



# REGULATORY GUIDE

## OFFICE OF NUCLEAR REGULATORY RESEARCH

### REGULATORY GUIDE 4.22

*(Draft was issued as DG-4014, dated December 13, 2011)*

## DECOMMISSIONING PLANNING DURING OPERATIONS

### A. INTRODUCTION

This guide describes a method acceptable to the U.S. Nuclear Regulatory Commission (NRC) for licensees to use in implementing portions of the Decommissioning Planning Rule (DPR) (Ref. 1). The DPR revised, in part, Section 20.1406, "Minimization of Contamination," and Section 20.1501 "General," of Part 20 of Title 10 of the *Code of Federal Regulations* (10 CFR 20.1406 and 10 CFR 20.1501, respectively). Under the DPR, licensees of operating facilities are required to minimize contamination and radioactive waste generation, conduct appropriate radiological surveys including of the subsurface, maintain records of residual radioactivity, and provide adequate funding to complete decommissioning.

The DPR also revised financial assurance requirements for licensees. Guidance on financial assurance requirements is provided in NUREG-1757, "Consolidated Decommissioning Guidance," Volume 3, Revision 1, "Financial Assurance, Recordkeeping, and Timeliness," issued November 2011 (Ref. 2).

This regulatory guide contains information collection requirements covered by 10 CFR Part 20 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0014. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number. This regulatory guide is a rule as designated in the Congressional Review Act (5 U.S.C. 801–808). However, OMB has not found it to be a major rule as designated in the Congressional Review Act.

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This guide was issued after consideration of comments received from the public. The public comments and NRC staff response to them may be found in ADAMS under Accession No. ML12278A021.

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## **B. DISCUSSION**

### **Background**

In 1997, the NRC issued Subpart E, “Radiological Criteria for License Termination,” of 10 CFR Part 20, “Standards for Protection Against Radiation” (Ref. 3), known as the “License Termination Rule” (LTR). At that time, 10 CFR 20.1406 of the LTR required license applicants to describe in their applications how the design and procedures for operation of new facilities would minimize contamination and facilitate decommissioning. This requirement is an inherent, integral part of 10 CFR 20.1101, “Radiation Protection Programs” (Ref. 4).

At the direction of the Commission, the NRC staff reviewed implementation of the LTR and developed several recommendations for revisions (Ref. 5). In its response (Ref. 6) to the staff recommendations, the Commission approved the staff recommendations to develop rules to minimize the likelihood of new “legacy sites” — those sites with insufficient resources to complete decommissioning and terminate the license at the end of operations. On June 17, 2011, the NRC promulgated the DPR. The DPR requires all licensees to establish operational practices to minimize site contamination and perform reasonable subsurface radiological surveys and sets forth new financial assurance requirements.

The ultimate goal of the DPR is for licensees to have sufficient funds to conduct site remediation and terminate their licenses effectively and efficiently. This means having an adequate decommissioning trust fund. For the trust fund to be adequate, it must include sufficient funds to remove and dispose of all residual radioactivity that is above the criteria for release for unrestricted use at the time of license termination unless a licensee demonstrates it can meet all of the criteria for restricted release in 10 CFR 20.1403, or for the use of alternate criteria in 10 CFR 20.1404. That is, the trust fund must cover (1) the costs of packaging, shipping, and disposal for the total amount of material to be removed from the site, and (2) surveys to demonstrate compliance with approved release criteria. Licensees, except those whose financial assurance for decommissioning is determined by a fixed formula, should adjust the decommissioning fund so that it will be sufficient to complete decommissioning at the time of license termination. If a licensee identifies residual radioactivity that would require remediation to terminate the license, it should increase the value of the fund to account for the added cost. Likewise, if a licensee elects to remediate during the operational phase of facility life, it may reduce the fund to account for remediation it has completed; the remaining fund must be sufficient to complete any remediation necessary to meet release criteria. Appendix A to NUREG-1757, Volume 3, Revision 1 provides additional information and references on estimating decommissioning costs for various types of facilities.

### **Requirements of the DPR**

The current 10 CFR 20.1101 requirements to achieve doses that are as low as is reasonably achievable (ALARA) during facility operations and decommissioning are related to those in the new 10 CFR 20.1406(c). The DPR requires licensees to minimize the introduction of significant residual radioactivity into the site, including the subsurface, and to perform radiological surveys to identify the extent of significant residual radioactivity at their sites, including the subsurface. These surveys are to be reasonable under the circumstances to evaluate concentrations or quantities of significant residual radioactivity that would require remediation at the time of decommissioning. The term “residual radioactivity” is defined in 10 CFR 20.1003 (Ref. 7), “Definitions,” as radioactivity in structures, materials, soils, ground water, and any other media at a site resulting from activities under the licensee’s control. The DPR characterizes “significant” residual radioactivity as “a quantity of radioactive material that would later require remediation during decommissioning to meet the 25 mrem/yr [millirem/year] unrestricted use criteria of 10 CFR 20.1402.” Significant residual radioactivity may not present a risk to

public health and safety during the operational phase of plant life, but may require remediation at the time of decommissioning.

The DPR broadens and clarifies the 1997 LTR as follows:

- It establishes the requirements for operations to be conducted in a manner to minimize contamination, but does not mandate any design changes to operating facilities.
- It explicitly includes the subsurface in the radiological surveys required of all licensees by 10 CFR 20.1501(a).
- It establishes a threshold for when residual radioactivity becomes “significant” residual radioactivity.
- It requires licensees having significant residual radioactivity to retain 10 CFR 20.1501(a) survey results with records important to decommissioning that are kept onsite and available for review. (It does not require licensees to submit reports of survey results.)
- It requires licensees having significant residual radioactivity to arrange for sufficient funding to complete decommissioning and terminate the NRC license.

Although the DPR does require subsurface surveys, it does not require the extensive site characterization and compliance surveys that are required by decommissioning regulations and defined in NUREG-1575, Revision 1, “Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM),” issued in August 2000 (Ref. 8). Rather the DPR does require licensees to conduct surveys to identify the extent of residual radioactivity. Further, it does not revise the existing decommissioning criteria in Subpart E to 10 CFR Part 20. The DPR also does not mandate any remedial activities for onsite or offsite residual radioactivity during operations.

The DPR does require that the results of the monitoring and surveys be included in records important to decommissioning. For 10 CFR 20.1501(b), licensees would document the records from surveys of subsurface residual radioactivity at the site as records important for decommissioning, under the requirements of 10 CFR 30.35(g), 40.36(f), 50.75(g), 70.25(g), and 72.30(d).

For nuclear power plant (NPP), licensees whose license applications were submitted prior to August 21, 1997, existing radiological environmental monitoring programs and subsurface (ground water) monitoring conducted by implementation of Nuclear Energy Institute (NEI) 07-07, “Industry Ground Water Protection Initiative—Final Guidance Document,” issued August 2007 (Ref. 9), are generally considered adequate to meet the DPR. NPP licensees with license applications submitted after August 20, 1997 are subject to 10 CFR 20.1406(a) - (c). Guidance for these facilities is in Regulatory Guide (RG) 4.21 “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning” (Ref. 10) and NEI-08-08, Revision 3, “Generic FSAR Template Guidance for Life Cycle Minimization of Contamination” (Ref. 11). Implementing the guidance in these documents is generally considered adequate to meet the DPR.

#### **Relationship between RG 4.21 and RG 4.22**

Guidance on implementing the minimization of contamination provisions of the 1997 LTR is in RG 4.21 which states, in part: “[T]he development of a contaminant management philosophy...requires the use of...conservative radiation protection principles, and attention to operational practices.” RG 4.21 provides guidance to applicants on implementing the requirements of 10 CFR 20.1406(a) and (b) to

design facilities and develop operational procedures to minimize radioactive waste generation and facility contamination. The guidance consists of specific design and programmatic considerations drawn from nuclear industry experience and lessons learned from decommissioning. These are combined in a threefold contaminant management philosophy: (1) prevention of unintended releases, (2) early detection, if there is unintended release of radioactive contamination, and (3) prompt assessment to support a timely and appropriate response.

This regulatory guide provides guidance for operating facilities on methods of meeting regulatory requirements for effective decommissioning planning. This guidance provides methods for determining if changes to operations or monitoring programs are needed to comply with 10 CFR 20.1406(c) and revised 10 CFR 20.1501. The guidance also describes survey methods suitable to identify affected areas and to estimate the approximate volume of radiological contamination that may have to be remediated at the time of license termination. The guidance also will help to determine whether existing financial assurance provided for site-specific decommissioning is adequate.

### **Harmonization with International Standards**

The following International Atomic Energy Agency (IAEA) Safety Standards and Guides provide useful information on nuclear facility safety, and this guide incorporates their principles: SSG-5, “Safety of Conversion Facilities and Uranium Enrichment Facilities,” (Ref. 12); SSG-6, “Safety of Uranium Fuel Fabrication Facilities,” (Ref. 13); NS-G-4.6, “Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors,” (Ref. 14); NS-R-5, “Safety of Nuclear Fuel Cycle Facilities,” (Ref. 15); and WS-G-3.1, “Remediation Process for Areas Affected by Past Activities and Accidents,” (Ref. 16). The difference between this guide and the IAEA Safety Standards and Guides is that the latter are generic, whereas this guide provides direct linkage to NRC regulations.

### **Scope**

NRC and Agreement State licenses cover many different kinds of activities that reflect the widely varying potential for contamination of a facility and the environment and for the generation of radioactive waste. Therefore, although this guide applies to all types of facilities, it recognizes that there is a wide range of potential contamination sources and facility conditions and so provides a risk-informed, performance-based approach to implementing the DPR. The risk-informed approach to implementing the DPR recognizes the need for minimizing contamination to the extent practical while at the same time not requiring definitive identification and quantification of all residual radioactivity.

NRC has always required licensees to minimize and control radioactive contamination but the emphasis has been on limiting human exposure. The DPR adds a new paragraph, 10 CFR 20.1406(c), that establishes a new requirement for licensees with operating licenses to operate their facilities in a manner that minimizes to the extent practical the introduction of residual radioactivity into the site, including the subsurface. The purpose of this requirement is to facilitate remediation of the site for unrestricted use at the time of license termination.

The DPR also amends 10 CFR 20.1501(a) to include an explicit requirement for radiological surveys in the subsurface necessary to evaluate residual radioactivity at licensed sites. This revised regulation retains its existing provision of “reasonable under the circumstances.” The term “residual radioactivity” is defined in 10 CFR 20.1003 as any radioactivity from licensed and unlicensed sources that has been introduced to the site by activities under the licensee’s control. “Significant residual radioactivity” is defined in the DPR as an amount that would require remediation during decommissioning to meet the unrestricted use criteria specified in 10 CFR 20.1402. Significant residual

radioactivity in subsurface media, such as soil, is an important component of decommissioning costs because, after operations cease, it must be removed and disposed off site to meet unrestricted use criteria.

The new 10 CFR 20.1501(b) requires licensees to keep records of the required surveys describing the locations and amounts of significant residual radioactivity identified at the site with other records important to decommissioning that are retained until the license is terminated. It does not require licensees to submit to the NRC reports of survey results or other records important to decommissioning.

