TECHNICAL BASIS FOR PROPOSED RULE TO AMEND 10 CFR PART 61 TO SPECIFY REQUIREMENTS FOR THE DISPOSAL OF UNIQUE WASTE STREAMS, INCLUDING LARGE QUANTITIES OF DEPLETED URANIUM (FSME-10-XXXX)

Existing Regulatory Framework

The Commission's licensing requirements for the disposal of commercial low-level radioactive waste (LLW) in near-surface disposal facilities, 10 CFR Part 61, were published in the *Federal Register* (FR) in 1982 (47 FR 57446). The rule applies to any near-surface (approximately the uppermost 30 meters (100 feet)) LLW disposal facility licensed after the effective date of the rule; many of the Part 61 requirements were applied through license conditions to near-surface disposal facilities in operation on the effective date of the rule. Near-surface disposal methods include shallow-land burial, engineered land disposal techniques (such as below-ground vaults), earth-mounded concrete bunkers, and augered holes. Part 61 emphasizes an integrated systems approach to the disposal of commercial LLW, including site selection, disposal facility design and operation, minimum waste form requirements, and disposal facility closure. To lessen the burden on society over the long periods of time contemplated for the control of the radioactive material and thus lessen reliance on institutional controls, Part 61 emphasizes the use of passive rather than active systems to limit and retard radioactive releases to the environment.

Subparts of Part 61 include: (1) general provisions and procedural licensing matters; (2) the performance objectives; (3) financial assurances; (4) State and tribal participation; and (5) records, reports, tests, and inspections. The regulations cover all phases of shallow, near-surface commercial LLW disposal from site selection through termination of active institutional controls.

Part 61 includes the following key provisions:

- Specification of the minimum characteristics for a disposal site (§ 61.50);
- Definition of a three-tier waste classification system (LLW classes designated Class A, Class B, or Class C) for commercial LLW based on the concentrations of certain radionuclides (§ 61.55);
- Specification of minimum waste form physical characteristics that all commercial LLW forms must meet to be acceptable for near-surface disposal (§§ 61.56(a) and (b)); and
- Requirements for caretaker oversight in the form of institutional controls of LLW disposal sites for a period of 100 years following facility closure (§ 61.59).

Subpart C sets forth standards for:

(1) Protection of the general population from releases of radioactivity (§ 61.41);

(2) Protection of individuals from inadvertent intrusion (§ 61.42);

(3) Protection of individuals during operations (§ 61.43); and

(4) Stability of the disposal site after closure (§ 61.44).

To reach a licensing determination, the NRC staff must conclude, with reasonable assurance, that the proposed facility would meet the performance objectives of Subpart C. To demonstrate that they will meet those performance objectives, Part 61 license applicants need to prepare assessments of potential future dose impacts to the general population. License applicants must demonstrate that potential inadvertent intruders into the disposal facility, who may occupy the site at any time after institutional controls over the disposal site are removed, will be protected. The requisite technical analyses and associated information needs for both the analyses and any licensing determination based on those analyses are provided in §§ 61.13(a)–(d). Thus, Part 61 is intended to be performance-based rather than prescriptive; the technical criteria are written in relatively general terms, which allows applicants to demonstrate how their proposals meet the respective performance objectives for the specific near-surface disposal method selected. The overall philosophy and concepts that underlie the regulatory requirements of Part 61 are provided in § 61.7. The regulatory requirements ensure public health and safety are protected in the operation of any commercial LLW disposal facility.

The three-tier waste classification system introduced by Part 61 was intended to provide reasonable assurance that the proposed facility would meet the performance objectives in Subpart C. The Part 61 waste classification system considered stylized human intrusion scenarios. The NRC developed the waste classification system to consider both the physical stability of the waste form and its isotopic concentration. The isotopic concentration limits in Part 61 are based on the staff's understanding (circa 1980) of the characteristics and volumes of commercial LLW that were reasonably expected for commercial disposal, as well as the disposal methods then thought likely to be used. In the *Statements of Consideration* for the final rule (47 FR 57457), the Commission noted that:

> "… waste that is stable for a long period helps to ensure the long-term stability of the site, eliminating the need for active maintenance after the site is closed. This stability requirement helps to assure against water infiltration caused by failure of the disposal covers and, with the improved leaching properties implicit in a stable waste form, minimizes the potential for radionuclide migration in groundwater. Stability also plays an important role in protecting an inadvertent intruder, since the stable waste form is recognizable for a long period of time and minimizes any effects from dispersion of the waste upon intrusion ...."

The Commission also expressed its belief that "… to the extent practicable, waste forms or containers should be designed to maintain gross physical properties and identity over 300 years, approximately the time required for Class B waste to decay to innocuous levels ..." (47 FR 57457).

As noted above, when it developed Part 61, the staff assumed that certain types of wastes were likely to go into a commercial LLW disposal facility. Part of the staff's analysis of the likely waste inventory at a hypothetical Part 61 facility included a survey of existing LLW generators; the survey, documented in Volume 3 of NUREG-0782 (NRC, 1981), revealed that there were certain distinct commercial waste streams consisting of 24 radionuclides of potential regulatory interest. The staff considered these waste streams to be representative of the types of commercial LLW likely to go into a near-surface disposal facility. Waste streams associated with the U.S. Department of Energy's (DOE) nuclear defense complex were not considered (NRC, 1981, p. 3-8). In addition, large quantities of depleted uranium (DU) were not considered. The results of this survey ultimately formed the basis for the source terms used to define the allowable isotopic concentration limits—the "waste classification tables" found at § 61.55(a)—for commercial LLW to be disposed of in a Part 61 facility.

