

# NRC INSPECTION MANUAL

NMSS

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## TEMPORARY INSTRUCTION 2800/043 REVISION 4

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### INSPECTION OF FACILITIES POTENTIALLY CONTAMINATED WITH DISCRETE RADIUM-226 SOURCES

Effective Date: 01/01/2021

#### 2800/043-01 PURPOSE

This Temporary Instruction (TI) applies to sites identified by the Office of Nuclear Material Safety and Safeguards (NMSS) in non-Agreement States, where byproduct material (specifically, discrete sources of radium-226) was historically used, or suspected to be used for commercial, medical, or research activities and the site was not cleaned up or records of clean-up are not available.

#### 2800/043-02 OBJECTIVE

The Energy Policy Act of 2005 (EPAcT) amended section 11e.(3) of the Atomic Energy Act of 1954, as amended (AEA), to place discrete sources of radium-226 (Ra-226) under the U.S. Nuclear Regulatory Commission (NRC) regulatory authority as byproduct material. The objective of this TI is to evaluate former manufacturing and other facilities, operational from as far back as the late 1800s, to determine, via an initial site visit and possibly a scoping survey, if Ra-226 sources are present at concentrations that could reasonably result in a radiological dose greater than the dose criterion in Title 10 of the *Code of Federal Regulations* (CFR) Part 20, "Standards for Protection Against Radiation," Section 20.1402.

#### 2800/043-03 BACKGROUND

The EPAcT expanded the definition of byproduct material to include certain discrete sources of radium-226, other discrete sources of naturally-occurring radioactive material, and certain accelerator-produced radioactive material under NRC jurisdiction (collectively, these materials are referred to as Naturally-occurring or Accelerator-produced Radioactive Material (NARM)). The NRC's Agreement States and certain non-Agreement States may have had regulatory programs for NARM prior to the implementation of the EPAcT.

Specifically, Section 651(e)(3)(A) of the EPAcT (§11e.(3) of the AEA; 42 U.S.C. 2014(e)) amended the definition of byproduct material to include "any discrete source of radium-226 that is produced, extracted, or converted after extraction, before, on, or after [August 8, 2005] for use for a commercial, medical, or research activity." On November 30, 2007, the NRC implemented this provision of the EPAcT by amending the definition of byproduct material in 10 CFR Parts 20, 30, 50, 72, 150, 170, and 171 to be consistent with the EPAcT in the final rule "Requirements for Expanded Definition of Byproduct Material" (72 FR 55864; October 1, 2007) (NARM rule). Additionally, the NRC established a definition for the term "discrete source" to be used for the purposes of the new definition of byproduct material as this term was not specifically defined by

the EPA Act. Accordingly, the NRC regulations in 10 CFR Parts 20, 30, 110, and 150 define a discrete source as “a radionuclide that has been processed so that its concentration within a material has been purposely increased for use for commercial, medical, or research activities.” *Id.*, at 55870. The Statements of Consideration (SOC) for the NARM rule noted that “once a discrete source meets the definition of byproduct material, any contamination resulting from the use of such discrete sources of this byproduct material will also be considered byproduct material and is not low-level waste.” *Id.*, at 55871.

The NRC staff initiated an effort through its contractor, Oak Ridge National Laboratory (ORNL), to identify non-military sites with potential radium contamination, concentrating on sites in non-Agreement States. The ORNL staff began this effort by identifying manufacturers of radium containing consumer products. The purpose of focusing on manufacturers of radium containing consumer products was to identify sites that likely handled large amounts of radium as unsealed material. The result of the ORNL effort (ORNL 2015) is a list of sites that may have potentially possessed discrete sources of Ra-226 along with summaries of available information regarding these sites. The ORNL effort did not verify whether radium contamination exists at these sites. The scope of this TI is limited to these non-military sites located in non-Agreement States and federally-owned sites in Agreement States. The scope of the TI is also limited to providing guidance for planning, conducting, and reporting on surveys of selected commercial, medical, or research sites potentially contaminated with radium. Some supporting activities such as outreach to States, resolving policy issues related to site clean-up, requesting site information from the States, letters to and initial phone calls with the property owners requesting site access, conducting initial dose assessments, and determining future actions are separate activities not within the scope of this TI.

The survey described in this TI may be performed in two steps: an initial site visit and the scoping survey. For the initial site visit, a survey will be conducted with the objective of determining whether there are any current health and safety concerns. Therefore, the NRC staff will use an action level related to a dose of 100 mrem/yr (the NRC public dose limit of 10 CFR 20.1301) to verify there are no meter readings above the screening threshold for occupancy. This will allow the NRC staff to assess whether there is a current public health and safety concern at a site. See also Section 04.02.d and Figure 1 for additional information on this action level and the associated actions. If the NRC concludes that a follow-up scoping survey is warranted, the objective of the survey will be to determine whether or not remediation will be necessary to meet the NRC’s dose limit for license termination for unrestricted use in 10 CFR 20.1402 (i.e., 25 mrem/yr), so action levels for the scoping survey are based on a dose of 25 mrem/yr. It is also possible that the NRC staff meet this objective during the initial site visit.

## 2800/043-04 INSPECTION REQUIREMENTS AND GUIDANCE

### 04.01 Survey Planning and Agreements

- a. The site summaries from the ORNL site identification effort are the starting point for understanding the publicly available information about each site. The inspector will review the site summary documents, information received from the State related to the site, and other pertinent information prior to the development of the initial site visit/scoping survey plan to identify the likely locations where discrete sources of Ra-226 were manufactured, stored, etc.; and, therefore, to indicate the highest potential for locating residual contamination. Survey planning requires an understanding of potentially impacted media (e.g., building surfaces and soils), boundary conditions

(physical, temporal, and practical boundaries of the area being evaluated), site scale, potential interferences (e.g., sources may be covered or buried), and other factors that should be considered during the planning phase of the survey.

- b. Prior to performing the initial site visit, the inspector and the NMSS project manager should determine the institutional memory of site operations by interviewing key personnel with knowledge of former operations, e.g., current site owners or other knowledgeable individuals. These inquiries can be made by telephone or written correspondence. A historical records review at local libraries, historical societies, and museums, as well as Chamber of Commerce reports and business guides from the time period should be considered.
- c. Data sharing opportunities will be initiated by the region and shall be coordinated with NMSS, as appropriate, so that all (need-to-know) parties have as complete a file as practicable for each property.
- d. In an effort to have complete files, the regional staff shall obtain copies of documentation for the docket file, whenever possible. Documentation on any previous clean-up effort shall be obtained, if available, from the site, or through State record archives. If official (i.e., State or other government agency) documents are not available, then verbal confirmation may be considered to augment other documents to close out specific concerns about Ra-226 sources. A record of such conversations shall be placed in the docket file.
- e. The Region, in consultation with NMSS, will plan outreach discussions with the appropriate radiological control program staff within the State. Site information provided by the State will be used to decide if a site visit and scoping survey is necessary.
- f. For sites in non-Agreement States, it is the responsibility of the regional assigned staff to coordinate all site visits with the appropriate radiological control program staff within the State. NMSS should be informed periodically of the status of site visits.
- g. An informal email confirmation of site access with the property owners, will be initiated by the NMSS project manager. This communication will confirm the date and time of the initial site visit and include additional information regarding the scope of the visit. If a site owner refuses access, the NMSS project manager shall discuss next steps to gain access with NRC management and Office of the General Counsel staff to determine a path forward. The NMSS project manager shall document the site owner's confirmation or refusal of the site visit in the docket file.
- h. State personnel should be invited to accompany the inspector on any initial site visits and scoping surveys. It shall be clearly communicated that accompanying State personnel are responsible for their own health and safety (see also Appendix A, Section 4.0).
- i. Before, during, and after the initial site visit and scoping survey, the inspector or the NMSS project manager, will be in contact with the site owner about the project. These interactions should be used as opportunities to answer questions or address concerns for the site owner. Before leaving the site from the initial site visit and the scoping survey, the inspector will communicate to the site owner the general results of the visit,

as available, and approximately when the NRC anticipates being able to provide additional information.

