United States
Environmental Protection
Agency

Office of
Solid Waste and
Emergency Response

OSWER 9200.5-144
EPA 540-R-94-038
PB94-963414
October 1996

Superfund

Removal Response to Radiation Sites: Reference Document

Publication 9200.5-144
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1.0 INTRODUCTION

1.1 Purpose of the Document

Currently, only a small proportion of Superfund removal sites contain radioactive materials. However, the number of these sites has been steadily increasing and will probably continue to rise. This will present On-Scene Coordinators (OSCs) with unique challenges and considerations. This guide provides OSCs and site managers with sources of information and guidance to address radioactive materials incidents.

It is not possible to write a comprehensive radiation removal reference document which covers all site eventualities and obviates the need for expert assistance. Since radionuclides are not encountered very frequently and since site conditions can vary considerably, each radiation contamination site must be dealt with on a case-by-case basis.

Therefore, this document does not provide the OSC with specific procedures for identifying, treating, and removing radionuclides. The expertise of a radiation specialist is highly recommended[1] when initiating action at a site where radioactive materials are believed to be present. Necessary emergency actions, of course, should always be performed as quickly and safely as possible.

The purpose of this document is to provide references and a planning guide for removal actions involving radioactive materials. This document includes:

- Information on the differences between a radiation site and a hazardous waste site without radioactive contamination;
- A statement of the relevant issues for responding to a radiation release, and references to detailed technical information;
- A guide to the response planning process as it relates to radiation;
- Assistance available to OSCs and site managers in dealing with radiation sites; and
- Information about radiation-related training.

1.2 Should the EPA respond?

Before commencing incident/site response, the OSC must determine if a Superfund response is appropriate or authorized. Generally, radioactive materials are considered "hazardous substances" under CERCLA and as such, qualify for Superfund cleanup. However, certain radioactive materials are specifically excluded from CERCLA, or in some cases authority to respond may have been delegated to an agency other than EPA. Situations involving these materials are to be handled under the Federal Radiological Emergency Response Plan.[2]

Specific exclusions and situations are discussed in chapter 2, but, as a general rule, an OSC should check further if either of the following general conditions apply to the site or incident:

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[1] See chapter 5 for sources of radiation expertise.

[2] See sections 2.2 and 2.4 of this document.

1. The facility is (or was) licensed by the Nuclear Regulatory Commission (NRC) or an NRC Agreement State, is (was) regulated by the Department of Energy, or is (was) regulated by an NRC Agreement State.[3]

2. The materials are high-level or transuranic wastes,[4] or wastes from energy production or weapons production.

Under CERCLA, EPA has the authority to respond if the release meets the legal definition [of a release]; even though the site may meet either of the above conditions. However, depending on the nature of the release, there may be other agencies that are better suited to respond. The OSC should contact the National Response Center at **800-424-8802** or **(DC) 202-267-2675** for appropriate information on which agency to contact for assistance.

1.3 What is Different About a Radiation Response?

Response to radiation contamination is, in most ways, the same as response to other hazardous substances. Many response procedures used for chemical contaminants are also used for radioactive contaminants (e.g., protective clothing, respiratory protection, personnel surveillance, delineation of controlled entry areas). While the instrumentation used for radiological monitoring is different from that used for chemical monitoring, the basic approaches of ambient monitoring, media collecting, etc., are intrinsically similar. Laboratory analyses can be done either in the field or at a fixed site, as with hazardous contaminants. Treatment, storage, cleanup, transportation, and disposal options are often similar to those for chemicals.

Radiation is not necessarily more complex, difficult, or dangerous than chemical contamination. In fact, radiation can be easier to detect, simpler to control, and less hazardous than many other materials. Many direct-reading instruments, for example, can give instantaneous results when monitoring for radiation. Radiation can often be detected without having to open drums or enter confined spaces. The health effects of radioactive materials are generally better documented than those of other hazardous substances. Acute effects are unlikely to occur with the type of radioactive materials found on a Superfund site.

On the other hand, radiation presents threats that are intrinsically different from most chemical hazards. The nature of contamination is different and the procedures to deal with radiation sites (such as site evaluation, monitoring, and sampling) vary from those for most other sites. There are special considerations for treatment, cleanup, storage, transportation, and disposal of radioactive wastes.

This document is meant to alert the OSC to the unique problems, dangers, precautions, procedures, and constraints posed by radioactive materials.

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[3] NRC has delegated regulatory authority to certain State agencies in the Agreement States.

[4] Transuranic (TRU) wastes are materials contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium, and curium, and that are in concentrations greater than 10 nanocuries per gram.

1.4 The Regional Radiation Program

EPA's Regional Radiation Program is a prime resource for OSCs to obtain technical support on issues dealing with radiation exposure and contamination. The Regional Radiation Program Manager (RRPM) can provide advice on personal protective equipment, site safety protocols, assessment and sampling techniques, waste treatment and disposal, and other site operations. The RRPMs are also familiar with the staffs and procedures at the laboratories and EPA's Office of Radiation and Indoor Air (ORIA). They can help speed the removal process and achieve the best results for the OSC. A listing of phone numbers of RRPMs appears in chapter 5.