Discussion

When it developed Part 61 the staff assumed, for the purposes of its analysis, that an inadvertent intruder occupied a LLW disposal site sometime in the future. Inadvertent intruders could engage in normal activities without knowing that they were being exposed to radiation from LLW after institutional controls over the site were no longer in place—staff refers to this as the inadvertent intruder scenario. The Commission recognized that, taking into account the long timeframes of regulatory concern, the inadvertent intruder scenario would likely be a key factor influencing the site selection and design requirements necessary to ensure public safety. The Commission also recognized that specific design precautions, waste form specifications, or both might be necessary to protect the public from more hazardous, long-lived LLW. To this end, the waste classification system imposes different requirements, including radionuclide concentration limits and specified physical forms, for different LLW classes. The regulations specify that for certain radionuclides prone to migration in the environment, a maximum disposal site inventory based on the characteristics of the disposal site may be established to limit potential exposures. In addition, the regulations specify a maximum concentration of radionuclides for all waste classes, so that after 500 years the remaining radioactivity would be at a level that would not pose an unacceptable hazard to an inadvertent intruder or to public health and safety (47 FR 57466). Waste with concentrations above those limits is generally unacceptable for near-surface disposal, although the Commission noted that such types of wastes may be acceptable for disposal under Part 61 when more stringent disposal methods are used (54 FR 22580). The Part 61 analyses considered both direct and indirect exposure pathways: direct exposure, such as through inadvertent intrusion, was considered at 100 and 500 years; indirect exposure, such as offsite exposure to contaminated groundwater, persists for more than 500 years.

The current rule provides for the protection of individuals from inadvertent intrusion by requiring licensees to demonstrate that the Part 61 waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion have been included in the disposal facility design. Tables 1 and 2 of § 61.55 provide concentration limits for select radionuclides that may be used to determine the Part 61 waste classification designation for a particular LLW type. Based on the waste classification, requirements for segregation, intruder barriers, and disposal depth are stipulated in the regulations to ensure the protection of inadvertent intruders. Dose limits for an inadvertent intruder are not provided in Part 61, but the concentrations of radionuclides established in Tables 1 and 2 assumed a (maximum) dose of 5 mSv/yr (500 mrem/yr). The § 61.55 waste classification tables are used to demonstrate compliance with the performance objective in § 61.42, "Protection of individuals from inadvertent intrusion."

Regulatory Issue

As noted in the previous section, the Commission recognized that there might be a situation in which a commercial waste stream could be created that was not contemplated as part of the original technical basis for Part 61, which is found in the Draft and Final Environmental Impacts

Statements for the rule. The radionuclides provided in the § 61.55 waste classification tables were based on a best estimate (in 1980) of projected inventories of radioactive waste that would be disposed of in a commercial LLW disposal facility. Table 1 provides limiting concentrations for long-lived radionuclides and Table 2 provides limiting concentrations for short-lived radionuclides. Some radionuclides, such as isotopes of uranium, were not expected to be generated in sufficient quantities or concentrations to warrant inclusion in the tables. The Part 61 Draft Environmental Impact Statement (DEIS) [NUREG-0782 (NRC, 1981)] assumed that only 629,000 MBq (17 Ci) of U^{238} and 111,000 MBq (3 Ci) of U^{235} would be disposed of in one million cubic meters (35 million cubic feet) of waste over a 20-year generic LLW site operating life. Concentration limits for uranium were derived, but were not included in the final regulation because it was determined that the relatively small quantities of uranium waste expected to be generated by commercial facilities at the time did not warrant inclusion. Because it wasn't considered in the original technical analysis, the staff needs to consider what type of analysis is needed today to determine whether a waste stream, such as one with significant quantities of uranium, is acceptable for disposal in a Part 61 disposal facility. Part 61 considered potential doses to an offsite member of the public and an inadvertent intruder based on certain assumptions regarding the waste streams likely to be found in a commercial LLW disposal facility.

Although § 61.42 requires that an inadvertent intruder be protected, the regulation does not explicitly require an intruder dose assessment to demonstrate that protection can be achieved with reasonable assurance. The NRC staff performed intruder dose calculations when it derived the concentration limits in the waste classification tables (§ 61.55(a)). The regulations only require that a licensee demonstrate that the waste classification and segregation requirements of the rule will be met and provide information that the barriers intended to deter inadvertent intrusion will be effective. This determination is based on a review of § 61.13(b) and the information needs identified in Section 6.2 of NUREG 1200 — *Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility* (NRC, 1994). In NUREG-1573 — *A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities* (NRC, 2000) the staff acknowledged that applicants and licensees are not expected to perform intruder dose analyses because the waste classification and segregation requirements found in § 61.13(b) were developed to protect an inadvertent intruder.

As noted above, the waste classification tables and the segregation and intrusion protection requirements found in Part 61 were based on estimated generic waste inventory and waste characteristics derived from known commercial waste streams in 1980. For the purposes of the NEPA analysis, it was assumed that commercial LLW destined for any Part 61 disposal facility would not be substantially different in terms of radiological inventory and physical characteristics from the 36 projected waste streams evaluated. Therefore, the staff had confidence that waste streams not substantially different from those evaluated in the technical analysis could be disposed of in a manner consistent with the Part 61 waste classification and segregation requirements. Similarly, there was also confidence that the associated intruder dose (if calculated) would be within the limits used to develop the § 61.55 waste classification tables. The staff has less assurance that waste streams that are significantly different from those evaluated as part of the Part 61 technical analysis will meet the inadvertent intruder protection requirements.