#### 04.02 Initial Site Visit

- a. The inspector will conduct an initial site visit. The top half of Figure 1 presents high-level decision logic for the site visit. The purpose of the site visit is two-fold, to determine if there is a current health and safety concern, and to identify the locations where the scoping survey if needed should focus.
- b. Inspectors shall document the following during the initial site visit, based on observation or from the property owner when available: 1) where occupants spend time; and 2) what type of activities take place in the area. This information will be used to better assess potential doses from Ra-226, if identified. Appendix C presents a field notes template for the initial site visit (and scoping survey) to help ensure that the gathered information is sufficient to plan future activities.
- c. For the initial site visit, measurements shall consist primarily of gamma dose rate (or exposure rate) measurements at approximately 1 meter from the floor as an indication of dose rates to which occupants may be exposed. The inspector should use his or her judgment to survey walls and window sills as appropriate. In cases of vertical sources (e.g., a wall), dose rate (or exposure rate) measurements should generally be made at a distance of 1 meter from the surface or at closer distance, as applicable based on professional judgment, to represent dose rates to which occupants are or may be exposed (e.g., measurements on contact, at 1 meter, and occupational areas should all be considered). Representative background radiation levels should be determined in a nearby reference area that closely approximates the area to be surveyed. Per the site-specific plan, inspectors should also take limited smear samples in locations based on their professional judgment (e.g., in areas of elevated gamma dose rate) to provide an indicator of dispersible activity. Samples (e.g., soil, water, sediments, swipes) may be taken and used to help determine if Ra-226 is present. Staff may discuss with management on a site-specific basis if Radon measurements may also be used.

NOTE: If Ra-226 is identified, the inspector will contact their management, before leaving the site, to discuss the need for barriers, postings, and/ or administrative controls necessary to address any health and safety concerns.

- d. Inspectors shall complete NRC Form 303, "Request for Analysis and Chain of Custody" or an equivalent chain of custody document. Inspectors should plan for shipping of samples and shall use a shipping method that maintains chain of custody.
- e. For the initial site visit, 2 Action Levels (ALs) based on current site use will be used to identify radiation levels that could conservatively produce a dose of 100 mrem/yr per the public dose limit in 10 CFR 20.1301. The first AL of 15  $\mu$ rem/hr (above background) at 1 meter or as appropriate for vertical surfaces, correlates to 100 mrem/yr conservatively assuming a residential receptor spends up to 6800 hr/yr in close proximity to the source. This screen will be applied to areas that are clearly residential. The second AL of 40  $\mu$ rem/hr (above background) at 1 meter or as appropriate for vertical surfaces, correlates to 100 mrem/yr conservatively assuming a worker (or non-residential receptor) spends up to 2300 hr/yr in close proximity to the source. This screen will be applied to areas that are not clearly residential. External

dose rate measurements above these ALs, applied to the appropriate setting, will prompt the inspector or NMSS project manager to contact NMSS and regional management for further instruction. If external dose rates above the ALs are found, access controls should be discussed and agreed to with the site owner. In some cases, consideration of other measurements, such as the concentration of radium on surfaces, soil, water, sediment, and radon levels, may be needed to determine whether access controls are needed. The inspector or NMSS project manager should discuss the need for measurements other than external dose rates with NMSS and regional management. The inspector, the NMSS project manager, and management shall also refer to Inspection Manual Chapters (IMCs) 1301 and 1302 for information on potential site controls and other actions that may be taken. The implementation of these controls will be the responsibility of the site owner. NMSS will also use the information gathered from the surveys and additional measurements to reconsider the site's priority.

NOTE: for the initial site visit, it is presumed that elevated gamma radiation levels are due to Ra-226 – confirmation may be made with portable gamma spectroscopy instrumentation.

- f. As a tool, radon monitoring may be considered on a case-by-case basis (as approved by management) to better inform site decisions. A health physicist should be consulted prior to surveys being performed and when discrete radium is identified at a site. The health physicist will make a recommendation to management, for approval, before radon monitoring is initiated. This tool could apply to (a) better assessing potential dose for current occupants to inform controls that might be undertaken; and (b) to identify cases where discrete radium is present but not found through other measurements (c) to areas where there is an indication of large discrete sources or an indication that radon from discrete sources may be present. Radon measurements should be used to determine if radon would expand the areas of concern for controls on exposures already identified through direct gamma measurements. For example, if controls are placed on an area of concern based on direct gamma measurements for a large discrete source of radium, occupants near the large discrete source of radium that are unaffected by direct gamma measurements could be impacted by radon. In this situation, radon measurements would be used to make an informed decision on necessary controls for the area of concern.
- g. After the initial site visit is complete, the inspector will prepare a summary of the initial site visit. Based on this report, the inspector and NMSS project manager will evaluate the need for performing a scoping survey and make a recommendation to NMSS and regional management. On a site-by-site basis, a scoping survey may not be needed. For most sites, only an initial site visit may be performed if adequate data is collected during the initial site visit to assess whether (1) controls are needed, as described in Section 4.2.e above, and (2) future actions may be needed to ensure doses remain below the NRC's unrestricted use criterion, 25 mrem/yr, as described in Section 4.3.
- h. A preliminary dose assessment may be performed (see also Section 04.04), as appropriate, to further inform management's decision on the need to perform the scoping survey. Other considerations for this decision could include, but are not limited to: the suspected or known historic uses of radium on the site; additional information obtained during the visit regarding locations where radium was historically used; and the feasibility of obtaining additional data to demonstrate the presence or absence of radium on the site.