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2.0 RADIATION RELEASES AND SUPERFUND RESPONSE

2.1 Radioactive Materials and Wastes

Radioactive material is defined as any material that contains, is composed of, or is contaminated with elements that spontaneously undergo radioactive decay (i.e., radionuclides). Radioactive materials (and the waste and contamination associated with the production and use of such materials) are generally categorized based on their origin and composition. The principal categories are defined by statute, although a number of interchangeable and different terms are often used in practice (see section 2.3 and Figure 1).

2.2 CERCLA and Radiological Releases

In general, radioactive materials are a hazardous substance under CERCLA and are subject to CERCLA's notification, cleanup, and liability provisions. In terms of legislative authority, therefore, radionuclides are considered like any other hazardous substance on site. However, CERCLA response authority does not apply to sites falling within the following categories at specific facilities:

- Releases of radioactive wastes from uranium mill tailings that are being cleaned up by the Department of Energy under Title I of the Uranium Mill Tailings Radiation Control Act.[5]

- Releases of "source, special nuclear, and byproduct materials" resulting from a nuclear incident at private commercial facilities that are subject to the financial protection requirements established by the Nuclear Regulatory Commission.[6]

However, releases under these categories account for a small portion of radiation releases in general.

Source, special nuclear, and byproduct materials are often referred to as **"AEA wastes or material."** These are radiological materials associated with the production of nuclear energy that are given special status by the Atomic Energy Act (AEA). In general, response to releases of these materials is handled by either the Department of Energy (DOE) or the Nuclear Regulatory Commission (NRC). Figure 1 provides brief descriptions of several types of AEA wastes.

If AEA materials are encountered on site, OSCs and site managers should contact the RRPM for information about the proper agencies to contact and CERCLA eligibility.

2.3 Radioactive Materials at Superfund Sites

Radioactive wastes that are discovered at Superfund sites may consist of either AEA wastes, non-AEA wastes, or both. However, since some AEA wastes are specifically excluded by CERCLA, Superfund response is generally limited to non-AEA wastes (also known as naturally-occurring or

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[5] CERCLA §101 (22)(C)

[6] CERCLA §101 (22)(C). CERCLA also restricts cleanup authority by excluding these materials specifically in the definition of a release (§101).

AEA Wastes

The following categories of radioactive material and wastes are given special status under AEA §2010 and §2011. CERCLA §101 (22)(C) excludes these materials from the definition of "release," limiting Superfund authority to respond.

- Source Material -- natural uranium, thorium, or any combination thereof, in any physical or chemical form, or ores that contain 0.05 percent or more (by weight) of uranium, thorium, or any combination of the two.

- Special Nuclear Material -- plutonium, uranium-233, uranium enriched in the U-233 or U-235 isotope, and any other material that the Nuclear Regulatory Commission, pursuant to the provisions or §51 of the AEA, determines to be special nuclear material.

- Byproduct Material -- any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure incident to the process of producing or utilizing special nuclear material; and the tailings or wastes produced by the extraction or concentration of uranium and thorium from ore processed primarily for source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore operations do not constitute "byproduct" material within this definition.

Figure 1: Categories of AEA Wastes

accelerator-produced radioactive materials (**NARM**)). As implied by the name, NARM consists of the following two subsets of materials:

1. Any radioactive material produced as a result of nuclear transformations in an accelerator.
2. Naturally-occurring (not man-made) radioactive material, excluding source and special nuclear material (**NORM**).

NORM can be further categorized based on whether the radioactive materials are found in their natural setting or whether they are found in an altered or man-made setting. This distinction is important because there are additional CERCLA exclusions for naturally-occurring substances found in their natural settings (see section 2.4).

Examples Superfund response at NARM-contaminated sites include: facilities or laboratories that handle radium needles for medical applications; radium refining facilities; formulators of industrial radiographics and radiochemicals; manufacturers of X-ray equipment and radiation detection equipment (calibration materials); metal processing facilities; mine tailings piles; landfills; and midnight dumps. Often, there are responses at associated facilities, residences, and properties that have radiation contamination because of poor housekeeping practices at the primary facilities (listed above). For example, a typical site might consist of an abandoned factory that previously manufactured watches with radioluminescent faces and dials. Not only is the facility itself contaminated, but contamination is often found off site as well. An associated site might be a nearby residence where a former employee of the watch factory stored radioactive materials taken from the job.

2.4 Radon and Other Naturally Occurring Materials

CERCLA excludes response to releases of "a naturally occurring substance in its unaltered form ... from a location where it is naturally found."[7] This exclusion is cited most frequently during responses to radon contamination, where the radon originates from natural radioactive formations in the ground. This doesn't prevent EPA from responding to radon resulting from radioactive materials placed on a site (i.e., not naturally occurring.)

The exclusion may be waived in certain emergency conditions, with Headquarters concurrence.[8] To respond to radon, there must be a finding that:

1. The release is causing a public health or environmental emergency, and
2. No other person or agency with the authority and capability to respond to the emergency will do so quickly enough.

If this situation comes up, the OSC should consult with the Regional Coordinator at EPA Headquarters for information about the waiver.

2.5 Catastrophic Disasters

If cleanup is conducted under the authority of CERCLA, then any response to the radionuclide release is carried out in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), just as with any oil spill or other hazardous substance release.