The licensing of new uranium enrichment facilities in the United States has brought DU to the forefront of commercial LLW disposal issues. In the technical analysis in the DEIS that supported the development of Part 61, the staff did not consider the relatively high concentrations and large quantities of DU that are generated by enrichment facilities. As noted above, when the DEIS was under development, the staff specifically excluded from consideration DU and other DOE-generated streams. Moreover, at the time the staff did not anticipate that DOE would dispose of its DU or any other defense-related radioactive wastes in commercial disposal facilities, such as facilities that might be licensed under Part 61. With the existing DOE DU stockpile at the Paducah and Portsmouth Gaseous Diffusion Plants and the recent licensing of commercial enrichment facilities—LES National Enrichment Facility and the United States Enrichment Corporation (USEC) American Centrifuge Plant—DOE and industry will need to dispose of more than 10^9 kilograms (1 million metric tons) of depleted uranium hexafluoride (DUF_6) which will be de-converted into an oxide form for the purposes of disposal. The technical analysis in the FEIS considered 629,000 MBq (17 Ci) of U^{238} compared to approximately 3.7×10^9 – 7.4×10^9 MBq (100,000 – 200,000 Ci) of U^{238} that will be generated from LES during its 25-year lifespan (NRC, 2005b).

Besides DU, other waste streams not considered during the original development of the regulation might need to be evaluated as generators may wish to dispose of the material as commercial LLW. For example, in 2005 the *Energy Policy Act (EPAct)* of 2005 expanded the NRC's regulatory authority under the *Atomic Energy Act* to include discrete sources of naturally occurring radioactive material (NORM), including radium-226 that might be produced, extracted, or converted as a byproduct material. The Part 61 technical basis considered only a small quantity of radium-226 bearing wastes for the purposes of designating the respective waste classes.[1]

In addition, changes within the broader LLW management system could result in the generation of materials that materially differ from the material considered in the Part 61 technical basis. For example, in SECY-09-0082 (NRC, 2009a) the staff performed a gap analysis of the current regulatory framework applicable to the potential reprocessing of spent nuclear fuel (SNF). Gap #16 addressed waste classification and discussed issues with DU as well as wastes generated from reprocessing (i.e., the waste streams from reprocessing could be significantly different from the waste streams originally anticipated in the Part 61 technical basis). Similarly, in SECY-10-0043 (NRC 2010), the staff noted that large-scale blending of Class B and Class C concentrations of LLW with Class A to produce a Class A mixture could result in doses to an inadvertent intruder that are above 5 mSv/yr (500 mrem/yr) (i.e., the dose limit used in developing the waste classification limits in § 61.55(a)); this type of blending is now being contemplated by industry. In SECY-10-0043, the staff presented several options that could address blending, including an option that would include the evaluation of blended wastes as a unique waste stream. During the original development of Part 61, the staff did not evaluate large-scale blending, which could generate large volumes of LLW concentrations near the limit for Class A. As noted above, the Part 61 waste classification tables reflect certain assumptions

[1] For example, the equivalent of 0.5 nCi/gm of radium-226 contained in about 68 kg (~150 pounds) of natural uranium ore (at equilibrium with its daughter products) was considered for the purposes of designating Class A LLW (47 FR 57453-57454).

about the waste streams to be disposed of, the distributions of concentrations of radionuclides in those waste streams, and how those waste streams might be combined for disposal. Blending of different classes of wastes could result in waste streams with characteristics that were not evaluated in the earlier Part 61 technical analyses.

In summary, the proposed rulemaking would solicit public comment on the following amendments to Part 61:

1. Amend § 61.41 to require Part 61 licensees to conduct a site-specific performance assessment for LLW disposal facilities to ensure that the facility can meet the dose requirements in this section. The analyses would be used to identify if disposal of unique waste streams at a specific site should be restricted or prohibited.

2. Amend § 61.42 to require Part 61 licensees to conduct a stylized human intrusion analysis that considers the time period after the end of the period of active institutional controls.

3. As necessary, provide additional changes that will reduce ambiguity and facilitate implementation of Part 61 (e.g., provide a period of performance, update the radiation safety standards to Total Effective Dose Equivalent (TEDE), provide a dose limit for § 61.42, and update § 61.7).

<u>Basis for Requested Change</u>

Section 61.55(a)(6) specifies that: *If radioactive waste does not contain any nuclides listed in either Table 1 or 2, then it is Class A.* This regulation is consistent with the § 61.42 performance objective for wastes that are not significantly different from those considered in the technical basis for Part 61. However, if waste significantly differs in quantity and concentration from what was considered in the development of Part 61, it may be possible to dispose of a waste stream that would meet the disposal requirements and § 61.42 performance objectives, but would result in an intruder dose (if calculated) that exceeds the dose limit (i.e., 5 mSv (500 mrem)) used to develop the waste classification tables. Currently, a licensee is not required to perform an intruder dose assessment to demonstrate compliance with the § 61.42 performance objective.

A 2005 adjudicatory decision concerning the license for LES (NRC, 2005a; pp. 16-17) directed the staff, outside of the adjudication, "to consider whether the quantities of depleted uranium at issue in the waste stream from uranium enrichment facilities warrant amending section 61.55(a)(6) or the section 61.55(a) waste classification tables." In SECY-08-0147 (NRC, 2008), the staff completed a technical analysis of the impacts of near-surface disposal of large quantities of DU, such as those expected to be generated at uranium enrichment facilities. The technical analysis addressed whether amendments to § 61.55(a) might be necessary to ensure that large quantities of DU are disposed of in a manner that meets the Subpart C performance objectives. The staff concluded that near-surface disposal of large quantities of DU may be appropriate in some circumstances, but not under all site conditions.