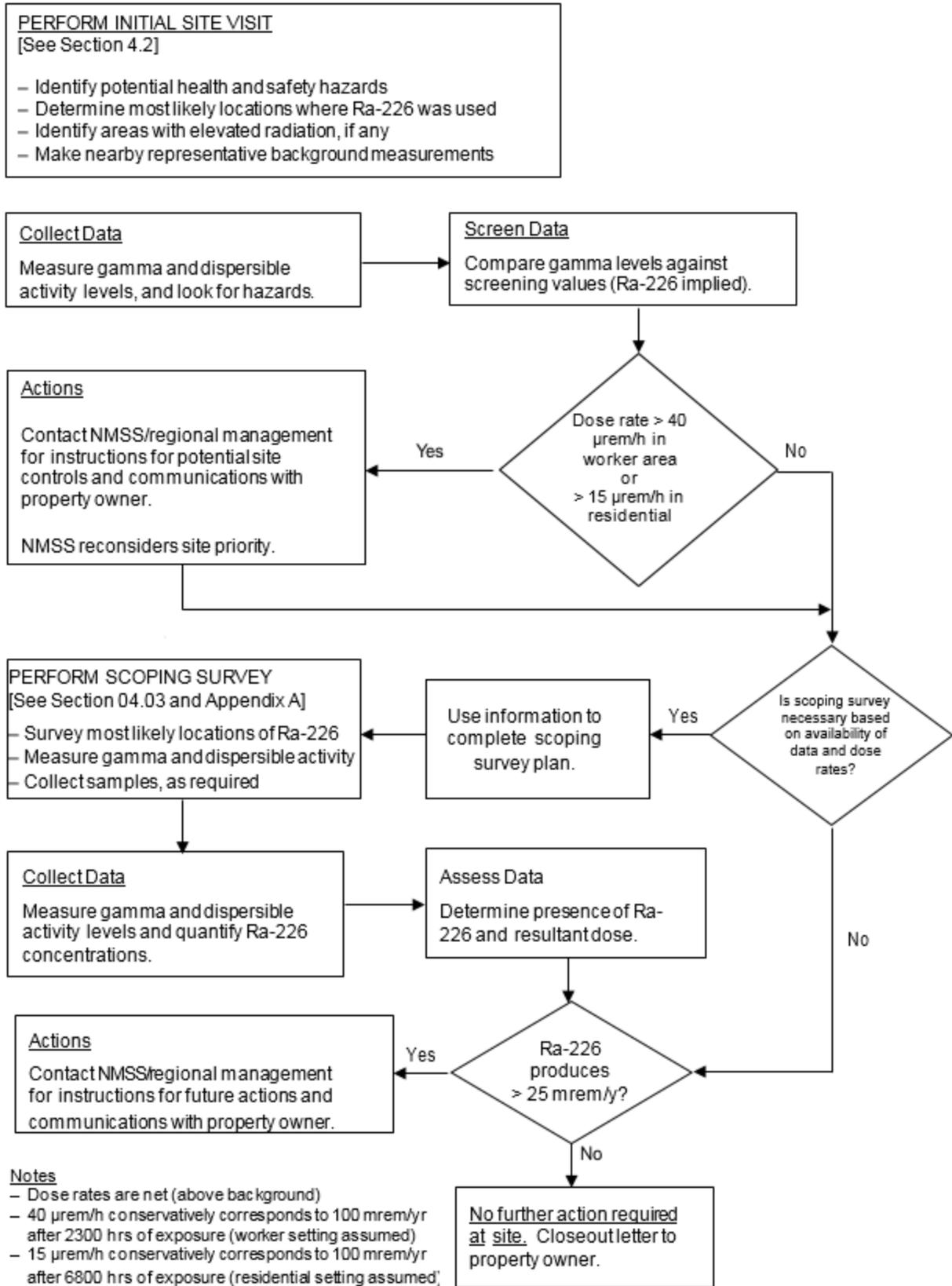


Figure 1. Typical Process for Site Visit and Scoping Survey

#### 04.03 Scoping Survey

- a. After the initial site visit is complete and a scoping survey has been determined to be necessary, the inspector will finalize a scoping survey plan considering the template presented in Appendix B. The bottom half of Figure 1 presents high-level decision logic that inspectors will use during the scoping survey. In general, no surveys or sampling requiring destruction of property should be planned. If destruction of property is necessary to obtain critical measurements, the inspector shall consult with regional management for guidance. Access to areas, such as inhabited apartments, will be considered on a case-by-case basis. Professional judgement should be used to determine if surveys are necessary for areas that are inaccessible due to furniture, equipment, or other objects. The completed site visit field notes contained in Appendix C, annotated maps, and other relevant information will be used as inputs to the plan. The goal of the scoping survey is that sufficient data will be obtained so that the NRC management can make a no-further-action determination (i.e., there is no Ra-226 resulting in dose greater than 25 mrem/yr), or to require future actions from the site owner (e.g., establish controls, perform additional site characterization, or clean-up).
- b. The inspector will conduct the scoping survey to locate, delineate and quantify radiation levels and Ra-226 concentrations. For the scoping survey, measurements shall consist of gamma dose rate (or exposure rate), surface contamination concentrations, removable surface contamination concentrations (swipes), and samples of soil or other media, as appropriate. Inaccessible areas will not be surveyed unless there is a clear indication that the inaccessible area may have levels of contamination critical to the NRC's decision. In such cases, the path forward will be discussed with NMSS and regional management. Data collected during the scoping survey will be used to estimate the site-specific dose for comparison to the 25 mrem/yr limit in 10 CFR 20.1402. If Ra-226 is identified and confirmed via either field screening or laboratory spectroscopic analysis, then the inspector will promptly notify regional management for instructions on plans to proceed.

NOTE: If Ra-226 is identified, the inspector will contact their management, before leaving the site, to discuss the need for barriers, postings, and/ or administrative controls necessary to address any health and safety concerns.

- c. Guidance on personal protective equipment (PPE) requirements for the survey is provided in Appendix B, Section 4.0, of this TI.
- d. Appendix C presents a template for the scoping survey field notes to help ensure that the gathered information is sufficient to determine if further action is needed by the site owner.
- e. The inspector or NMSS project manager will complete the site status report, considering the Appendix A template, and make recommendations to the NMSS and regional management for either no-further-action or remedial action.
- f. The NRC will convey by letter to the property owners the outcome of the findings.

#### 04.04 Dose Assessment

- a. If Ra-226 is identified, doses will be calculated after receipt of all survey and laboratory analytical data (see Section 04.02.e for further details). Dose assessments to determine whether thresholds are met (25 or 100 millirem/year) are to be calculated using readings at 1 meter from the source, in the direction of the torso depending on the location of the source on floor or walls. At some sites (e.g., sites with no or insignificant radium contamination), adequate data may be available following the initial site visit to perform a dose assessment without the need for a scoping survey. On a case-by-case basis, the dose assessment is intended to determine whether Ra-226 is present at concentrations that could reasonably result in a radiological dose greater than the 25 mrem/yr dose criterion in 10 CFR 20.1402.
- b. The inspector shall obtain adequate data (e.g., surveys and samples) as well as physical descriptions of contaminated areas (e.g., areal extent, removable fractions) consistent with the site-specific survey plan, in order for the NRC to perform a dose assessment. The site-specific dose analysis will be performed to assess whether or not current and plausible future exposures to Ra-226 exceed the criterion. The technical basis and the information necessary for the dose assessments are available in the Dose Assessment Technical Basis Document (NRC 2017).

#### 2800/043-05 REPORTING REQUIREMENTS

05.01 Reports to Site Owner. A letter summarizing the site visit and scoping surveys results, as applicable, and associated report discussed below will be sent to the site owner and a copy will be provided to State. This letter will be drafted by the NMSS project manager and be signed by the Director, Division of Decommissioning, Uranium Recovery and Waste Programs.

