April 15, 1998 SECY-98-084

FOR: The Commissioners

FROM: L. Joseph Callan /s/
Executive Director for Operations

SUBJECT: STATUS OF EFFORTS TO FINALIZE REGULATIONS FOR RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION: URANIUM RECOVERY FACILITIES

PURPOSE:

This paper provides information to the Commission and requests approval by negative consent of the staff's proposed alternative for proceeding with final rulemaking to amend criterion 6 of 10 CFR Part 40, Appendix A in order to provide radiological criteria for termination of uranium recovery licenses.

SUMMARY:

In a Staff Requirements Memorandum (SRM) on SECY-97-046A, dated May 21, 1997, the Commission instructed staff to develop a rule that addresses radiological criteria (decommissioning land and buildings) for license termination for uranium recovery facilities, i.e., uranium mills and in-situ leach facilities (ISLs), on an expedited basis. The staff has requested additional public comment on this issue, and is preparing a final rule for Commission approval. If the Commission approves the staff's recommended approach, the final rulemaking package will be forwarded to the Commission within 5 months after receiving approval. If the Commission selects an alternative approach, an additional opportunity for public comment may be necessary. A discussion of the alternatives considered is in Attachment 1. Attachment 2 is a differing viewpoint (as allowed under Office of Nuclear Material Safety and Safeguards Policy and Procedures Letter 1-8, Revision 4, December 1996) on the approach delineated in this Commission Paper, submitted by a staff member on April 8, 1998. A differing viewpoint is an allowed alternative to a Differing Professional View (DPV) or a Differing Professional Opinion (DPO). This alternative allows employees to document their differing professional views and attach these views to proposed staff positions or other documents, to be forwarded as the document moves through the management chain. Attachment 3 contains the dose modeling assumptions and results that support the staff's recommended approach.

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BACKGROUND:

As the Commission considers the options for uranium recovery facilities decommissioning criteria, it is important to recognize that the proposed rule, or any other standard that could be adopted by the U.S. Nuclear Regulatory Commission (NRC), would not cover all aspects of site decommissioning at ISL sites. At these sites, there are two distinct waste streams that are involved in the uranium extraction process. One stream is the bleed resulting from the processing of lixiviant to obtain uranium. This bleed and any resultant residual material is by definition 11e.(2) byproduct material, and is subject to NRC regulation. The second waste stream is generated as a result of ground water restoration activities and is regulated by the states. Although in the early stages of cleanup licensees will extract some uranium, the process is mainly initiated to cleanup ground water and not concentrate uranium. Therefore, the waste is not defined as 11e.(2) byproduct material. This material is the same physically, chemically, and radiologically as the 11e.(2) byproduct material, but is subject to state mining regulations. As such, ISLs will be cleaned up to the radium benchmark standard if the contamination is the result of the processing of ore, and to a state mine waste requirement if the contamination results from ground water cleanup. Similarly, some of the mill sites in Wyoming are adjacent to areas remediated by the Wyoming Abandoned Mine Lands Program that uses a 20 pCi/g (0.74 Bq/g) radium standard for surface soil, while NRC licensees remediate surface soil to 5 pCi/g (0.19 Bq/g).

Therefore, the application of any option outlined in Attachment 1 will not result in the entire site being reclaimed to that standard. The uranium recovery industry is in the process of completing a white paper that discusses a number of topics including this difference in legal definition of the same types of waste and the resultant dual regulation by NRC and states. The industry has indicated that it plans to submit that paper to the Commission by mid-April.

The existing 5/15 radium standard[1] for soil cleanup at uranium mills, which has also been applied at ISL facilities, contained in 10 CFR Part 40, Appendix A, was promulgated to conform to the generally applicable U.S. Environmental Protection Agency (EPA) standards as required by the Uranium Mill Tailings Radiation Control Act of 1978. However, in some mill and ISL site areas proximate to locations where radium contamination exists (e.g., under the mill building; under raffinate ponds; in a yellowcake storage area; under or around an ore pad; at ISLs in soils where spray irrigation has occurred as a means of disposal, or where spills or leaks have occurred), uranium or thorium would be the radionuclide of concern. Because Part 40 codifies cleanup criteria for ground water but not for buildings or for soil contamination from radionuclides other than radium, staff has relied on NRC guidance documents for surface activity and soil uranium and thorium cleanup criteria.

On August 22, 1994 (59 FR 43200), the NRC published a proposed rule for comment in the Federal Register, to amend 10 CFR Part 20, “Standards for Protection Against Radiation,” to include radiological criteria for decommissioning. The proposed rule applied to uranium mill facilities, but did not apply to mill tailings disposal or to soil cleanup at mill sites, as they are regulated under 10 CFR Part 40, Appendix A. The comment period closed on January 20,

[1]Appendix A to 10 CFR Part 40, criterion 6(6), states that for land at uranium or thorium mill sites, the concentration of radium-226 (uranium sites) or radium-228 (thorium sites), averaged over areas of 100 square meters, shall not "exceed the background level by more than: (I) 5 pCi/g ... averaged over the first 15 cm below the surface; and (ii) 15 pCi/g ... averaged over 15-cm-thick layers more than 15 cm below the surface." This is known as the 5/15 radium standard.

1995. Over 100 organizations and individuals submitted comments on the proposed rule. Comments on the proposed rule generally agreed with the exclusion for disposal of mill tailings and soil cleanup. Some commenters also recommended that the rule exempt conventional thorium and uranium mill facilities and ISLs.

In SECY-97-046A, entitled "Final Rule on Radiological Criteria for License Termination," the staff recommended that the final rule not apply to the uranium and thorium mill facilities, as well as ISLs. These sites would be subject to the 5/15 radium standard, and doses from other radionuclides would be limited to no greater than the potential dose resulting from the 5/15 radium standard (benchmark approach).

The SRM on SECY-97-046A instructed the staff to exclude, from the final rule, facilities that are currently subject to Appendix A of 10 CFR Part 40 (i.e., uranium mills and ISLs). The Commission expressed concern that the complexity of the issues surrounding uranium recovery sites had been overshadowed by other provisions of the rule. Therefore, the Commission decided that NRC and affected parties should give additional consideration to the resolution of the issues.

DISCUSSION:

On July 21, 1997 (62 FR 39093), the staff published in the Federal Register a request for additional comments, entitled "Radiological Criteria for License Termination: Uranium Recovery Facilities." The staff summarized the history of this rulemaking, and indicated that the main contaminant at uranium mills, in the large areas (20-405 hectares (50-1000 acres)) where windblown contamination from the tailings pile has occurred, and at ISL holding ponds, is radium. The 5/15 radium standard would generally result in doses greater than the 25 mrem/yr (0.25 mSv/yr) all-radionuclides, all-pathways standard in the final "Radiological Criteria for License Termination" rule. The notice requested comments on the standard to be used for cleanup of residual radioactivity at uranium recovery facilities. The preferred approach would use the 5/15 radium standard as a source term to establish a dose benchmark for the cleanup of radionuclides other than radium.

The comment period for the July 1997 Federal Register notice ended on October 6, 1997. Six comments were received from the uranium recovery industry, one from the State of Illinois, and one from EPA. EPA submitted additional comments on November 28, 1997, and the State of Illinois submitted additional comments on December 15, 1997. On February 10, 1998, comments were received from a representative of the public interest group, "For A Clean Tonawanda Site." The staff will address these comments during finalization of the rule, in the response to public comment section.

Industry commenters expressed general agreement with the benchmark approach to establishing decommissioning standards for uranium recovery facilities. They cited the complexity of performing dose calculations at these facilities because of background variations in radium and uranium that span three orders of magnitude. They emphasized the need to make sure that the standard limit only the dose that is distinguishable from background, as they believe that dose criteria on the order of 25 mrem/yr (0.25 mSv/yr) would not be distinguishable from the widely varying background levels of uranium and radium at many of the mill sites.

The State of Illinois disagreed with the proposed benchmark approach as it would, in essence, codify a different dose limit for each facility. The State indicated that it would be preferable to establish a consistent dose-based standard at a substantial fraction of 100 mrem/yr (1 mSv/yr). In supplemental comments submitted in December, the State described some of the complexities of dose modeling and emphasized the need for guidance to clearly articulate the importance of justifying parameter value selections.