In a 2008 analysis (SECY-08-0147, Enclosure 1) involving a land disposal scenario for large quantities of DU, the staff identified conditions that would likely result in the Part 61 performance objectives not being met (e.g., shallow disposal, such as commonly associated with Class A LLW, or disposal at humid sites with a potable groundwater supply). Additionally, the staff determined that the disposal of large quantities of DU as Class A LLW with no additional restrictions could result in inadvertent intruders receiving a dose greater than 5 mSv/yr (500 mrem/yr) for both acute and chronic exposure scenarios (see Attachment 1). The estimated dose would result from pathways, such as inadvertent ingestion of uranium-contaminated soil and inhalation of radon gas (a member of the uranium decay chain). These results are consistent with those found in an earlier analysis of possible DU disposal in a Part 61 disposal facility (Kozak et al., 1992). Based on the unique characteristics of the waste and additional considerations required for its disposal, the staff concluded in SECY-08-0147 that licensees should be required to conduct site-specific analyses to demonstrate compliance with the performance objectives in 10 CFR Part 61.

The primary change that is being considered would add explicit requirements for both a performance assessment calculation and a site-specific intruder dose assessment for unique waste streams. As used in this context, "unique waste streams" would mean those radioactive wastes not identified in the § 61.55 waste classification tables. Requiring a performance assessment and a site-specific intruder dose assessment would provide additional confidence that the § 61.42 performance objective would be met for the disposal of radioactive waste streams not previously considered, including DU and blended LLW. As discussed below in the Stakeholder Interactions section, the staff held two workshops to solicit early feedback from stakeholders and other interested members of the public on the need for and content of a potential rulemaking for the disposal of unique waste streams. The participants discussed a variety of issues including: period of performance, exposure scenarios, source term issues, modeling of uranium geochemistry, modeling of radon, and definition of unique waste streams and significant quantities.

The period of performance is a key component of performance assessments used to evaluate the safety of integrated radioactive waste management systems. Although a number of countries operate disposal facilities for low- and intermediate-level radioactive wastes (Nuclear Energy Agency, 2005; U.S. Government Accountability Office, 2005), approaches to the specification of a period of performance vary from country to country (Ryan, 2005; Nuclear Energy Agency, 2009). The NRC did not specify a period of performance in Part 61, in part due to both the site- and source-specific influence of the timing of the projected radiological risk from the operation of a LLW disposal facility. The Part 61 technical basis used a period of performance of 10,000 years. The staff previously recommended a similar period of performance for the purposes of evaluating the performance of a typical commercial LLW facility in the context of the final Part 61 rule (NRC, 1996). For radionuclides considered in the Part 61 technical basis, this performance period is considered to be sufficient to capture the risk from the short-lived radionuclides, which comprise the bulk of the activity disposed of, as well as the peak dose from the more mobile longer-lived radionuclides, which tend to bound the potential doses at longer timeframes (greater than 10,000 years).

Based on independent calculations (Cady and Thaggard, 1994), NRC's performance assessment working group recommended and described in NUREG-1573 (NRC, 2000) an approach to period of performance. The working group recommended a 10,000-year period of performance, but also noted there could be exceptions to the suggested 10,000 year timeframe. Disposal of large quantities of uranium or transuranics, involving in-growth or longer-lived isotopes, were cited as exceptions because the ultimate radiological hazard would not be realized until well after 10,000 years. When specifying a period of performance for a radioactive waste disposal facility, both technical (e.g., the characteristics and persistence of the radiological hazard attributed to the waste) and socioeconomic (e.g., trans-generational equity) factors need to be considered (Nuclear Energy Agency, 1995; ICRP, 2000). In the matter of unique waste streams, such as those bearing uranium, the Advisory Committee on Reactor Safeguards (ACRS) recommended the proposed rule not specify a period of performance (Abdel-Khalik, 2010). The ACRS instead recommended that the period of performance be judged on a case-by-case basis that considers the nature of the timing of the radiological hazard.

During the public workshops conducted by NRC staff, a variety of stakeholders expressed the view that a period of performance should be included in the regulations and assigned to Compatibility Category B (which would require the Agreement States to adopt essentially identical regulations) to ensure consistency across Agreement States and that the period of performance used for regulatory analysis was appropriate. The current ambiguity of the period of performance has resulted in Agreement States taking different approaches. The selection of a period of performance can have a significant impact on waste disposal licensing decisions because there is a regulatory requirement (§ 61.50(a)(2)) that requires the disposal site to be capable of being characterized, modeled, analyzed, and monitored. Selection of the period of performance can influence whether the site is interpreted as amenable to modeling and analysis. For unique radioactive waste streams, there may be much larger quantities and higher concentrations of long-lived radionuclides for which the selection of a period of performance can have a more significant influence on estimated impacts from disposal. The staff recommends that either a specific period of performance or procedures to select a period of performance be included in this revision to Part 61. The regulatory impact analyses performed to support the development of the rule would determine the period of performance or the approach to selection of a period of performance.

If a requirement for a site-specific intruder dose assessment for the disposal of unique waste streams is added to the regulations, the staff recommends specifying an intruder dose limit as described in both the Part 61 technical basis to develop a uniform waste classification system. The analysis assessed the impacts to offsite members of the general public and the onsite acute and chronic scenarios resulting from exposure to or disruption of the waste. The analysis also assumed that inadvertent intrusion occurred following a caretaker or institutional control period, and that the intruder occupied the disposal facility and engaged in normal activities, such as agriculture or dwelling construction resulting in direct contact with the waste. The inadvertent intruder analysis considered exposure to radionuclides through inhalation of contaminated soil and air, direct radiation, and ingestion of contaminated food and water. The waste classification tables [§ 61.55(a)] are based on radionuclide concentrations that would yield a 5 mSv/yr (500 mrem/yr) dose.