Under disaster conditions meeting the criteria for a Presidential declaration, other response mechanisms are more appropriate, or are used in addition to CERCLA and the NCP. These include incidents such as: major releases at nuclear reactors; releases associated with the manufacture, transport, testing, and use of nuclear weapons; accidents or releases involving nuclear fuel or high-level radioactive wastes; and incidents involving nuclear-powered satellites. In such cases, EPA should act under other response mechanisms, which generally fall outside the scope of Superfund and are covered only briefly below. In such a disaster, EPA will be working under the FRERP (Federal Radiological Emergency Response Plan),[9] which was established in 1985 as an interagency planning and response guide to direct Federal agencies during responses to peacetime radiological disasters. The FRERP covers any peacetime radiological disasters that require response by several Federal agencies, including those at fixed nuclear facilities or during transportation of radioactive materials.

Depending on the type of radiological emergency, EPA may be the lead agency for coordinating the Federal response in accordance with the provisions of the FRERP. The EPA is the lead agency for (1) emergencies at radiological facilities not licensed, owned, or operated by a Federal agency or an Agreement State; (2) transportation emergencies that involve radioactive material not licensed or owned by a Federal agency or an Agreement State; and (3) emergencies that involve radioactive

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[7] CERCLA §104 (a)(3)(A).

[8] See OSWER Directive 9360.0-19, *Guidance on Non-NPL Removal Actions Involving Nationally Significant or Precedent-Setting Issues*, and OSWER Directive 9360.3-12, *Response Actions at Sites with Contamination Inside Buildings*.

[9] As required in the NCP §300.130 (f).

material from a foreign source (e.g., Chernobyl, foreign satellite) that has actual, potential, or perceived radiological consequences in the United States, its Territories, or possessions. Besides its role as lead agency, EPA will act in a monitoring and technical support role to other lead Federal agencies. In the event of such peacetime radiological emergencies, EPA's activities will be directed by specialists from the Office of Radiation and Indoor Air (ORIA).

Figure 2: Limits of OSC Authority

As a general rule, the OSC's responsibility and/or authority to respond is limited if:

1. The facility is owned by DOE or DOD.
2. The release is from a facility licensed by the NRC or an NRC Agreement State (e.g., a nuclear power plant or a research facility).
3. The waste is an AEA waste.
4. There has been a disaster declaration, or the FRERP has been implemented.

EPA activity under the FRERP is guided by the EPA Radiological Emergency Response Plan. This plan discusses EPA's specific authorities, procedures, resources, organization, responsibilities, and capabilities for responding to radiological emergencies either as an independent agency or as a participant in the implementation of the FRERP. Figure 2 provides general limits of OSC authority for radiation sites.

3.0 WORKER SAFETY ISSUES

3.1 Radiation Hazard Assessment

An initial radiation assessment should be performed in conjunction with initial site entry at any site containing unknown materials. As with hazardous chemical substances, it is important to determine, as soon as possible, whether radionuclides are present on site. Prior to any work being conducted on site, perform a thorough areal survey using appropriate radiation detection equipment (see section 4.2.3). Using this survey information, the RRPM can assist in the interpretation and characterization of both surface contamination and buried waste.

Most radioactive material encountered at Superfund sites can be considered an internal hazard (i.e., internal contamination through ingestion, inhalation, entry through open wounds, or from dermal absorption). As such, it can present a significant health risk. In addition, much of the radioactive material encountered at Superfund sites is also an external hazard (i.e., it does not require direct contact to be hazardous). Alpha radiation is typically only an internal hazard through ingestion since it does not have enough penetrating ability to pass through the body's outer layer of dead skin cells. However, alpha particles with energies greater than about 7.5 MeV will penetrate the skin to underlying tissue. Both uranium and thorium decay series have alpha particles with energies this high. Therefore, digging in uranium, thorium, or radium-contaminated soil might lead to increased dermal exposure as well as internal exposure to alpha particles. Beta particles can penetrate the outer layer of skin and the lens of the eye. Gamma is high energy radiation and can readily pass through the body. All of these types of ionizing radiation can damage cells.

If "labpack" quantities of suspected radioactive substances are present at the site, the OSC should ensure that a complete radiological survey of the containers is made using appropriate surveying equipment. The RRPM can assist the OSC in determining which laboratory substances may require special attention as radioactive substances.

Once the types of radiation hazards and levels of contamination are known, specific control measures can be employed to minimize both internal and external exposure to site workers. These measures include: minimizing the time spent in a radiation-contaminated area; increasing the distance from the source of radiation; using proper shielding to control external hazards; using personal protective equipment; and implementing source and environmental controls to minimize internal hazards.

3.2 Special Precautions and Procedures for Site Entry

Prior to a response, selection of the proper equipment and survey instruments is extremely important to assess the site adequately and protect workers. For example, a scintillation detector will easily detect contamination at near-background levels but only for gamma radiation. A Geiger-Muller (GM) detector may have difficulty detecting background gamma levels that indicate soil contamination but can be used to monitor worker exposure levels where beta particles are of concern. The RRPM or a health physicist should be consulted regarding monitoring needs.