The EPA comments indicated that the surface radium standard was consistent with a 15-mrem/yr (0.15 mSv/yr)-dose limit and that no dose limit in excess of 15 mrem/yr (0.15 mSv/yr) would be acceptable. This disagreement on the radium standard potential dose was discussed in a December 12, 1997, letter from Chairman Jackson to the EPA Administrator. Also, in formulating the final (25 mrem/yr) rule, "Radiological Criteria for License Termination," NRC held discussions with EPA and EPA subsequently stated that 25 mrem/yr is not protective of public health. Therefore, based on EPA's dose limit position and its assertion that the 5/15 radium standard is acceptable, no further discussion was attempted with EPA, and the staff has chosen to consider the EPA comments as public comments. Since the staff is proposing an approach that is consistent with the EPA 5/15 radium standard, the staff does not believe it is necessary to invoke the 1992 NRC/EPA Memorandum of Understanding on resolution of issues. However, EPA may oppose the Commission's final rule for uranium recovery facilities if it reconsiders the potential dose resulting from the radium standard.

The public interest group comments included opposition to a rule allowing greater than 100 mrem/yr (1 mSv/yr), excluding radon, or allowing less than a 10,000-year dose time frame. Other comments requested clarification of the dose resulting from the radium standard and the total maximum dose allowed by the final rule. It was also noted that, if the rule includes windblown areas, this would be an enlargement of scope and would require notice and review.

The staff is now drafting a final rule for Commission approval. This rule would not apply to sites that have a decommissioning plan approved by NRC. This is different than the grandfathering clause (decommissioning plan in accordance with criteria identified in the Site Decommissioning Management Plan (SDMP) Action Plan of April 16, 1992) contained in the July 1997 Federal Register notice, in which NRC published the final rule on "Radiological Criteria for License Termination" amending 10 CFR Part 20. The reason for this difference is that the uranium recovery facilities were never part of the SDMP, so it is inappropriate to apply criteria from guidance identified in the SDMP Action Plan as the basis for grandfathering a uranium recovery site.

The NRC-licensed sites that could be impacted by this rule include four mill facilities that do not have approved decommissioning plans (five mill sites are currently undergoing soil cleanup, and final survey reports have been submitted for two others; these sites would be grandfathered by the rule). Also, there are six licensed ISLs, and two applications for ISL facilities are expected to be submitted in 1998. None of the ISLs has approved decommissioning plans. Sites in the four Agreement States for source and 11e.(2) byproduct material should not be impacted by this rule because either the sites have approved decommissioning plans, or equivalent, or more stringent state regulations for radiological criteria for license termination are in place.

Staff Recommended Alternative:

After considering several alternatives, the staff is recommending the implementation of

alternative 3 in attachment 1, which is the use of the 5/15 radium standard as a dose benchmark for the cleanup of all residual radionuclides at uranium recovery sites. This would mean that surface cleanup (buildings or the top 15 cm (6 inches) of soil) of radionuclides other than radium would have as a dose criterion, the estimated dose resulting from 5 pCi/g (0.19 Bq/g) radium at that site. Subsurface soil cleanup would use the estimated dose resulting from the 15 pCi/g (0.56 Bq/g) radium standard at that site. The reasons that this approach is preferred are: (1) it is unreasonable to require licensees to clean up uranium at the relatively small mill or ISL facility to the 25 mrem/yr (0.25 mSv/yr) standard contained in the final rule, while surrounding huge tracts of land are subject to the 5/15 radium standard that could result in greater doses; (2) this approach is consistent with the EPA standard; (3) the benchmark approach would ensure that the dose limit across the uranium recovery site would be equal for all residual radionuclides (other than radon); and (4) it is the approach that was presented to the Commission for approval in the draft final rulemaking contained in SECY-97-046A and that was published in the request for additional comments (62 FR 39093). The same concept of regulation would be applicable to thorium mills, if any are licensed in the future.

The benchmark approach will require uranium recovery licensees to calculate the potential dose to the average member of the critical group that would result from the 5/15 radium standard within 1000 years, based upon site-specific parameters and/or models. Licensees would be required to provide justification for the models and parameters selected in the dose calculations. Licensees would remediate the site such that the radioactive materials remaining on the site, that are distinguishable from background, would not result in a dose that is greater than that which would result from radium in soil at the 5/15 standard (the surface standard would be applicable for most of the site contamination). In addition, uranium recovery licensees would be required to demonstrate that doses were “as low as is reasonably achievable” (ALARA). Guidance on dose modeling for the benchmark approach will be developed in conjunction with the standard review plans under development for uranium mill reclamation and ISLs.

Using realistic parameters for typical sites that would be affected by the rule, and the RESRAD code, the staff has recently calculated (Table 3 in Attachment 3) that the potential dose from the 5 pCi/g (0.19 Bq/g) surface radium standard is between 35 and 45 mrem/yr (0.35 and 0.45 mSv/yr), exclusive of the radon contribution. The staff determined that this site-specific dose range was reasonable by comparing it to an estimated national average dose from radium (and its long-lived progeny) based on empirical data (gamma measurements and the radionuclide content of organs). The average background level of radium in soil is approximately 1 pCi/g (0.04 Bq/g) at an infinite depth, so five times the dose from this source was used to estimate the potential 5 pCi/g (0.19 Bq/g) radium dose. The result from this method was approximately 90 mrem/yr (0.9 mSv/yr).

Modeling an application of both the surface and subsurface radium standards with the farm (conservative) scenario resulted in a potential dose of 85 mrem/yr (0.85 mSv/yr) (dose modeling assumptions presented in Attachment 3). However, the actual impact of the subsurface benchmark dose would be low, as the model input would be based on the area likely to require application of the subsurface radium standard in the portion of the site to be released for unrestricted use. For mill sites, the deeper excavations have been in the area to be deeded to the perpetual custodian (restricted release). At ISLs, the areas requiring subsurface cleanup would be very limited.

The rule also requires application of the ALARA principle. This application has resulted in,

based on soil cleanup data from the last three mill sites to complete remediation, an average residual radium level in the unrestricted release area of less than 2 pCi/g (0.07 Bq/g). When the staff modeled 600 acres (240 ha) at 2 pCi/g (0.07 Bq/g) radium for the ranch scenario, the resulting dose was 14 mrem/yr (0.14 mSv/yr). Using the farm scenario, the dose was 18 mrem/yr (0.18 mSv/yr). Although it is possible that some site-specific values would result in a higher dose than that estimated by the staff for the various scenarios, the staff has high confidence that a site-specific dose using the benchmark approach will generally be a small fraction of 100 mrem/yr (1 mSv/yr), and in all cases will not exceed 100 mrem/yr (1 mSv/yr). In the unlikely event that a site benchmark dose (before the application of ALARA) exceeds 100 mrem/yr (1 mSv/yr), staff will consult with the Commission before approving such a benchmark dose.

The staff proposes to finalize the rule by amending Criterion 6 (6) of Appendix A to 10 CFR Part 40, rather than Part 20 Subpart E. This was an administrative decision based on the ease of use by having all the soil cleanup criteria for uranium recovery facilities in the same location, and based on the limited audience, placement of the rule in Part 20 is not appropriate.

RESOURCES:

Resources to complete and implement this rulemaking are included in the current budget.

COORDINATION:

This paper has been coordinated with the Office of the General Counsel. The Office of the Chief Financial Officer has reviewed this Commission Paper for resource implications and has no objection.

RECOMMENDATION:

Unless directed otherwise by the Commission, the staff will move forward to develop the final rulemaking using the staff recommended alternative (alternative 3 in attachment 1) 10 days from the date of this paper. In addition, this rulemaking will amend Criterion 6 (6) of Appendix A to
10 CFR Part 40, rather than Part 20 Subpart E. The rulemaking will be completed and forwarded for Commission approval approximately 5 months after that date.

L. Joseph Callan
Executive Director
for Operations

Attachments: 1. Discussion of Alternatives
2. Differing Viewpoint
3. Dose Modeling

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TICKET NO: 9700524 (WITS 9700210) **See previous concurrence***

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OFFC	DWM*	E	NMSS*		URB*	E	IMNS*		DWM*	E
NAME	EBrummett		E Kraus		JHolonich		DACool		JGreeves	
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OFFC	OGC(via phone)*		CFO(via email)*		NMSS*		DEDR*		EDO* !
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DATE	03/11 /98		01/21 /98		03/17 /98		4//08/98		4/09/98

DISCUSSION OF ALTERNATIVES

The staff has considered several alternatives for resolution of the issue of radiological decommissioning criteria (for soil and buildings) for radionuclides other than radium, for uranium recovery facilities (mills and in-situ leach (ISLs)). The as low as is reasonably achievable (ALARA) process would apply to all alternatives considered. Each alternative is presented below in the format of a description of the alternative, the rationale for the application of this alternative, the advantages, and difficulties associated with the alternative. It should be noted that none of the decommissioning dose limits or estimates discussed considers background radiation levels or the contribution from radon. This is consistent with the approach taken in the main decommissioning rule. However, under the existing soil radium standard, the radon dose could be several hundred mrem/yr (several mSv/yr). The alternatives are:

1. STATUS QUO

APPROACH -- Continue with the case-by-case approach, using existing guidance. Radium is limited to the 5/15 standard[2]. Total (natural) uranium is limited in guidance to 30 pCi/g (1.11 Bq/g), exclusive of the contribution from decay products. Thorium (both thorium-232 and thorium-230) has been considered to be limited to the 5/15 standard. Higher concentrations of uranium or thorium have been justified on a case-by-case basis, using an ALARA analysis. Areas with elevated radium levels are not expected to overlap areas with elevated uranium or thorium, but at one site two soil samples contained both residual uranium and radium, and the unity rule[3] was applied.