Neither the DPR nor this regulatory guide defines a specific number of monitoring, surveying, or sampling events to comply with the new requirements. Because of the wide diversity of licensee facilities and processes and the equally wide variation in site conditions, each licensee must develop its own site-specific surveillance and monitoring plan and procedures for the following:

- Operating the facility in a manner that minimizes the introduction of radiological contamination into the site environment, including the subsurface;
- Performing surveys sufficient to determine the extent of significant residual radioactivity contamination in the site environment; and
- Periodically evaluating the costs to remediate significant residual radioactivity to unrestricted release levels at the time of license termination. Changes to financial assurance regulations require licensees to include the results of this evaluation in required decommissioning cost and financial assurance updates. The DPR also requires licensees, other than power reactors, to arrange for adequate decommissioning funds by the time of license termination to remediate significant residual radioactivity to the criteria of 10 CFR 20.1402, “Radiological Criteria for Unrestricted Use.”

The NRC’s technical basis for requiring licensees to identify the effect that significant residual radioactivity has on decommissioning costs is a 2005 NRC staff study (Ref. 17). The purpose of the study was to compile and evaluate experience at sites undergoing decommissioning to identify the types of events that have caused subsurface contamination. Evaluating these events provided a means for the NRC staff to identify the potential for future subsurface contamination at currently operating facilities. The study identified a number of events that could increase decommissioning costs by increasing the possibility of significant soil or ground water contamination and concluded that these events should cause the licensee to reevaluate its decommissioning cost estimate. In particular, slow and long-lasting leaks of radioactive material, characterized by long-lived and environmentally mobile radionuclides, into the subsurface may eventually produce radiological hazards and significantly increase the cost of decommissioning. The study concluded that the sites with a higher likelihood of becoming legacy sites shared the following characteristics:

- Relatively large volumes of low specific activity radioactively contaminated liquids, and other readily dispersible materials or wastes;
- Large inventories of long-lived radionuclides;
- Large production throughput of readily dispersible materials or wastes;
- Liquid processes, e.g., where some or all of the production streams are held in unlined impoundments, storage ponds, and basins; or



- Processes that involve large quantities of solid radioactive material stored outdoors e.g., in bulk form without containerization or protection from inclement weather conditions.

If a facility will handle dispersible radioactive material that, if released, could necessitate extensive cleanup to meet decommissioning criteria, the licensee should consider control of the form of the material that could be released. The three basic forms are liquids, gases (including aerosols), and solids. Appendix A provides further information that may be useful in determining the applicability of the guide.

The DPR modified NRC regulations to require licensees other than NPP licensees to have sufficient funding to remediate significant residual radioactivity (NPP licensees have specific funding requirements). Decommissioning regulations require licensees to remediate sites to one of the release criteria specified in Subpart E to 10 CFR Part 20. From initial issue of the license through the operational phase of plant life, licensees should plan the activities and funding to remediate the site for unrestricted use. In 1988 the NRC revised 10 CFR 50.2, “Definitions,” to define decommissioning as, in part, the reduction of residual radioactivity to a level that permits release for unrestricted use, and added 10 CFR 50.75, “Reporting and recordkeeping for decommissioning planning,” which specifies decommissioning funding requirements for release for unrestricted use (Ref. 18). In 1997 (Ref. 3), the NRC further modified the definition of decommission in 10 CFR 20.1003 and 10 CFR 50.2 to state: “*Decommission* means to remove a facility or site safely from service and reduce residual radioactivity to a level that permits—(1) Release of the property for unrestricted use and termination of the license; or (2) Release of the property under restricted conditions and termination of the license.” If a licensee determines that it may not be able to meet the planned unrestricted use criteria, it may then submit a decommissioning plan or license termination plan proposing restricted release in accordance with 10 CFR 20.1403(d). In that plan, the licensee must demonstrate how it will meet all of the requirements of 10 CFR 20.1403(a) - (d), including enforceable institutional controls, financial assurance, and advice from affected parties. To use the alternate criteria of 10 CFR 20.1404, “Alternate criteria for license termination,” the licensee must meet additional requirements including specific approval by the Commission. Early detection of significant subsurface contamination through surveys and monitoring and appropriate response by the licensee are the preferred approach because the regulatory objective is to ensure that the licensee and the NRC are aware of contamination that may create conditions that would complicate decommissioning and possibly create a legacy site. Therefore, essential parts of decommissioning planning are early identification of significant residual radioactivity, estimating the total cost of remediation, and financial planning to ensure that funds are available when needed.

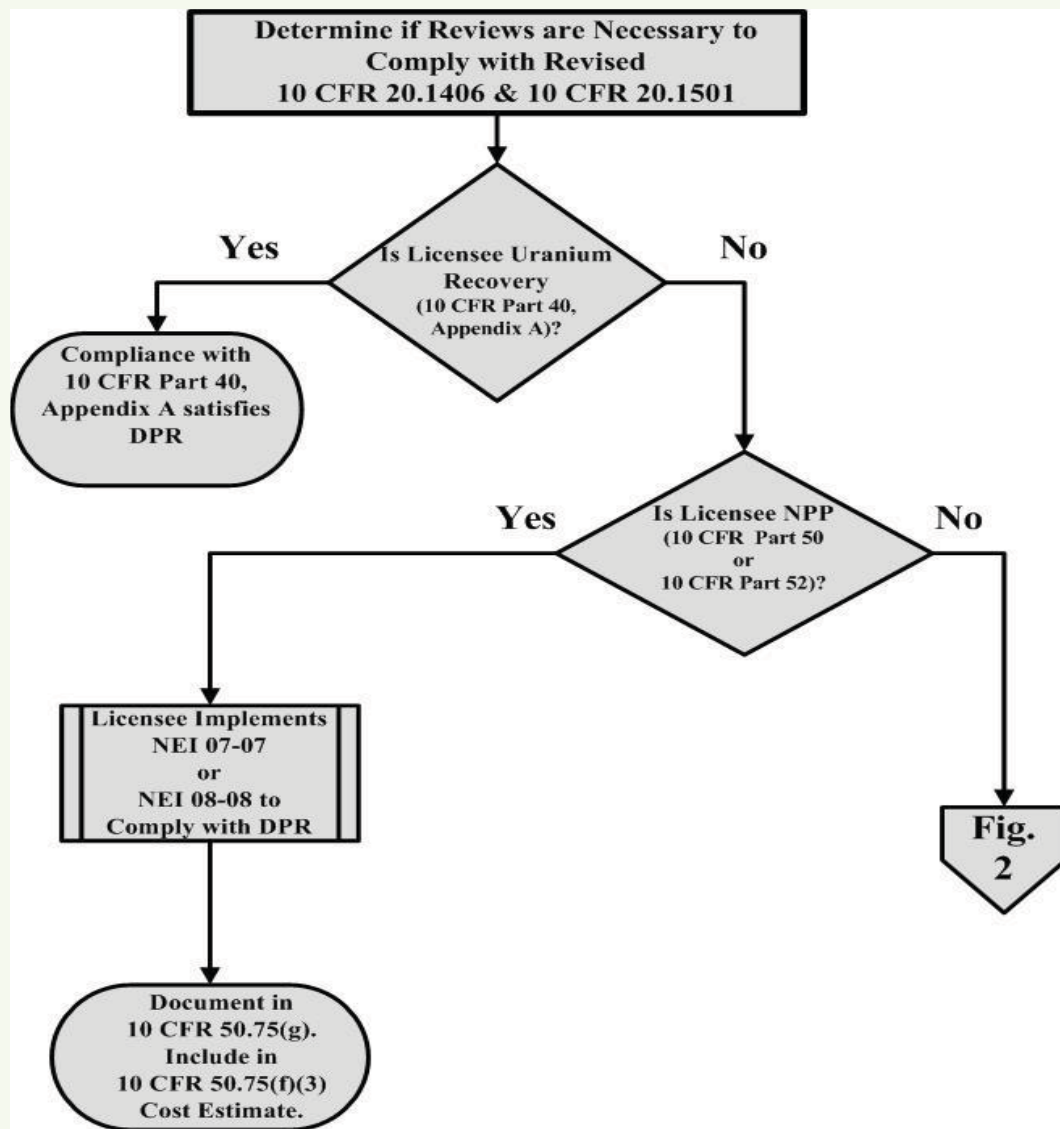
This regulatory guide provides a risk-informed, graded performance-based approach to implementing the regulation. Figures 1–3 illustrate a risk-informed approach to implementing the DPR. The figures present a screening process with which licensees can demonstrate compliance with the requirements of the DPR and associated revisions to 10 CFR Part 20. A more detailed discussion of each block of the figures is in Appendix A to this guide. Licensees may propose methods and solutions other than those in this guide. Those will be acceptable if they provide the information required by the DPR.

Table 1, shown on the following page, provides further information that may be useful for licensees to determine how the actions identified in this guide apply to various facility types. For major, complex facilities with significant inventories of radioactive materials, such as commercial NPPs or radioactive waste facilities, the actions in this guide should assist a licensee in meeting the requirements of 10 CFR 20.1406(c) and the revised 10 CFR 20.1501. For facilities that do not have large inventories, especially ones in which the material has a relatively short half-life (e.g., no more than 5 years) or is in the form of a sealed source, licensees need to consider only those measures and operational procedures that directly apply to the type of radioactive material and the potential for contamination of the facility or environment. Licensees should focus on historical information and process knowledge that reflect the

likelihood of contamination of the facility and environment. Applicability of the guidance should be done on a facility-by-facility basis.

**Table 1 Extent to Which Actions in this Guide Apply to the  
Type of Facility, Physical Form of Radioactive Material, Half-Life, and Inventory  
(Adapted from RG 4.21 (Ref. 10))**

