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Dr. Donald A Cool, Chief
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Office of Nuclear Regulatory Research
U. S. Nuclear Regulatory Commission
One White Flint North (NL/S-139)
Washington, DC 20555

Dear Dr. Cool

Thank you for the opportunity to review and comment on your "staff draft" of the radiological criteria for decommissioning. In general, we support the NRC's staff's development of these criteria and note that the "staff draft" shows considerable effort to incorporate and address the views that arose during the NRC sponsored regional workshops on this issue.

The Department supports NRC's position to develop risk-based standards employing dose as a surrogate for risk . The approach is methodical and generic enough to include most sites that are under Commission regulation. Furthermore, the general approach used by the Commission staff to establish a goal and limit is reasonable and implementable. The flexibility to develop site-specific criteria is important to ensuring both cost effective and protective requirements. We believe that setting a single dose criterion covering all pathways is preferable to having several values for specific media or exposure pathways, e.g., soil, groundwater, and direct radiation. It will be easier to implement in that tradeoffs between different release modes or pathways can be made in order to control the total dose and balance dose reduction with competing risks rather than having to assess a myriad of separate media-specific limits.

The Department also strongly supports the recognition of restricted use as one alternative for decommissioning. However, we believe that several elements of the draft warrant additional review and consideration. These are detailed in the enclosed comments and include the selection of the value for a dose limit, the importance of collective dose in the criteria setting process, development of exposure sceanrio selection guidance and the implementation of the Site-Specific Advisory Board concept.

We have also enclosed several analysis of remedial action criteria, including the cost and collective dose, for various planned and completed remedial actions completed by the Department that we feel may be pertinent to NRC's

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development of this rule. We have several other analyses in preparation but will provide them separately due to time constraints. If you have any questions concerning these comments, please contact Andrew Wallo (202-586-4996) or Harold Perterson (202-586-9640).

Sincerely,

for Raymond F. Pelletier
Director
Office of Environmental Guidance

Enclosure: comments and examples

cc:
NRC Docketing and Service Branch
Federal Register of February 2, 1994
[59 FR 4868]
R. A. Meck, NRC/RES
B. Hostage, EPA/ORIA
N. Lailas, EPA/ORIA
A. C. B. Richardson, EPA/ORIA

U. S. Department of Energy Comments on the NRC Draft Radiological Criteria for Decommissioning

Overview

The Department of Energy staff have reviewed the Nuclear Regulatory Commission's (NRC) Draft Radiological Criteria for Decommissioning and the Department is providing the following comments for the Commission's consideration. Although under current laws this rule is not directly applicable to DOE sites, it could set a precedent or be determined relevant and appropriate for cleanup requirements that DOE will have to address in its remediation activities. These NRC criteria could, therefore significantly impact DOE's environmental restoration program. Furthermore, several cleanups presently being completed by the Department were formally licensed facilities and the Department's experience at these facilities may benefit NRC staff in their development and selection of the radiological criteria for decommissioning.

In general, the Department supports NRC's position to develop risk-based standards employing dose as a surrogate for risk. The staff proposal appears to be an attempt at a process that can meet or at least consider as many needs as possible in the area of radiological decommissioning criteria development. The approach is methodical and generic enough to include most sites that are under Commission regulation. Furthermore, the general approach established by the Commission staff to establish a goal and limit is reasonable and implementable. We believe that setting a single dose criterion covering all pathways is preferable to having several values for specific media or exposure pathways, e.g., soil, groundwater, and direct radiation. This will be easier to implement in that tradeoffs between different release modes or pathways can be made to control the total dose rather than having to meet a myriad of separate limits.

The Department also strongly supports the recognition of restricted use as one alternative for decommissioning. However, we believe that several elements of the draft warrant additional review and consideration. These include the level NRC is proposing as the limit or dose constraint for decommissioning and the Commission's position that collective dose is not an important factor in development of site-specific criteria.

Summary of Major Recommendations[1]

1. It is not clear that the societal benefit from each of the processes or practices evaluated is the same or would warrant the same decommissioning criteria. It might be helpful in the statement of considerations for the final rule to expand on the benefits (and drawbacks) of having a single standard applicable to all types of NRC licensees.

2. The 3 mrem/yr goal would be more practical as a concentration-based "screening level" to define a level below which detailed radiological dose or risk assessments are not required to demonstrate compliance. The NRC staff should discuss in more detail their selection of 3 mrem/yr as an approximation to a lifetime risk level of 10^{-4}. The EPA criterion of a lifetime risk of 10^{-4} is used by EPA as an order of magnitude value, not as a "bright line" 1×10^{-4}. This is demonstrated by the EPA's selection of 10 mrem/yr as equivalent to a "10^{-4}" risk for that same order of magnitude risk level in the radionuclide NESHAPs (40 CFR Part 61, Subparts H and I) under the Clean Air Act and the selection of numerous remediation criteria that produce a calculated risk in excess of 1×10^{-4}. It should be recognized that the lifetime risk caused by an annual dose is dependent on the number of years an individual is exposed to that dose. Given that the average time a person in the U.S. resides at a given location is 7 years, the average individual would incur a hypothetical lifetime risk of about 1×10^{-5} at the 3 mrem/year dose rate and given that the 95th percentile for time spent at a single residence is 30 years, 95% of the effected population would be likely to incur a potential lifetime risk of less than 5×10^{-5}.

