	Co-60 or ^{60}Co
Atomic Number:	27	**Mass Number:**	60 (33 neutrons)
Chemical Form:	Cobalt metal	**Physical Form:**	Thin cylinder of cobalt metal

Part 2 – Radiation Characteristics

Physical half-life:	5.27 years	**Specific Activity (GBq/g):**	41,800

Principle Emissions	^{E}Max (keV)	^{E}eff (keV)	Dose Rate (mSv/h/GBq at 1m)	Shielding Required
Beta* (*B*)	318 (100%)	96	-	-
Gamma (y) / X-Rays	1173 (100%) 1332 (100%)	-	370[a]	HVL Lead: 1.2 cm
Alpha (*a*)	-	-	-	-
Neutron (*n*)	-	-	-	-

* Where Beta radiation is present, Bremsstrahlung radiation will be produced. Shielding may be required.
Note: Only emissions with abundance greater than 10% are shown.
[a] *The Health Physics and Radiological Health Handbook,* Scintra, Inc., Revised Edition, 1992

Progeny: Nickel-60 (Ni-60)

Part 3 – Detection and Measurement

Methods of detection (in order of preference)

1.	A radiation survey meter equipped with an energy-compensated Geiger Mueller detector.
2.	Ion chamber survey meter – tends to be less sensitive than a Geiger Mueller survey meter but is

	able to respond more precisely in higher radiation fields.
3.	Gamma scintillation detector – very sensitive but is also energy dependent. Must be calibrated for Co-60 before it can be used for dose assessment surveys.

Dosimetry

Whole Body ☑ Skin ☐ Extremity ☐ Neutron ☐

Internal:	Sealed sources pose no internal radiation hazard. However, in the event of loss of containment by the sealed source, all precautions should be taken to prevent inhalation or ingestion of the material.
Critical Organ(s):	None known at this time.
Annual dose limits:	*Non-nuclear energy workers:* 1mSv per year *Nuclear energy workers:* a) 50 mSv in one year b) 100 mSv total over five years *Pregnant nuclear energy workers:* 4 mSv over the balance of the pregnancy

Part 4 – Preventive Measures

Always use the principles of time, distance and shielding to minimize dose

Engineering Controls:	Sealed radioactive sources used in industrial applications should always be within a protective source housing to minimize radiation dose and to protect the source capsule from damage.
Personal Protective Equipment (for normal handling of unsealed sources only. Always wear disposable gloves, safety glasses, personal protective equipment and clothing as appropriate to the material handled).	No special PPE required.
Special Storage Requirements:	None

Part 5 – Control Levels

Oral Ingestion Inhalation	Inhalation	
ALI (kBq)	ALI (kBq)	DAC (Bq/ml)
18,500	7,400	2.6×10^{-3}
Exemption Quantity (EQ):	100,000 Bq	

Part 6 – Non-Radiological Hazards

Prolonged exposure to airborne particles mat result in coughing, dyspnea, decreased pulmonary functioning and respiratory hypersensitivity. Confirmed animal carcinogen with unknown relevance to humans.
OSHA Permissible Exposure Limit (PEL):
0.1 mg/m^3

Part 7 - Emergency Procedures

The following is a guide for first responders. The following actions, including remediation, should be carried out by qualified individuals. In cases where life-threatening injury has resulted, first treat the injury, second deal with personal decontamination.

Personal Decontamination Techniques
· Wash well with soap and water and monitor skin
· Do not abrade skin, only blot dry
· Decontamination of clothing and surfaces are covered under operating and emergency procedures

Spill and Leak Control
· Alert everyone in the area
· Confine the problem or emergency (includes the use of absorbent material)
· Clear area
· Summon Aid

Damage to Sealed Radioactive Source Holder
· Evacuate the immediate vicinity around the source holder
· Place a barrier at a safe distance from the source holder (min. 5 meters)
· Identify area as a radiation hazard
· Contact emergency number posted on local warning sign

Suggested Emergency Protective Equipment
· Gloves
· Footwear Covers
· Safety Glasses
· Outer layer or easily removed protective clothing (as situation requires)

Revision Date: December 17, 2001

This information was prepared by: DOE ANL

Cobalt

What Is It? Cobalt is a hard, silvery-white metal that occurs in nature as cobalt-59. Cobalt is a constituent of the minerals cobaltite, smaltite, erythrite, and other ores, and it is usually found in association with nickel, silver, lead, copper, and iron. Pure cobalt metal is prepared by reducing its compounds with aluminum, carbon, or hydrogen. It is similar to iron and nickel in its physical properties. Cobalt has relatively low strength and little ductility at normal temperatures and is a component of several alloys.

There are nine major radioactive cobalt isotopes. (Isotopes are different forms of an element that have the same number of protons in the nucleus but a different number of neutrons.) Of these, only cobalt-57 and cobalt-60 have half-lives long enough to warrant concern. The half-lives of all other isotopes are less than 80 days. Cobalt-57 decays with a half-life of 270 days by electron capture and cobalt-60 decays with a half-life of 5.3 years by emitting a beta particle with two energetic gamma rays; the combined energy of these two gamma rays is 2.5 MeV (one has an energy of 1.2 MeV and the other has an energy of 1.3 MeV). Cobalt-60 is the isotope of most concern at Department of Energy (DOE) environmental management sites such as Hanford, for the cobalt-57 produced more than 20 years ago has long since decayed away. The two energetic gamma rays that accompany the radioactive decay of cobalt-60 make this isotope an external hazard (that is, it can be hazardous without being taken into the body).