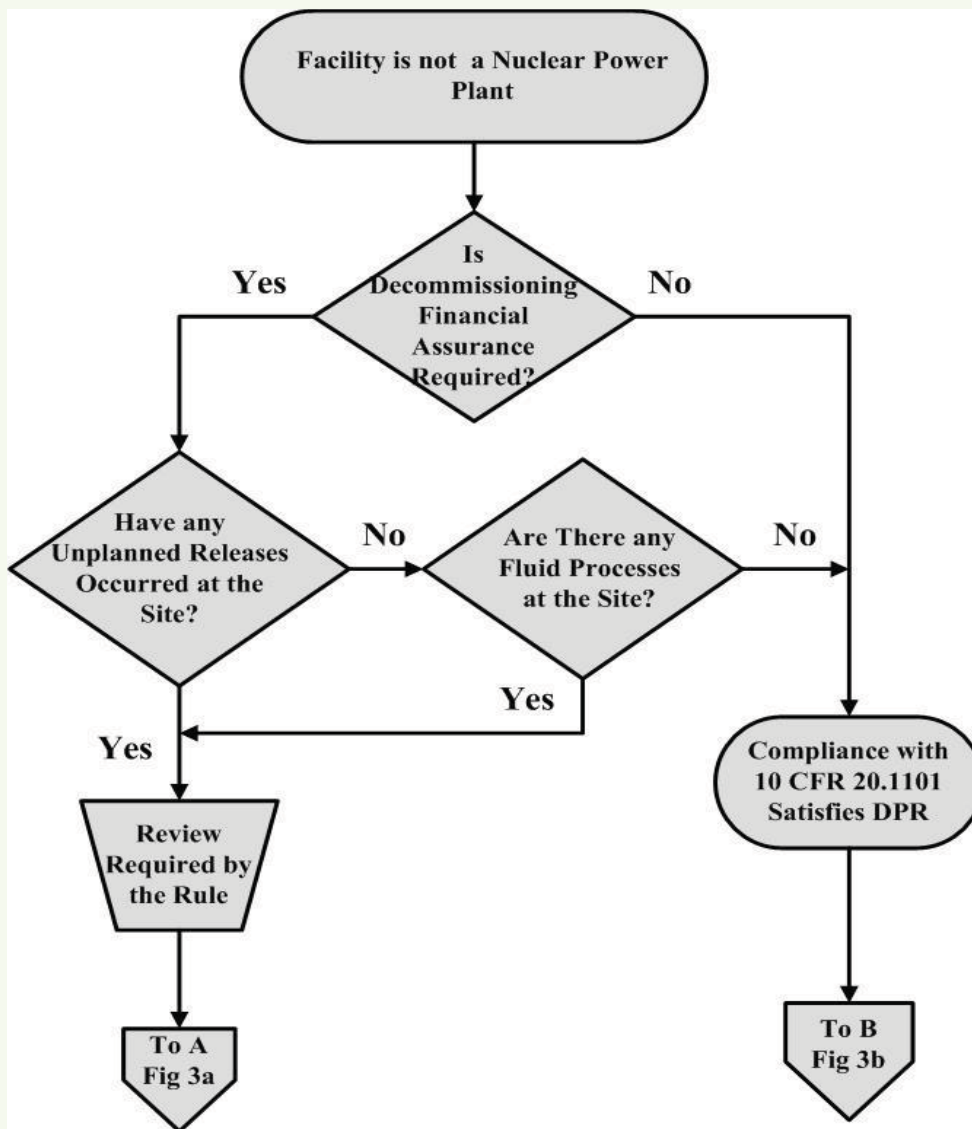
Typical Type of Facility or Use of Radioactive Material	Physical Form of Radioactive Material Involved		
	Liquid	Gas	Dry Solid
<b>Group 1 High Inventory, Long Half-Life—Power Plants, Fuel Cycle Facilities</b>			
Commercial nuclear power plants	high	high	high
Fuel fabrication, enrichment, reprocessing	high	high	high
<b>Group 2 High Inventory, Long Half-Life—Waste Facilities</b>			
High-level waste disposal facility	high	moderate	moderate
Low-level waste disposal facility	moderate	low	high
Radioactive waste processors	moderate	low	moderate
<b>Group 3 Intermediate to Low Inventory, Long Half-Life</b>			
Research and test reactors	moderate	moderate	high
Laboratory, research facility, and academic and broad-scope facility	moderate	moderate	moderate
<b>Group 4 Low Inventory, Half-Life Generally Not Long</b>			
Medical use of radioactive material	low*	low	low*
Industrial use of radioactive material	low	low	low, dependent on material*
Medical or industrial use of sealed sources	low	low	low
<b>Legend:</b> high            likelihood of using most of the measures in this guide moderate      likelihood of using some of the measures in this guide low             likelihood of using few of the measures in this guide *                emphasis on inventory control			



**Figure 1. Does the DPR Affect Me?**

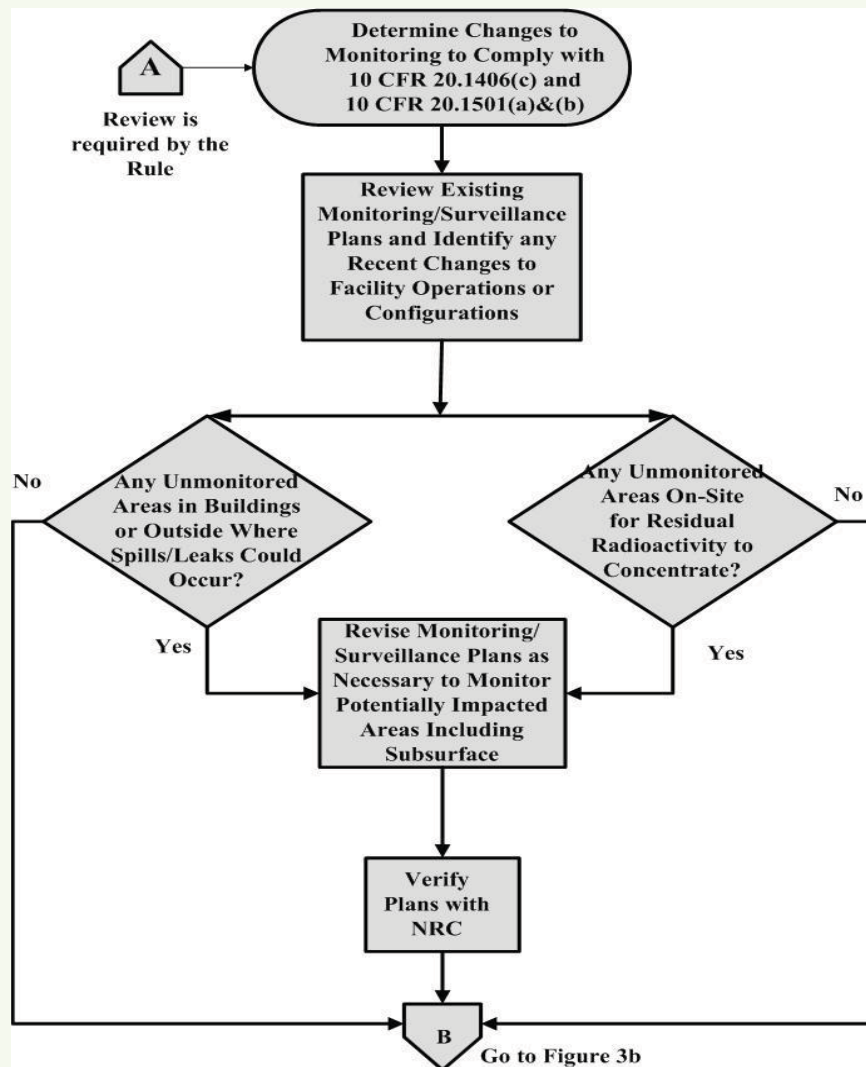
Figure 1 illustrates the questions to determine if a licensee needs to do anything because of the DPR. Uranium recovery licensees complying with the requirements of Appendix A to 10 CFR Part 40 are generally considered to be in compliance with the requirements of this rule, including subsurface monitoring. As indicated in Section C of this guide, for NPPs with applications that were submitted prior to August 21, 1997, the NEI's voluntary Industry Ground Water Protection Initiative (GPI) in NEI 07-07, provides an acceptable approach to meeting the requirements of the DPR. For reactor license applications submitted after August 20, 1997, NEI 08-08 also stated that applicants for combined construction and operating licenses should implement the GPI before fuel loading to enable application of the GPI throughout the operational phase of these reactors. The DPR does not add to the existing requirements for these licensees. NPP licensees may propose alternate methods of identifying and recording the information about radiological contamination. In instances where a licensee proposes an alternate method for complying with the DPR, the licensee should provide sufficient information for the staff to conduct an independent evaluation of the alternate method.





**Figure 2. Does the DPR Really Require Me to Do Something?**

Figure 2 identifies additional questions for licensees (except uranium recovery and NPP licensees) to use to determine whether the DPR requires them to perform any actions. The first question is whether the licensee is authorized to possess enough radioactive material to create a potential decommissioning obligation. If the possession limit in the license is below the levels requiring financial assurance specified in 10 CFR 30.35(d), 40.36(b), or 70.25(d), then the DPR requires no additional action. Any licensee that is required to provide financial assurance must determine if there have been previous spills or leaks during the operating history of the site including operations conducted by prior owners under separate licenses. Also, the licensee must identify the potential for such events to occur in the future and whether such events are expected to be characterized by the presence of significant levels of radioactivity. Therefore, if fluids—liquids, gases, aerosols—that can spread radiological contamination are part of the operations at the site, licensees should conduct a more detailed review of monitoring and survey plans to ensure identification of the sources and extent of future leaks or spills. The DPR does not mandate any design changes to the physical facility. Figure 3 shows considerations for revisions to procedures.



**Figure 3a. What Does the DPR Require Me to Do?**

Figure 3a illustrates specific areas to consider as part of a licensee's review of monitoring and surveillance plans. They include (1) unmonitored areas inside buildings or outside where spills or leaks could occur and (2) unmonitored areas on site where residual radioactivity, e.g. from effluents, might concentrate. For materials licensees, this may include such things as dispersible powders or aerosols. Note that some of these areas where significant residual radioactivity may be present may not be readily accessible for direct surveys because of the physical layout of systems and structures. If the licensee identifies areas that cannot be reasonably surveyed directly, it should establish surrogate monitoring (e.g., monitoring locations that are accessible downstream of potential leaks and spills) on a schedule commensurate with the likelihood of significant residual radioactivity occurring there. In addition, licensees are encouraged to investigate and characterize contamination levels in such areas when opportunity arise, such as when undertaking facility refurbishment and modifications. Appendix B provides some examples of how to identify sampling locations. For many licensees, either license conditions or documents specifically referenced in the license may establish survey and monitoring requirements. Therefore, changes to these plans may require the submission of license amendments and approval by the NRC.

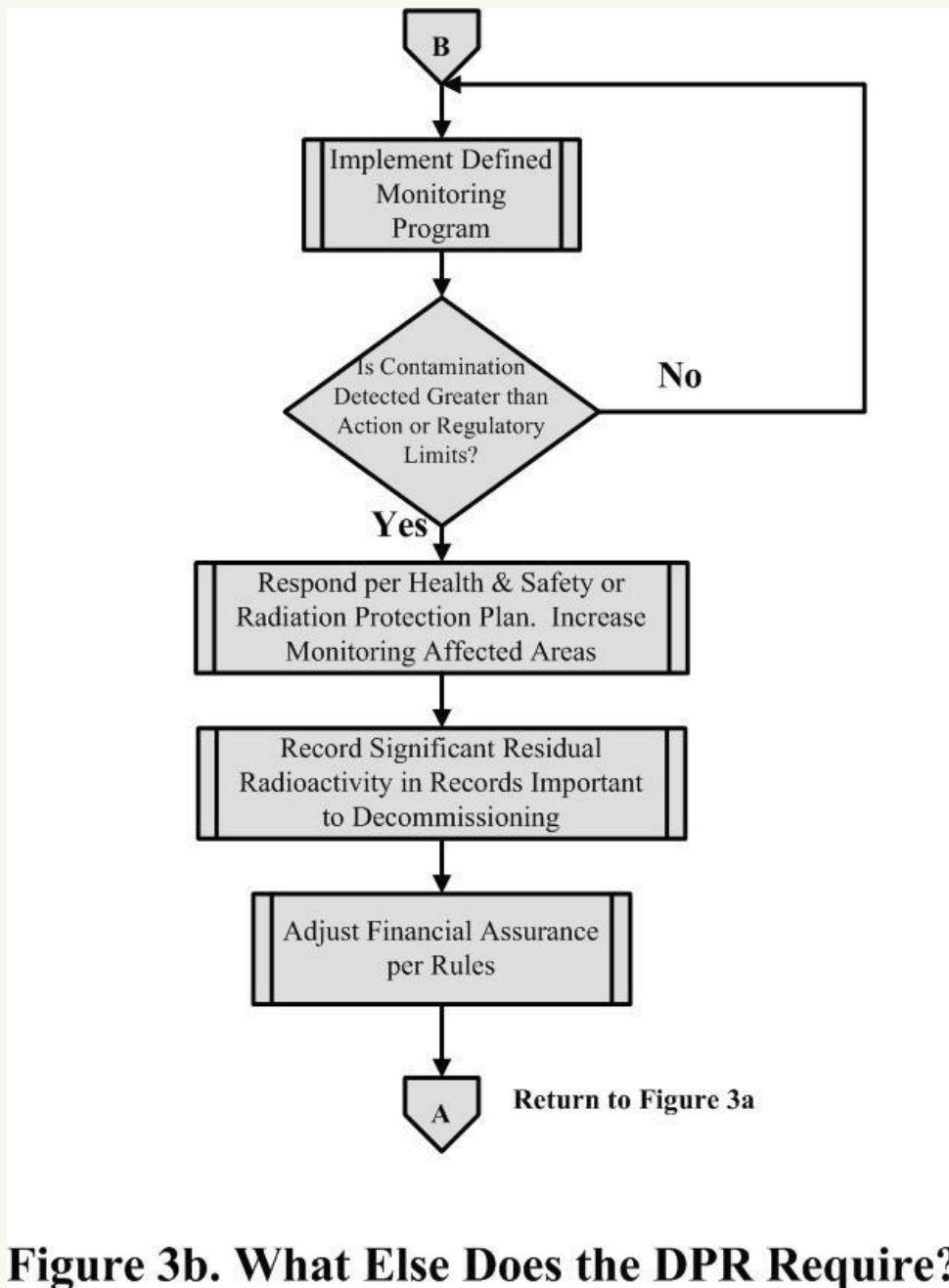


Figure 3b shows the actions that licensees should normally follow in implementing survey and monitoring plans. Once the cause of the contamination is identified, licensees should take corrective action to minimize further contamination (e.g., repair or replace leaking components and contain and collect liquid leaks and spills). If significant residual radioactivity is not expected to remain at the time of license termination, the DPR requires no additional actions. If significant residual radioactivity may remain at the time of license termination, licensees should estimate the financial impact and consider timely remediation and the implementation of additional radiological monitoring in tracking the movement of radioactive materials. Licensees should monitor the area until concentrations are decreasing to ensure that the corrective action has been effective.