RATIONALE -- The approach is now successfully implemented.

ADVANTAGES --

- Rulemaking is not required.
- Licensees have no problem complying with this approach.
- The approach is similar to Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I site guidelines for other radionuclides.

DIFFICULTIES --

- Due to the uncertainty of some site-specific parameters, such as area of application of the subsurface radium standard, there is the potential for a benchmark dose approaching the public dose limit (before application of ALARA).
- Does not achieve the goal of the rule to codify a standard for termination of uranium recovery licenses.

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[2]Appendix A to 10 CFR Part 40, criterion 6(6), states that for land at uranium or thorium mill sites, the concentration of radium-226 (uranium sites) or radium-228 (thorium sites), averaged over areas of 100 square meters, shall not "exceed the background level by more than: (i) 5 pCi/g ... averaged over the first 15 cm below the surface; and (ii) 15 pCi/g ... averaged over 15-cm thick layers more than 15 cm below the surface." This is known as the 5/15 radium standard.

[3]The unity rule is contained in 10 CFR Part 20, Appendix B, footnote 4 to the combined Tables 1, 2, and 3. It states that if the identity and concentration of each radionuclide in a mixture are known, the limiting values should be derived as follows: determine, for each radionuclide in the mixture, the ratio between the concentration present in the mixture and the concentration otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").

- Existing guidance is in need of updating.
- The dose/risk will not be consistent across an individual uranium recovery site or between uranium recovery sites and other types of sites.

2a. MAY 21, 1997, RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION

APPROACH -- Apply the same criteria as approved for other facilities by the Commission on May 1, 1997, (Subpart E to 10 CFR Part 20). That is, the concentration of residual radioactive material that is distinguishable from background shall result in a dose to the average member of the critical group of no more than 25 mrem/yr (0.25 mSv/yr), from all pathways and all radionuclides. Where achieving this dose level would cause net public or environmental harm, or where higher levels were justified in terms of benefits versus cost (ALARA), then license termination under restricted conditions and alternative criteria (10 CFR 20.1403 and 20.1404) provide flexibility. Restricted conditions would result in doses no greater than 25 mrem/yr (0.25 mSv/yr) with legally enforceable, durable institutional controls in place, and would not exceed 100 mrem/yr (1 mSv/yr) should such restrictions fail, or not more than 500 mrem/yr (5 mSv/yr) under certain conditions. Under specified conditions, licensees can request alternate criteria of not more than 100 mrem/yr (1 mSv/yr) with site use restrictions in place.

RATIONALE -- This applies the fraction of the public dose limit that the Commission decided was appropriate for termination of licenses as a dose limit for uranium recovery facilities. Uranium recovery facilities would be treated the same as any other licensee in the consistent application of the radiological criteria for license termination rule.

ADVANTAGES --

- Dose to members of the public from residual radionuclides would generally not exceed 25 mrem/yr (0.25 mSv/yr).
- This is a dose-based consistent with other Nuclear Regulatory Commission (NRC)-licensed decommissioning sites.
- If a dose of 25 mrem/yr (0.25 mSv/yr) is too restrictive to be reasonable, restricted conditions or alternate criteria would be available to licensees.

DIFFICULTIES --

- This approach would require notice and comment on the proposal, and probably involve extensive discussions with the U.S. Environmental Protection Agency (EPA), adding up to 1 year to the schedule.
- More restrictive than the existing 5/15 radium standard, which could result in doses greater than 25 mrem/yr (0.25 mSv/yr).
- This approach would be inconsistent with EPA generally applicable rule.
- Licensees have expressed concern that compliance with the 25 mrem/yr (0.25 mSv/yr) standard would be unreasonably expensive, given large variations in background and the verification costs for doses near background.
- Previously remediated sites (including U.S. Department of Energy (DOE) Title I sites under UMTRCA) were generally cleaned up to a less stringent standard.

2b. MAY 21, 1997, RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION APPROACH FOR RADIONUCLIDES OTHER THAN RADIUM AND THE 5/15 RADIUM STANDARD FOR RADIUM-CONTAMINATED AREAS

APPROACH -- Apply the 25 mrem/yr (0.25 mSv/yr) dose standard to all radionuclides except radium, and the 5/15 radium standard for radium-contaminated areas. If an area is contaminated with thorium or uranium, in addition to radium, the dose could not exceed the 5/15 radium standard benchmark dose (consistent with the Part 20, Appendix B, unity rule).

RATIONALE -- This applies the fraction of the public dose limit that the Commission decided was appropriate for termination of all licenses, as a dose limit for uranium recovery license termination, for radionuclides other than radium.

ADVANTAGES --

- Dose to members of the public from radionuclides other than radium would not exceed 25 mrem/yr (0.25 mSv/yr).
- This is a dose-based approach (for radionuclides other than radium) consistent with other types of NRC-licensed sites.

DIFFICULTIES --

- This approach would require notice and comment on the proposal, adding at least 6 months to the rulemaking schedule.
- Due to the uncertainty of some site-specific parameters, there is the potential for a benchmark dose approaching the public dose limit (before application of ALARA).
- Licensees have expressed concern that compliance with 25 mrem/yr (0.25 mSv/yr) would be unreasonably expensive, given large variations in background and the verification costs for doses near background.
- For radionuclides other than radium, generally more restrictive than the existing 5/15 radium standard.
- Not a consistent site-wide risk-based approach, as the 5/15 radium standard could result in potential doses higher than the 25 mrem/yr (0.25 mSv/yr) all-radionuclide, all-pathway standard to which only the thorium and uranium contaminated areas would be subject.
- Previously remediated sites (including DOE Title I sites under UMTRCA) were generally cleaned up to a less stringent standard.

3. BENCHMARK APPROACH (STAFF'S RECOMMENDATION)

APPROACH -- Apply a dose standard that uses the radium standard as a benchmark. In this approach, the licensee uses site-specific models and/or parameters to calculate the dose that would result from unrestricted release of the site contaminated to the radium standard. This would mean that surface cleanup (buildings or the top 15 cm (6 inches) of soil) of radionuclides other than radium would have, as a dose criterion, the estimated dose resulting from 5 pCi/g (0.19 Bq/g) radium at that site. Subsurface soil cleanup would use the estimated dose resulting from application of the 15 pCi/g (0.56 Bq/g) radium standard at that site (usually a very small area of the unrestricted use area), as a dose criterion.

Potential doses to members of the public are expected to be a small fraction of 100 mrem/yr (1 mSv/yr) from this approach, based on dose modeling by the staff. Also, the three mill sites that recently completing soil cleanup each averaged less than 2 pCi/g (0.07 Bq/g) radium which at these sites results in a potential dose of less than 20 mrem/yr (0.20 mSv/yr).

RATIONALE -- Under UMTRCA, EPA has the authority to establish generally applicable radiation standards, and it has established the radium standard for uranium recovery facilities. As such, NRC should not impose a more restrictive standard. The benchmark approach limits the dose from all radionuclides other than radium, to that dose that could be expected at the site from the 5/15 radium standard.

ADVANTAGES --

- The relatively small mill area will be subject to a dose limit that is the same as the dose from the radium standard to which the large tracts of land (windblown tailings areas) are subject. At ISLs, the uranium-contaminated areas (yellowcake or pregnant lixiviant spills) would be subject to the same dose limit as the radium-contaminated areas.
- Measurements and remediation at this level would be less costly than for an all-radionuclide, all-pathway limit of 25 mrem/yr (0.25 mSv/yr), unrestricted release option.
- Dose limits across the site would be equivalent.
- This approach is consistent with the EPA cleanup standards for uranium mill sites.
- This approach is supported by industry.