05.02 Reports to NMSS. The inspector should document results of the initial site visit and provide the report to the NMSS project manager. The field notes and site visit report will be completed by the inspector. If necessary, the inspector should document results of the scoping survey, including the type of information described in the example site status report provided in Appendix A, and provide the report to the NMSS project manager. Site status reports shall be forwarded to the contact listed in the site-specific scoping survey plan (see Appendix B, Section 3). Documentation demonstrating whether or not the site satisfies 10 CFR 20.1402 shall be placed in the docket file for that site and sent to the NMSS project manager.

05.03 NMSS Tracking of Site Status. NMSS project manager will track each site referred to the region.

#### 2800/043-06 COMPLETION SCHEDULE

The expected completion schedule for this TI is December 31, 2022.

#### 2800/043-07 EXPIRATION

This TI remains in effect until December 31, 2022.

2800/043-08 CONTACT

Questions regarding this TI should be addressed to Christopher Grossman, NMSS/LLWPB, at (301) 415-0140.

2800/043-09 RESOURCE ESTIMATE

The estimated on-site inspection time necessary to perform the initial site visit is 0.5 – 1 day (excluding travel). The time for a scoping survey is estimated to be 1 – 4 days per site (excluding travel), depending on the size and complexity of the property. Currently there are 29 known sites but the number of sites is an approximation and may change.

2800/043-10 TRAINING

Inspections conducted under this TI will be performed by staff qualified to perform decommissioning inspections under Inspection Procedure 87104. No additional training is required.

2800/043-11 REFERENCES

ORNL 2015. *Historical Non-Military Radium Sites Research Effort Addendum*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 24. (Agencywide Documents Access and Management System [ADAMS] Accession No. ML16291A488).

NRC 2017. *Dose Assessment Technical Basis Document for U.S. Nuclear Regulatory Commission Inspectors to Assist Non-Military Radium Site Visit and Scoping Surveys*, U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Washington, D.C., June. (ADAMS Package Accession No. ML17072A414).

END

Appendices:

- A. Example Site Status Report
- B. Sample Survey Plan
- C. Site Visit and Scoping Survey Field Notes

## APPENDIX A

### EXAMPLE SITE STATUS REPORT

Property:      Historical Name  
                  Address  
                  City, State, Zip Code

Docket Number:

Current Property Name(s): (as applicable)

Current Property Owner(s): (as applicable)

Inspection Dates:      Month, Day, Year

Inspector(s):           Name(s) and affiliation(s)

#### 1.0 INTRODUCTION

The Energy Policy Act of 2005 amended section 11e.(3) of the Atomic Energy Act of 1954 to place discrete sources of radium-226 (Ra-226) under U.S. Nuclear Regulatory Commission (NRC) regulatory authority as byproduct material. The NRC is evaluating [SITE NAME], a former manufacturing facility, operational from [DATES], to determine via a scoping survey if discrete sources of Ra-226 and distributed contamination are present at concentrations that could reasonably result in a radiological dose above 25 mrem/yr, per Title 10 of the *Code of Federal Regulations* (CFR) Part 20, Standards for Protection Against Radiation, Section 20.1402.

Data from [DATES] the initial site visit and/or scoping survey are used herein [EITHER] to [eliminate the property from future NRC consideration (i.e., no sources were identified)] [OR] [plan future actions and minimize exposure of current or plausible future receptors to source materials.]

#### 2.0 PROPERTY DESCRIPTION AND CONCEPTUAL MODEL

The site summary report (ORNL [YEAR]) provides known site details about the type, form, history, potential locations and other information related to discrete sources of Ra-226. The property is [BRIEF PHYSICAL DESCRIPTION OF CURRENT CONDITIONS]. Based on the site history and the property's current configuration, Ra-226 is most likely to be located [WHERE] in [MEDIUM]. The initial site visit and/or scoping survey determined that Ra-226 [IS OR IS NOT] present at the site, as described in the following discussion.

### 3.0 SITE OBSERVATIONS AND FINDING

#### 3.1 Summary of Activities.

[The author should describe the nature of the survey, including, but not limited to the following]:

- A general description of the property covered by the inspector, noting inaccessible areas, the reasons for access restrictions and the potential impact to final decisions, relevant property features, etc.;
- A summary of conversations that relate to the survey; and
- Maps of the property noting the general location of scoping survey activities, relevant property features, and Ra-226, if identified.

#### 3.2 Summary of Results.

- A description of on-site radiation measurements collected during the initial site visit and/or scoping survey:
  - Instruments used during the survey;
  - A text description of data collected (direct alpha measurements, direct alpha-plus-beta measurements, 2x2 measurements, etc.);
  - A map, if practicable, of measurement locations;
  - Tabulated results for each type of measurement data collected;
  - An estimate of the percent of the property covered during the scoping survey (e.g., inspectors collected data in eight of the ten rooms in a building); and
  - The specific location, nature, and extent of contamination associated with identified discrete sources of Ra-226.
- A description of the samples collected for off-site analysis:
  - A text description of each type of sample, including the total number of samples collected;
  - A map, if practicable, of sample locations;
  - Tabulated results for each type of sample collected; and
  - The specific location, nature, and extent of contamination associated with identified discrete sources of Ra-226.

#### 3.3 Summary of Dose Assessment Results.

- Residual radioactivity source information, including radionuclides of interest, configuration of the source, and areal variability of the source;
- Description of the conceptual model of the site, including the source term and physical features important to modeling the transport pathways;
- Description of the exposure scenario and pathways, including a description of the critical group;

- Discussion and justification for use of screening assessment versus site-specific dose assessment;
- Identification and description of the mathematical model used (e.g., hand calculations, DandD, or RESRAD);
- Description of and justification for the parameters used in the analysis;
- Discussion about the effect of uncertainty on the results;
- Input and output files or printouts, if a computer program was used; and
- Results (calculated doses).

#### 4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on this body of evidence, the property [NAME] [does, does not, or may] contain discrete sources. [The author should expand upon the following]:

- No Ra-226 was found. Therefore, it is concluded that the NRC does not require remedial action at the property.
- If Ra-226 was found, but the dose is less than 25 mrem/yr; it is concluded that the NRC does not require remedial action at the property.
- Ra-226 was found, and there is a reasonable probability that the 25 mrem/yr dose limit will be exceeded by current or reasonably foreseeable receptors [PROVIDE DETAILS]. Therefore, it is concluded that the NRC does require remedial action at the property.
  - Describe the sources and give the rationale for this conclusion.

## APPENDIX B<sup>1</sup>

### SAMPLE SURVEY PLAN

Property: Historical Name  
Address  
City, State, Zip Code

Docket Number:

Current Property Name(s): (as applicable)

Current Property Owner(s): (as applicable)

Inspection Dates: Month, Day, Year

Inspector(s): Name(s) and affiliation(s)

#### 1.0 INTRODUCTION

The Energy Policy Act of 2005 amended section 11e.(3) of the Atomic Energy Act of 1954, as amended (AEA), to place discrete sources of radium-226 (Ra-226) under the U.S. Nuclear Regulatory Commission (NRC) regulatory authority as byproduct material. The NRC is evaluating [SITE NAME], a potentially contaminated facility, operational from [DATES], to determine via a survey if discrete sources of Ra-226 or distributed contamination from the manufacturing or use of such sources are present at concentrations that could reasonably result in a radiological dose above 25 mrem/yr to a current or plausible future receptor, per Title 10 of the *Code of Federal Regulations* (CFR) Part 20, Standards for Protection Against Radiation, Section 20.1402, *Radiological criteria for unrestricted use*.