Necessary equipment may include respirators with the appropriate radionuclide cartridges, thermoluminescent dosimeters (TLDs or radiation badges) for monitoring individual exposure levels, and portable field radiation detection instruments, including GM detectors, scintillation detectors, and/or ionization detectors. Detailed information on survey equipment is presented in chapter 4.

Proper decontamination procedures are important to prevent radioactive material uptake into the human body, to limit external radiation exposure, and to prevent further spread of contamination (see section 4.3).

3.3 Personal Protection

Personal protective equipment should include respiratory protection with appropriate cartridges if suspended (airborne) particulates are of concern. Coveralls, gloves, and overboots can provide protection against skin exposure. Air monitoring can be conducted using air pumps and particulate filters. The filters can be scanned for the presence of gross levels of radioactive particles or can be further analyzed for concentrations by isotope. Since site activities (e.g., digging) may increase the risk of exposure, additional steps may become necessary, on a site-specific basis, to ensure personal protection.

Biological monitoring for determination of internal exposure can include urinalysis, whole body counting, nasal smears, and/or fecal analysis. External exposure can be measured with TLDs, film badges, and/or direct-reading pocket dosimeters.

Specialists, like the RRPM or staff from ORIA, can function as OSC representatives or Health and Safety Officers, as per 40 CFR §300.120 (h)(2). They can assist in determining the appropriate personal monitoring needs for radiation safety concerns.

3.4 EPA Radiation Safety and Health Program

EPA 1440, *Occupational Safety and Health Manual*, documents the Agency's Radiation Safety and Health Protection Program. This program implements policy and procedures for minimizing exposure of EPA workers to ionizing radiation by defining exposure monitoring and safety training requirements. The Standard Operating Procedure (SOP), "Radiation Safety and Health Practices for Field Work," establishes guidelines for health and safety practices at Superfund and other sites.

3.5 Training

The Radiation Safety and Health Protection Program requires that dosimetry monitoring and basic safety training be provided to each worker required to enter areas where there is potential for radiation exposure above normal background levels. Additionally, advanced radiation safety training is required for personnel who routinely work in radiation areas, and for supervisors of all workers requiring dosimetry monitoring. For information about training and dosimetry, consult with the Regional or Program Safety, Health, and Environmental Management Program (SHEMP) Manager, or the RRPM.

All workers on a radiation site should receive some site-specific training designed specifically for the individual site. Typical training should cover such topics as the nature and health effects of ionizing radiation, prenatal radiation exposure, exposure limitations, and basic protective measures.

3.6 Reference

EPA 1440, *Occupational Safety and Health Manual*, "Radiation Safety and Health Practices for Field Work."

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4.0 CONDUCTING REMOVALS AT RADIATION SITES

4.1 Site Evaluation Issues

The primary objective of a site evaluation, either for chemical contaminants or for radionuclides, is to determine whether there has been a release or if there is a threat of release of hazardous substances. For chemical contaminants, rather than searching for the existence of any of the universe of possible contaminants, the assessment frequently begins by narrowing down the target parameters, if possible. The assessment is directed toward searching for those contaminants that are most likely to be present, based on the site history or actual site conditions. This is appropriate when the risk of a mistake (i.e., exposure) is relatively low, and the cost of testing for all contaminants is high. During the assessment, a subset of the total number of samples usually undergoes confirmatory (or full parameter) laboratory analysis to check whether the initial assumptions are correct. If at any time during the site evaluation unexpected contaminants are detected or suspected to be present, then response actions are adjusted accordingly. For example, if containers marked "cyanide" are unexpectedly found during the initial site evaluation, then the sampling plan, health and safety plan, and other response actions are adjusted to account for the actual or potential presence of cyanide. This fairly conservative procedure is typical for sites where the anticipated hazardous substances are other than radiation.

During the initial site evaluation, a radiation survey is required by the Occupational Safety and Health Act (OSHA) at every site[10]. Although not necessarily more dangerous than chemical contaminants, radiation is not visible to the naked eye and can affect site workers some distance from the source. As such, initial site evaluation procedures for radionuclides detection assume that radiation contamination is present in some form. An initial site survey might be fairly simple and might consist of a gamma radiation survey only. This will be sufficient to detect most hidden hazards in order to protect site workers, it will detect many but not all radionuclides, and is easy and inexpensive to perform. Gross alpha and beta laboratory analysis can be run on selected samples to detect alpha and beta sources which are not picked up in the initial survey. If radionuclides are detected, then just as for chemical contaminants above, response actions are adjusted accordingly. Note that negative survey results can be just as useful as positive ones when conducting a site evaluation.

If the survey reveals the presence of radioactive materials, or if EPA is notified of a release (or threatened release) of radioactive materials, the OSC **should** notify the RRPM. The RRPM can supply the OSC with important information for a more comprehensive assessment, including personal protective equipment, recommended surveillance equipment, and suggestions on other safety issues necessary for site entry. The radiation program may already be aware of the site and might be able to provide the OSC with site-specific information. A list of phone numbers of Regional Radiation Program Offices appears in chapter 5.