DIFFICULTIES --

- Due to the uncertainty of some site-specific parameters, there is the potential for a benchmark dose approaching the public dose limit (before application of ALARA). If a site benchmark dose exceeds 100 mrem/yr (1 mSv/yr), staff will consult with the Commission before approving the benchmark dose.
- Each site released will have a unique, but similar dose limit. The only State commenting on this approach disagreed with the approach.
- EPA would oppose any dose limit not consistent with a 15-mrem/yr (0.15-mSv/yr) limit, however, EPA considers that the 5 pCi/g (0.19 Bq/g) surface radium standard meets the 15-mrem/yr (0.15-mSv/yr) limit.
- Not a consistent risk-based approach across all types of licensees as uranium recovery facilities would be subject to a dose limit equivalent to the dose from the 5/15 radium standard, whereas other sites are subject to the 25-mrem/yr (0.25-mSv/yr) all-radionuclide, all-pathway limit.

DIFFERING VIEWPOINT ON THE APPROACH FOR RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION OF URANIUM RECOVERY FACILITIES

Duane W. Schmidt, CHP
Health Physicist, NMSS/DWM/URB

In its May 21, 1997, SRM (M970521), the Commission stated that the piece of the license termination rule dealing with uranium recovery facilities warranted additional consideration by the Nuclear Regulatory Commission (NRC) and affected parties. For the work on reviewing comments and developing the package for finalizing this piece of the rule, I have reconsidered the proposed approach for criteria for uranium recovery facilities. With the perspective of the main license termination rule that the Commission approved, and from other considerations, I have concerns with the proposed approach, that I believe should also be considered by the NRC staff and the Commission. This differing viewpoint is represented as mine alone.

The Commission Paper upon which this viewpoint was based has been revised. I have updated this viewpoint, so that it is now based on the April 2, 1998, draft of the Commission Paper.

SUMMARY

The staff position, as provided in the Commission Paper on this subject, recommends using the EPA 5/15 radium standard to provide a benchmark dose for the cleanup of all radionuclides at uranium recovery facilities, including conventional mills and *in situ* leach (ISL) facilities.

I have a differing viewpoint in three main areas:

- The distributions of contamination and primary contaminants of concern at ISL facilities are significantly different from those at conventional mill sites. Thus, ISLs should not necessarily be treated the same as conventional mills, in terms of criteria for license termination.

- The proposed benchmark approach is inconsistent with Commission policy in that:
  - the benchmark criterion would allow the class of uranium recovery licensees to use what is essentially an alternate criterion (of the main license termination rule) without having to meet the requirements generally imposed;
  - the benchmark approach is not dose-based (and risk-informed); and
  - the benchmark approach could allow the dose from residual radioactivity to exceed the NRC's public dose limit of 100 mrem/year (1 mSv/year) for some sites.

- The support for the proposed benchmark approach is not compelling, because the weights or importance of the advantages and disadvantages of the benchmark approach have not been sufficiently considered.

I believe that the criteria from the final rule on radiological criteria for license termination (the main license termination rule) should be relied on to a greater extent for uranium recovery licensees. I propose that the main license termination rule be applied to ISL facilities. I propose that for conventional mills the main license termination rule apply either to all radionuclides other than radium or to all radionuclides including radium, with the decision based on considerations of eliminating dual regulation of radium in soil (the EPA 5/15 radium standard).

STAFF PROPOSED APPROACH

As described in the Commission Paper and its Attachment 1, the staff is recommending using the 5/15 pCi/g radium standard to provide dose benchmarks for the cleanup of all radionuclides

at uranium recovery sites (conventional mills and ISLs). In this approach, the licensee uses site-specific models and/or parameters to calculate the dose that would result from unrestricted release of the site contaminated to the radium standard. This would mean that surface cleanup (buildings or the top 15 cm (6 inches) of soil) of all radionuclides would use, as a dose criterion, the estimated dose resulting from 5 pCi/g (0.19 Bq/g) radium at that site. Subsurface soil cleanup would use as a dose criterion the estimated dose resulting from 15 pCi/g (0.56 Bq/g) radium in subsurface soil at that site. In addition, uranium recovery licensees would be required to demonstrate that doses were as low as is reasonably achievable (ALARA).

The dose that would result from radium in soil at the 5/15 standard is estimated by staff (in Attachment 3 to the Commission Paper) to be on the order of a few tens of mrem/year (tenths of mSv/year) to greater than 100 mrem/year (greater than 1 mSv/year), depending on the specifics of the site, and excluding any dose from radon and its daughters. If a site benchmark dose exceeds 100 mrem/year (1 mSv/year), staff will consult with the Commission before approving the benchmark dose.

DIFFERING VIEWPOINT OF DUANE SCHMIDT

ISLs Are Different from and Should Not Be Treated the Same as Conventional Mills

One of the main arguments for the proposed benchmark approach has been that there are postage-stamp-sized (small) areas at uranium mills contaminated with radionuclides other than radium (primarily uranium or thorium-230), amidst huge tracts of land where the most important contaminant is radium, to which the existing EPA 5/15 radium standard applies. This argument is commonly referred to as the postage-stamp argument. At conventional uranium mills, the huge tracts of land are lands contaminated by windblown tailings. The windblown tailings, which can cover areas of up to hundreds of acres, result from the wind erosion of tailings materials off of the tailings impoundment. The areas contaminated primarily with uranium or thorium-230 result from releases from particular stages of the milling and are localized to smaller areas. Most of the conventional mills are older facilities, and are in some stage of shutdown and reclamation.

However, at ISL facilities, the areas where radium is the important contaminant are much different. At ISLs, radium is generally removed from the liquid waste streams by precipitation followed by either filtration or forced settling in ponds. In either case, the wastes are generally well controlled. For filtration, the filtered waste, containing the radium, can be readily packaged and shipped offsite for disposal. With settling ponds, proper construction of the impoundment and liners allows for straightforward cleanup of the radium-containing sludge at the end of operations. In addition, some ISLs make use of land application (irrigation) to dispose of waste water which still contains low concentrations of radium. Many years of land application can result in the accumulation of radium and other radionuclides in surface soils. In recent NRC staff evaluations of proposed land application, the acceptability of the accumulated radionuclide concentrations has been evaluated based on a comparison of potential doses to future residents to a small fraction of 100 mrem/year (1 mSv/year). The ISL facilities are generally newer than conventional mills, and the NRC staff expects most new uranium recovery facilities to be ISLs.

Thus, the distribution of contaminants at ISLs is much different from that at conventional mills. The postage-stamp situation does not generally exist at ISLs. In addition, since ISL facilities are generally newer, they are amenable to better control of wastes. Therefore, ISLs should not necessarily be treated the same as conventional mills. It appears that the criteria of the main license termination rule (25 mrem/year for unrestricted release, etc.) should be quite appropriate for ISLs.

Proposed Approach Is Inconsistent with Commission Policy

In the *Federal Register* notice for the main license termination rule (62 FR, No. 139, dated July 21, 1997) the NRC placed significant emphasis on the desirability of consistency in licensing actions related to site remediations. In the Introduction to the Supplementary Information to that FRN (page 39058), the NRC stated (emphasis in italics added here):

> The *intent of this rulemaking is to provide a clear and consistent regulatory basis* for determining the extent to which lands and structures must be remediated before decommissioning of a site can be considered complete and the license terminated. The Commission believes that inclusion of criteria in the regulations will *result in more efficient and consistent licensing actions* related to the numerous and frequently complex site remediation activities anticipated in the future. …
>
> … Although site-specific situations will still occur, the Commission believes that codifying radiological criteria for decommissioning in the regulations will allow the NRC to more effectively carry out its function of protecting public health and the environment at decommissioned sites by providing for more efficient use of NRC and licensee resources, *consistent application across all types of licenses*, and a predictable basis for decommissioning planning.

There are three areas in which the proposed benchmark approach is inconsistent with Commission policy regarding radiological criteria for decommissioning and regarding limitations of radiation dose due to licensed materials:

- the benchmark approach, in allowing a different dose criterion for uranium recovery facilities, allows one class of licensee the use of what are essentially alternate criteria (of the main license termination rule) without meeting the requirements generally imposed for the use of alternate criteria;
- the benchmark approach provides radiological criteria that are not purely dose-based, and are thus inconsistent with the current emphasis on risk-informed, risk-based, and dose-based regulation of radiation sources or practices; and
- the benchmark approach could allow the benchmark dose at a site to exceed the NRC public dose limit of 100 mrem/year (1 mSv/year).