A survey is required to determine the extent of Ra-226 contamination and its boundary and assess the quantity of Ra-226 to determine the radiological dose from exposure to Ra-226. Data from this survey will be used either to eliminate the property from future NRC consideration (i.e., when no sources are identified that cause a radiation exposure to any member of the public that exceeds the 25 mrem/yr limit) or to plan future actions and minimize exposure of current or plausible future receptors to source materials.

#### 2.0 PROPERTY DESCRIPTION AND CONCEPTUAL MODEL

The site summary report (ORNL [YEAR]) provides known site details about the type, form, history, potential locations and other information related to manufacture or use of discrete sources of Ra-226. The property is [BRIEF PHYSICAL DESCRIPTION OF CURRENT CONDITIONS]. Based on the site history and the property's current configuration, discrete sources of Ra-226 were most likely to be located or used during prior operations [WHERE] in [MEDIUM]. [ADDITIONAL DETAIL ADDED TO DESCRIBE THE CONCEPTUAL MODEL]

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<sup>1</sup> Appendix B, Sample Survey Plan, will be completed by inspectors with input from the Office of Nuclear Material Safety and Safeguards (NMSS) staff prior to inspectors performing the Survey.

### 3.0 DATA QUALITY OBJECTIVES

The Data Quality Objectives (DQO) described herein are consistent with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NUREG-1575, 2000) and provide a formalized method for planning radiation surveys, improving survey efficiency and effectiveness, and ensuring that the type, quality, and quantity of data collected are adequate for the intended decision applications. The seven steps in the DQO process are outlined below.

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

#### 3.1 Step 1 – State the Problem.

The first step in the DQO process defines the problem that necessitates the study, identifies the planning team, and examines the budget and schedule. The Energy Policy Act of 2005 (EPA Act) amended section 11e.(3) of the AEA, to place discrete sources of Ra-226 under NRC regulatory authority as byproduct material. The NRC is evaluating former manufacturing facilities and other identified locations where Ra-226 was historically used or stored to determine if residual Ra-226 sources are present and at concentrations above 10 CFR 20.1402 requirements. Based on this background, the problem statement is as follows:

The initial site visit identified one or more discrete sources of Ra-226. Because of the number or extent of the sources, a scoping survey is required to further locate the extent of Ra-226 contamination and its boundary, and assess the quantity of Ra-226 to determine the radiological dose from exposure to Ra-226.

- a. Project Organization and Responsibilities. Table B-1 presents the project organization across programs and departments, including key personnel, roles, and contact information.

The NMSS project manager will coordinate with the property owner to obtain email confirmation of site access and schedules. The inspector will coordinate with NMSS and the property owner to access the property. The inspector and NMSS project manager will coordinate with State and the NRC staff.

Table B-1. Key Personnel Contact Information				
Name	Organization	Role	Phone	E-mail
Branch Chief	NRC	Branch Chief	TBD	TBD
Inspector	TBD	Inspector	TBD	TBD
Project Manager	TBD	Project Manager	TBD	TBD
Other	TBD	Other (describe)	TBD	TBD

- b. Project Budget and Schedule. The project is funded by the NRC and the survey is tentatively scheduled for the month of [MONTH AND YEAR]. Fieldwork is anticipated to last [NUMBER] days and reporting should be completed [NUMBER] weeks after sample results, should sampling be required, are reported by the analytical laboratory.

### 3.2 Step 2 – Identify the Decision.

The second step in the DQO process identifies the Principal Study Question (PSQ) and Alternate Actions (AA); develops a decision statement; and organizes multiple decisions, as appropriate. This is done by specifying AAs that could result from a “yes” response to the PSQ and combining the PSQ and AAs into a decision statement. Table B-2 presents the PSQs and AAs combined into a decision statement.

Table B-2. Ra-226 TI PSQs, AAs and Decision Statement	
Principal Study Question	Alternative Actions
PSQ1: Has the survey identified Ra-226?	No: The data will be used to support the conclusion that the NRC does not have jurisdiction over the property. Yes: Proceed to PSQ2
PSQ2: If identified, could exposure to the Ra-226 clearly and reasonably produce a radiological dose above 25 mrem/yr to current or reasonably foreseeable receptors, based on a screening-level (non-site-specific) dose assessment?	No: If clearly no, the data will be used to support the conclusion that the NRC does not require remedial action. Unclear: Proceed to PSQ3 Yes: If clearly yes, the data will be used to plan future actions to control and mitigate risks from exposure to the source.
PSQ3: If identified, could exposure to the Ra-226 result in a radiological dose above 25 mrem/yr to current or reasonably foreseeable receptors, based on a site-specific dose assessment?	No: The data will be used to support the conclusion that the NRC does not require remedial action. Yes: The data will be used to plan future actions to control and mitigate risks from exposure to the source.
Decision Statement	
Ra-226 is (or is not) present and could (or could not) reasonably produce radiation doses above 25 mrem/yr, and the NRC does (or does not) require remedial action at the property.	

### 3.3 Step 3 – Identify Inputs to the Decision.

The third step in the DQO process identifies both the information needed and the sources for this information; determines the basis for action levels; and identifies sampling and analytical methods that will meet data requirements. For this effort, information inputs include the following:

- EPAAct amended section 11e.(3) of the AEA;
- 10 CFR Part 20, Standards for Protection Against Radiation, Sections 20.1402 and 1301;
- Site summary documentation (ORNL [YEAR]) and information gathered during the initial site visit;
- Site email confirmation of site access and associated limitations, if any;
- NUREG-1507 for estimating detector-specific Minimum Detectable Concentrations (MDCs);
- Applicable field instrumentation and survey procedures, method procedures, data/sample management procedures, and survey results;
- Applicable analytical laboratory procedures, method procedures, data/sample management procedures, and analytical results; and
- Dose modeling software (e.g., the RESRAD family of codes), data inputs, and dose consequence outputs.

### 3.4 Step 4 – Define the Study Boundaries.

The fourth step in the DQO process defines target populations and spatial boundaries; determines the timeframe for collecting data and making decisions; addresses practical constraints; and determines the smallest subpopulations, area, volume, and time for which separate decisions must be made.

Boundary conditions include physical, temporal, and practical factors that may limit an inspector's access to the property. More specifically:

- Physical boundary: Subject properties vary in physical size from very small (e.g., an abandoned shed) to very large (e.g., multiple large-scale manufacturing buildings). Tools such as photos and GPS coordinates should be considered to help define the boundaries.
  - ORNL [YEAR] may be used to better define physical boundary conditions and high-priority target areas.

- Temporal boundary: Inspectors may have limited time to survey all accessible portions of the property and access may only be available during small windows of time.
- Practical boundary: Inspectors may have limited property access, based on either the email confirmation of site access or the inspector's general health and safety.