Where Does It Come From? Cobalt is naturally present as the isotope 59 in various ores and to a lesser extent in soil. Cobalt-60 is produced by neutron activation of components in nuclear reactors; it can also be produced in a particle accelerator. When an atom of uranium-235 (or other fissile nuclide) fissions, it generally splits asymmetrically into two large fragments – fission products with mass numbers in the range of about 90 and 140 – and two or three neutrons. (The mass number is the sum of the number of protons and neutrons in the nucleus of the atom.) These neutrons can cause additional fissions (producing a chain reaction), escape from the reactor, or irradiate nearby materials. A number of reactor components are made of various alloys of steel that contain chromium, manganese, nickel, iron and cobalt, and these elements can absorb neutrons to produce radioactive isotopes, including cobalt-60. Cobalt-60 is a radionuclide of concern in spent nuclear fuel (as a component of the fuel hardware) and in the radioactive wastes associated with nuclear reactors and fuel reprocessing plants.

How Is It Used? Cobalt is used as a component of several alloys, including carboloy and stellite that are used to make very hard cutting tools. Cobalt is also used in some stainless steels. Alnico, an alloy of aluminum, nickel, cobalt, and other metals, is used to make high-strength, permanent magnets. Cobalt is also used in electroplating to give a hard surface that is resistant to oxidation, and as a blue colorant in pottery enamels and glass. High-energy gamma rays emitted during the radioactive decay of cobalt-60 can be used to detect flaws in metal components and in brachytherapy to treat various types of cancer. (Brachytherapy is a method of radiation treatment in which sealed sources are used to deliver a radiation dose at a distance of up to a few centimeters by surface, intracavitary, or interstitial application.)

What's in the Environment? Cobalt-59 is present in soil as a stable isotope at a concentration of about 1 to 2 milligram per kilogram (mg/kg). Trace amounts of cobalt-60 are also present around the globe from radioactive fallout as a result of past atmospheric weapons tests. It may also be present as a contaminant at certain facilities, such as nuclear reactors and facilities that process spent nuclear fuel. The highest concentrations of cobalt-60 at the Hanford Site are in areas that contain waste from processing irradiated fuel, principally in the hardware associated with the spent fuel. Transport of cobalt in the environment is strongly influenced by its chemical form. It is generally one of the less mobile radioactive metals in soil, although certain forms can move downward with percolating water into underlying layers of soil. Liquid wastes containing cobalt-60 were disposed of in cribs in the 200 East Area of Hanford, and this radionuclide has been detected in groundwater in concentrations above 100 picocuries (pCi) per liter. Cobalt-60 in the 200 Area appears to be highly mobile, probably because of the presence of a soluble cobalt-cyanide (or ferrocyanide) complex. In other settings, cobalt has been found to adhere preferentially to soil. For sandy soil, the concentration in soil particles is estimated to be about 60 times higher than in water between the soil particles, and cobalt binds even more tightly to loam where the estimated concentration ratio is 1,300.

What Happens to It in the Body? Cobalt can be taken into the body by eating food, drinking water, or
breathing air. Gastrointestinal absorption from food or water is the principal source of internally deposited cobalt in the general population. Estimates of the gastrointestinal absorption of cobalt range from 5 to 30%, depending on the chemical form and amount ingested. Cobalt is an essential element found in most body tissues, with the highest concentration in the liver. Vitamin B12 is a cobaltcontaining
vitamin essential for red blood cell formation in humans, and the intestinal absorption of cobalt in this vitamin is high. Fifty percent of cobalt that reaches the blood is excreted right away, mainly in urine; 5% deposits in the liver, and the remaining 45% deposits evenly in other tissues of the body. Of the cobalt that deposits in the liver and other tissues, 60% leaves the body with a biological half-life of 6 days and 20% clears with a biological half-life of 60 days; the last 20% is retained much longer, with a
biological half-life of 800 days (per simplified models that do not reflect intermediate redistribution). Inhaled cobalt oxide moves from the lung to body tissues quite readily.

What Are the Primary Health Effects? Cobalt-60 poses both an internal and external hazard, and the
main health concern is associated with the increased likelihood of cancer. External exposure is a concern
because of the strong external gamma radiation, and shielding is often needed to handle wastes and other materials with high concentrations of this isotope. Inside the body, cobalt presents a hazard from both beta and gamma radiation.

What Is the Risk? Lifetime cancer mortality risk coefficients have been calculated for nearly all radionuclides, including cobalt *(see box at right).* While the coefficients for ingestion are somewhat lower than for inhalation, ingestion is generally the most common means of entry into the body. Similar to other radionuclides, the risk coefficients for tap water are about 70% of those for dietary ingestion. In addition to the risk from internal exposure, there is a risk from external gamma exposure. Using the external gamma risk coefficient to estimate a lifetime cancer mortality risk, if it is assumed that 100,000 people were continuously exposed to a thick layer of soil with an initial average concentration of 1 pCi/g cobalt-60, then 6 of these 100,000 people would be predicted to incur a fatal cancer. (This is compared to the 25,000 people from the group predicted to die of cancer from all other causes per the U.S. average.) The external risk for cobalt-57 is less than 1% of this risk.

APPENDIX 3. COMMUNITY INVOLVEMENT FACT SHEETS

Fact sheets included in this appendix are:

- Radiation Quick Facts: Protective Action Guides (PAGs)
- Radiation Quick Facts: Americium
- Radiation Quick Facts: Cesium
- Radiation Quick Facts: Cobalt
- Radiation Quick Facts: Plutonium
- Radiation Quick Facts: Radium
- Radiation Quick Facts: Strontium
- Radiation Quick Facts: Thorium
- Radiation Quick Facts: Uranium
- Radiological Attack, Dirty Bombs and Other Devices

Radiation Quick Facts
Protective Action Guides (PAGs)

Three sets of PAGs for the three phases of a nuclear incident:

Early (Emergency) Phase - from recognition of the incident through a few days. This is the period when immediate decisions to take protective actions such as evacuation or shelter-in-place for members of the public living in or nearby the affected area must be made without significant radiation measurement data.