The proposed benchmark approach mentioned in the staff position would result in uranium recovery facilities being subject to different dose criteria (generally less restrictive) than other classes of licensee sites (those subject to the main license termination rule). The main license termination rule does allow for alternate criteria (10 CFR 20.1404) which may be less restrictive than the 25 mrem/year (0.25 mSv/year) dose limit, but only if certain requirements are met. These requirements are: (1) the licensee must assure that the public dose limit (100 mrem/year (1 mSv/year)) would be met; (2) practical restrictions on site use are employed; (3) doses are reduced to ALARA levels; and (4) the use of alternate criteria is proposed by the licensee, and the advice of individuals and institutions in the community who may be affected by the decommissioning has been sought and addressed, as appropriate. While some uranium recovery licensees may be able to satisfy these requirements, it has not been shown that the whole class of uranium recovery licensees would meet all of these requirements. In the May 21, 1997, SRM (M970521) the Commission stated, in referring to alternate criteria, “The Commission expects the use of such criteria to be relatively rare.” It thus appears contradictory to the Commission’s policy to generically grant, to a whole class of licensees, criteria that are essentially the same as alternate criteria, without having to meet the requirements that might otherwise be necessary (requirements in 10 CFR 20.1404).

In the current regulatory environment, the usual approach to regulations of sources and practices involving radiation is to provide dose-based or risk-based limits ("risk-informed"). The use of risk-informed regulation has been emphasized recently by the Commission. The benchmark dose limit is ultimately based on a radionuclide concentration limit, which can result in different potential doses at each different site, due to the site-specific conditions. Thus, the benchmark approach does not provide for a true dose-based criterion for decommissioning. The proposed approach also provides for separate benchmark doses for surface application (buildings and surface soil) and subsurface-soil application, so there could be two benchmark dose limits at a site. As noted in the staff position, the Illinois Department of Nuclear Safety, the only state that commented on the request for additional comments, also expressed a preference for a dose-based criterion rather than a concentration-based criterion.

The proposed benchmark approach does not provide for any cap on the allowable benchmark dose. Calculations (in Attachment 3 to the Commission Paper) indicate that the benchmark dose at uranium recovery sites could range from a few tens of mrem/year (tenths of mSv/year) to greater than 100 mrem/year (1 mSv/year), and thus could potentially exceed the NRC public dose limit of 100 mrem/year (1 mSv/year). The 100 mrem/year (1 mSv/year) limit has been set by the NRC as the dose level for members of the public that is necessary for protection of health and safety. Based on the criteria of the main license termination rule, other licensees would not be allowed to terminate their license with doses from residual radioactive material exceeding 100 mrem/year (1 mSv/year). I acknowledge that, as indicated in the Commission Paper, it should be unlikely that the benchmark dose would exceed 100 mrem/year (1 mSv/year). However, without specific justification, the lack of a cap on the benchmark dose appears to be contradictory to the Commission's policy.

The staff has addressed this difficulty by indicating that if the benchmark dose exceeds 100 mrem/year (1 mSv/year) at a site, the staff will consult with the Commission before approving the benchmark dose. However, there still would not be any cap on the dose from residual radioactive materials, nor any prohibition against doses exceeding the 100 mrem/year (1 mSv/year) limit. If the NRC wishes to limit doses from decommissioned sites to less than 100 mrem/year (1 mSv/year), I believe that including a cap on the benchmark dose would be a better alternative than the proposed approach. (I note that such a "capped" benchmark approach, which is essentially Alternative 3 with the addition of a cap on the benchmark dose, was previously preferred by the staff.)

I believe that it is a significant disadvantage that the proposed approach is inconsistent with the main license termination rule, with current approaches to risk-informed regulation of radiation doses, and with the public dose limit.

Reasons Supporting Recommendation of the Benchmark Approach Are Not Compelling
The reasoning in support of the proposed benchmark approach is not compelling. The decision to support the proposed benchmark approach does not seem to have considered the weights or importance of the various advantages and disadvantages described in the Commission Paper and in the attachment, *Discussion of Alternatives*. Some of the advantages of the proposed benchmark approach appear to be very weak, while some of the disadvantages appear to be very important.

One of the main arguments for the proposed benchmark approach has been that there are postage-stamp-sized (small) areas at uranium mills contaminated with radionuclides other than radium (primarily uranium or thorium-230), amidst a sea (large areas) of radium contamination (from the windblown tailings) to which the existing EPA 5/15 radium standard applies. Based on this, the staff position is that it is an advantage to develop criteria for radionuclides other than

radium that are consistent with or not more restrictive than the EPA 5/15 radium standard. I agree that it would be an advantage to have consistent criteria (in terms of dose) for all radionuclides at a given site. However, it does not seem to be an advantage to be consistent with the EPA 5/15 radium standard. The EPA standard was promulgated in 1983, with the approach chosen based on considerations of acceptable risk and dose, feasibility, and costs. According to the EPA's EIS, the primary concern for public health was the risk due to radon progeny, and the 5/15 standard would allow lifetime cumulative risks of 2×10^{-2}, due to emissions of radon from the radium in soil. At the time the rule was developed, the NRC's public dose limit was 500 mrem/year (5 mSv/year). This EPA 5/15 standard was developed in a different regulatory regime than currently exists, and appears to allow a risk level that is higher than would currently be acceptable. Thus it does *not* seem to be an advantage to develop new criteria to be consistent with the existing standard. The Illinois Department of Nuclear Safety, in its comments, also indicated that consistency with the existing EPA standard was not a reasonable motivation for establishing new criteria.

Another advantage described in the staff position is that the benchmark approach provides for consistent dose criteria across all parts of individual sites. As noted in the discussion of alternatives this is only true exclusive of the radon contributions to dose (as noted above, the radon pathway was considered the most important in the development of the EPA 5/15 standard). It certainly is an advantage to have consistent dose criteria for all areas of a site, but the benchmark approach does not provide for consistent dose criteria across all sites (different sites may have different benchmark doses), as discussed below regarding disadvantages.

The staff position indicates that it is also an advantage that the uranium recovery industry generally supported the benchmark approach. While six of the nine commenters were from the industry, the quality of comments (technical merit) should be considered more important than the quantity.

Another stated advantage of the proposed approach was that the approach is similar to that presented to the Commission in the final draft of the main license termination rule (SECY-97-046A). Since the Commission's SRM of May 21, 1997 (M970521), did not approve or disapprove of the benchmark approach, there does not seem to be any advantage (or disadvantage) in retaining the same approach.

Another advantage described in the staff position is that measurements and cleanup to meet the benchmark criterion would be less costly than meeting the 25 mrem/year (0.25 mSv/year) dose criterion of the main license termination rule for unrestricted release. This statement is based on the determination that the 25 mrem/year (0.25 mSv/year) limit would be more restrictive than the benchmark criterion (hence cleanup would cost more). The additional cost would presumably result in lower residual concentrations and thus lower doses in the future. Since the two approaches result in different levels of dose, it is not appropriate to look solely at costs; it would be more appropriate to consider cost-effectiveness.

Three of the disadvantages of the proposed benchmark approach mentioned in the staff position are that: (1) the approach would result in uranium recovery facilities being subject to different dose criteria (generally less restrictive) than other classes of licensee sites (subject to the main license termination rule); (2) each site released could have a unique benchmark dose limit, because the benchmark dose limit is not a purely dose-based limit; and (3) doses to members of the public due to residual radioactive material could exceed the (level of the) NRC's public dose limit of 100 mrem/year (1 mSv/year). As described above, these all represent major inconsistencies with Commission policy, and thus should be considered very significant disadvantages.

Another disadvantage of the proposed approach noted in the staff position is that the risk from the benchmark dose limit for radionuclides other than radium would not actually be consistent with the risk from radium-contaminated areas cleaned to the 5/15 radium limit. This is because the most important risk consideration for the 5/15 radium limit (as described in the EPA's EIS) was the risk due to the radon pathway. The NRC does not include the dose from radon in assessing the dose from radium, so the dose and risk bases of the benchmark dose limit would be different from the bases for the 5/15 radium standard. This is an important disadvantage because one of the benefits of the benchmark approach is supposed to be a consistent (in terms of dose or risk) limit to be applied to all areas of a site. (It should be noted that this disadvantage would also apply to use of the main license termination rule.)

A final disadvantage of the proposed approach noted in the staff position is that EPA would oppose any dose limit not consistent with a 15 mrem/year (0.15 mSv/year) limit. The determination of the importance of this disadvantage can only be fully answered by persons better versed in the NRC-EPA interactions than I. This issue is made more difficult by EPA's comment that the 5/15 radium standard is consistent with a dose limit of 15 mrem/year (0.15 mSv/year).