The NRC developed the waste classification tables to limit doses to potential inadvertent intruders. At the time, the NRC did not believe it was necessary to specify additional requirements for a specific intruder scenario or dose value. If a requirement for a site-specific intruder dose assessment for the disposal of unique waste streams is added to Part 61, then the staff recommends that the proposed rule also include an intruder dose limit that could be used to determine whether the intruder dose assessment complies with the regulations. Participants in the 2009 public workshops generally stated that the details of the intruder scenario should not be specified in any rule, but should be discussed in guidance (viz Wescott and McCartin, 2001). However, workshop participants also supported the inclusion of an intruder dose limit in the rule.

The staff also recommends that the proposed rule consider an update to the performance objective in § 61.41. This update should consider using the Total Effective Dose Equivalent (TEDE) as the appropriate dose limit. The performance objective in § 61.41 currently requires that concentrations of radioactive material released to the general environment "… not result in an annual dose exceeding an equivalent of 0.25 mSv (25 mrem) to the whole body, 0.75 mSv (75 mrem) to the thyroid, and 0.25 mSv (25 mrem) to any other organ of any member of the public." Updating the requirements for the § 61.41 performance objective would make it consistent with the current Part 20 dose methodology. In addition, this dose limit has been considered and adopted by the Commission in other contexts; the staff believes that these past Commission actions, although not directly related to this rulemaking, support the use of 25 mrem TEDE as the appropriate dose limit. The first example is a proposed rule addressing disposal of spent nuclear fuel and other high-level radioactive waste at Yucca Mountain, Nevada, the staff considered 0.25 mSv (25 mrem) TEDE as the appropriate dose limit within the range of potential doses represented by the older limits found in regulations, such as § 61.41, that were published prior to the adoption of a dosimetry system capable of accounting for the radio-sensitivity of different organs. Further, in SRM-SECY-05-0073 (NRC, 2005c), the Commission directed the staff in its responsibilities related to incidental waste determinations under the Ronald Reagan National Defense Authorization Act of Fiscal Year 2005 to use the latest science based on radiological protection requirements in the ICRP Publication 26 methodology (ICRP, 1977) instead of the older requirements in ICRP Publication 2 (ICRP, 1959). The NRC incidental waste determinations use the performance objectives specified at Part 61, Subpart C. The ICRP-26 methodology basically uses a standard of 0.25 mSv (25 mrem) TEDE. The rulemaking process would be used to evaluate and select a specific methodology.

The addition of an explicit performance assessment requirement to Part 61 would better align Part 61 with the Commission's *1995 Policy Statement* regarding its expectations concerning the use of probabilistic risk assessment (PRA) methods in nuclear regulatory matters. In that *Policy Statement*, the Commission expressed its view that the NRC staff should use PRA methods to evaluate the safety of waste management systems, such as a LLW disposal facility (NRC, 1994, 1995).

Alternatives Considered

In SECY-08-0147, staff presented four options to the Commission to address the disposal of unique waste streams. The options included: (1) Issue a generic communication to clarify the need to demonstrate compliance with performance objectives; (2) Perform a limited rulemaking to specify the requirement for site-specific analysis in § 61.55(a)(6); (3) Determine the classification for DU within the existing Part 61 classification framework, and (4) Re-examine and possibly update the existing Part 61 waste classification system through a new rulemaking.

The advantages and disadvantages of the four options considered were presented to the Commission in SECY-08-0147 and the staff recommended Option 2. The Commission approved the staff recommendation to proceed with rulemaking to amend Part 61 to specify a requirement for a site-specific analysis for the disposal of large quantities of DU and the technical requirements for this analysis. The Commission also supported the development of a guidance document for public comment that outlines the parameters and assumptions to be used in conducting these site-specific analyses. As a longer-term action, the Commission directed the staff to request in a future budget request the necessary resources to risk-inform the Part 61 waste classification framework, with conforming changes to the regulations as needed, using updated assumptions and referencing the latest ICRP methodology.

Of the four options presented to the Commission, Option 1 would have resolved the problem within the existing regulatory framework. As discussed below, the staff did not recommend it to the Commission. Although licensees, the NRC, or Agreement States could, and in some cases have, take action to resolve the problem (e.g., the State of Texas applied a period of performance longer than 10,000 years and imposed a license condition on the concentration of DU waste that could be disposed of based on uncertainty in the long-term risk), the existing regulatory framework may not allow Agreement State regulators to enforce the requirement that a licensee perform a site-specific intruder dose assessment for unique waste streams. As noted above, in developing Part 61 the NRC considered whether to require licensees to perform intruder dose assessments, but instead decided to introduce a waste classification system that would apply to all LLW disposal facilities based on an assumed intruder scenario (NRC, 1981). Moreover, one of the key goals in developing the Part 61 regulatory framework was to achieve consistency in national LLW disposal practices, which had been lacking prior to the promulgation of the rule (Ryan et al., 2007). In light of the Interstate LLW Compact Program, the NRC anticipated that at least 10 LLW disposal facilities would be developed nationally and that by standardizing the system used to classify LLW, it would be easier to achieve consistency and promote the safe handling and disposition of LLW. The use of a standardized waste classification system, which accounted for potential doses to an inadvertent intruder, removed the need for individual licenses to perform separate intruder dose assessments. However, the original Part 61 technical analyses did not evaluate DOE waste streams, including large quantities of highly concentrated DU. Introducing a new requirement for applicants and licensees to perform a site-specific performance assessment along with an inadvertent human intrusion calculation would allow decision-makers to ensure that this waste form can be safely managed in a Part 61 shallow land disposal facility.