To address these boundary conditions, the survey plan must be based on judgmental sampling (rather than statistical sampling) to target accessible locations with the highest potential for containing Ra-226 contamination. In general, the inspector will collect as much data as possible from accessible areas with the highest potential of containing Ra-226 sources, in the time allotted to perform the survey. Inaccessible areas will not be surveyed unless there is a clear indication that the inaccessible areas may have levels of contamination critical to the NRC's decision. In such cases, the path forward will be discussed with regional management.

Decisions may be made based on any single confirmed discrete source (the smallest subpopulation) that could produce a radiological dose of 25 mrem/yr, assuming a plausible current-use scenario. If suspected Ra-226 is encountered, the inspector should spend enough time to gather data from the area to delineate and quantify contamination levels [ADDITIONAL DETAILS ADDED TO PROVIDE FIELD GUIDANCE ON APPROPRIATE TIME/EFFORT]. These data will support the dose analysis and programmatic decisions.

### 3.5 Step 5 – Develop a Decision Rule.

The fifth step in the DQO process specifies appropriate population parameters (e.g., mean, median); confirms ALs are above detection limits; and develops an "if...then..." decision rule statement. The objective of the survey is to locate discrete sources of Ra-226 and, if located, determine if the sources (either individually or in combination) could result in an unacceptable dose based on current or reasonably expected future use. Inspectors are required, via implementation of this plan, to collect the data that will be used to locate and delineate Ra-226 contamination. This data will then be used to calculate the site-specific dose for comparison to the 25 mrem/yr limit. Specific ALs, therefore, are thresholds that will be used to prompt more extensive data collection in a particular area:

1. Positive identification, by visual inspection or other means, of discrete sources of Ra-226.
2. For dose rate measurements near any identified source or any medium (e.g., soil, piping, an unsealed instrument dial), a result that is clearly above ambient background, determined using the inspector's professional judgment.
3. For direct measurements on any medium at any location within the facility, based on detectable concentrations as described in NUREG-1507:
  - [VALUE] gross counts per minute (cpm) corresponding to a concentration of [VALUE] pCi/g above background in soil or bulk materials, or
  - [VALUE] dpm/100 cm<sup>2</sup> on facility structures/surfaces.
4. Surface contamination (e.g., building media), confirmed removable Ra-226 activity [VALUE] dpm/100 cm<sup>2</sup> as an indication of dispersible, potential airborne, contamination.

In all these cases it is presumed that the resulting dose, to a current or potential future receptor, could reasonably exceed 25 mrem/yr. A site-specific dose analysis may result from the confirmation of any of these four items.

For Item 2, dose rate measurements will be made using a sodium-iodide, tissue-equivalent scintillator that is calibrated for the measurement of Ra-226, or a comparable detector which produces stable dose rate measurements at typical ambient environmental levels. The inspector will use professional judgment to identify localized dose rates that are clearly above ambient levels and suggest the presence of Ra-226. Elevated dose rate measurements will generally not be sufficient to conclude no further action will be needed. Thus, elevated results will prompt the inspector to collect additional data/information in the area.

For Item 3, inspectors will use the methods described in NUREG-1507 to estimate the MDC for hand-held instruments. MDCs may be calculated using the NUREG-1507 methods considering a variety of alpha, beta, and gamma radiation detectors and potentially contaminated media. A detector response above the corresponding MDC will prompt the inspector to collect additional data/information in the immediate area.

For Item 4, smears will be collected and measured for gross alpha or beta activity to quantify the removable fraction, or more specifically, to determine if removable Ra-226 is present. Smears may be counted in the analytical laboratory to confirm the presence of Ra-226. Direct measurements will also be performed using a combination gas proportional detector (or functional equivalent). Both alpha and alpha-plus-beta measurements should be collected to optimize detection potential. Ra-226 and some associated decay products are alpha emitters. The alpha radiation may be easily attenuated by thin layers of dust, clean paint, moisture, etc. The beta emissions from other progeny will often provide a more accurate quantification of the total surface activity levels. Smear and direct measurement (totals) data may be used to support dose calculations, as required.

All quantitative ALs are measurements in excess of background for confirmed Ra-226 contamination. Inspectors may use in situ or volumetric sampling, as required, to confirm that radiation emanating from the source is due to Ra-226.

### 3.6 Step 6 – Specify Limits on Decision Errors.

The sixth step in the DQO process specifies the decision maker's limits on decision errors, which are then used to establish performance goals for the survey. The nature of this project, and boundary conditions typical for surveys, do not support robust decision error as may be developed for a statistical (rather than judgmental) survey design. Statistical-based methods are routinely applied to characterization or final-status efforts and not site visits and scoping surveys, which are typically smaller scaled and rely on judgmental (rather than statistical) data. Additionally, the identification of only one discrete source of Ra-226 would result in future NRC action. Therefore, decision errors here are associated with a measurement goal of no more than 10–50 percent of quantifiable ALs.

1. The positive identification of Ra-226 through visual inspection or other means is not associated with a quantifiable AL. Thus there is no measurement goal.

2. The survey meter produces a stable response at ambient levels, on the order of 10  $\mu\text{rem/hr}$ . Therefore, the measurement goal is satisfied even for a relatively restrictive AL (e.g., a few  $\mu\text{rem/hr}$  above background).
3. For direct measurements:
  - a. The analytical MDC for Ra-226 is typically  $\sim 0.5$  pCi/g, therefore laboratory analysis can easily satisfy the measurement goal for the [VALUE] pCi/g net (above background) AL.
  - b. Direct measurement MDCs using a gas proportional detector are dependent on background/medium-specific and instrument-specific inputs. Thus associated ALs are not included here. NUREG-1507 provides guidance on determining MDCs for direct measurements. However, some dpm/100  $\text{cm}^2$  for alpha and beta activity may be used to support site-specific dose analysis, when required.
4. The Minimum Detectable Activity (MDA) for smears is  $\sim 5$  dpm/100  $\text{cm}^2$  for gross alpha and  $\sim 15$  dpm/100  $\text{cm}^2$  for gross beta. There is no specific quantitative AL (it is detected or not detected); thus there is no measurement goal. However, the confirmed detections of Ra-226 above the MDAs may lead to additional actions.

Though not directly associated with scoping ALs, hand-held instruments may be used to locate and delineate contamination associated with Ra-226. Table B-3 presents example MDCs for a Ludlum Model 43-68 gas proportional detector, assuming an alpha background response of 2 cpm and an alpha-plus-beta background response of 350 cpm. A 2-inch  $\times$  2-inch sodium iodide detector (2 $\times$ 2) may also be used to locate and delineate Ra-226 contamination. Using the default methods of NUREG-1507 (Minimum Detectable Concentrations with Typical Radiation Survey Contaminants and Field Conditions), the scan MDC for Ra-226 is estimated at 2.8 pCi/g, as presented in Table B-3. Property-specific MDCs will be established in the associated plan and site-specific background conditions and instrumentation.