The revised 10 CFR 20.1501(b) also requires licensees to record, in records important to decommissioning, the amounts and locations of subsurface residual radioactivity that may need remediation at the time of license termination. These records provide important input to the historical site assessment.

At 10 CFR 30.35(e), 40.36(d), 70.25(e), and 72.30(b), the DPR also requires licensees to adjust decommissioning funding as appropriate to the license type. At or about 5 years prior to the projected end of operations, NPP licensees must submit a preliminary decommissioning cost estimate which should include the cost of remediation based on survey results as required by 10 CFR 50.75(f)(3). Within 2 years of permanent cessation of operations, NPP licensees must submit a post-shutdown decommissioning activities report to the NRC that contains a description of the planned decommissioning activities including remediation in accordance with 10 CFR 50.82(a)(4)(i) and a site specific cost estimate as required by 10 CFR 50.82(a)(8)(iii). For NPPs that have implemented the provisions of 10 CFR 50.83 in releasing part of the reactor site for unrestricted use, the records should reflect the results of such regulatory actions and if needed, make appropriate corrections to the reported inventories of residual radioactive material actually present onsite and adjust decommissioning cost estimates accordingly. Other licensees should adjust decommissioning funds to reflect the necessary cost of remediation to meet unrestricted use criteria at the time of license termination. See NUREG-1757, Volume 3, Revision 1, for additional information.

## **C. STAFF REGULATORY GUIDANCE**

1. NPP licensees that implement NEI 07-07 and/or NEI 08-08 are presumed to be in compliance with the 10 CFR 20.1406 minimization requirements and the 10 CFR 20.1501 survey requirements of the DPR.
  - 1.1. NPP licensees should ensure that the results of all surveys conducted according to existing monitoring and surveillance programs, including NEI 07-07, that identify significant residual radioactivity are recorded, or incorporated by reference, in records important to decommissioning as specified in 10 CFR 50.75(g).
  - 1.2. Regulations at 10 CFR 50.75(f)(3) require that each power reactor licensee, at or about 5 years before the licensee's projected end of operations, submit a preliminary decommissioning cost estimate. Licensees should include the costs of remediating significant residual radioactivity identified by the surveys in this estimate.
  - 1.3. Regulations at 10 CFR 50.82(a)(8)(iii) require a site-specific cost estimate within 2 years following permanent cessation of operations, if not already submitted. This estimate should also include the costs of removing and disposing of significant residual radioactivity.
  - 1.4. Subsurface surveys of residual radioactivity in ground water are generally suitable surrogates for subsurface soil monitoring for mobile radionuclides (e.g., tritium).
2. Regulations at 10 CFR 50.83 provide the means for a NPP licensee to release part of the site for unrestricted use before termination of the license under 10 CFR 50.82. For NPPs that have implemented the provisions of 10 CFR 50.83 in releasing part of the reactor site for unrestricted use the records should reflect the results of such regulatory actions.

3. Licensees that are not NPPs should periodically conduct surveys that are reasonable under the circumstances in accordance with 10 CFR 20.1501(a) to identify the horizontal and vertical extent of significant residual radioactivity throughout the site taking into consideration the temporal distribution of radioactive contaminants. Licensees do not need to conduct formal site characterization such as that defined in MARSSIM. The survey design should consider areas likely to contain residual radioactivity, such as, but not limited to:
  - a. Building interiors, including in and around floor and wall joints, drains, hoods, exhaust stacks, and other features that could provide pathways for residual radioactivity to concentrate at or migrate to inaccessible areas;
  - b. The soil and other media in outside areas at the facility and areas immediately adjacent to building foundations and footings or pads on which process equipment and storage tanks are located;
  - c. Subsurface media, especially around building footers, subsurface pipes and conduits, pipe tunnels linking buildings that process radioactive materials, and below-grade tanks; and
  - d. Site surface water drainage systems and ground water that could be impacted by leaks and spills.
- 3.1. Affected licensees should review, and adjust if necessary, procedures and practices to ensure early identification of potential or actual radiological releases to the environment and act promptly to minimize the spread of radioactivity in accordance with the DPR. If the existing significant residual radioactivity will naturally reduce to levels that meet unrestricted release criteria by the time of license termination, the DPR does not require any further action.
- 3.2. Licensees should also evaluate the potential for long-lived radionuclides to migrate and concentrate over time into significant residual radioactivity such that the site would not meet the release for unrestricted use criteria of 10 CFR 20.1402.
- 3.3. For NRC licensees that have subsurface residual radioactivity with no current or projected ground water contamination, a minimal, routine monitoring plan may remain in effect through license termination activities. NUREG/CR-6948, "Integrated Ground-Water Monitoring Strategy for NRC-Licensed Facilities and Sites: Logic, Strategic Approach and Discussion," (Ref. 19), presents a logical framework for assessing what, how, where, and when to monitor underground water.
- 3.4. Whenever new production processes are implemented, licensees should review production methods, process equipment, expected radionuclide distribution and concentrations and physical and chemical forms of process and effluent streams, and confirm compliance with the requirements of the DPR and assess whether a license amendment is necessary.
4. All licensees must document the results of the surveys required by 10 CFR 20.1501(a) in records important to decommissioning in accordance with 10 CFR 20.1501(b). The NRC is not requiring licensees to submit reports of survey results.
  - 4.1. The DPR also places a lower bound on the amount of significant levels of residual radioactivity that licensees should record: the amount that would require remediation at the time of license termination to meet the unrestricted release criteria of 10 CFR 20.1402. The requirement to remediate would be defined by the cumulative amount of activity present, including that from



multiple or repeat events. This level of contamination may not present a risk to public health and safety during the operational phase of plant life once it is confirmed that radioactive contaminants are not environmentally mobile and will not migrate into unrestricted areas. However, records of surveys performed that demonstrate that the residual radioactivity has not exceeded the level of significant residual radioactivity may be useful in demonstrating compliance.

5. In 10 CFR 20.1406(c), the NRC requires all licensees to minimize the introduction of radiological contamination into the site environment. To do so, licensees should implement procedures and practices that minimize the occurrence of leaks and spills from piping, tanks, and storage containers. Licensees should also have procedures that will (1) identify the plant systems and radioactive materials storage containers with the potential for leaks and spills, (2) identify, to the extent practical, degraded equipment and containers before release and spills occur, and (3) detect leaks and spills throughout the facility as soon as they occur or soon thereafter. As part of the ALARA program, licensees should have plans and procedures to avoid and minimize, to the extent practical, the spread of leaks and spills especially when the residual radioactivity could migrate to inaccessible areas and contaminate subsurface soils and ground water.

- 5.1. Storage containers are commonly used to store radioactive material and to minimize the spread of contamination. In the context of this guidance, containers mean any methods to store or hold radioactive materials in durable containers, such as steel drums and boxes, storage tanks, shipping casks and containers, high integrity containers, concrete vaults, etc.

Licensees are required to conduct radiological surveys of containers to meet 10 CFR 20.1501(a)(2) requirements. Container inspections should be performed to verify that container integrity meets 10 CFR 20.1406(c) requirements. Licensees should develop a container inspection program based on the likelihood of radiological risk from container failure. There are no regulatory requirements for a specific inspection frequency. Containers having a higher radiological risk significance may need to be inspected on a more frequent basis (e.g., quarterly, semi-annually, or annually), and containers with less radiological risk significance may be inspected on a less frequent basis (e.g., yearly or longer time interval inspection may be appropriate). The basis for selecting the inspection frequency should be documented. Factors to consider when developing a container inspection program include the:

- a. Type of container (e.g., high integrity container, carbon steel drum and boxes, canister, shipping containers, storage safe);
- b. Age and condition of containers including the possibility of internal corrosion and external deformation via internal generation of decomposition products;
- c. Waste form / type of material being stored (e.g., wet filters or resins vs. dry active waste, spent resins and charcoals (as bulk form and filters), medical waste, sealed sources);
- d. Potential chemical or physical changes of the material being stored (e.g., labile radiochemicals and combustible gas mixtures generated by radiolysis during prolonged storage);
- e. Radionuclide distributions, concentrations, and radiation levels;
- f. Storage environment (e.g., storage in an unprotected outdoor area subject to weathering vs. storage in an indoor protected environment);

- g. Length of anticipated storage (e.g., short term storage, interim storage, decay in storage);
  - h. Secondary containment (e.g., sumps, concrete floors and walls, storage safe, earthen berms, basin impoundments);
  - i. Installed radiation monitoring equipment and/or air sampling to provide detection of loss of container integrity;
  - j. Ability to inspect remotely using sensors and/or video cameras in keeping radiation exposures and doses ALARA, and
  - k. ALARA considerations and operating experience.
6. Licensees should review, and update if necessary, the actions to ensure a timely and effective response to unplanned releases of radiological material.
  7. For holders of licenses under 10 CFR Parts 30, 40, and 70, if the quantity of material authorized in the license is below the amount requiring financial assurance as specified in 10 CFR 30.35(d), 40.36(b), and 70.25(d), respectively, the DPR does not require any further action. Experience shows that such licensees will have minimal residual radioactivity resulting from operations, have current ALARA and health and safety programs that are adequate to identify radioactivity requiring remediation, and will have funds from operating revenues to remediate the facility to unrestricted use criteria.
  8. Staff experience (Ref. 17) shows that fluids are the primary source of contamination in the environment outside of facility equipment. If there are no fluid processes, the NRC presumes that licensees' current ALARA and health and safety programs are adequate to identify radioactivity requiring remediation to meet unrestricted use criteria at time of license termination. The DPR requires action only if there is likely to be significant residual radioactivity such as in fluids (gases or liquids), dispersible powders, aerosols, or nanoparticles in site processes.
  9. The DPR does not require licensees to perform any dose analyses; however, licensees can use dose assessments on a site-specific basis to determine whether the amount or concentration of residual radioactivity is significant with respect to meeting the radiological criteria for unrestricted use in 10 CFR 20.1402. Alternatively, a licensee should make a reasonable effort to estimate the amount or concentration of residual radioactivity in all media that would require remediation to meet the release for unrestricted use criteria of 10 CFR 20.1402 at the time it intends to terminate the license. The licensee should consider the following:
    - a. The radionuclide distribution and contamination level in all impacted media;
    - b. Actual and potential migration as temporal vertical and horizontal distributions;
    - c. Dilution and natural attenuation for specific types of materials and radionuclides; and
    - d. Radioactive decay.