In addition to the options discussed in SECY-08-0147, staff evaluated the possible use of § 61.58 to require that a site-specific analysis be performed prior to disposal of large quantities of DU. Section 61.58 allows the Commission, either upon request or on its own initiative, to authorize alternate provisions for classification or characteristics for a LLW stream taking into account a specific site and design. Use of an exception-like provision, such as § 61.58, to *require* an additional site-specific study of certain Class A waste streams, without any associated rule change is inconsistent with the basic premise of a regulatory exception. Specifically, the purpose of an exception provision is to allow for an activity that would not otherwise be permitted, rather than to impose an additional requirement (e.g., performance of a site-specific study) on an activity that is already permitted by the rule (e.g., near-surface disposal of Class A LLW). Thus, if § 61.58 were used to approve an alternate waste classification system or waste form characteristic for a previously unevaluated waste stream, such an action might provide additional options for a licensee, but would not require use of that particular option for other licensees. Compliance with the approved alternative would not be the only method of compliance. Therefore, if the staff intended to use § 61.58 to develop an alternate waste classification or alternate characteristics for a Class A waste stream such as DU, and to require licensees to conform to the alternate classification or characteristics as the sole method of compliance in place of (as opposed to as an alternative to) the existing regulations, a rule change would be necessary.

The staff also considered whether the Commission could, on its own initiative, undertake a site-specific analysis for large quantities of DU using § 61.58. While the language of § 61.58 provides for such a Commission-initiated action, performance of this analysis under § 61.58 alone, without an associated rule change, would not replace the existing regulations as the sole method of compliance.

Stakeholder Interactions

The staff had a variety of interactions with stakeholders and other interested members of the public. For example, the staff conducted two public workshops (Bethesda, Maryland; Salt Lake City, Utah) in September 2009 to solicit early feedback from interested stakeholders on major issues associated with a potential rulemaking for land disposal of unique waste streams, including significant quantities of DU in LLW disposal facilities. Participants included representatives of other Federal agencies, Agreement States, LLW disposal facility operators, academia, and public interest groups. NRC staff provided technical presentations on a variety of topics that might be included in the proposed rulemaking. Participants engaged in a discussion of technical, regulatory, and legal issues. Transcripts of those meetings are available in ADAMS under the following numbers: ML092580469; ML092580481; ML092890516; and ML092890511. In general, the workshop participants did not dispute the overall need for the rulemaking effort. However, they did have differing views about the appropriate scope of the rulemaking. Suggestions ranged from specific changes to the current rule to limited rulemaking amendments combined with new guidance. Generally, the workshop participants stated that both the period of performance and a requirement for a site-specific analysis should be included in the rule. There were differing opinions about the appropriate performance period for a site-specific analysis. Most participants recommended that the performance assessment calculate the estimated dose to at least 10,000 years and some participants believed that the calculation should be extended until the time of estimated peak dose. The participants also stated that a definition of unique waste streams or significant quantities of DU should not be specified as part of the rulemaking. The staff committed to considering the comments received as part of the workshops during its deliberations related to the development of the technical basis for the rulemaking.

More recently, the staff briefed the Commissioner Assistants and a subcommittee and the full committee of the ACRS (Abdel-Khalik, 2010). Information related to the proposed rulemaking has also been presented to the *LLWForum* and at technical conferences.

Strategic Plan

The proposed rule supports NRC's *2008-2013 Strategic Plan* in the areas of safety and organizational excellence. In the area of safety, the proposed rule supports this NRC Safety Goal (Strategy 5 — "Use of sound science and state-of-the-art methods to establish, where appropriate, risk-informed and performance-based regulations") by explicitly introducing into the Part 61 regulatory framework domestic and international experience from the use of quantitative performance assessment techniques to evaluate the safety of waste disposal systems.

In the area of organizational excellence, the proposed rule supports the objective regarding the use of state-of-the-art technologies and risk insights to improve the effectiveness and the realisms of NRC actions, with the goals of continuous improvement (Strategy 1).

Guidance Documents

Staff plans to develop a new guidance document to support the review of site-specific analysis for the disposal of unique waste streams. A variety of technical topics can have an important impact on the analysis of the disposal of unique waste streams and some of these technical topics are not well covered in the existing LLW disposal guidance. If necessary, the guidance document could be separated into multiple documents focused on specific topics. The topics that will likely be covered include guidance on conducting risk-informed, performance-based period of performance analyses; technical analysis considerations such as the incorporation of features, events, and processes into performance assessments; as well as other considerations such as setting inventory limits and mitigation techniques.

Resources

The staff estimates that the resources required for the rulemaking are 9.3 Full Time Equivalent (FTE) and $1.5 million in contract funding. In fiscal year (FY) 2010 staff estimated, and budgeted for, 2.5 FTE of effort by DWMEP. In FY 2011 staff estimated and was allocated to the Office of Federal and State Materials and Environmental Programs (FSME), Division of Waste Management and Environmental Protection (DWMEP), Division of Intergovernmental Liaison and Rulemaking (DILR), Office of Information Services (OIS), Office of the General Counsel (OGC), and Office of Administration (ADM), the following FTE:

Office	FTE Allocation
FSME/DWMEP	2.5
FSME/DILR	0.7
OIS	0.1
OGC	0.2
ADM	0.1

These resource estimates also take into consideration the necessary NEPA analyses, described above.