Intermediate Phase - lasting days to months. This is the period beginning after the source and releases have been brought under control and reliable environmental measurements are available for use as a basis for decisions on protective actions.

Late or Recovery Phase - lasting months to years. This is the period beginning when recovery actions designed to reduce radiation levels in the affected area to acceptable levels for unrestricted use are begun, and ends when all recovery actions have been completed.

What are PAGs?

The Protective Action Guides or PAGs are decision levels at which EPA recommends state and local authorities take protective actions to manage and minimize the impact of a radiological emergency or incident on public health.

How were the PAGs developed?

EPA applied four principles in developing the PAGs:

- Avoid acute health effects,
- Keep the risk of delayed health effects within upper bounds that are adequately protective of public health, within emergency conditions, and reasonably achievable.
- Reduce any risk to public health that is achievable at acceptable cost.
- Avoid actions that would result in a higher health risk than if no action had been taken, regardless of the above principles.

When would PAGs be used?

While the PAGs were originally developed specifically for nuclear power plant incidents, they can be applied to any radiological incident. However, the PAGs are only guidance, and state and local officials may decide to use different levels based on incident-specific information.

What are some of the types of protective actions?

Sheltering-in-place and evacuation are usually the first two protective actions taken after a radiological incident to help the public avoid exposure to radioactive material in the air and to move them out of the affected area.

How would the PAGs be used?

PAGs would be used with any available reliable information on current radiological conditions and with other pertinent local information to help authorities make the best decision to protect the life, health, property, and economy of their citizens.

The **early (emergency) phase** is the period at the beginning of the incident when immediate decisions for effective use of protective actions are required and actual field measurement data is generally not available. The response during the early phase includes the initial emergency response actions to protect public health and welfare in the short term. Priority should always be given to life-saving and first aid actions. In general, early phase protective actions should be made very quickly, and the protective action decisions can be modified later as more information becomes available.

The **intermediate phase** of the response may follow the early phase response within as little as a few hours. The intermediate phase of the response is usually assumed to begin after the source and releases have been brought under control and protective action decisions can be made based on measurements of exposure and radioactive materials that have been deposited as a result of the incident. During the intermediate phase, decisions must be made on the initial actions needed to recover from the incident, reopen critical infrastructures and return to some state of normal activities. All of these decisions must take into account the health, welfare, economic and other factors that must be balanced by the local officials. For example, it can be expected that hospitals and their access roads will need to remain open or be reopened quickly.

The **late phase** is the period when recovery and cleanup actions designed to reduce radiation levels in the environment to acceptable levels are commenced and end when all the recovery actions have been completed. Long-term decisions should be made with stakeholder involvement, and can also include incident specific technical working groups to provide expert advice to the decision-makers on impacts, costs and alternatives.

Other Radiation Resources

Visit the URLs listed below for additional information on radiation related issues

- **Agency for Toxic Substances & Disease Registry**
  www.atsdr.cdc.gov
- **Department of Homeland Security**
  www.ready.gov/radiation.html
- **Department of Energy**
  www.doe.gov
- **Nuclear Regulatory Commission**
  www.nrc.gov/what-we-do/radiation.html

For more information contact EPA's Radiological Emergency Response Program
Website: www.epa.gov/radiation/rert
E-mail: radiation.questions@epa.gov

Radiation Quick Facts
Americium

Radiation Basics – Americium

☑ **Alpha Particles** - can be stopped by thin layers of light materials, such as a sheet of paper, and pose no direct or external radiation threat; can pose a serious health threat if inhaled or ingested (swallowed). Americium primarily emits alpha particles.

☐ **Beta Particles** - can be stopped by aluminum; can pose a serious direct or external radiation threat; can be lethal depending on dose received; can pose a serious health threat if inhaled or ingested. Americium does not emit beta particles.

☑ **Gamma Rays** - can be slowed or stopped by very dense materials such as lead; can pose a cancer risk to all organs from direct external exposure and can pose a serious health threat internally if inhaled or swallowed; have high energy and a short wave length; travel at the speed of light and can cover hundreds to thousands of meters in air and pass through many kinds of materials, including human tissue. Americium emits some gamma rays as it decays.

What is americium?

Americium (chemical symbol Am) is a man-made radioactive metal that is solid under normal conditions. All isotopes of americium are radioactive. The most important isotope of americium is Am-241.

What happens to americium-241 when it enters the environment?

- When released into air, americium deposits particles in the soil and water. Small particles in air can travel far from the release site.
- In water, americium will stick to particles in the water or to the sediment at the bottom.
- Deposited on soil, americium will stick to surface particles, but not travel very deep into the ground.
- Plants and vegetation growing in or nearby contaminated soil may take up small amounts of americium from the soil.
- Fish may take up small amounts of Americium, but the fleshy tissue will absorb very little. In shellfish, americium attaches to the shell and not the parts you normally eat.

How can people come in contact with americium-241 ?

Exposure to any significant amount of Am-241 is unlikely under normal circumstances.

Because americium-241 was widely dispersed globally during the testing of nuclear weapons, very minute amounts of it are found in the soil, plants, and water. Also, living near a weapons testing or production facility may increase your chances of exposure to Am-241.

Smoke detectors containing Am-241 also provide some radiation exposure. However, the radiation exposure people receive from a smoke detector is very low. The health risk reduction from the fire protection vastly outweighs the health risk from the radiation. To avoid radiation exposure, you should handle your smoke detector carefully and follow the manufacture's disposal instructions.

How can americium affect my health?