10. Licensees can determine whether the residual radioactivity is significant residual radioactivity<sup>1</sup> by comparing the measured concentrations or dose assessments to (1) screening values, (2) 10 CFR Part 20, Appendix B, Table 2, Effluent Concentrations, (3) derived concentration guidelines, and (4) unrestricted use radiological criteria for unrestricted use, to determine if they may need to conduct remediation to meet the license termination criteria for release for unrestricted use. Available sources for this comparison include the following:
- a. Screening values are in Appendix H to NUREG-1757, Volume 2, Revision 1, "Characterization, Survey, and Determination of Radiological Criteria," issued September 2006 (Ref. 20).
  - b. Remediation levels (derived concentration guidelines) appear in final status survey plans approved by the NRC for other facilities as potential interim action levels, given an appropriate comparative evaluation of differences in facility and site characteristics and types and extent of radiological contamination.
  - c. Radiological criteria for unrestricted use in 10 CFR 20.1402 are 25 mrem per year plus ALARA.

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<sup>1</sup> Licensees should use the sum of fractions, as appropriate, to determine the current level of activity at the location of the measurement.

## D. IMPLEMENTATION

The purpose of this section is to provide information on how licensees<sup>2</sup> may use this guide and information regarding the NRC's plans for using this regulatory guide. In addition, it describes how the NRC staff complies with the Backfit Rule (10 CFR 50.109) and any applicable finality provisions in 10 CFR Part 52.

### Use by Licensees

Licensees may voluntarily<sup>3</sup> use the guidance in this document to demonstrate compliance with the underlying NRC regulations. Methods or solutions that differ from those described in this regulatory guide may be deemed acceptable if they provide sufficient basis and information for the NRC staff to verify that the proposed alternative demonstrates compliance with the appropriate NRC regulations.

Licensees may use the information in this regulatory guide for actions which do not require NRC review and approval such as changes to a facility design under 10 CFR 50.59 that do not require prior NRC review and approval. Licensees may use the information in this regulatory guide or applicable parts to resolve regulatory or inspection issues.

### Use by NRC Staff

During regulatory discussions on plant specific operational issues, the staff may discuss with licensees various actions consistent with staff positions in this regulatory guide, as one acceptable means of meeting the underlying NRC regulatory requirement. Such discussions would not ordinarily be considered backfitting even if prior versions of this regulatory guide are part of the licensing basis of the facility. However, unless this regulatory guide is part of the licensing basis for a facility, the staff may not represent to the licensee that the licensee's failure to comply with the positions in this regulatory guide constitutes a violation.

If an existing licensee voluntarily seeks a license amendment or change and (1) the NRC staff's consideration of the request involves a regulatory issue directly relevant to this new or revised regulatory guide and (2) the specific subject matter of this regulatory guide is an essential consideration in the staff's determination of the acceptability of the licensee's request, then the staff may request that the licensee either follow the guidance in this regulatory guide or provide an equivalent alternative process that demonstrates compliance with the underlying NRC regulatory requirements. This is not considered backfitting as defined in 10 CFR 50.109(a)(1) or a violation of any of the issue finality provisions in 10 CFR Part 52.

The NRC staff does not intend or approve any imposition or backfitting of the guidance in this regulatory guide. The NRC staff does not expect any existing licensee to use or commit to using the guidance in this regulatory guide, unless the licensee makes a change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this regulatory guide to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action which would require the use of this regulatory guide. Examples of such unplanned NRC regulatory actions include issuance of an order requiring the use of the regulatory guide, requests for information under

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<sup>2</sup> In this section, "licensees" refers to licensees of nuclear power plants under 10 CFR Parts 50 and 52.

<sup>3</sup> In this section, "voluntary" and "voluntarily" means that the licensee is seeking the action of its own accord, without the force of a legally binding requirement or an NRC representation of further licensing or enforcement action.

10 CFR 50.54(f) as to whether a licensee intends to commit to use of this regulatory guide, generic communication, or promulgation of a rule requiring the use of this regulatory guide without further backfit consideration.

If a licensee believes that the NRC is either using this regulatory guide or requesting or requiring the licensee to implement the methods or processes in this regulatory guide in a manner inconsistent with the discussion in this Implementation section, then the licensee may file a backfit appeal with the NRC in accordance with the guidance in NUREG-1409, “Backfitting Guidelines” (Ref. 21), and NRC Management Directive 8.4, “Management of Facility-specific Backfitting and Information Collection” (Ref. 22).

## GLOSSARY

**fluids**—means process and effluent streams which contain radioactive materials in forms (such as gases, vapors, liquids, sludge, slurries, resins, sediments, particulates, powders, dust, and wind-borne re-suspended material) that are readily dispersible in the environment, including air, surface water streams and bodies, ground water, and soils.

**monitoring**—(radiation monitoring, radiation protection monitoring) means the measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses (Ref. 7).

**NPP**—Nuclear power plant

**residual radioactivity**—means radioactivity in structures, materials, soils, ground water, and other media at a site resulting from activities under the licensee’s control. This includes radioactivity from all licensed and unlicensed sources used by the licensee, but excludes background radiation. It also includes radioactive materials remaining at the site as a result of routine or accidental releases of radioactive material at the site and previous burials at the site, even if those burials were made in accordance with the provisions of 10 CFR Part 20.

**significant residual radioactivity**—An amount of radioactive material that would require remediation to meet the unrestricted use criteria specified in 10 CFR 20.1402 (25 mrem/yr) at the time of decommissioning (Ref. 1).

**subsurface**—any media below about 15 centimeters (6 inches) from a surface.

**survey**—means an evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present (Ref. 7).



## REFERENCES<sup>4</sup>

1. U.S. Nuclear Regulatory Commission, “Decommissioning Planning Rule,” *Federal Register*, Volume 76, Number 117, June 17, 2011, pp. 35512–35575.
2. --- “Consolidated Decommissioning Guidance - Financial Assurance, Recordkeeping, and Timeliness,” NUREG-1757, Volume 3, Revision 1, November 2011, ADAMS Accession No. ML12048A683.
3. --- “Radiological Criteria for License Termination,” *Federal Register*, Volume 62, Number 139, July 21, 1997 pp. 39057–39095.
4. *U.S. Code of Federal Regulations*, “Radiation protection programs,” Section 20.1101, Chapter I, Title 10, “Energy.”
5. U.S. Nuclear Regulatory Commission, “Results of the License Termination Rule Analysis,” Commission Paper SECY-03-0069, May 2, 2003, ADAMS Accession No. ML030840302.
6. --- “Results of the License Termination Rule Analysis,” Staff Requirements Memorandum (SRM) SECY-03-0069, November 17, 2003, ADAMS Accession No. ML033210595.
7. *U.S. Code of Federal Regulations*, “Definitions,” Section 20.1003, Chapter I, Title 10, “Energy.”
8. U.S. Nuclear Regulatory Commission, “Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM),” NUREG-1575, Revision 1, August 2000, ADAMS Accession No. ML082310759.
9. Nuclear Energy Institute, “Industry Ground Water Protection Initiative—Final Guidance Document,” NEI 07-07, Washington, DC, August 2007, ADAMS Accession No. ML072600295.<sup>5</sup>
10. U.S. Nuclear Regulatory Commission, “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning,” Regulatory Guide 4.21.
11. Nuclear Energy Institute, “Generic FSAR Template Guidance for Life Cycle Minimization of Contamination,” NEI 08-08, Revision 3, Washington, DC, September 2009, ADAMS Accession No. ML092720253.

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<sup>4</sup> Publicly available NRC published documents are available electronically through the NRC Library on the NRC’s public Web site at <http://www.nrc.gov/reading-rm/doc-collections/>. The documents can also be viewed on-line or printed for a fee in the NRC’s Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone 301-415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail to [pdr.resource@nrc.gov](mailto:pdr.resource@nrc.gov).

<sup>5</sup> Publications from the Nuclear Energy Institute (NEI) are available at their Web site: <http://www.nei.org/> or by contacting the headquarters at Nuclear Energy Institute, 1776 I Street NW, Washington DC 20006-3708, Phone: 202-739-800, Fax 202-785-4019.

12. International Atomic Energy Agency (IAEA), “Safety of Conversion Facilities and Uranium Enrichment Facilities,” Specific Safety Guide SSG-5, Vienna, Austria, 2010<sup>6</sup>.
13. --- “Safety of Uranium Fuel Fabrication Facilities,” Specific Safety Guide SSG-6, Vienna, Austria, 2010.
14. --- “Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors,” Safety Standard NS-G-4.6, Vienna, Austria 2008.
15. --- “Safety of Nuclear Fuel Cycle Facilities,” Safety Standard NS-R-5, Vienna, Austria, 2008.
16. --- “Remediation Process for Areas Affected by Past Activities and Accidents,” Safety Standard WS-G-3.1, Vienna, Austria, 2007.
17. Memorandum to Daniel M. Gillen, NRC, from Amy M. Snyder and David Brown, NRC, through Andrew Persinko, “General Guidance for Inspections and Enforcement To Prevent Future Legacy Sites, Integrated Decommissioning Improvement Plan (IDIP), Revision I, Item 4.2,” U.S. Nuclear Regulatory Commission, September 23, 2005, ADAMS Accession No. ML052630421.
18. U.S. Nuclear Regulatory Commission, “General Requirements for Decommissioning Nuclear Facilities,” *Federal Register*, Volume 53, Number 123, June 27, 1988, pp. 24018-24057.
19. U.S. Nuclear Regulatory Commission, “Integrated Ground-Water Monitoring Strategy for NRC-Licensed Facilities and Sites: Logic, Strategic Approach and Discussion,” NUREG/CR-6948, November 2007, ADAMS Accession No. ML073310297.
20. --- “Consolidated Decommissioning Guidance - Characterization, Survey, and Determination of Radiological Criteria,” NUREG-1757, Volume 2, Revision 1, September 2006, ADAMS Accession No. ML063000252.
21. --- “Backfitting Guidelines,” NUREG-1409, July 1990, ADAMS Accession No. ML032230247.
22. --- “Management of Facility-specific Backfitting and Information Collection,” NRC Management Directive 8.4, October 2004, ADAMS Accession No. ML050110156.
23. --- “Consolidated Decommissioning Guidance – Decommissioning Process for Materials Licensees,” NUREG-1757, Volume 1, Revision 2, September 2006, ADAMS Accession No. ML063000243.