Timing

The proposed rule and draft guidance document should be released for public comment sometime in early calendar year 2012. The final rule and guidance would be issued in the following calendar year.

Currently there have been proposals to dispose of DOE generated unique waste streams. Most other unique wastes are not anticipated to need disposal prior to the estimated completion date of the rule. The staff proposed to include consideration of blended wastes in the “Site-Specific Analysis for Demonstrating Compliance with Subpart C Performance Objectives” rulemaking and the Commission subsequently directed the staff to include blended wastes in this rulemaking effort. There are no other known potential conflicts between different policy issues or legal issues that need to be resolved prior to the initiation of rulemaking.

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Attachment 1

This attachment contains calculations to demonstrate how unique waste streams, if disposed of as Class A LLW, can result in radiological impacts larger than those used to develop the waste classification tables for demonstration of compliance with the § 61.42 performance objective. The example provided is for shallow land disposal of concentrated depleted uranium (DU).

The following assumptions applied to the calculation:

1) The waste is classified using the procedure found in § 61.55.

2) The waste does not contain any of the radionuclides listed in Table 1 or Table 2 of Part 61; therefore, by regulation, it is considered Class A LLW.

3) Depleted uranium waste meets all the waste characteristic requirements found in § 61.56(a).

4) Inhalation of dust and radon are the only pathways considered because they are sufficient to demonstrate the potential risks from disposal after the institutional control period ends.

5) The material to be disposed of is concentrated DU oxides in the U_3O_8 form.

6) The amount of material to be disposed of is relatively large, such that the area of land occupied by the intruder is smaller than the area necessary for the disposal of the DU waste.

7) The average packing fraction (volume of waste per total disposal facility volume) is 0.7.

8) The waste is disposed of in shallow trenches and covered with one meter of soil.

9) A foundation for a dwelling is excavated to a depth of 3 m, resulting in 2 m of waste being exhumed per m^2.

10) The waste is disposed of under 1 m of cover.

<u>Intruder-Construction Scenario — Soil Inhalation Pathway</u>
An inadvertent intruder occupies the site at the end of the 100-year institutional control period and constructs a dwelling with a foundation extending to a depth of three meters below the ground surface, into the disposal cell. The soil exhumed from the disposal cell is spread uniformly around the excavation.

Input	**Value**
U_3O_8 concentration (wt. %)	100
Packing Fraction (m^3/m^3)	0.7
Exposure time (hours/year)	500
Breathing Rate (m^3/year)	8000
Mass loading (g soil / m^3 air)	1E-3
$DCF_{inhalation}$ – Class Y (mrem/pCi)	1.2E-1
U^{238} specific activity (Ci/g)	3.4E-7

The exposure time is the same value assumed in the analysis supporting the Part 61 EIS (NRC, 1982). The breathing rate is also the same value used in the draft EIS, which includes the technical basis for Part 61 (NRC 1981, p. G-83). The update of the Part 61 impacts analysis methodology provided mass loading values that ranged from 0.26 to 7.4 mg/m^3 for humid to arid sites (Oztunali and Roles, 1986). The value used here is representative of a semi-arid site, but is not a bounding value on a national scale. The dose conversion factor (DCF) for inhalation of uranium is from Federal Guidance Report No. 11 (EPA, 1988). The solubility class is based on the ICRP 30 recommendation for UO_2 and U_3O_8 (ICRP, 1979).

Concentration of uranium in soil –

$$U_{conc} = 100\ wt.\% \cdot \left(\frac{84.8\ g\ U}{100\ g\ U_3O_8} \right) \cdot 0.7 \cdot \left(\frac{2\ m\ waste}{3\ m\ total} \right) = 0.396 \frac{g\ U}{g\ total}$$

Amount of uranium inhaled during construction –

$$Mass_{inh} = \left(\frac{0.396\ g\ U}{g_{total}} \right) \cdot \left(\frac{1E-3\ g_{total}}{m^3 air} \right) \cdot \left(\frac{8000\ m^3\ air}{yr} \right) \cdot \left(\frac{1 yr}{8760\ hr} \right) \cdot 500\ hr = 0.18\ g\ U$$

Dose from uranium inhalation –

$$D_{inhalation} = 0.18\ g\ U \cdot \left(3.4E-7 \frac{Ci}{g\ U} \right) \cdot \left(\frac{1E12\, pCi}{Ci} \right) \cdot \left(1.2E-1 \frac{mrem}{pCi} \right) = 7750\ mrem$$

Intruder-Construction Scenario — Radon Pathway

The calculation of the dose from radon gas to an intruder during construction of a dwelling is estimated using the approach documented in Regulatory Guide 3.64 to estimate the radon flux and the approach documented in the RESRAD user's manual to convert the flux to an outdoor concentration (NRC, 1989; ANL, 2001). The assumptions pertinent to each approach are provided in the original documentation and are not duplicated here. Additional assumptions include:

1) The average radon flux through one meter of cover can be used to approximate the radon dose to the intruder (construction). In this scenario an excavation is created, which, based on the assumed disposal of waste, would result in exposure to uncovered tailings for some period of time before a foundation is established. Because this calculation is designed to demonstrate that the dose impacts are sufficiently large to necessitate a change to the regulations, the exact value at which the radon dose may exceed the implicit regulatory annual limit of 500 mrem/yr (5 mSv/yr) by is not important.