Americium-241 is primarily an alpha emitter, but also emits some gamma rays. It poses a significant risk if ingested (swallowed) or inhaled. Once in the body, it tends to concentrate in the bone, liver, and muscle. Americium can stay in the body for decades and continue to expose the surrounding tissues to radiation, increasing the risk of developing cancer.

When inhaled, some Americium stays in the lungs; eventually dissolving in the bloodstream. Undissolved material passes from the body through the feces.

Americium also poses a cancer risk to all organs of the body from direct external exposure to its gamma radiation. One source of direct exposure would be contaminated soil. Exposure to any significant amount of Am-241 is unlikely under normal circumstances.

How can I reduce my health risk?

Most Americans never get close to a significant amount of americium-241.

Ionizing chamber smoke detectors contain a small amount of Am-241. Smoke detectors pose very little risk if used and disposed of according to manufacturers' instructions. However, you can follow some precautions to protect yourself and your family:

- Never try to access or remove the Am-241 source in your smoke detector.
- Be aware that industrial instruments, using americium-241 can be lost, stolen, or otherwise fall out of monitored control. These "orphan sources" present a significant risk to those who come in contact with them.

Other Radiation Resources

Visit the URLs listed below for additional information on radiation related issues.

- **Agency for Toxic Substances & Disease Registry**
  www.atsdr.cdc.gov/toxfaq.html
- **Department of Homeland Security**
  www.ready.gov/radiation.html
- **Department of Energy**
  www.doe.gov
- **Nuclear Regulatory Commission**
  www.nrc.gov/what-we-do/radiation.html
- **Conference of Radiation Control Program Directors**
  www.crcpd.org

For more information contact EPA's Radiological Emergency Response Program
Website: http://www.epa.gov/radiation/radionuclides/index.html
E-mail: radiation.questions@epa.gov

Radiation Quick Facts
Cesium

Radiation Basics – Cesium

☐ **Alpha Particles** - can be stopped by thin layers of light materials, such as a sheet of paper, and pose no direct or external radiation threat; can pose a serious health threat if inhaled or ingested (swallowed). Cesium does not emit alpha particles.

☑ **Beta Particles** - can be stopped by aluminum; can pose a serious direct or external radiation threat; can be lethal depending on dose received; can pose a serious health threat if inhaled or ingested. Cesium primarily emits beta particles.

☑ **Gamma Rays** - can be slowed or stopped by very dense materials such as lead; can pose a cancer risk to all organs from direct external exposure and can pose a serious health threat internally if inhaled or swallowed; have high energy and a short wave length; travel at the speed of light and can cover hundreds to thousands of meters in air and pass through many kinds of materials, including human tissue. Cesium emits gamma rays as it decays.

What is Cesium?

Cesium (chemical symbol Cs) is a soft, malleable, silvery white metal that becomes liquid near room temperature. Cesium is a naturally-occurring element found combined with other elements in rocks, soil, and dust in low amounts. Naturally occurring cesium is not radioactive and is referred to as stable cesium. The most common radioactive form of cesium, cesium-137, is produced when uranium and plutonium absorb neutrons and undergo fission or when splitting of uranium and plutonium occurs in a reactor or atomic bomb.

What happens to cesium-137 when it enters the environment?

- In air, cesium moves easily through the environment. This makes the cleanup of Cs-137 difficult.
- Cesium dissolves easily in water.
- Deposited on soil, cesium binds strongly and does not travel very far below the surface.
- Plants and vegetation growing in or nearby contaminated soil may take up small amounts of Cs-137from the soil.

How can people come in contact with cesium-137?

Cesium-137 in the environment comes from a variety of sources. The largest single source was fallout from atmospheric nuclear weapons tests in the 1950s and 1960s, which dispersed and deposited cesium-137 world-wide. However much of the cesium-137 from testing has now decayed. Nuclear reactor waste and accidental releases such as the Chernobyl accident in the Ukraine release some cesium-137 to the environment.

People may also be externally exposed to the gamma radiation emitted by cesium-137 by walking on contaminated sites, coming in contact with waste materials at contaminated sites, breathing the air around these sites, and drinking contaminated water. People may also unknowingly handle a strong industrial source of Cs-137.

How can cesium affect my health?

It is highly unlikely that you would be exposed to high enough amounts of stable cesium to cause harmful health effects.

Like all radionuclides, exposure to radiation from cesium-137 increases the risk of cancer. Exposure to large amounts of radioactive cesium can damage cells in your body. In the case of very high exposures, you might also experience acute radiation syndrome which includes nausea, vomiting, diarrhea, bleeding, coma, and even death.

Everyone is exposed to very small amounts of cesium-137 in soil and water as a result of atmospheric fallout. Exposure to waste materials, from contaminated sites, or from nuclear

The magnitude of the health risk depends on exposure conditions. These include such factors as strength of the source, length of exposure, distance from the source, and whether there was shielding between you and the source (such as metal plating).

How can I reduce my health risk?

Since cesium is naturally found in the environment, we cannot avoid being exposed to it. However, these relatively low amounts do not warrant immediate steps to reduce exposure.

In the unlikely case that you are exposed to high levels of radioactive cesium because of accidental release at a nuclear plant or a nuclear weapon has been detonated, follow the advice of public health officials who will publish appropriate guidelines for reducing exposure.

Other Radiation Resources

Visit the URLs listed below for additional information on radiation related issues.

- **Agency for Toxic Substances & Disease Registry**
  www.atsdr.cdc.gov/toxfaq.html
- **Department of Homeland Security**
  www.ready.gov/radiation.html
- **Department of Energy**
  www.doe.gov
- **Nuclear Regulatory Commission**
  www.nrc.gov/what-we-do/radiation.html
- **Conference of Radiation Control Program Directors**
  www.crcpd.org

Radiation Quick Facts
Cobalt

Radiation Basics – Cobalt

☐ **Alpha Particles** - can be stopped by thin layers of light materials, such as a sheet of paper, and pose no direct or external radiation threat; can pose a serious health threat if inhaled or ingested (swallowed). Cobalt does not emit alpha particles.