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<sup>6</sup> Copies of International Atomic Energy Agency (IAEA) documents may be obtained through their Web site: [WWW.IAEA.Org/](http://WWW.IAEA.Org/) or by writing the International Atomic Energy Agency P.O. Box 100 Wagramer Strasse 5, A-1400 Vienna, Austria. Telephone (+431) 2600-0, Fax (+431) 2600-7, or E-Mail at [Official.Mail@IAEA.Org](mailto:Official.Mail@IAEA.Org)

## **APPENDIX A**

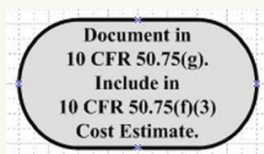
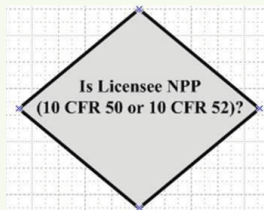
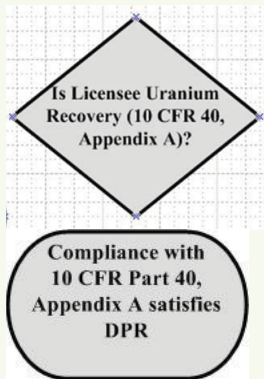
### **EXPLANATION OF RISK-INFORMED APPROACH TO DETERMINING ACTIONS TO COMPLY WITH THE DECOMMISSIONING PLANNING RULE**

## **APPENDIX A-1**

### **DISCUSSION OF FIGURES 1–3**

This appendix discusses the individual pieces of Figures 1 through 3 in the guidance on implementing the Decommissioning Planning Rule (DPR). It does not present any regulatory information. This appendix only provides additional information on the U.S. Nuclear Regulatory Commission (NRC) staff's intentions for licensees to consider in developing the risk-informed approach to implementing the DPR.

Determine if Reviews are  
Necessary to Comply with  
Revised  
10 CFR 20.1406 & 10 CFR  
20.1501



## Discussion of Figure 1. Does the DPR Affect Me?

The first step in the process is for each licensee to determine if it needs to take any action because of the changes to Title 10, Sections 20.1406, “Minimization of Contamination,” and 20.1501, “General,” of the *Code of Federal Regulations* (10 CFR 20.1406 and 10 CFR 20.1501). The first action that any licensee would have to perform would be a comprehensive review of its existing monitoring and surveillance plans.

The first question to ask in making this determination is whether the current license is a uranium recovery license under 10 CFR Part 40, “Domestic Licensing of Source Material,” Appendix A, “Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content.” If the answer is no, then no further actions are necessary because these licensees are specifically exempt from the requirements of 10 CFR 20.1406 by 10 CFR 20.1401(a), and are presumed to meet the requirements of 10 CFR 20.1501 by complying with Criteria 5 and 7 of Appendix A to Part 40.

The second question is whether the licensee is a power plant licensed under 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities” or 10 CFR Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants.” If so, the NRC has determined that the monitoring and surveillance activities that 10 CFR Part 50 licensees are conducting as part of existing as low as is reasonably achievable (ALARA) and radiological and environmental monitoring program activities, and the Nuclear Energy Institute (NEI) Ground Water Protection Initiative (NEI 07-07), meet or exceed the requirements of 10 CFR 20.1501(a). Therefore, the DPR does not impose any additional survey or monitoring requirements on these licensees.

The DPR does require that nuclear power plant licensees record the results of the existing monitoring and sampling programs in their 10 CFR 50.75(g) files, either directly or by reference.

The regulation in 10 CFR 50.75(f)(3) requires a preliminary decommissioning cost estimate about 5 years before the projected end of operations, which includes an up-to-date assessment of the major factors that could affect the cost to decommission. This estimate should include the results of monitoring and sampling.

Within 2 years after permanent shutdown, 10 CFR 50.82(a)(8)(iii) requires an updated site-specific estimate of remaining decommissioning costs, which should include the results of DPR monitoring. If the answer to the second question is no (the licensee is not a nuclear power plant licensed under 10 CFR Part 50 or Part 52), the licensee should proceed to Figure 2 to determine the next actions.



Facility is not a Nuclear Power Plant

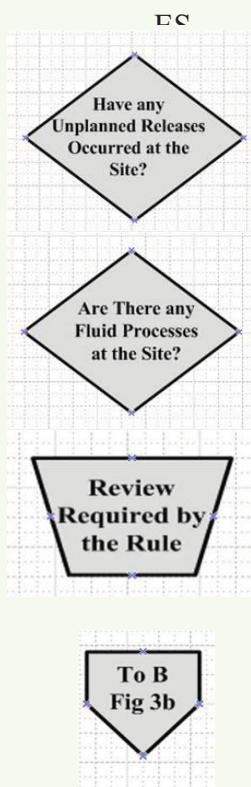
Is Decommissioning Financial Assurance Required?

Compliance with 10 CFR 20.1101 Satisfies DPR

## Discussion of Figure 2. Does the DPR Really Require Me To Do Something?

For purposes of the DPR, the NRC is using the requirement for financial assurance as a surrogate for the amount of material a licensee is authorized to possess. NRC regulations at 10 CFR 30.35, 40.36, and 70.25, each entitled “Financial Assurance and Recordkeeping for Decommissioning,” require some licensees to set aside funds devoted to decommissioning the site at the time of license termination. The amount of funds is a function of how much radiological material the licensee is authorized to possess. Licensees can meet the financial assurance requirements either by the methods specified in those regulations or by a site-specific estimate.

If a licensee’s possession limit does not require it to have financial assurance, the DPR does not require the licensee to perform any further action because the potential for significant residual radioactivity is low. These licensees should continue executing the existing ALARA and health and safety programs as discussed in Figure 3b.



If, however, regulations do require financial assurance, either by formula or by site-specific estimate, the licensee must determine if there have been previous spills or leaks during the operating history of the site. Also, the licensee must identify the potential for such events to occur in the future. Staff experience (Ref. 17) shows that the presence of liquid or gaseous processes presents the possibility of unplanned or unmonitored releases. Further, after planned discharges within regulatory limits (e.g., Appendix B to Part 20), fluids can concentrate in various locations to greater than NRC-approved limits for release of the area. Therefore, if fluids are part of the operations at the site, licensees should conduct a more detailed review of monitoring and survey plans to ensure that they will identify the sources and extent of future leaks or spills. The outflow of hoods, which can move particulates beyond the facility, should also be considered. The amount of review depends on the complexity of the process and facility and on the potential release.

If there are no fluids in the site processes, the DPR requires no further review, and licensees should continue implementing existing plans as illustrated in Figure 3b.

Review Existing  
Monitoring/Surveillance  
Plans and Identify any  
Recent Changes to  
Facility Operations or  
Configurations

Any Unmonitored  
Areas in Buildings  
or Outside Where  
Spills/Leaks Could  
Occur?

Any Unmonitored  
Areas On-site for Residual  
Radioactivity to  
Concentrate?

### Discussion of Figure 3a. What Does the DPR Require Me To Do?

Licensees should review existing plans and procedures related to identification and management of leaks, spills, aerosols, dispersible solids, and other unplanned releases. Licensees should pay particular attention to identifying any changes in the facility operations, such as revisions to specifications for products, addition of new products or discontinuation of previous products, and changes to the process rate since the last revision of the procedures. The review should also note any physical changes to the facility, especially those that could result in unanalyzed release paths, such as new discharge ducts or piping. These changes are not limited to those in the immediate vicinity of the process. For example, rerouted plumbing could result in irregular fittings in normally inaccessible areas, or construction of a tall building on adjacent land could alter the airborne discharge paths.

The ultimate goal of the DPR is for licensees to identify the extent of contamination on the site and reserve enough money during operations to complete site remediation and license termination in a timely manner at the end of operations. In this review, licensees should identify any areas of the site not currently monitored regularly for radiological contamination. In addition to “under-” sources (such as embedded or buried pipes, tanks, valves, and onsite disposals under 10 CFR 20.2002, “Method for Obtaining Approval of Proposed Disposal Procedures”), leaks and spills onto interior or exterior surfaces may migrate through floor joints, cracks, failed seals, or through porous media to other areas. Some of these areas may not be readily accessible for direct observation. In these cases, licensees should consider alternatives to identify potential contamination, such as use of remote sensors and robotics. Contamination could also enter utility conduits and move far from the point of origin. If the contamination moves into the subsurface, it could concentrate there over time, or it could migrate through ground water to other locations where it could concentrate. Monitoring of the subsurface should be established downstream of potential sources, such as building footers and buried tanks and pipes. NUREG/CR-6948, “Integrated Ground-Water Monitoring Strategy for NRC-Licensed Facilities and Sites: Logic, Strategic Approach and Discussion,” issued November 2007, contains detailed information on establishing a subsurface monitoring program. Likewise, airborne effluents may precipitate and concentrate in some pattern because of the local meteorology, such as prevailing wind direction and speed, and relative humidity. Licensees should identify these potential locations and include them in survey and monitoring plans.

**Revise Monitoring/  
Surveillance Plans as  
Necessary to Monitor  
Potentially Impacted  
Areas Including  
Subsurface**

At the time of license termination, 10 CFR Part 20, “Standards for Protection against Radiation,” Subpart E, “Radiological Criteria for License Termination,” requires licensees to remediate existing residual radioactivity to approved criteria. Unless a licensee can demonstrate compliance with the requirements of 10 CFR 20.1403 or 10 CFR 20.1404, it must remediate to the unrestricted use criteria of 10 CFR 20.1402. Therefore, licensees must have a monitoring plan sufficient to identify the complete extent of contamination at that time. An intent of the DPR is to encourage licensees to develop plans that will identify contamination as it occurs rather than wait until license termination when significant amounts of previously unknown contamination can result in sizable cost and time overruns during decommissioning.

For licensees that do not have significant residual radioactivity because they possess only small amounts of short-lived radioactive material or sealed sources, the staff does not expect significant changes to the existing monitoring and health and safety programs.

For licensees with subsurface residual radioactivity but no ground water implications, a minimal, routine monitoring plan may be sufficient through operations.

Licensees other than those described above should enhance the existing programs to include areas of potential contamination not previously identified. The revised plans should also contain provisions for altering the frequency of surveillance in response to contamination events and the “conclusion” of those events.

**Verify  
Plans with  
NRC**

Surveillance plans are identified in the license, so licensees should discuss changes with the NRC. Because the emphasis of the DPR is decommissioning, this discussion should focus on meeting the requirements for information in the decommissioning plan (DP) or license termination plan (LTP). If specific activities are defined in the license, the licensee must obtain an amendment to implement those changes. For other licensees, inspectors periodically review the plans to determine the sufficiency of revisions. These actions – discussions between the licensee and NRC staff, license amendment requests, inspections – allow the NRC staff to verify the plans.



### Discussion of Figure 3b. What Else Does the DPR Require?

Once a licensee has an approved plan(s) for monitoring and surveillance, whether changed or not as a result of review, it should conduct the activities specified in the plan(s).

As long as no readings are above the site action limits specified in the plans or regulatory limits for worker or public exposure, the DPR does not require any additional actions. Licensees should continue to implement the existing plans routinely.

If the results of the sampling are above the specified limits, the licensee should respond according to the site health and safety plan. This response should include defining the extent of contamination, identifying and implementing corrective actions to mitigate the event (e.g., locate and stop the leak or spill), and remediating the area to meet occupational requirements. Once it completes those actions, the licensee should conduct additional periodic monitoring for a time to ensure that the “fix” is effective.

Another important part of the DPR is the requirement in 10 CFR 20.1501(b) that licensees record the results of surveys identifying significant subsurface residual radioactivity—requiring remediation to meet unrestricted use criteria—in records important to decommissioning. This will assist in planning and costing remedial actions and surveys to support license termination. It also provides important input to the historical site assessment required by the decommissioning section of the NRC’s licensing regulations.<sup>7</sup>

Once it has collected this information, the licensee should use it in revising decommissioning cost estimates, as appropriate to license type requirements. Nuclear power plant licensees should include this information in the decommissioning cost estimates required by 10 CFR 50.75(f)(3) and 10 CFR 50.82(a)(8)(iii). Other licensees should adjust financial assurance for decommissioning to reflect the necessary cost of remediation to meet unrestricted release criteria at the time of license termination. See NUREG-1757, “Consolidated Decommissioning Guidance,” Volume 3, Revision 1, “Financial Assurance, Recordkeeping, and Timeliness,” issued November 2011 (ADAMS Accession No. ML090850301), for additional information. If a licensee has adjusted its financial assurance in response to previous contamination events, it could elect to conduct partial site remediation during operations. If this results in a decrease in the remaining remediation necessary to meet unrestricted release limits, it could also result in a decrease in the required trust fund amount. The staff encourages licensees to evaluate the total costs of prompt versus delayed remediation. Nothing in the DPR mandates remediation during operations.