For all of the alternative approaches considered (in Attachment 1 to the Commission Paper) except for the status quo (alternative 1) and the proposed benchmark approach (alternative 3), the staff indicates that a difficulty is that renotice and a comment period would be required, which would increase the time required to complete the rulemaking. This consideration might also apply to a capped benchmark approach (alternative 3 with a cap on the benchmark dose). However, I believe that considerations of schedule and renotice should have only minor importance for the decision as to which approach should be followed.

Differing Proposal: Use Main License Termination Rule to the Extent Reasonable
Based on the above considerations, I believe that the radiological criteria for license termination from the main license termination rule should be relied on to a much greater extent than in the proposed benchmark approach. The main license termination rule allows for significant flexibility in cleanup criteria for licensees: (1) the dose limit is applied only to radioactivity that is distinguishable from background concentrations; (2) license termination under restricted conditions is available in cases where compliance with the limit for unrestricted release would result in net public or environmental harm, or where compliance with the limit for unrestricted release would result in residual radioactivity levels lower than what would be considered ALARA; and (3) alternate dose criteria are also available if certain requirements are met, including (a) assuring that the public dose limit (100 mrem/year (1 mSv/year)) would be met; (b) practical restrictions on site use are employed; (c) doses are reduced to ALARA levels; and (d) the use of alternate criteria is proposed by the licensee and the advice of individuals and institutions in the community who may be affected by the decommissioning has been sought and addressed, as appropriate. It appears that no substantial reasons have been put forth that show that the main license termination rule is not appropriate for application to uranium recovery sites.

Specifically, I propose that:

- For ISL facilities, all the criteria of the main license termination rule be applied to the cleanup of all radionuclides, including radium (option 2a of the Commission Paper attachment).
- For conventional mills, either (1) the criteria of the main rule be applied to all radionuclides (option 2a); or (2) the criteria of the main rule be applied to radionuclides other than radium in soil and to all radionuclides contaminating buildings, and the 5/15 radium standard continue to be applied to radium in soil (option 2b of the Commission Paper).

- The decision as to which of these options should be used for conventional mills should be made based on feasibility and reasonableness of eliminating dual regulation for radium (by changing the EPA 5/15 standard or by a Commission position stating that the 25 mrem/year (0.25 mSv/year) dose limit meets the intent of the 5/15 standard, and is adequate to implement that standard).

POTENTIAL CONSEQUENCES OF STAFF PROPOSED APPROACH

There are potential detrimental consequences if the Commission approves the proposed benchmark approach for radiological criteria for license termination of uranium recovery facilities. The level of protection of public health could be slightly less than provided under the main license termination rule. A whole class of licensees may be subject to decommissioning criteria that are less restrictive than those applied to the majority of licensees, without meeting requirements that would be imposed on other licensees. The benchmark approach would not be consistent with the Commission's emphasis on risk-informed (dose-based) regulation. The benchmark criterion could allow the termination of licenses in cases where residual radioactive material result in doses greater than the NRC's public dose limit of 100 mrem/year (1 mSv/year). Based on these inconsistencies, the Commission may lose credibility with the public, State agencies, and other Federal agencies.

DOSE MODELING TO SUPPORT THE URANIUM RECOVERY DECOMMISSIONING RULE

1. TYPES OF RADIOACTIVE CONTAMINATION AT URANIUM RECOVERY FACILITIES

Those uranium recovery facilities that would be subject to the requirements currently being considered for cleanup of contaminated soil and buildings would be four uranium mills, six operating in situ leach (ISL) facilities, and any new facility licensed after promulgation of the rule. To design a model for calculation of potential doses caused by residual radioactivity at these sites, one must understand the processes used at the two types of facilities.

At uranium mills, the ore is crushed and treated, and the uranium (U-nat, i.e., U-238, U-234, and U-235) is extracted and dried. The resulting product is yellowcake (triuranium octoxide). The sandy residue from milling operations (tailings) is slurried to impoundments, and after the end of operation, the tailings are dried and covered with soil. The mill tailings contain the decay products of uranium, the most important of which are thorium (Th-230), radium (Ra-226), radon (Rn-222), bismuth (Bi-214), and lead (Pb-214 and Pb-210). In the past, the tailings piles were not covered as they dried and wind and water moved the tailings to surrounding areas, causing soil contamination. The Th-230 in tailings is in approximate secular equilibrium with Ra-226 (their activity levels are nearly the same), so usually the Th-230 is adequately remediated by meeting the radium standard. However, holding ponds for acidic tailings solutions can leak and areas under these ponds can become contaminated with Th-230, as it is more mobile than the radium.

Unlike mills, the operation of ISLs does not generate a large volume of tailings. At ISLs, a solution of oxygen and bicarbonate (lixiviant) is pumped into the ore body to liberate uranium. The “pregnant” lixiviant is then pumped, via pipelines, to the processing plant where the uranium is extracted. A small portion of the process solution is bled out of the system, to ensure that the flow of ground water is always toward the well field. Bicarbonate is added to the solution remaining in the process, and it is reinjected into the well fields to extract more uranium. Management of the waste (bleed) water has historically been handled by storing it in ponds, and then either allowing it to evaporate, discharging it into unusable aquifers, or applying it to land through irrigation practices. While in the waste water management ponds, the waste water is chemically treated to precipitate out the radium. When the water is then managed through land irrigation, it results in the deposition of other radionuclides onto the soil.

Soil contamination at ISL facilities can occur from three sources. First, the waste water storage ponds may leak, and cause buildup of Ra-226 in the soil. Second, the land application of waste process water results, by design and license condition (monitoring required), in low levels of radioactivity in the soil. Finally, pipe breaks, valve leaks, and spills can cause soil contamination. Depending on which part of the system is involved, the contamination could either be both uranium and radium, or just radium. Preliminary data on pregnant lixiviant indicate that the Th-230 activity is much lower than the Ra-226; thus, an ISL may not need to consider Th-230 in its cleanup plan.

Although individual spills from the pipelines have resulted in the release of many thousands of gallons, the fluid generally covers less than 40,468 m^2 (10 acres), and if residual contamination is detected in the soil, it is in the upper 7 cm (3 inches). If ponded spills are not cleaned promptly, contamination could extend deeper. As with mills, spills of yellowcake or uranium-enriched solutions around or in the processing building can occur.

2. CLEANUP REQUIREMENTS

The only standard applicable to the cleanup of soil contamination at uranium recovery facilities is the 5/15 radium standard[4] in 10 CFR Part 40, Appendix A. In implementing the proposed benchmark approach recommended for inclusion in the final rule, the staff would treat radionuclides other than radium in the same manner as radium is treated (i.e., to have a surface and subsurface standard). This would involve calculating the potential dose resulting from the 5 pCi/g (0.19 Bq/g) concentration of radium in the surface (top 15 cm (6 inches) of soil), and a second dose from the 15 pCi/g (0.56 Bq/g) of subsurface radium contamination. The results from these calculations would then be used to establish a surface and subsurface dose limit for radionuclides other than radium.

3. DOSE MODELING CODE

The RESRAD code (version 5.76, 1997), developed by the U.S. Department of Energy, was chosen to perform the dose calculations because it is widely used and has been validated by comparison with other widely used codes. In addition, some calculations were performed using the Nuclear Regulatory Commission (NRC) DandD code (under development), as discussed in Section 7.

4. EXPOSURE PATHWAYS

In developing scenarios to model the potential dose to the public from residual radioactivity at uranium recovery sites affected by the rule, the staff had to determine future land use. Only one site, in northwest Nebraska, was considered likely to support a resident farm family. The other sites would most likely be used for ranching, mining, or possibly light industry. Based on these projected land uses, staff then determined what pathways (food, water, air, soil) could expose people to the residual radioactivity.

The staff considered that dairies are not likely to be established in these areas, but if milk cows were to graze in contaminated areas, the milk would probably be sent for processing (thus diluted), and not be consumed at the site. Therefore, milk consumption was not considered a reasonable exposure pathway. Also, a pond in the contaminated area providing a significant quantity of fish in the diet was not considered possible, so the aquatic exposure pathway was not modeled. All other pathways were used. Although the radon pathway was used, the resulting dose was not considered in the discussion of dose from radium. This reflects the approach in the main decommissioning rule (radiological criteria for license termination) and the uranium recovery decommissioning rule, to consider that controlling the radium level or dose will provide adequate protection from all of its decay products (progeny). Given the uncertainty of the health effects from radon and the lack of regulation of radon from other sources, this approach is reasonable.