Table B-3. Example Minimum Detectable Concentrations					
Gross Activity	Instrument <sup>a</sup>	Typical Bkg (cpm)	Typical Total Eff. <sup>b</sup>	Detector Area ( $\text{cm}^2$ )	Static MDC
Alpha only	GP	2	0.11	126	70 dpm/100 $\text{cm}^2$
Alpha-plus-beta	GP	350	0.80	126	90 dpm/100 $\text{cm}^2$
Gamma (soil)	2 $\times$ 2	10,000	N/A	N/A	2.8 pCi/g <sup>c</sup>

<sup>a</sup> GP = gas proportional, 2 $\times$ 2 = 2-inch by 2-inch sodium iodide

<sup>b</sup> Assumes 50 percent equilibrium with progeny

<sup>c</sup> Scan MDC from NUREG-1507

### 3.7 Step 7 – Optimize the Design for Obtaining Data.

The seventh step in the DQO process is used to review DQO outputs; develop data collection design alternatives; formulate mathematical expressions for each design; select the sample size to satisfy DQOs; decide on the most resource-effective design of agreed alternatives; and document requisite details. The overall approach is to collect as much data as possible given the boundary conditions identified in Section 3.4, Step 4. The survey approach is divided into several general steps, starting with property reconnaissance and the division of accessible areas into logical Survey Units (SU). The inspector should clearly specify which areas are accessible and which are not (and for what reasons). Within each SU, and considering Figure B-1, the inspector shall:

- Perform a cursory survey using a NaI detector to locate areas of elevated gamma radiation. These locations will represent the highest potential for containing Ra-226.
- Based on professional judgment, collect measurements at the locations with the highest gamma radiation levels:
  - For all media, collect a dose rate measurement and a gross NaI measurement at contact with the surface and at 1 meter from the surface; and
  - For building/structural media only, also collect alpha and alpha-plus-beta measurements, plus a smear sample.
- If a potential Ra-226 source is identified:
  - Collect isotopic data to confirm the presence of Ra-226 using an isotope identifier (e.g., SAM-940 or Gr-135) or by collecting a sample for off-site laboratory analysis;
  - Delineate the contaminated area and specifies location, boundaries, and magnitude of contamination including “hot spots” and illustrates this information in a logbook or annotates a map for future reference;
  - Collect sufficient smear samples (from appropriate media) to estimate the removable fraction in the area; and
  - Note the proximity of the contaminant relative to habitable spaces.

This information will be used, if required, to conduct a property-specific dose assessment.
- Collect any random or systematic samples as required by the site-specific plan.

To document and plan for possible access restrictions, the site-specific plan will address, as appropriate, the potential for subsurface contamination in foundations and filled-in basements of previously demolished buildings; subsurface contamination under paved parking lots; subsurface soil sampling; and contamination in pipes and drains of buildings. The site-specific plan will also address surveys of occupied buildings with many occupants. These unusual site conditions may require specialty equipment, communication and coordination with the property owner, longer scoping survey durations, or other considerations that should be identified and incorporated in the site-specific scoping plan, as necessary. In general, no surveys or sampling requiring destruction of property should be performed. If destruction of property is necessary to obtain critical measurements, then the inspector shall consult with regional management for guidance.

Given a typical scoping survey will be performed during a relatively short time window and property access may be restricted, the inspectors should focus their efforts on the areas most likely to contain Ra-226. The selection of these areas will be based on the site summary and the property layout. Example target areas should include but are not limited to: storage areas, loading docks, ventilation systems, drains, outfalls, ditches, downspouts, and run-off areas.

It is presumed that Ra-226 will generate a detectable gamma radiation signal and is most easily located in the field using gamma radiation instrumentation. Therefore, inspectors will initially screen the property using hand-held or cart-mounted NaI detectors, depending on the survey environment. Locations with a maximum gamma radiation signature, potentially containing Ra-226, may then be prioritized for further evaluation using dose-rate and alpha/beta instruments, and/or may be sampled, as deemed necessary.

A detailed logbook will be maintained, which will provide a comprehensive description of field activities. Inspectors, at a minimum, will clearly document the following:

- Dates, times, and individual performing the survey;
- Instrumentation type and identification numbers;
- Site and environmental conditions and instrument background measurement data;
- NaI screening results by room, area, or other logical property division;
- Direct measurement results;
- Sample (smear and volumetric) identification numbers and proposed analyses;
- Detailed maps or drawings documenting measurement and sample location information;
- Detailed description of the location, and physical characteristics and radiation levels associated with confirmed discreet sources, if identified;
- Relevant discussions or interactions with non-project personnel/stakeholders; and
- Details regarding any deviation from the plan.

Survey forms, interview forms, and annotated maps should also be used to record radiation measurement and location information.