<sup>7</sup>

While not required by the DPR, records of less, or no, contamination can be useful in defining and costing site remediation and in setting initial classes of survey areas.

## APPENDIX A-2

### RISK-BASED EVALUATION FOR NECESSITY TO SAMPLE

A challenge presented by the DPR is for licensees to determine if, when, and where additional sampling may be required for compliance with the DPR. The goal of the DPR is to ensure that licensees reasonably define the condition of the site and plan sufficient financial resources to remediate the site efficiently and effectively for unrestricted use following licensed activities. Following is a set of questions to assist licensees in determining if additional sampling of fluid-based radiological contamination is necessary to comply with the DPR.

**Table A-2 Risk Evaluation Table for Sampling Decisions**

Condition		If Yes	If No
1	Do I have complete records of my inventory since my initial license was issued?	continue	go to 3
2	Have there ever been concentrations in the inventory greater than limits for release for unrestricted use?	continue	go to 4
3	Has there ever been a release of inventory that was <u>not</u> remediated to limits for release for unrestricted use?	sample the affected areas, record results	continue
4	Are there locations where any releases, including those planned and monitored, of the inventory could concentrate over time?	sample the affected area(s), record results	continue
5	If I released the entire inventory at one time, would I have to remediate any areas to meet limits for release for unrestricted use?	sample the affected areas, record results	No additional sampling required by DPR



## APPENDIX A-3

### EXCERPTS FROM NUREG-1757

The following information is from NUREG-1757, “Consolidated Decommissioning Guidance,” Volume 1, Revision 2, “Decommissioning Process for Materials Licensees,” (Ref. 23). The first table, which is adapted from Table 1.1 of NUREG-1757, Volume 1, shows a division of licensees into groups as a function of the existing or potential contamination at the site and the expected complexity in decommissioning. The second table is excerpted from one indicating the level of detail that the staff expects in a decommissioning plan (DP). While the purpose of this regulatory guide is not to develop a DP, this table can be used as a guide to the amount of information licensees should collect during operations to support decommissioning planning.

**Table A-3-1 Description and Examples of Decommissioning Groups**

Group	Brief Description	Examples
1	Licensed material was not released into the environment, did not cause the activation of adjacent materials, and did not contaminate work areas.	Licensees who used only sealed sources such as radiography cameras and irradiators
2	Licensed material was used in a way that resulted in residual radioactivity on building surfaces and/or soils. The licensee is able to demonstrate that the site meets the screening criteria for unrestricted use.	Licensees who used only quantities of loose radioactive material that they routinely cleaned up (e.g., R&D facilities)
3	Licensed material was used in a way that could meet the screening criteria, but the license needs to be amended to modify or add procedures to remediate buildings or sites.	Licensees who may have occasionally released radioactivity within NRC limits (e.g., broad scope)
4	Licensed material was used in a way that resulted in residual radiological contamination of building surfaces or soils, or a combination of both (but not ground water). The licensee demonstrates that the site meets unrestricted use levels derived from site-specific dose modeling.	Licensees whose sites released loose or dissolved radioactive material within NRC limits and may have had some operational occurrences that resulted in releases above NRC limits (e.g., waste processors)
5	Licensed material was used in a way that resulted in residual radiological contamination of building surfaces, soils, or ground water, or a combination of all three. The licensee demonstrates that the site meets unrestricted use levels derived from site-specific dose modeling.	Licensees whose sites released, stored, or disposed of large amounts of loose or dissolved radioactive material on site (e.g., fuel cycle facilities)
6	The site meets restricted use levels derived from site-specific dose modeling. Not used for purposes of the DPR.	N/A
7	The site meets alternate restricted use levels derived from site-specific dose modeling. Not used for purpose of the DPR.	N/A

Table A-3.2, adapted from Table D.1 of NUREG-1757, Volume 1, is a guide to assist licensees in developing the information expected at the beginning of the decommissioning process. The table shows that describing site conditions for simpler sites does not require as much information as for complex sites.

<b>Table A-3-2 Application of Information Checklist to Decommissioning Groups</b>			
	<b>Group 3</b>	<b>Group 4</b>	<b>Group 5</b>
<b>Facility Operating History</b>			
License Number/ Status/Authorized Activities	<b>1</b>	<b>1</b>	<b>2</b>
License History	<b>1</b>	<b>1</b>	<b>2</b>
Spills	<b>1</b>	<b>1</b>	<b>2</b>
<b>Radiological Status of Facility</b>			
Contaminated Structures	<b>2</b>	<b>2</b>	<b>2</b>
Contaminated Systems and Equipment	<b>2</b>	<b>2</b>	<b>2</b>
Surface Soil Contamination	<b>1</b>	<b>1</b>	<b>3</b>
Subsurface Soil Contamination	<b>N/A</b>	<b>N/A</b>	<b>3</b>
Surface Water	<b>1</b>	<b>1</b>	<b>3</b>
Ground Water	<b>1</b>	<b>1</b>	<b>3</b>
<b>Facility Radiation Surveys</b>			
Release Criteria	<b>1</b>	<b>2</b>	<b>2</b>
Characterization Surveys	<b>1</b>	<b>2</b>	<b>2</b>
In-Process Surveys	<b>1</b>	<b>2</b>	<b>2</b>
Final Status Survey Design	<b>1</b>	<b>2</b>	<b>2</b>
Final Status Survey Report	<b>1</b>	<b>2</b>	<b>2</b>
<b>Financial Assurance</b>			
Cost Estimate	<b>1</b>	<b>2</b>	<b>2</b>
Certification Statement	<b>1</b>	<b>2</b>	<b>2</b>
Financial Mechanism	<b>1</b>	<b>2</b>	<b>2</b>
<ul style="list-style-type: none"> <li>• For the blocks labeled with 1, only minimal information is normally expected. This information is usually in existing documentation.</li> <li>• For blocks marked with 2, additional information would normally be needed to allow the NRC staff to complete its independent assessment. Some specific data and short analysis may be required.</li> <li>• For blocks marked with 3, a complete discussion is needed to explain the topic. Significant data and analysis may be required. Such information is obtained through detailed site characterization and planning for remediation.</li> <li>• For Decommissioning Groups 1 &amp; 2, the basic qualitative approach for required information is the same, but a formal DP is not required.</li> </ul>			

## **APPENDIX B**

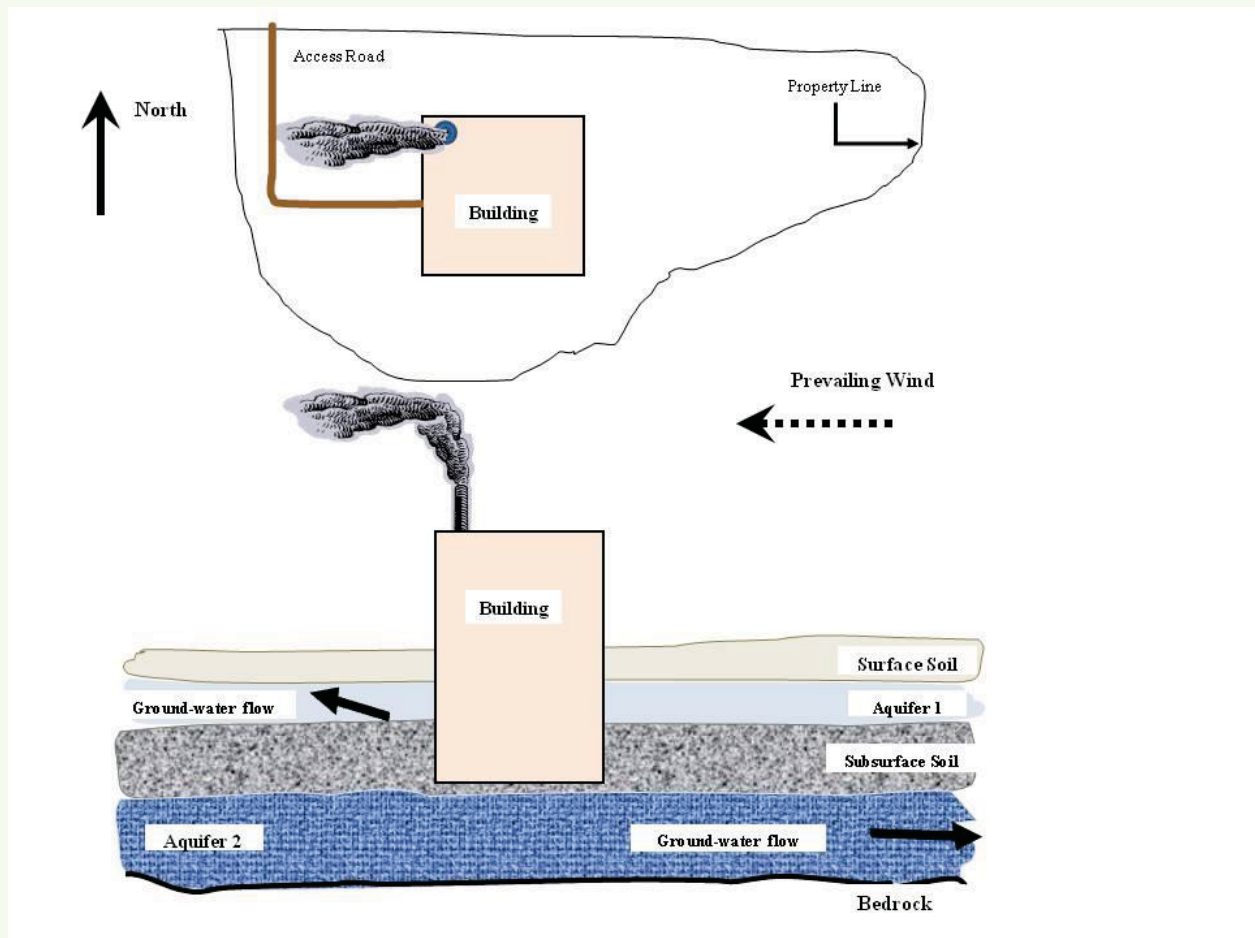
### **EXAMPLES FOR DETERMINING SAMPLE LOCATIONS**

#### **MONITORING BASES AND EXAMPLES**

NRC regulations require that, as part of the decommissioning process, licensees provide a comprehensive definition of the radiological condition of the site. The Decommissioning Planning Rule requires licensees to begin the process of site characterization during the operational phase of plant life. Licensees should use the “defense in depth” concept in demonstrating the radiological condition of the site. Licensees should already be monitoring areas where contamination is likely to occur. As shown earlier in Figure 3a, licensees should review existing plans to ensure that all potential areas are adequately monitored. For those areas not currently being monitored that could become contaminated but are not accessible, alternate monitoring should be developed. If the use of remote monitors, robotics, or other techniques is not feasible within the facility, subsurface monitoring downstream of release areas should be evaluated and instituted as appropriate to the potential risk. The preconstruction site characterization should provide an understanding of the underlying hydrogeology of the site. Following are some examples of updating survey plans for various license types. These examples are for illustration and are not intended to be comprehensive.