☑ **Beta Particles** - can be stopped by aluminum; can pose a serious direct or external radiation threat; can be lethal depending on dose received; can pose a serious health threat if inhaled or ingested. Cobalt emits beta particles.

☑ **Gamma Rays** - can be slowed or stopped by very dense materials such as lead; can pose a cancer risk to all organs from direct external exposure and can pose a serious health threat internally if inhaled or swallowed; have high energy and a short wave length; travel at the speed of light and can cover hundreds to thousands of meters in air and pass through many kinds of materials, including human tissue. Cobalt primarily emits gamma rays.

What is cobalt?

Cobalt (chemical symbol Co) is a hard, brittle, gray metal with a bluish tint that is solid under normal conditions. Cobalt is similar to iron and nickel in its properties and can be magnetized like iron. Cobalt may be stable (non-radioactive, as found in nature), or unstable (radioactive, when man-made). The most common radioactive isotope of cobalt is cobalt-60.

What happens to cobalt when it enters the environment?

Cobalt enters the environment from natural sources and the burning of coal or oil or the production of cobalt alloys. Cobalt cannot be destroyed in the environment. It can only change its form or become attached or separated from particles.

- In air, cobalt will be associated with particles which will settle to the ground within a few days.
- In water or soil, cobalt will stick to particles. Some cobalt compounds may dissolve in water.
- Radioactive decay is the only way of decreasing the amount of radioactive cobalt-60 in the environment.

How can people come in contact with cobalt?

Most exposure to cobalt-60 takes place intentionally during medical tests and treatments. Such exposures are carefully controlled to avoid adverse health impacts and to maximize the benefits of medical care.

Accidental exposures may occur as the result of loss or improper disposal of medical and industrial radiation sources. Though relatively rare, exposure has also occurred by accidental mishandling of a source at a metal recycling facility or steel mill.

Cobalt-60 can also be released to the environment through leaks or spills at nuclear power plants, and in solid waste originating from nuclear power plants. Nuclear Regulatory Commission regulations allow small amounts of cobalt-60 to be released into the air, or poured down drains as part of a liquid.

How can cobalt affect my health?

External exposure to the gamma radiation from cobalt-60 increases cancer risk. The magnitude of the health risk depends on the quantity of Co-60 involved and on exposure conditions:

- length of exposure
- distance from the source (for external exposure)
- whether the cobalt-60 was ingested or inhaled.

How can I reduce my health risk?

You are unlikely to encounter cobalt-60 unless you undergo certain medical treatments. Thorough discussions with your doctor about the amount of exposure and potential alternatives allow you to make informed decisions about the relative risks.

Other Radiation Resources

Visit the URLs listed below for additional information on radiation related issues.

- **Agency for Toxic Substances & Disease Registry**
  www.atsdr.cdc.gov/toxfaq.html
- **Department of Homeland Security**
  www.ready.gov/radiation.html
- **Department of Energy**
  www.doe.gov
- **Nuclear Regulatory Commission**
  www.nrc.gov/what-we-do/radiation.html
- **Conference of Radiation Control Program Directors**
  www.crcpd.org

Radiation Quick Facts
Plutonium

Radiation Basics – Plutonium

☑ **Alpha Particles** - can be stopped by thin layers of light materials, such as a sheet of paper, and pose no direct or external radiation threat; can pose a serious health threat if inhaled or ingested (swallowed). Plutonium primarily emits alpha particles.

☑ **Beta Particles** - can be stopped by aluminum; can pose a serious direct or external radiation threat; can be lethal depending on dose received; can pose a serious health threat if inhaled or ingested. Only a few isotopes of plutonium emit beta particles.

☑ **Gamma Rays** - can be slowed or stopped by very dense materials such as lead; can pose cancer risk to all organs from direct external exposure and can pose a serious health threat internally if inhaled or swallowed; have high energy and a short wave length; travel at the speed of light and can cover hundreds to thousands of meters in air and pass through many kinds of materials, including human tissue. Some isotopes of plutonium emit gamma rays.

What is plutonium?

Plutonium (chemical symbol Pu) is a radioactive metal with Atomic Number 94. Plutonium is considered a man-made element, although scientists have found trace amounts of naturally-occurring plutonium produced under highly unusual geologic circumstances. The most common radioisotopes of plutonium are plutonium-238, plutonium-239, and plutonium-240.

What happens to plutonium when it enters the environment?

Plutonium is:

- Released to the air, from nuclear reactors weapons production plants, and research facilities.
- Released to the water from accidental releases and disposal of radioactive wastes.
- Deposited on soil from fallout from nuclear weapons testing.

Plants and vegetation growing in or nearby contaminated soil may take up small amounts of plutonium from the soil.

All isotopes of plutonium undergo radioactive decay. As plutonium decays, it releases radiation and forms other radioactive isotopes. For example, Pu-238 emits an alpha particle and becomes uranium-234; Pu-239 emits an alpha particle and becomes uranium-235.

This process happens slowly since the half-lives of plutonium isotopes tend to be relatively long: Pu-238 has a half-life of 87.7 years; Pu-239 has a half-life is 24,100 years, and Pu-240 has a half-life of 6,560 years. The decay process continues until a stable, non-radioactive element is formed.

How can people come in contact with plutonium?

Since plutonium levels in the environment are very low, they pose little risk to most people. However, residual plutonium from atmospheric nuclear weapons testing is dispersed widely in the environment. As a result, virtually everyone comes into contact with extremely small amounts of plutonium.