2) The average annual wind speed is 2 m/s. Annual average wind speed varies by location, time of day, and by season. A distribution of annual average wind speeds was complied for RESRAD-Offsite and the 50th percentile value was 4.2 m/s with a range of 1.4 m/s to 13 m/s (ANL, 2007). The average value for a 500 hr exposure period would have a considerably larger range than the annual averages. Use of 2 m/s is reasonably conservative for this calculation. Because this calculation is designed to demonstrate that the dose impacts are sufficiently large to necessitate a change to the

regulations, the exact value by which the radon dose may exceed the implicit regulatory annual limit of 500 mrem by is not important.

3) The amount of material disposed of is large, such that a correction for an outdoor area factor is not necessary.

4) The amount of material disposed of occupies an area larger than 160,000 m^2 such that the characteristic length (used below) is approximately 400 m.

5) Parameter values given in the table below represent average values representative of the area encompassed by the disposal facility.

Parameter	**Description**	**Value**
Φ_{soil}	Soil porosity	0.3
S_{soil}	Soil liquid saturation	0.4
Φ_{source}	Source porosity	0.4
S_{source}	Source liquid saturation	0.6
H_{rn}	Henry's law constant for radon	3.85
ρ_w	Waste density (g/m^3)	1.5
Z	Waste thickness (m)	5
Z_w	Waste depth (m)	1
DCF_{RN}	Dose conversion factor for RN-222 (mrem/pCi)	5.11E-5
$T_{1/2RN}$	Half life of RN-222 (days)	3.82
E	Radon emanation coefficient	0.35
H_o	Height of uniform mixing of plume (m)	2
U_s	Annual average wind speed (m/s)	2
X	Effective length of waste disposal area (m)	400
i_r	Inhalation rate (m^3/yr)	8000
ex	Exposure time (hr)	500
Ra_conc	Concentration of radium (Ci/g) at time (yr): 0 1,000 10,000 100,000 1,000,000	 0 2.53E-10 8.68E-9 9.17E-8 3.17E-7

The calculation used the approach described in Regulatory Guide 3.64 to estimate the radon flux and the approach presented in the RESRAD user's manual to estimate the approximate outdoor radon concentration.

The tortuosity was represented as:

$$RG\_Tortuosity = 0.67 \cdot \exp^{-4\left(S_{soil} - S_{soil} \cdot \phi_{soil}^{2} + S_{soil}^{5}\right)} = 0.1499$$

The radon diffusivity was represented as:

$$radon\_diff = RG\_Tortuosity \cdot 1.0E-5\,\frac{m^2}{s} = 1.5E-6\,\frac{m^2}{s}$$

The following three terms are used in the equations from Regulatory Guide 3.64 to calculate radon fluxes:

$$a_c = \phi_{soil}{}^2 \cdot radon\_diff \cdot \left(1-\left(1-\frac{1}{H_{rn}}\right)\cdot S_{soil}\right)^2 = 1.46E-5\,\frac{cm^2}{s}$$

$$b_c = \left(\frac{2.1E-6\,s^{-1}}{radon\_diff}\right)^{0.5} = 0.0118\,cm^{-1}$$

$$a_t = \phi_{source}{}^2 \cdot radon\_diff \cdot \left(1-\left(1-\frac{1}{H_{rn}}\right)\cdot S_{source}\right)^2 = 5.83E-5\,\frac{cm^2}{s}$$

The flux of radon from the source is calculated with:

$$RG364\_source = Ra\_conc \cdot \rho_w \cdot E \cdot \left(2.1E-6\,s^{-1} \cdot radon\_diff\right)^{0.5} \cdot \tanh(Z \cdot b_c) = 8086\,\frac{pCi}{m^2\,s}$$

The radium concentration used to calculate the source flux was the value for 10,000 years provided in the table above. The corresponding radon flux through the soil is calculated as:

$$RG364\_soil = 2 \cdot RG364\_source \cdot e^{\left(\frac{-b_c \cdot Z_w}{1+\left(\frac{a_t}{a_c}\right)^{0.5}}\right)} = 1651\,\frac{pCi}{m^2\,s}$$

The flux through the soil is converted into an average annual outdoor concentration (C_o) using the approach documented on page 156 of the RESRAD manual (ANL, 1997). C_o is given by:

$$C_o = \frac{J_o\,F_{ao}}{\lambda\,H_o}\left(1-e^{-\left(\frac{\lambda\,X}{2\,U}\right)}\right) = 98256\,\frac{pCi}{m^3}$$

Where,

J_o = the radon flux from the soil (RG364_soil) in pCi/m^2 s,
F_{ao} = outdoor area factor = 1 for A > 100 m^2,

and the other parameters are identified in the table above. The radon dose is calculated as:

$$Radon\_dose = C_o \cdot i_r \cdot ex \cdot DCF_{RN} = 1923\,mrem$$

The dose calculation was implemented using the Goldsim computer code (GoldSim Technology Group, 2004). Goldsim is a proprietary software package. In order to facilitate independent review, the file was saved as a player file. A player file can be viewed and executed without purchasing a license for the GoldSim software. The player file (RG364.gsm) has been provided with this package. The GoldSim player can be downloaded from http://www.goldsim.com/Form_DownloadPlayer.asp. The file can be used to estimate the resultant radon dose over a range of conditions, conditions that may differ from those selected for this calculation.

Because the intruder construction scenarios resulted in doses well in excess of 500 mrem/yr (5 mSv/yr) it is not necessary to perform the intruder-agriculture calculations, which typically result in much higher doses due to more pathways being involved and much longer exposure times.

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