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[10] OSHA 1910.120 (c)(6)(i)

Initial Information

If the site is known or suspected to be radiologically contaminated, review all existing data about the site to determine (1) the type of hazard present, (2) the level of contamination, and (3) potential exposure to site workers. A health physicist or the RRPM will use this information to ensure that workers' exposure to radiation is maintained at levels that are as low as reasonably achievable (ALARA). Following notification of a threat, it is important to secure information about the site or incident. For a release of radioactive materials, it is important to answer the following questions:

- Is there immediate danger, or is the situation stable? Should evacuation of surrounding populations be considered?
- Have radiation measurements been taken? If there has been a release, what is the quantity?
- What radioactive materials are involved?
- Are there labeling or shipping papers that contain information?
- Are there shielded containers? In what condition are they?
- Is the site owned, operated, or licensed by DOE or DOD? Is the site regulated by DOE, NRC, NRC Agreement State, or solely by the State? If so, those agencies have primary responsibility (see chapter 2). Have they been notified? Are they responding?

Based on the information obtained in a preliminary assessment, consult the Regional Decision Team about the appropriate action (early action, long-term action, etc.). These decisions may need to be based on information collected during a more thorough site evaluation.

4.2 Site Surveying and Sampling

Site radiation monitoring generally occurs in two phases, a general area survey and a detailed contamination survey. First, a general area survey is performed to find any radiation threat. If this survey indicates the need (e.g., a threat is detected or more information is necessary), a more detailed contamination survey is performed. Investigation during either phase can help to locate airborne plumes, determine background radiation levels, and locate radiation areas close to the site. Since radiation sampling involves greater expertise and knowledge of the methods and procedures for acute site characterization than radiation survey techniques, the RRPM or other trained individuals should be consulted to perform this phase of the investigation.

4.2.1 General Area Survey

A general area survey usually begins with a gamma detection sweep. Gamma is the most penetrating form of radiation, the principal hazard to site workers, and the most detectable from the farthest distances. Radionuclides are also usually readily detectable in air samples at ground level, and initial air monitoring may provide the first indication of the presence and nature of radioactive contamination. Be aware that radionuclides, even at high levels, will probably not be detectible through or in surface water and/or groundwater.

Once preliminary radiation levels are established, the OSC, in consultation with the RRPM, can determine site safety precautions for site workers and the surrounding population. In the ERT

Standard Operating Safety Guides, EPA has established the following guidelines for action:[11]

Less than twice gamma background	Assume no radiation hazard is present.
Greater than three to five times background but less than 1 mR/hr on contact	There is probably radioactive material present which could present a disposal problem, but no immediate danger from external gamma radiation. Obtain samples for radiological analysis to see whether there is an ingestion hazard.
Above 1 mR/hour but less than 10 mR/hr on contact	There is the potential for a radiation hazard. Consult a qualified health physicist before disturbing or sampling the radioactive material.
Above 10 mR on contact	There is a radiation hazard present. Pull back from the contaminated area and establish a hot zone where the area gamma measurements are 2-3 mR/hr. This establishes a formal radiation area and should be posted as such. No one should enter the hot zone without supervision of a certified health physicist, appropriate badging, and other specific radiation protection measures.

Background radiation levels for most Superfund sites can be determined by taking at least one detector reading off site (i.e., outside the boundary but in the proximity of the site). Multiple background readings can also be taken at several locations and then averaged. Note: Background levels should be established away from high-energy electronic equipment, power lines, large rocks and boulders, road-fill materials, direct sunlight, sources of electro-magnetic waves, and other potential sources which can interfere with the direct-reading instrument's circuits or its ability to measure naturally-occurring or manmade radiological substances.

Based on the initial monitoring data, the OSC in consultation with the Radiation Program Manager can answer the following questions: Is evacuation of local residents necessary? Can a hot zone be delineated? Can clean areas and decontamination areas be set up safely? Where might appropriate sampling points for further investigation be located?

4.2.2 Detailed Contamination Survey and Sampling for Contamination

After the general area survey indicates the presence of radionuclides, a detailed contamination survey is conducted. The purposes of the detailed survey are to:

1. Confirm the specific radionuclide(s) present and the concentration.

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[11] OSWER Directive 9285.1-03.

2. Locate specific sources of radiation and hot spots.
3. Define the extent and boundaries of areas of contamination.

Sampling methods for radionuclides are similar to those for sampling other types of contaminants, but there are some special sampling considerations involving:

- The media to be sampled
- Sampling collection and storage equipment
- The filtration of water samples
- The volume to be sampled
- The selection of ecological samples

Determine on-site levels of contamination by direct counting with a radiation detector, by wipe or smear testing, and by air sampling. Gamma surveys should be conducted at ground level (for maximum detection) and at one meter above ground level for dose and risk assessment purposes. Since alpha and beta radiation do not travel far from the emitting source, the sweep for specific sources is conducted with the detector or detector probe placed within one inch of potentially contaminated surfaces. A more detailed contamination survey, therefore, is more time-consuming and labor-intensive than the general area survey (or gamma survey). The information collected from a detailed contamination survey can be used to formulate a more comprehensive assessment strategy, and to begin mapping hot zones and areas of varying site contamination. Such a map, set out on a grid, would ideally include sectors noting varying rates of exposure throughout the hot zone. Consult a health physicist and/or the RRPM for the selection, application, and interpretation of sampling methods and results for radionuclides.