People who live near nuclear weapons production or testing sites may have increased exposure to plutonium, primarily through particles in the air, but possibly from water as well.

How can plutonium affect my health?

External exposure to plutonium poses very little health risk, since plutonium isotopes emit alpha radiation, and almost no beta or gamma radiation. In contrast, internal exposure to plutonium is an extremely serious health hazard. It generally stays in the body for decades, exposing organs and tissues to radiation, and increasing the risk of cancer. Plutonium is also a toxic metal, and may cause damage to the kidneys.

How can I reduce my health risk?

Since plutonium levels in the environment are very low, they pose little risk to most people.

Plutonium particles in dust are the greatest concern, because they pose the greatest health risk. People living near government weapons facilities can track radiation monitoring data made available by site personnel. If radiation levels rise, they should follow the radiation protection instructions given by site personnel.

Other Radiation Resources

Visit the URLs listed below for additional information on radiation related issues.

- **Agency for Toxic Substances & Disease Registry**
  www.atsdr.cdc.gov/toxfaq.html
- **Department of Homeland Security**
  www.ready.gov/radiation.html
- **Department of Energy**
  www.doe.gov
- **Nuclear Regulatory Commission**
  www.nrc.gov/what-we-do/radiation.html
- **Conference of Radiation Control Program Directors**
  www.crcpd.org

For more information contact EPA's Radiological Emergency Response Program
Website: http://www.epa.gov/radiation/radionuclides/index.html
E-mail: radiation.questions@epa.gov

Radiation Quick Facts
Radium

Radiation Basics – Radium

☑ **Alpha Particles** - can be stopped by thin layers of light materials, such as a sheet of paper, and pose no direct or external radiation threat; can pose a serious health threat if inhaled or ingested (swallowed). Radium emits alpha particles.

☐ **Beta Particles** - can be stopped by aluminum; can pose a serious direct or external radiation threat; can be lethal depending on dose received; can pose a serious health threat if inhaled or ingested. Radium does not emit beta particles.

☑ **Gamma Rays** - can be slowed or stopped by very dense materials such as lead; can pose a cancer risk to all organs from direct external exposure and can pose a serious health threat internally if inhaled or swallowed; have high energy and a short wave length; travel at the speed of light and can cover hundreds to thousands of meters in air and pass through many kinds of materials, including human tissue. Radium emits gamma rays as it decays.

What is radium?

Radium (chemical symbol Ra) is a naturally-occurring radioactive metal. Its most common isotopes are radium-226, radium 224, and radium-228. Radium is a radionuclide formed by the decay of uranium and thorium in the environment. It occurs at low levels in virtually all rock, soil, water, plants, and animals. All isotopes of radium are radioactive.

What happens to radium when it enters the environment?

Radium decays in the environment to produce radon.

- Radium can be found in air.
- Radium is soluble in water. As a result, groundwater in areas where concentrations of radium are high in surrounding bedrock typically has relatively high radium content. Uranium mining results in higher levels of radium in nearby water.
- Radium is present at very low levels in rocks and soil and may attach to those materials.
- Radium is constantly being produced by the decay of uranium and thorium.
- Plants and vegetation may take up radium from the soil.
- Radium may concentrate in fish and other aquatic animals.

How can people come in contact with radium?

Since radium is present at low levels in the natural environment, everyone has some minor exposure to it. Individuals may be exposed to higher levels of radium if they live in an area where there are high levels of radium in rock and soil. Private well water in such areas can also be an added source of radium.

The concentration of radium in drinking water is generally low, but some regions have higher concentrations due to geologic sources. Radium concentrations in food and air are believed to be very low.

People can also be exposed to radium if it is released into the air from the burning of coal or other fuels. Working in a uranium mine or in a plant that processes ores can lead to higher exposures. Phosphate rocks typically contain relatively high levels of both uranium and radium and can raise exposures in phosphate mining areas.

The greatest health risk from radium in the environment is its decay product, radon, which can collect in buildings.

How can radium affect my health?

Long-term exposure to radium increases the risk of developing several diseases. Inhaled or ingested radium increases the risk of developing such diseases as lymphoma, bone cancer, and diseases that affect the formation of blood, such as leukemia and aplastic anemia. These effects usually take years to develop.

External exposure to radium's gamma radiation increases the risk of cancer to varying degrees in all tissues and organs.

However, the greatest health risk from radium is from exposure to its radioactive decay product radon. It is common in many soils and can collect in homes and other buildings.

How can I reduce my health risk?

The most effective way to protect yourself and your family is to test your home for radium's decay product, radon.

Other Radiation Resources

Visit the URLs listed below for additional information on radiation related issues.

- **Agency for Toxic Substances & Disease Registry**
  www.atsdr.cdc.gov/toxfaq.html
- **Department of Homeland Security**
  www.ready.gov/radiation.html
- **Department of Energy**
  www.doe.gov
- **Nuclear Regulatory Commission**
  www.nrc.gov/what-we-do/radiation.html
- **Conference of Radiation Control Program Directors**
  www.crcpd.org

Radiation Quick Facts
Strontium

Radiation Basics – Strontium

☐ **Alpha Particles** - can be stopped by thin layers of light materials, such as a sheet of paper, and pose no direct or external radiation threat; can pose a serious health threat if inhaled or ingested (swallowed). Strontium does not emit alpha particles.

☑ **Beta Particles** - can be stopped by aluminum; can pose a serious direct or external radiation threat; can be lethal depending on dose received; can pose a serious health threat if inhaled or ingested. Strontium emits beta particles.