To illustrate the complexity of sampling see Figure B-1 in which the facility comprises a building of several stories with the basement set about 25 feet below grade and some surrounding open land. Site studies show ground water aquifers at 15 feet and at 27 feet below grade. Regional geologic information indicates that the upper aquifer flows generally northwesterly and the lower one flows generally easterly. Meteorological data show the predominant wind (greater than 85 percent) is from the east. Because the leaks are mostly likely to occur in the same general area of the facility, it is not generally reasonable to try to separate contamination from the various occurrences. So, under these circumstances, where is it reasonable to sample?

*Figure B-1. SCHEMATIC FOR POTENTIAL SAMPLING LOCATIONS*



- INSIDE:
- Tops of ducts, cabinets, open structures, etc.
  - Floors around drains, edges and joints, under equipment
- OUTSIDE:
- Surface soil northwest along road and west of the building for airborne deposits
  - Shallow aquifer northwest of the building for soluble isotopes if indicated
  - Deep aquifer east of building for potential releases around footer if indicated

## **I. Large Fuel Cycle Facility**

Fuel cycle facilities have reported unplanned releases to various parts of the facilities, including inside and outside of buildings, some resulting in radiological contamination in the subsurface. Over time, process leaks have resulted in extensive subsurface contamination that has spread through ground water migration. Once the licensee learns that process leaks have occurred, it must survey the interior areas where the contamination was released, where it may collect—sumps, drains, building joints—and the potentially affected subsurface to determine the actual extent of contamination. Sampling and monitoring of the subsurface should occur downstream of and close to potential release points from buildings, tanks, piping, etc. Preconstruction studies should provide some information on the hydrogeology of the area, such as material types, depth(s) to ground water, and geochemistry, which is useful in identifying potential sampling locations.

## **II. RTR (Research & Test Reactors)**

RTRs may experience unplanned losses of pool water through drain overflows and erroneous valve alignments. In the case in which facility records include comprehensive water quality data that demonstrate (1) no elevated radionuclide concentrations during the entire operational life, and (2) water level/makeup data demonstrate no losses during the entire operational life, including from any auxiliary systems, “rabbits,” etc., then a licensee could then argue that it is “reasonable under the circumstances” not to conduct additional sampling.

Lacking any of this information, the licensee should review its sampling program to identify potential unmonitored releases downstream of possible release points, including connected piping systems, drains, building joints, and the subsurface. Potential sample locations include those where liquids can “pool” and could, over the operational life of the facility, result in concentration of radionuclides.

## **III. Radiopharmaceutical Processor**

A facility “tags” chemicals with radionuclides. The facility air system controls internal contamination and discharges some radioactive material up the stack within the limits of Table 2 of Appendix B, “Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage,” to 10 CFR Part 20. Because the radiolabeled pharmaceuticals are heavier than air, they subsequently fall to the ground and may concentrate above release limits in the predominant wind direction(s). They could also migrate into the ground water and result in wider contamination. Parameters affecting the potential concentration include process discharge rate, weight of particulates, radionuclide half-life, terrain, precipitation, and variability of wind speed and direction. The licensee could calculate the maximum concentration using conservative assumptions such as monodirectional stable wind conditions, maximum half-life, and minimum solubility for the isotope(s) processed. Assuming higher solubility would potentially result in lower surface concentrations but higher ground water concentrations. Alternatively, the licensee could take some samples based on known processes and meteorological conditions. If a licensee does not have sufficient meteorological data, then it should do more surface monitoring to determine possible deposition patterns.

#### **IV. Medical Laboratory**

In laboratories, on rare occasions, radioactive materials may be spilled, or dropped into drains or onto floors. Generally, the materials are dilute or are diluted by subsequent drain use. However, some radioactive compounds may concentrate in building joints or at irregular fittings in piping systems, such as p-traps. Materials may also escape from hoods and associated vent ducting into the rooms, or collect within the ductwork, more likely at joints or other fittings.



## APPENDIX C

### EXCERPTS FROM PERTINENT REGULATIONS

#### 10 CFR 20.1003, “Definitions”

*Residual radioactivity* means radioactivity in structures, materials, soils, groundwater, and other media at a site resulting from activities under the licensee’s control. This includes radioactivity from all licensed and unlicensed sources used by the licensee, but excludes background radiation. It also includes radioactive materials remaining at the site as a result of routine or accidental releases of radioactive material at the site and previous burials at the site, even if those burials were made in accordance with the provisions of 10 CFR Part 20.

#### 10 CFR 20.1101, “Radiation protection programs”

- (a) Each licensee shall develop, document, and implement a radiation protection program commensurate with the scope and extent of licensed activities and sufficient to ensure compliance with the provisions of this part.
- (b) The licensee shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA).
- (c) The licensee shall periodically (at least annually) review the radiation protection program content and implementation.

#### 10 CFR 20.1402, “Radiological criteria for unrestricted use”

A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE [total effective dose equivalent] to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA)...

#### 10 CFR 20.1403, “Criteria for license termination under restricted conditions”

A site will be considered acceptable for license termination under restricted conditions if:

- (a) The licensee can demonstrate that further reductions in residual radioactivity necessary to comply with the provisions of § 20.1402 would result in net public or environmental harm or were not being made because the residual levels associated with restricted conditions are ALARA....
- (b) The licensee has made provisions for legally enforceable institutional controls....
- (c) The licensee has provided sufficient financial assurance to enable an independent third party, including a governmental custodian of a site, to assume and carry out responsibilities for any necessary control and maintenance of the site.
- (d) The licensee has submitted a decommissioning plan or License Termination Plan (LTP) to the Commission indicating the licensee’s intent to decommission in accordance with [regulations], and

specifying that the licensee intends to decommission by restricting use of the site. The licensee shall document in the LTP or decommissioning plan how the advice of individuals and institutions in the community who may be affected by the decommissioning has been sought and incorporated, as appropriate, following analysis of that advice.

(e) Residual radioactivity at the site has been reduced so that if the institutional controls were no longer in effect, there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is as low as reasonably achievable and would not exceed either—

(1) 100 mrem (1 mSv) per year; or

(2) 500 mrem (5 mSv) per year provided the licensee—

(i) Demonstrates that further reductions in residual radioactivity necessary to comply with the 100 mrem/y (1 mSv/y) value of paragraph (e)(1) of this section are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm;

(ii) Makes provisions for durable institutional controls;

(iii) Provides sufficient financial assurance to enable a responsible government entity or independent third party, including a governmental custodian of a site, both to carry out periodic rechecks of the site no less frequently than every 5 years to assure that the institutional controls remain in place as necessary to meet the criteria of § 20.1403(b) and to assume and carry out responsibilities for any necessary control and maintenance of those controls.

#### **10 CFR 20.1406, “Minimization of contamination”**

(c) Licensees shall, to the extent practical, conduct operations to minimize the introduction of residual radioactivity into the site, including the subsurface, in accordance with existing radiation protection requirements in Subpart B and radiological criteria for license termination in Subpart E of this part.

#### **10 CFR 20.1501, “General” (part of Subpart F, “Surveys and Monitoring”)**

(a) Each licensee shall make or cause to be made, surveys of areas, including the subsurface, that—

(1) May be necessary for the licensee to comply with the regulations in this part; and

(2) Are reasonable under the circumstances to evaluate in a timely manner—

(i) The magnitude and extent of radiation levels; and

(ii) Concentrations or quantities of residual radioactivity; and

(iii) The potential radiological hazards of the radiation levels and residual radioactivity detected.

(b) Notwithstanding § 20.2103(a) of this part, records from surveys describing the location and amount of subsurface residual radioactivity identified at the site must be kept with records important for decommissioning, and such records must be retained in accordance with §§ 30.35(g), 40.36(f), 50.75(g), 70.25(g), or 72.30(d), as applicable.

### **10 CFR 30.35, “Financial assurance and recordkeeping for decommissioning”**

(d) Table of required amounts of financial assurance for decommissioning by quantity of material. Licensees required to submit the \$1,125,000 amount must do so by December 2, 2004. Licensees required to submit the \$113,000 or \$225,000 amount must do so by June 2, 2005. Licensees having possession limits exceeding the upper bounds of this table must base financial assurance on a decommissioning funding plan.

Greater than $10^4$ but less than or equal to $10^5$ times the applicable quantities of appendix B to part 30 in unsealed form. (For a combination of isotopes, if R, as defined in § 30.35(a)(1), divided by $10^4$ is greater than 1 but R divided by $10^5$ is less than or equal to 1.)	\$1,125,000
Greater than $10^3$ but less than or equal to $10^4$ times the applicable quantities of appendix B to part 30 in unsealed form. (For a combination of isotopes, if R, as defined in § 30.35(a)(1), divided by $10^3$ is greater than 1 but R divided by $10^4$ is less than or equal to 1.)	\$225,000
Greater than $10^{10}$ but less than or equal to $10^{12}$ times the applicable quantities of appendix B to part 30 in sealed sources or plated foils. (For a combination of isotopes, if R, as defined in § 30.35(a)(1), divided by $10^{10}$ is greater than, 1, but R divided by $10^{12}$ is less than or equal to 1)	\$113,000

### **10 CFR 40.36, “Financial assurance and recordkeeping for decommissioning”**

(b) Each applicant for a specific license authorizing possession and use of quantities of source material greater than 10 mCi but less than or equal to 100 mCi in a readily dispersible form shall either—

- (1) Submit a decommissioning funding plan as described in paragraph (d) of this section; or
- (2) Submit a certification that financial assurance for decommissioning has been provided in the amount of \$225,000 by June 2, 2005 using one of the methods described in paragraph (e) of this section. For an applicant, this certification may state that the appropriate assurance will be obtained after the application has been approved and the license issued but before the receipt of licensed material. If the applicant defers execution of the financial instrument until after the license has been issued, a signed original of the financial instrument obtained to satisfy the requirements of paragraph (e) of this section must be submitted to NRC prior to receipt of licensed material. If the applicant does not defer execution of the financial instrument, the applicant shall submit to NRC, as part of the certification, a signed original of the financial instrument obtained to satisfy the requirements of paragraph (e) of this section.

### **10 CFR 50.75, “Reporting and recordkeeping for decommissioning planning”**

(f)(3) Each power reactor licensee shall at or about 5 years prior to the projected end of operations submit a preliminary decommissioning cost estimate which includes an up-to-date assessment of the major factors that could affect the cost to decommission.

### **10 CFR 50.82, “Termination of license”**

(a)(8)(iii) Within 2 years following permanent cessation of operations, if not already submitted, the licensee shall submit a site-specific decommissioning cost estimate.

**10 CFR 70.25, “Financial assurance and recordkeeping for decommissioning”**

(d) Table of required amounts of financial assurance for decommissioning by quantity of material. Licensees required to submit the \$1,125,000 amount must do so by December 2, 2004. Licensees required to submit the \$225,000 amount must do so by June 2, 2005. Licensees having possession limits exceeding the upper bounds of this table must base financial assurance on a decommissioning funding plan.

greater than $10^4$ but less than or equal to $10^5$ times the applicable quantities of appendix B to part 30. (For a combination of isotopes, if R, as defined in § 70.25(a), divided by $10^4$ is greater than 1 but R divided by $10^5$ is less than or equal to 1.)	\$1,125,000
greater than $10^3$ but less than or equal to $10^4$ times the applicable quantities of appendix B to part 30. (For a combination of isotopes, if R, as defined in § 70.25(a), divided by $10^3$ is greater than 1 but R divided by $10^4$ is less than or equal to 1.)	\$225,000