4.2.3 Instrumentation for Surveying and Sampling

An initial gamma detection sweep is usually performed with a hand-held radiation meter(s) using either gamma scintillation probes, Geiger-Müller (GM) detectors, or ionization chambers. When choosing an instrument, remember that each type of detector has different sensitivities and responses to alpha, beta, and gamma radiation; the instruments are also susceptible to electromagnetic waves and interference from temperature extremes and humidity.

Scintillation detectors, using materials such as zinc sulfide crystals for alpha detection or sodium iodide crystals for gamma detection, are highly sensitive instruments. A microR meter with a sodium iodide crystal can measure extremely low levels of gamma radiation (in the microRoentgen per hour range). This portable instrument is an excellent choice for an initial field survey (provided it is used properly and the sensitivity of the instrument does not give inaccurate or misleading results from other interference sources).

For area monitoring, one of the most common portable field instruments is the GM detector, which is used to measure exposure rate. GM detectors are particularly useful for obtaining relative comparisons rather than absolute numerical levels. GM detectors with thin windows are sensitive to beta radiation and to alpha radiation (if the window is thin enough), but are relatively insensitive to gamma radiation. Gas proportional counters are especially good for alpha radiation. Thermoluminescent dosimeters (TLDs) can be left on site for short-term or long-term gamma exposure assessment. Radon monitors can be left indoors for short-term or long-term radon assessment. Ionization chambers are primarily used for beta and gamma radiation detection.

All instruments must be properly calibrated at least once a year. Check sources should be used for calibration, prior to surveying, to ensure proper instrument response in the field. Consult with your RRPM before making a choice of instruments for general area surveys or detailed contamination surveys.

4.3 Decontamination

It is generally easier to spread radionuclides off site, due to improper decontamination procedures, than most chemical contaminants. Equipment and personnel decontamination procedures at radiation sites, therefore, are likely to be even more stringent than those at chemically-contaminated sites. Detailed radiation decontamination procedures are beyond the scope of this reference document; it is recommended that a qualified health physicist be consulted when implementing a radiation decontamination and control program for a site.

4.4 Cleanup and Treatment Issues

The two ways for mitigating the hazard of radioactive materials from a site are:

1. gross removal with off-site disposal at a licensed facility, or
2. on-site treatment and stabilization.

Historically, gross removal and off-site disposal is the most widely used method of disposal at radiation sites. However, several options exist for on-site treatment of radioactive material, although they may have limited use at most Superfund sites. These include capping, vertical barriers, stabilization and solidification, and in-situ vitrification.

Capping consists of covering the contaminated area with a thick layer of low-permeability soil, sometimes augmented with a liner system to further prevent infiltration of water. This option would attenuate the radiation and protect the groundwater. However, capping does not eliminate the source of radioactivity and severely limits further use of the site. The cap must be maintained as long as the contaminant exists. Also, horizontal migration of the radionuclides in groundwater could still occur.

Vertical barriers serve as subsurface barriers to horizontal migration of radionuclides and, more important, as barriers to the horizontal movement of groundwater that may be contaminated with radionuclides.

Stabilization and **solidification** immobilize radionuclides by trapping them in an impervious matrix. The solidification agent (such as silica grout, or chemical grout) can either be injected directly into the waste mass *in situ* or the waste can be excavated, mixed, and replaced. Care should be exercised before using this treatment on site because it may reduce options for future disposal and it can greatly increase disposal costs.

The **in-situ vitrification** process also immobilizes radionuclides by trapping them in an impervious matrix, but the method is somewhat different from solidification. The in-situ process melts the waste materials between two or more electrodes using large amounts of electricity; the melted material then cools to a glassy mass in which the radionuclides are trapped. Again, care should be exercised before using this technology on site because vitrification can drive radon and other hazardous substances and toxic gases from the soil out into the atmosphere; controls may be required.

Note that some common cleanup methods may also spread radioactivity. For example, air stripping and soil gas evacuation would remove radon from the groundwater or soil concurrently with volatiles and release it to the air. This activity might also concentrate radionuclides, such as radon and other volatile gases, at a point source. Such treatment methods may trigger applicable or relevant and appropriate requirements (ARARs) under other Federal or State standards or criteria. It is important to note that charcoal collection media used for cleanup at a site containing radionuclides would become a gamma source.

4.4.1 Mixed Waste

Mixed waste is waste that contains both RCRA hazardous waste and AEA waste (source, special nuclear, or by product material — see section 2.2 of this reference document).[12] Because of the combined risks, mixed wastes often pose additional problems for treatment and disposal. Most chemical and radiological waste disposal facilities will not accept mixed wastes for disposal. There are only a few facilities that will accept mixed waste and their requirements can be very restrictive. The problem may be simplified by eliminating one or the other (chemical or radiological) contaminant from the waste stream. One treatment option which has been suggested is chemical separation. Pyrolysis or distillation might eliminate a combustible component, leaving a simple radwaste. A second treatment option might be chemical neutralization. For example, a radioactive "acid" (characteristic hazardous waste) could be neutralized to form a radioactive salt and water. Controlled evaporation could reduce the material to a radioactive, non-hazardous waste salt. A third potential treatment method is fixation. This is where a mixed waste (such as a radioactive/ignitable waste) could be "fixed" onto another "inert" waste, eliminating its hazardous waste characteristic. The remaining radioactive material could then be disposed of at an appropriate radioactive waste facility.