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[4]Appendix A to 10 CFR Part 40, criterion 6(6), states that for land at uranium or thorium mill sites, the concentration of radium-226 (uranium sites) or radium-228 (thorium sites), averaged over areas of 100 square meters, shall "not exceed the background level by more than: (i) 5 pCi/g ... averaged over the first 15 cm below the surface; and (ii) 15 pCi/g ... averaged over 15-cm thick layers more than 15 cm below the surface." This is known as the 5/15 radium standard.

5. INPUT PARAMETERS

The input data for the RESRAD code used to calculate dose are listed in Table 1 below, and reflect data generally appropriate for these sites. The column marked Wyoming sites represents
values which are also generally applicable to the Utah and New Mexico uranium recovery sites. The column marked Nebraska contains values representative of the one (ISL) Nebraska site. The code default values were used for those parameters not listed in the table, because they were considered reasonable for the sites. The lifestyle parameters (percentage of time inside, outside, and offsite) used are described in Table 2, below. They are similar to default values in RESRAD and recommended values in the Office of Nuclear Material Safety and Safeguards Policy and Guidance Directive PG-8-08 (NRC, 1994), based on draft guidance developed for the main decommissioning rule (NUREG/CR-5512, NRC, 1992).

As indicated in Table 1, the first group of radionuclides modeled were 5 pCi/g (0.19 Bq/g) Ra-226 and its progeny. The Th-230 (parent to Ra-226) was also considered because it is often in approximate equilibrium (same activity) with Ra-226 in mill tailings. The resulting dose from the radium and its progeny (Table 3) represents a typical surface cleanup benchmark dose limit applied to cleanup of building surfaces and uranium or thorium in the top 15 cm (6 inches) of contaminated soil, such as spills of pregnant lixiviant at ISLs. The second group, at 15 pCi/g (0.56 Bq/g), represents the subsurface radium cleanup standard, and the resulting dose would be the benchmark for subsurface cleanup of radionuclides other than radium. The third group of radionuclides, 30 pCi/g (1.12 Bq/g) natural uranium (equivalent to approximately 14.5 pCi/g (0.53 Bq/g) U-238, 14.9 pCi/g (0.55 Bq/g) U-234, and 0.6 pCi/g (0.02 Bq/g) U-235), represents the current cleanup limit used by the staff. This group was modeled to demonstrate the dose level that may have been achieved at uranium recovery sites in the past.

The values for area and depth of contamination were based on experience at mill sites (ranch scenario) and ISLs (farm scenario). The area value for the farm is conservative, reflecting the uncertainty in this value because the maximum size and number of solution spills are unknown, because none of the NRC-licensed ISLs has completed decommissioning.

The erosion rate value used is less than the default value because in regions drier than normal, the erosion rate is less, as discussed in the RESRAD Data Collection Handbook (Argonne, 1993). Drinking water wells, in the regions under consideration, vary in depth from 24.4- to 91.4-meters (80- to 300-feet)-deep, as the upper aquifer is often of poor quality and quantity. Therefore, a value of 30 meters (98 feet) instead of the default value of 10 meters (33 feet) was used.

Because of the low level of precipitation in these regions, extensive gardens or dense animal grazing is not possible, so the percentage of the diet from contaminated areas is lower than the default value (see Table 2). The staff assumed that half of the contaminated food consumed was plants and the other half meat. Plant root depth was estimated by averaging the root depth for local grasses (animal grazing) and typical garden vegetables. The default value is not appropriate and not conservative.

6. MODELING RESULTS

The results of the example benchmark calculations are shown in Table 3, below. The columns marked WY represent the Wyoming sites which are similar to the Utah and New Mexico sites. The columns marked NE represent the one Nebraska (ISL) site. As expected, the largest dose from radium is derived from the resident farmer scenario. Under this scenario, the dose from the surface radium standard was 45 mrem/yr (0.45 mSv/yr). The ranch scenario resulted in 35 mrem/yr (0.35 mSv/yr).

The total potential dose from the cleanup of soil to the 5/15 radium standard was approximately 85 mrem/yr (0.85 mSv/yr) for the farm scenario (Nebraska). For the other uranium recovery facilities affected by the rule, the ranching scenario is the most likely situation, and the results indicate a total dose of 54 mrem/yr (0.54 mSv/yr). It should be noted that the subsurface radium contamination was modeled 30 cm (12 inches) deep and for 10 acres (40,468 m^2), not the entire contaminated area. Dose modeling for the 15 pCi/g benchmark dose would need to incorporate the area likely to be cleaned to the subsurface contamination standard, in the area to be released for unrestricted use, which is typically less than 1 acre (4,046 m^2). The reason for this is that radium soil cleanup is usually achieved by removing 15 to 30 cm (6 to 12 inches) of contaminated soil. Backfill soil is rarely used because it is cheaper to regrade large areas. This approach results in the application of the 5 pCi/g (0.19 Bq/g) surface radium standard, even for spots deeper than 30 cm (12 inches).

Modeling the post-reclamation condition represented by the last three decommissioned mill sites that averaged less than 2 pCi/g (0.07 Bq/g) radium, resulted in 14 and 18 mrem/yr (0.14 and 0.18 mSv/yr) for the ranch and farm scenarios, respectively.

The major pathway of exposure for most of the dose calculations was external (gamma) radiation from the ground. The percentage of dose from this pathway varied from 59 to 95 percent. The exception was the farm scenario where the major pathway was plant ingestion (35 to 66 percent of the dose).

For the ranch scenario with radium contamination, the second most important pathway was plant ingestion, providing 15 to 35 percent of the dose. When uranium was the type of contamination, inhalation (other than radon) contributed 23 to 29 percent of the dose, but this was also second to the gamma pathway.

According to the modeling performed, the peak dose for 5 pCi/g (0.19 Bq/g) radium occurs at time zero, and for the uranium exposure, the time of peak dose varies by scenario from 0.25 to 79.2 years. Of course, the erosion rate used in the model will greatly affect both the peak dose and the time of its occurrence. Other parameter value alterations modeled and their dose effects (in mrem/yr) that are not reflected in the tables are: 1) decreasing the root depth from 0.25 to 0.20 increased the farm radium dose by 5; 2) using the default root depth value of 0.9 decreased the farm dose by 10 and the ranch dose by 6; 3) increasing the area of contamination on the ranch to 600 acres (2,428,080 m^2) did not change the dose; and 4) using the NUREG/CR-5512 values recommended in PG-8-08 (except milk consumption) for the farm resulted in a decrease of 9.5 mrem/yr (0.09 mSv/yr). This latter effect was primarily caused by the lower (0.33 versus 0.7 default value) gamma shielding factor in NUREG/CR-5512. It would be appropriate to use this lower shielding factor in future modeling. The staff also recognizes that changes in sensitive modeling parameters, such as the mass loading factor or the soil to

plant transfer factor, could significantly alter the resulting dose. Therefore, dose modeling has to
be performed on a site-specific basis in order to provide the dose estimate that will be used in the benchmark approach for site cleanup of radionuclides other than radium. Guidance for dose modeling will be developed in conjunction with the standard review plans for mill reclamation and ISL applications currently under development.

The RESRAD dose modeling performed by staff indicates that, for uranium recovery sites in general, application of the radium soil cleanup standard will result in doses substantially less than the public dose limit (Table 3). The results for all scenarios using the cleanup standard for uranium that is in the staff guidance and currently applied at uranium mill sites, indicate that the cleanup of uranium at mill sites has been conservative. Therefore, application at uranium recovery sites of the benchmark approach contained in the proposed rule should be protective of public health and safety, and provide a consistent dose limit across the site for all residual radionuclides.

7. CALCULATIONS USING THE DandD CODE

Calculations for contaminated surface soil were also performed using the DandD code, which was developed by the NRC specifically for evaluating compliance with the dose criteria of the main license termination rule. The DandD code cannot be used directly to calculate doses from subsurface contamination, so only the surface source terms were analyzed.

To the extent feasible, the parameter values listed in Table 1 were also used for these calculations. Because of the different model structure used in DandD, compared to RESRAD, not all parameters could be implemented exactly as in Table 1. In particular, DandD does not allow for a well depth different from the thickness of the unsaturated zone, so a thickness of 30 m was used for the unsaturated zone. Also, the DandD model currently allows input of only a fixed thickness (15 cm) of contamination. Values used in the DandD calculations for the parameters of Table 1 (and for related parameters, when the same parameter is not used) are shown in Table 4.