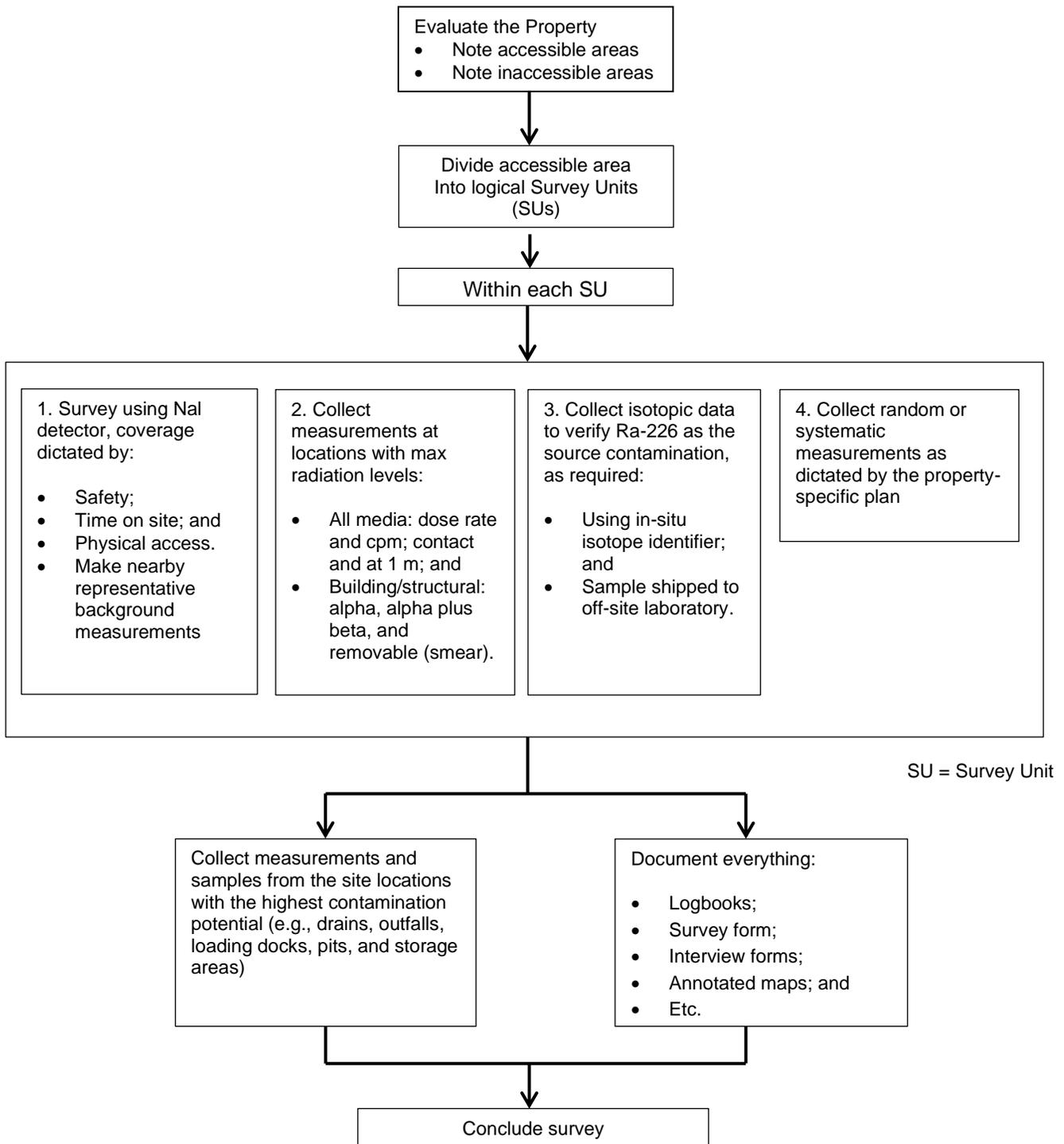


Figure B-1. Survey Overview

#### 4.0 HEALTH AND SAFETY

Because the level of contamination is unknown, inspectors will need to be flexible and prepared to upgrade Personal Protective Equipment (PPE) if needed. Initial PPE will be minimal and will be adjusted as necessary because radium can be dispersible.

- Appropriate PPE for the surveys consists of safety glasses and sturdy work shoes. Appropriate PPE will be determined by the Health and Safety Plan.
- If an exposure rate is encountered  $>2$  mrem/hr, or if the area is suspected of containing airborne contamination, then:
  - Coordinate with NMSS project manager and regional management to determine how best to limit access and control the area.
  - Coordinate with the property owners.
  - If appropriate, clearly post or cordon off the area to limit public access during and after sampling activities.
  - Inspectors may be required to upgrade the level of PPE while sampling.
  - Any waste (e.g., PPE and sampling equipment) will be managed according to the waste management plan (see Section 5.0).

NOTE: A State representative may request to accompany the inspector during the survey. It should be clearly communicated that these individuals are responsible for their own health and safety.

#### 5.0 WASTE MANAGEMENT

Survey activities have the potential for generating waste containing non-trivial levels of Ra-226 activity. Types of waste include PPE, sampling equipment (e.g., trowels, scrapers), and the sampled media (e.g., soil, smears). Inspectors will implement a waste management plan prepared for these activities to assure that potentially contaminated materials, generated during the survey, are safely removed and ultimately dispositioned at an appropriate facility.

#### 6.0 ANALYTICAL REQUIREMENTS

Table B-4 presents example parameters used to plan the collection and analysis of medium-specific radium samples. Inspectors will consider medium-specific requirements during the planning phase of the project, including coordinating with the contract laboratory to assure that analytical data meet quality requirements.

All samples, including smears, will be assigned a unique sample identification number and will be maintained under chain-of-custody until they are transferred to an approved laboratory. The analytical laboratory will perform analyses in accordance with:

- The NRC, "Quality Assurance Manual for the Office of Nuclear Material Safety and Safeguards";

- ASME-NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities"; and
- U.S. NRC, Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP), NUREG-1576.

Analyte	Matrix	Container	Preserv.	Hold Time	Method	MDC
Ra-226	Soil/solids	1 L HDPE	None	180 d	Gamma spec	0.5 pCi/g
					Alpha spec	0.33 pCi/g
	Surface Residue	Smear	None	180 d	Gross $\alpha/\beta$	15 dpm/100 cm <sup>2</sup>
					Gamma spec	14 pCi/smear
Alpha spec	0.05 pCi/smear					

HDPE = high-density polyethylene

APPENDIX C

SITE VISIT AND SCOPING SURVEY FIELD NOTES

SITE: \_\_\_\_\_

DATE: \_\_\_\_\_

INSPECTOR(S): \_\_\_\_\_

[OTHER PERSONNEL]: \_\_\_\_\_

PURPOSE:  Site Visit or  Scoping Survey

SITE DESCRIPTION

Brief description of the site location and physical characteristics

INSTRUMENTATION

List model and serial numbers (e.g., Ludlum model 44-10, no. 54321)

POTENTIAL HAZARDS OR ACCESS RESTRICTION (GENERAL)

General description of the site to be supplemented by location-specific descriptions

Inspectors can use Form C-1 below to describe each location of interest, including the range and maximum detector responses per location, applicable detector-specific background levels, and smear and sample identification numbers, if collected. A description of the location will also be included to document Ra-226 sources, physical or radiological hazards, access issues, or other information that may be used to plan future actions at each location. Locations should also be noted on a site map or drawing for ease of future reference.

LOCATION NO. \_\_\_\_\_

Dose rate or count rate and units: Range _____ Units _____ Max _____ Units _____ Background _____ Units _____ Smear/sample no. _____ Picture no. _____	Description:
---	--------------

LOCATION NO. \_\_\_\_\_

Dose rate or count rate and units: Range _____ Units _____ Max _____ Units _____ Background _____ Units _____ Smear/sample no. _____ Picture no. _____	Description:
---	--------------

LOCATION NO. \_\_\_\_\_

Dose rate or count rate and units: Range _____ Units _____ Max _____ Units _____ Background _____ Units _____ Smear/sample no. _____ Picture no. _____	Description:
---	--------------

LOCATION NO. \_\_\_\_\_

Dose rate or count rate and units: Range _____ Units _____ Max _____ Units _____ Background _____ Units _____ Smear/sample no. _____ Picture no. _____	Description:
---	--------------

LOCATION NO. \_\_\_\_\_

Dose rate or count rate and units: Range _____ Units _____ Max _____ Units _____ Background _____ Units _____ Smear/sample no. _____ Picture no. _____	Description:
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FORM C-1

Revision History Table  
Attachment 1 - Revision History for TI 2800/043

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment Resolution and Closed Feedback Form Accession Number (Pre-Decisional, Non-Public Information)
	ML16035A053 10/28/16 CN 16-028	This is an initial issuance for surveys of sites identified by the NMSS in non-Agreement States, where byproduct material (specifically, discrete sources of radium-226) was used, or suspected to be used, historically for commercial, medical, or research activities.		ML16145A370
	ML16330A678 01/06/17 CN 17-001	Revised to include language in the TI that matches the staff's current practice.		n/a
	ML17297B921 05/09/18 CN 18-011	Revised and updated for current practices. Role of inspectors, NMSS project managers, and Regions better defined. Comments received from OGC, NSIR, Region III, and comments and changes by the TI Working Group. Order of Appendices switched for proper flow.	N/A	ML16330A677
	ML19283B217 12/20/19 CN 19-041	Revised point-of-contact, completion and expiration dates.	N/A	N/A
	ML20351A280 12/22/20 CN 20-076	Revised point-of-contact, completion and expiration dates.	N/A	N/A