☐ **Gamma Rays** - can be slowed or stopped by very dense materials such as lead; can pose a cancer risk to all organs from direct external exposure and can pose a serious health threat internally if inhaled or swallowed; have high energy and a short wave length; travel at the speed of light and can cover hundreds to thousands of meters in air and pass through many kinds of materials, including human tissue. Strontium does not emit gamma rays.

What is strontium?

Strontium (chemical symbol Sr) is a silvery metal that rapidly turns yellowish in air. Strontium is a naturally occurring element found in rocks, soil, dust, coal, and oil. Naturally-occurring strontium is not radioactive and is referred to as stable strontium. Strontium can also exist as several radioactive isotopes. The most common, strontium-90, is formed in nuclear reactors or during the explosion of nuclear weapons. Sr-90 is the most important radioactive isotope in the environment.

What happens to strontium when it enters the environment?

- Radioactive decay is the only way of decreasing the amount of Sr-90 in the environment.
- In air, stable strontium is present as dust which eventually settles over land and water.
- Stable strontium dissolves in water.
- Stable strontium in soil can dissolve in water and move deeper in the soil to underground water.
- Plants and vegetation growing in or nearby contaminated soil may take up small amounts of from the soil.

How can people come in contact with Stontium-90?

Strontium-90 was widely dispersed in the 1950s and 1960s in fallout from the atmospheric testing of nuclear weapons. It has been slowly decaying since then so current levels from these tests are very low.

Sr-90 is also found in waste from nuclear reactors. It is considered one of the more hazardous constituents of nuclear wastes. The accident at the Chernobyl nuclear power plant introduced a large amount of Sr-90 into the environment. A large part of the Sr-90 was deposited in the Soviet Republics. The rest was dispersed as fallout over Northern Europe and worldwide. No significant amount of Sr-90 reached the United States.

Everyone is exposed to small amounts of Sr-90, since it is widely dispersed in the environment and the food chain. Dietary intake of Sr-90, however, has steadily fallen over the last 30 years with the suspension of nuclear weapons testing.

People who live near or work in nuclear facilities may have increased exposure to strontium-90. The greatest concern would be the exposures from an accident at a nuclear reactor, or an accident involving high-level radioactive waste.

How can strontium affect my health?

Strontium-90 is chemically similar to calcium, and tends to deposit in bone and blood forming tissue (bone marrow). Thus, Sr-90 is referred to as a "bone seeker." Internal exposure to Sr-90 is linked to bone cancer, cancer of the soft tissue near the bone, and leukemia. Risk of cancer increases depending on the concentration of Sr-90 in the environment and on the exposure conditions: time, distance, shielding and ingestion.

How can I reduce my health risk?

Strontium-90 dispersed in the environment, like that from atmospheric weapons testing, is essentially impossible to avoid. You may also be exposed to tiny amounts from nuclear power reactors and certain government facilities. The more serious risk to you (though it is unlikely), is that you may unwittingly encounter an industrial instrument containing a Sr-90 radiation source. This situation is more likely if you work in specific industries:

- scrap metal sorting, sales and brokerage
- metal melting and casting
- municipal and fill operations

Other Radiation Resources

Visit the URLs listed below for additional information on radiation related issues.

- **Agency for Toxic Substances & Disease Registry**
  www.atsdr.cdc.gov/toxfaq.html
- **Department of Homeland Security**
  www.ready.gov/radiation.html
- **Department of Energy**
  www.doe.gov
- **Nuclear Regulatory Commission**
  www.nrc.gov/what-we-do/radiation.html
- **Conference of Radiation Control Program Directors**
  www.crcpd.org

For more information contact EPA's Radiological Emergency Response Program
Website: http://www.epa.gov/radiation/radionuclides/index.html
E-mail: radiation.questions@epa.gov

Radiation Quick Facts
Thorium

Radiation Basics – Thorium

☑ **Alpha Particles** - can be stopped by thin layers of light materials, such as a sheet of paper, and pose no direct or external radiation threat; can pose a serious health threat if inhaled or ingested (swallowed). Thorium is an alpha emitter.

☐ **Beta Particles** - can be stopped by aluminum; can pose a serious direct or external radiation threat; can be lethal depending on dose received; can pose a serious health threat if inhaled or ingested. Thorium does not emit beta particles.

☑ **Gamma Rays** - can be slowed or stopped by very dense materials such as lead; can pose a cancer risk to all organs from direct external exposure and can pose a serious health threat internally if inhaled or swallowed; have high energy and a short wave length; travel at the speed of light and can cover hundreds to thousands of meters in air and pass through many kinds of materials, including human tissue. Thorium emits gamma rays.

What is thorium?

Thorium is a naturally-occurring radioactive metal found at low levels in soil, rocks, water, plants, and animals; and, is solid under normal conditions. It has several different isotopes, both natural and man-made, all of which are radioactive. In general, naturally-occurring thorium exists in the form of either thorium-232, -230, or -228. However, thorium-229 is man-made.

What happens to thorium when it enters the environment?

Natural thorium is present in very small quantities in virtually all rock, soil, water, plants and animals. Where high concentrations occur in rock, thorium may be mined and refined, producing waste products such as mill tailings. If not properly controlled, wind and water can introduce the tailings into the wider environment. Commercial and federal facilities that have processed thorium may also have released thorium to the air, water, or soil.

Man-made thorium isotopes are rare, and almost never enter the environment.

How can people come in contact with thorium?

Since thorium is naturally present in the environment, people are exposed to tiny amounts in air, food and water. The amounts are usually very small and pose little health hazard.

Thorium is used to make ceramics, gas lantern mantles, welding rods, camera and telescope lenses, and metals used in the aerospace industry and in nuclear reactions. Thorium can also be used as a fuel for generating nuclear energy.

Most people are not exposed to dangerous levels of thorium. However, people who live near thorium mining areas or near certain government or industrial facilities may have increased exposure to thorium, especially if their water is from a private well.