The lifestyle parameter values used for these DandD calculations are essentially the same as used for the RESRAD calculations, as indicated in Table 2. For partition coefficients, values were used that are judged appropriate as average values for the soil type (loam) thought to be representative of the Wyoming sites. For parameters other than those of Table 2, Table 4, and the partition coefficients, values recommended in NUREG/CR-5512, Volume 1, were used. These latter values were judged to be reasonable for a typical uranium recovery site when site-specific data (for these other parameters) are not available. Those that are both important to the resultant calculated doses and have significantly different values in DandD and RESRAD, are discussed below in the explanation of the difference in results between the RESRAD and DandD calculations.

As a simple method for accounting for the potentially dusty conditions at arid sites, relative to a national average site, two sets of mass loading (for resuspension) values were considered: (1) the values from NUREG/CR-5512, Volume 1, which may be more appropriate for an average site; and (2) the values from the draft of NUREG/CR-5512, Volume 3 (also included in version 1.0 of the DandD software), which may be more representative of dusty sites.

The results of the calculations using the DandD code are shown in Table 5. These results are somewhat higher than the results from the calculations using RESRAD. The DandD results indicate that doses from the 5 pCi/g radium cleanup standard could potentially exceed 100 mrem/yr (1 mSv/yr) for the only currently licensed site where there is the potential for a

resident farmer. The differences in results for an “average” site compared to a “dusty” site (Table 5) point out the potential importance of the inhalation pathway for the dose from Th-230 and U-nat.

The differences in results between the RESRAD and DandD calculations are primarily due to differences in the ingestion (of plants) and inhalation (from resuspension) pathways. The results for these pathways are different (between RESRAD and DandD) due to slight differences in the equations used in the two models and, most importantly, due to significant differences in the recommended parameter values related to soil-to-plant transfer and mass loading (for resuspension). The determination of appropriate site-specific values for these important parameters is difficult with the available information, and will likely be difficult for licensees. The staff will prepare guidance to clarify the range of acceptable input values for either code, that best reflect the uranium recovery facilities.

8. REFERENCES

Argonne National Laboratory (for the U.S. Department of Energy), “Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil,” ANL/EAIS-8, April 1993.

U. S. Nuclear Regulatory Commission, “Residual Radioactive Contamination from Decommissioning,” NUREG/CR-5512, PNL-7994, Vol. 1, 1992.

U. S. Nuclear Regulatory Commission, “Residual Radioactive Contamination from Decommissioning - Parameter Analysis,” (DRAFT FOR REVIEW), NUREG/CR-5512, Vol. 3, April 1996.

U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Division of Waste Management, Policy and Guidance Directive PG-8-08, “Scenarios for Assessing Potential Doses Associated with Residual Radioactivity,” May 1994.

TABLE 1
Dose Modeling Input for the RESRAD Calculations

For the parameters not indicated in the table, the RESRAD (version 5.76) code default value was considered appropriate and was used.

Input Parameters	**Wyoming Sites**	**Nebraska Site**	**RESRAD Default**
Radionuclide & concentration: first run second run, 0.15 meters of cover third run	 5 Ra, Th 15 Ra, Th 30 U-nat	 5 Ra, Th 15 Ra, Th 30 U-nat	
Area of contamination - 300, 100 acres	1,214,040	404,680	1000 m^2
Thickness of contamination	0.15, 0.45	0.15	2 m
Contaminated zone: erosion rate	1xE-5	6xE-4	1xE-3
b zone	4.9	5.1	5.3
effective porosity	0.25	0.25	0.2
hydraulic conductivity	5	5	1 m/yr
Evapotranspiration coefficient	0.9, 0.6	0.6	0.5
Precipitation	0.25	0.39	1 m/yr
Irrigation	0	0	.2 m/yr
Watershed area for nearby pond	default	3xE+6	1xE+6 m^2
Density of saturated zone	2	2	1.5 g/cm^3
Saturated zone: effective porosity	0.3	0.3	0.2
hydraulic conductivity	150	150	100 m/yr
hydraulic gradient	.08	.08	.02
Unsaturated zone: thickness	3	3	4
density	2	2	1.5
effective porosity	0.3	0.3	0.2
hydraulic conductivity	5	5	10 m/yr
Plant root depth	0.25	0.25	0.9 m
Well pump intake depth	30	30	10 m

TABLE 2
Scenarios

Land use, area of contamination, and other assumptions were derived from Policy and Guidance Directive PG-8-08, RESRAD 5.76 defaults, and assumptions based on specific site data. Values are used in both RESRAD and DandD calculations, except as noted.

Scenario (land use, contam)	Other Assumptions	% of Diet from Contaminated	% Inside	% Outside	% Offsite
industrial 20,230 m^2 (5 acres)	office/factory 50% onsite water	0	20	3	77
residential 20,230 m^2 (5 acres)	well, no pond tiny garden	2	40	10	50
ranching 1,214,040 m^2 (300 acres)	well, no pond, small garden, beef cattle	5	45	20 [1]	35
family farm 404,680 m^2 (100 acres)	well, no pond, large garden, animals for meat	20	50	25 [1]	25

[1]For DandD calculations, time outdoors is divided into general time outdoors (assumed 15% for ranching and for family farm) and time outdoors gardening (or disturbing soil) (assumed 5% for ranching and 10% for family farm).

TABLE 3
RESRAD Modeling Results[1]
Potential Dose (mrem/yr)

WY = Wyoming NE = Nebraska Radionuclide levels are in pCi/g soil.

Scenario	WY 5 Ra (Th)	WY 15 Ra (Th)	WY 30 U-nat	NE 5 Ra (Th)	NE 15 Ra (Th)	NE 30 U-nat
industrial	9 (0.1)	4 (0)	1	8 (0.1)	4 (0)	1
residential	23 (0.2)	12 (0.01)	3	20 (0.2)	12 (0.01)	2
ranching	35 (0.4)	19 (0.03)	4	----	---	---
family farm	---	---	---	45 (0.5)	40 (0.1)	5

[1]The potential radon dose (mrem/yr) resulting from 5 pCi/g (0.19 Bq/g) radium was 53-73 for industrial, 12-150 for residential, 186 for ranch, and 117 for the farm scenario. The radon dose due to 30 cm (12 inches) of subsurface contamination at 15 pCi/g (0.56 Bq/g) was 466 and 427 mrem/yr for the ranch and farm scenarios, respectively.
Modeling the post-reclamation condition represented by 2 pCi/g (0.07 Bq/g) radium, resulted in 14 and 18 mrem/yr for the ranch and farm scenarios, respectively.

TABLE 4
Dose Modeling Input for DandD Calculations

This table shows values used for the DandD calculations for the parameters shown in Table 1, or for related parameters (in cases where the same parameter is not used). Those parameters shown in Table 1, but not shown here, are not used in the DandD code.

Input Parameters	Wyoming Sites	Nebraska Site	DandD Default
Radionuclide & concentration: first run second run	 5 Ra, Th 30 U-nat	 5 Ra, Th 30 U-nat	
Cultivated area [1]	100,000	100,000	3800 m^2
Thickness of contamination [2]	0.15	0.15	0.15 m
Contaminated zone: density	1.625	1.625	1.625 g/cm^3
effective porosity	0.25	0.25	0.35
saturation fraction	0.45	0.45	0.16
Infiltration rate [3]	0.025	0.039	0.13 m/yr
Irrigation rate	0	0	1.31 L/m^2 day
Pond volume [4]	default	default	328,000 L
Unsaturated zone: thickness [5]	30	30	1 m
density	2	2	1.72 g/cm^3
effective porosity	0.3	0.3	0.4
saturation fraction	0.45	0.45	0.3

[1]The value used is the maximum value allowed by the software. In DandD, the cultivated area is used only for calculating infiltration to the aquifer.
[2]In DandD, the contamination thickness is fixed at 0.15 m.
[3]Based on 10% of precipitation rates from Table 1.
[4]A pond is included, but food (aquatic) from the pond is not included.
[5]The DandD model does not allow a well depth different from the unsaturated zone thickness. Thus, the well intake depth from Table 1 is used in DandD as the unsaturated zone thickness.

TABLE 5
DandD Modeling Results
Potential Dose (mrem/yr)

Radionuclide levels are in pCi/g soil.

Scenario (land use)	**5 Ra (Th)**	**30 U-nat**	**5 Ra (Th)**	**30 U-nat**
Ranch				
average	38 (2)	7	----	---
dusty	39 (19)	46		
Family Farm				
average	---	---	100 (6)	20
dusty			100 (31)	76