It is important that site workers refrain from mixing together materials with chemical and radiological hazards during response operations thereby creating mixed wastes. Contact your RRPM, the Emergency Response Team (ERT), or other specialists if confronted by these situations.

4.4.2 Cleanup Levels

No one cleanup level for a particular radionuclide or source of radiological contamination will be applicable at every removal action site. Cleanup levels under investigation might include cleanup thresholds or minimum standards to be addressed at a particular kind of Superfund site. Furthermore, State ARARs may also play a role in the OSCs' decision-making process where cleanup levels or standards have been established for particular radiological contaminants. Where appropriate and attainable, such standards or cleanup levels might be more restrictive than existing or proposed Federal requirements. Even though some cleanup goals may not be achievable as part of a long-term Superfund cleanup, removal actions may address interim measures to control the migration or spread of contaminants to the extent practicable (i.e., providing some measures to reduce the threat to the public and the environment.)

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[12] SWDA §1004 (41).

The Office of Radiation and Indoor Air (ORIA) is developing regulations for cleaning up sites contaminated with radionuclides. The regulations will include cleanup levels for radioactive contamination (how clean is clean?), disposal of investigation-derived wastes, and reuse/recycling of radioactive wastes. For information, contact the Radiation Studies Division of ORIA at 202-233-9340.

4.5 Waste Transportation and Disposal

Transportation and disposal of radioactive materials are subject to both Federal and State regulations, and to the requirements of storage and disposal facilities. This section lists sources of such information and other issues related to the transport and disposal of radioactive wastes.

4.5.1 Transportation Issues

The requirements for transporting radioactive materials are particularly critical. Any radioactive material which spontaneously emits ionizing radiation and has a specific activity in excess of 0.002 microcuries/gram of material is subject to Department of Transportation (DOT) and Nuclear Regulatory Commission (NRC) regulations. These regulations can be found in:

- 10 CFR Part 71 (NRC): "Packaging and Transportation of Radioactive Materials."
- 49 CFR (DOT) Part 173 Subpart I (for transportation of radioactive waste); also Part 177, "Carriage by Public Highway;" Part 178, "Shipping Container Specifications;" and Part 179, "Specifications for Tank Cars."

Be sure to contact the shipping company about its requirements for shipping radioactive materials.

4.5.2 Radioactive Waste Disposal Issues

Disposal of radioactively contaminated wastes is complicated not only by requirements of the Federal government, State governments, and disposal facilities, but also by the reluctance of disposal facilities to accept these wastes. Disposal facilities are often very reluctant to handle radioactive waste streams even if the radioactive portion of the stream is too small to be considered mixed waste.

Regulations referring to on-site storage of wastes can be found in 10 CFR Part 20 and clarified in NRC document NUREG-1101, "On-Site Disposal of Radioactive Waste." See also EPA regulations in 40 CFR Part 191. NRC regulations referring to final disposal can be found in 10 CFR Parts 61 and 71.

4.5.3 References

Radiochemistry Procedures Manual, NAREL. EPA 520/5-84/006.
Measurement of Radionuclides in Food and the Environment, International Atomic Energy Agency, Technical Reports Series, #295.
Sampling Surface Soils for Radionuclides, American Society for Testing Materials, Publication C-998-83.

Assessment of Technologies for Cleanup of Radiologically Contaminated Superfund Sites, OERR/ORD, January 1990. OSWER Directive 9380.0-20; EPA Report 540/2-90/001; NTIS #PB90-204140/CCE.
Forum on Innovative Hazardous Waste Treatment Technologies, OSWER/TIO, 1989. EPA Report 540/2-89/055; NTIS #PB90-268509/CCE.
ERT Standard Operating Safety Guides, OSWER Directive 9285.1-03.

5.0 AVAILABLE ASSISTANCE

There are several sources of assistance available within EPA for radiological contamination associated with Superfund sites. Programs, services, and training are available to cover virtually every type of radiological emergency that Superfund personnel may encounter.

If the situation involves a potentially significant release of radioactive substances and an emergency response, consult the Regional Response Team.

5.1 Regional Radiation Programs

Each EPA Region has a radiation program, with experts in nuclear engineering, health physics, and other relevant skills. **The Regional Radiation Program Manager is a dedicated source of technical assistance to the OSC** for sites with radioactive contamination.

OSCs are encouraged to maintain contact with the radiation representatives as needed, and to call on them for technical assistance. In addition to advice, radiation programs generally have access to a variety of survey instruments, personal protective equipment, and dosimeters. Table 1 lists phone numbers for the Radiation Program Office in each Region.

5.2 Environmental Response Team

The Removal Program specialists in radiation are located at the Environmental Response Team Operations Section in Cincinnati, Ohio. They can provide assistance in response planning and strategy, health and safety issues, and field monitoring.

ERT conducts a week-long course in *Radiation Safety at Superfund Sites* (Course No. 165.11). Topics covered include radiation exposure and biological effects; radiation exposure limits and methods to control exposure; basic concepts in radiation detection and measurement; surveying for radioactive materials; radiation signs and labels; decontamination procedures; radioactive material packaging; labeling, shipping and workshop; as well as regulations and guidance on radioactive waste disposal. The course also covers fundamental concepts of atomic structure and radiation and radioactive decay. It identifies the biological effects of radiation exposure and the existing rules and regulations which establish the protection criteria for exposure; discusses radiation detection including the theory of operation; and details the use and selection of radiation monitoring instruments.