How can thorium affect my health?

Studies have shown that inhaling thorium dust causes an increased risk of developing lung cancer and cancer of the pancreas. Bone cancer risk is also increased because thorium may be stored in bone.

How can I reduce my health risk?

Most people are not exposed to dangerous levels of thorium. However, people who live near thorium mining areas or near certain government or industrial facilities may have increased exposure to thorium, especially if their water is from a private well.

Analytical laboratories can test water for thorium content. Occasionally, household items may be found with thorium in them, such as some older ceramic wares in which uranium was used in the glaze, or gas lantern mantles. These generally do not pose serious health risks, but may nevertheless be retired from use as a prudent avoidance measure.

Other Radiation Resources

Visit the URLs listed below for additional information on radiation related issues.

- **Agency for Toxic Substances & Disease Registry**
  www.atsdr.cdc.gov/toxfaq.html
- **Department of Homeland Security**
  www.ready.gov/radiation.html
- **Department of Energy**
  www.doe.gov
- **Nuclear Regulatory Commission**
  www.nrc.gov/what-we-do/radiation.html
- **Conference of Radiation Control Program Directors**
  www.crcpd.org

Radiation Quick Facts
Uranium

Radiation Basics – Uranium

☑ **Alpha Particles** - can be stopped by thin layers of light materials, such as a sheet of paper, and pose no direct or external radiation threat; can pose a serious health threat if inhaled or ingested (swallowed). Uranium primarily emits alpha particles.

☐ **Beta Particles** - can be stopped by aluminum; can pose a serious direct or external radiation threat; can be lethal depending on dose received; can pose a serious health threat if inhaled or ingested. Uranium does not emit beta particles.

☑ **Gamma Rays** - can be slowed or stopped by very dense materials such as lead; can pose cancer risk to all organs from direct external exposure and can pose a serious health threat internally if inhaled or swallowed; have high energy and a short wave length; travel at the speed of light and can cover hundreds to thousands of meters in air and pass through many kinds of materials, including human tissue. Uranium emits weak gamma rays.

What is uranium?

Uranium (chemical symbol U) is a naturally-occurring radioactive element, with atomic number 92. Uranium is commonly found in very small amounts in rocks, soil, water, plants, and animals (including humans). When refined, uranium is a silvery-white metal. Uranium is weakly radioactive and contributes to low levels of natural background radiation in the environment.

Uranium found naturally has 3 different isotopes, U-238, U-235, and U-234. Other isotopes can be synthesized. All uranium isotopes are radioactive.

What happens to uranium when it enters the environment?

Uranium is present naturally in virtually all soil, rock and water. Uranium in soil and rocks is distributed throughout the environment by wind, rain and geologic processes. Rocks weather and break down to form soil, and soil can be washed by water and blown by wind, moving uranium into streams and lakes, and ultimately settling out and reforming as rock. Uranium can also be removed and concentrated by people through mining and refining. These mining and refining processes produce wastes such as mill tailings which may be introduced back into the environment by wind and water if they are not properly controlled. Manufacturing of nuclear fuel, and other human activities also release uranium to the environment.

All uranium isotopes are radioactive. The three natural uranium isotopes found in the environment, U-234, U-235, and U-238, undergo radioactive decay by emission of an alpha particle accompanied by weak gamma radiation. The dominant isotope, U-238, forms a long series of decay products that includes the key radionuclides radium-226, and radon-222. The decay process continues until a stable, non-radioactive decay product is formed (see uranium decay series). The release of radiation during the decay process raises health concerns.

How can people come in contact with uranium?

A person can be exposed to uranium by inhaling dust in air, or ingesting water and food. The general population is exposed to uranium primarily through food and water. The average daily intake of uranium from food ranges from 0.07 to 1.1 micrograms per day. The amount of uranium in air is usually very small. People who live near federal government facilities that made or tested nuclear weapons, or facilities that mine or process uranium ore or enrich uranium for reactor fuel, may have increased exposure to uranium.

How can uranium affect my health?

About 99 percent of the uranium ingested in food or water will leave a person's body in the feces, and the remainder will enter the blood. Most of this absorbed uranium will be removed by the kidneys and excreted in the urine within a few days. A small amount of the uranium in the bloodstream will deposit in a person's bones, where it will remain for years.

The greatest health risk from large intakes of uranium is toxic damage to the kidneys, because, in addition to being weakly radioactive, uranium is a toxic metal. Uranium exposure also increases your risk of getting cancer due to its radioactivity. Since uranium tends to concentrate in specific locations in the body, risk of cancer of the bone, liver cancer, and blood diseases (such as leukemia) are increased. Inhaled uranium increases the risk of lung cancer.

How can I reduce my health risk?

Most people are not exposed to dangerous levels of uranium. However, people who live near uranium mining areas, or near government weapons facilities or certain industrial facilities may have increased exposure to uranium, especially if their water is from a private well. Analytical laboratories can test water for uranium content. Occasionally, household wares may be found with uranium in them, such as some older ceramic dishes or plates in which uranium was used in the glaze. These generally do not pose serious health risks, but may nevertheless be retired from use as a prudent avoidance measure. A radiation counter is required to confirm if ceramics contain uranium.

Other Radiation Resources

Visit the URLs listed below for additional information on radiation related issues.

- **Agency for Toxic Substances & Disease Registry**
  www.atsdr.cdc.gov/toxfaq.html
- **Department of Homeland Security**
  www.ready.gov/radiation.html
- **Department of Energy**
  www.doe.gov
- **Nuclear Regulatory Commission**
  www.nrc.gov/what-we-do/radiation.html
- **Conference of Radiation Control Program Directors**
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For more information contact EPA's Radiological Emergency Response Program
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