Courses such as ERT's *Radiation Safety at Superfund Sites* and the EPA *Radiation Safety and Health Program* are designed to provide basic radiation safety information. It is still necessary to seek the assistance of a radiation specialist when radioactive materials are discovered at a site.

5.3 Headquarters Office of Radiation and Indoor Air (ORIA)

Within EPA Headquarters, ORIA is the primary regulatory and response organization for radiation contamination. ORIA expertise includes nuclear emergency response and contingency planning, emergency response capability for low-level and high-level radioactivity release incidents at hazardous waste sites, mobile field monitoring and analysis capability, and radiation site risk

Table 1: Regional Radiation Program Offices

REGION	OFFICE LOCATION	TELEPHONE
1	Boston, MA	(617) 565-4502
2	New York, NY	(212) 637-4010
3	Philadelphia, PA	(215) 597-8326
4	Atlanta, GA	(404) 347-4232
5	Chicago, IL	(312) 886-6175
6	Dallas, TX	(214) 655-7224
7	Kansas City, MO	(913) 551-7605
8	Denver, CO	(303) 293-1440
9	San Francisco, CA	(415) 744-1048
10	Seattle, WA	(206) 553-7660

assessment. In addition to radiation expertise, ORIA has staff experienced in Superfund removal operations and in carrying out the requirements of the NCP and FRERP.

OSWER Directive 9360.0-19 requires the OSC to notify ORIA to obtain health and safety advice when conducting radiation cleanup activities. However, during "classic" emergencies such as spills, fires, transportation incidents, etc., it may not be possible for the OSC to contact ORIA immediately. In such cases, the OSC must contact ORIA at the earliest time possible after the emergency situation is stabilized.

5.4 EPA Radiological Monitoring Laboratories

EPA maintains three laboratories that provide radiological monitoring and assessment services for emergency or day-to-day services:

- The National Air and Radiation Environmental Laboratory (NAREL) of the Office of Radiation and Indoor Air, located at Gunter Air Force Base in Montgomery, Alabama (334-270-3400)

- The Las Vegas Facility (LVF) of ORIA, located in Las Vegas, Nevada (702-798-2476)

- The Environmental Monitoring Systems Laboratory (EMSL) and Office of Research and Development, located near Nellis Air Force Base outside of Las Vegas, Nevada.

OSCs can access any of these laboratories in the following ways:

1. Contact the RRPM who, often, can handle many of the radiological situations or questions that might be presented. Or you may be referred to the laboratories, if necessary.

2. Contact the laboratory directly or through the Superfund Technical Support Center system.

3. Contact ORIA at EPA Headquarters in Washington, DC. They can direct you through the appropriate information channels.

Figure 3: Sources of Assistance

Training: *ERT, ORIA*
Health & Safety Consulting: *ERT, RPM*
Contingency Planning: *ORIA*
Response Strategies: *ERT, RPM, ORIA*
Field Monitoring/Analysis: *3 laboratories*
Risk Assessment: *ORIA, RPM*

- Regional Radiation Program Manager (Table 1)
- Environmental Response Team, Cincinnati (513-569-7537)
- Office of Radiation and Indoor Air, Washington (202-233-9360)
- National Air and Radiation Environmental Laboratory, Montgomery (NAREL) (205-270-3401)
- Office of Radiation and Indoor Air, Las Vegas (702-798-2476)
- Environmental Monitoring Systems Laboratory (EMSL) Nuclear Radiation Assessment Division, Las Vegas (702-798-2305)

In an emergency, these laboratories can provide radioanalytical services at the laboratory or at the scene of the accident. These radiological facilities have mobile laboratories, communications, and other support vehicles that can be deployed in various combinations, depending on the type and magnitude of response required. The support vehicles are equipped to provide command and control activities, sample preparation, sample storage, and supply and equipment dispatch. Using mobile equipment, staff from these facilities provide radiological services, including gamma spectroscopy and alpha/beta analyses. Local VHF and long-distance, shortwave communication capabilities help them keep in touch with response personnel from other agencies.

EMSL provides scientific and technical assistance in contaminant detection, hydrologic monitoring, site characterization, sample analysis, data interpretation, and geophysics. Services include: saturated and unsaturated zone monitoring; remote sensing; mapping and geostatistics; analytical methods and quality assurance; bore-hole and surface geophysics; and X-ray fluorescence field survey methods.

NAREL also operates the Environmental Radiation Ambient Monitoring System (ERAMS), which comprises sampling stations in each State that regularly collect air particulate, surface water, precipitation, and milk samples for radioactivity analyses. The system can track airborne radioactivity from any accidental release. If necessary, the ERAMS sampling frequency can be increased to meet the needs of any radiological emergency response.

5.5 Additional Assistance

Some States have their own State radiological teams which can offer assistance with certain aspects of radiological problems. These teams can be very helpful for small quantities of radiological materials, as they will actually handle the transportation and disposal tasks, often at little or no cost.