3. Draft NRC regulatory guides and technical documents to support the implementation of these criteria should be made available for public comment at a time sufficiently before issuance of the final rule that public comments on the implementation guides could be used in the preparation of the final rule.

4. Development of criteria for realistic exposure scenarios could significantly reduce costs of cleanup, while still ensuring protection of public health and the environment. This is one of the more important steps NRC could take in providing decommissioning criteria.

5. The NRC staff should consider providing further guidance on the selection of exposure pathways, usage factors, and parameters for a "typical individual in the critical group." Although the ICRP has used this concept for many years, neither the NCRP or the ICRP have provided guidance on its practical

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[1] To assist the NRC staff in reviewing these comments, we have extracted our principal recommendations into this section. The support and rationale underlying these recommendations are contained in our General and Specific Comments.

application.

6. In the draft rule, NRC suggests that collective dose is of little importance in selection of criteria. Given the importance of the as low as reasonably achievable (ALARA) process in Federal and international radiation protection guidelines, it would seem that collective dose should be an important consideration in NRC's criteria.

8. NRC's summary of impacts seems to imply a lack of correlation between residual criteria and waste volumes/decommissioning costs above the range being considered for the standard. Our experience is that there are strong correlations and that the relationship is non-linear. Without the supporting documentation, it is not possible to comment adequately on this issue; however, we suspect it may be an artifact of assumptions used in the analyses. Examples at our sites would lead to a different conclusion than that suggested by the Commission. To make the examples pertinent to the Commission's analyses, we have analyzed a number of different sites, among which are formerly licensed sites that were assigned by Congress to the Department for inclusion in DOE's remedial action programs. We believe that the assumptions used in the cost-benefit analysis in the GEIS will require additional scrutiny.

Detailed Comments

Scope

The proposed scope excludes previous NRC-approved decommissioning activities. It would be instructive, however, to show how the site-by-site criteria that were used for approving these decommissionings compare to the proposed levels.

Despite the public comments at the workshops that were critical of the Commission's initial intent to develop criteria only for "unrestricted release" of facilities, the proposed rule still seems to emphasize "unrestricted release criteria." The discussion on appropriate and implementable procedures for using restricted or controlled use is very limited. We had envisioned that the Commission staff might have developed criteria and some mechanism for controlling "restricted or limited use of sites and facilities." Although termination of the Commission's license might make it difficult for the NRC to enforce "restricted use" requirements, there are a number of other mechanisms to ensure "restricted uses" such as covenants on deeds, zoning ordinances, or appropriation by local government for a specialized use. These options should be discussed, particularly for smaller facilities that handled only nominal amounts of radioactive materials.

Purpose

One of the objectives of this rulemaking is: "providing for ... consistent application across all types of licenses..." It is not clear that imposing a single criterion applicable to all classes of NRC licensees is necessarily the optimum strategy for a decommissioning standard. This is especially true when the range of NRC licensees that this rule would apply to is considered; these licensees vary from small users of radioisotopes as tracers, sealed source users such as radiographers, to licensees possessing millions of curies such as nuclear power reactors. It is not clear that the societal benefit from each of these applications is the same or would warrant the same decommissioning criteria. It might be helpful in the statement of considerations for the proposed rule to expand on the benefits (and drawbacks) of having a single standard applicable to all types of NRC licensees. It would be useful if the Commission discussed this in regard to the "limit"/"goal" concept and the flexibility it provides to the various applications.

Timing and Coordination

We believe that there is a strong need to proceed with the Commission's rule in an expeditious manner. We also support the efforts of NRC and EPA to coordinate their respective decommissioning and cleanup criteria rulemaking proceedings. We emphasize the importance of this coordination and the need for consistent policies and criteria. We believe that proposed schedules and consistent approaches by both agencies can be achieved but, should there be a conflict, we strongly recommend that that consistency not be sacrificed at the expense of schedules.

Goal of Decommissioning

The definition of the goal for decommissioning begins with the following statement: "The Goal for decommissioning a site is to *reduce* the concentration of *each radionuclide* which could contribute to residual radioactivity at the site to a level which is indistinguishable from background" [emphasis added]. Many radionuclides present on nuclear facility sites are either not present or present in such low quantities in nature that determining whether this goal of "cleaning up to background levels" was achieved would be impossible to accomplish. Guidance on the implications of returning a site to near background conditions, can be found in a position statement of the Health Physics Society (HPS).[2]

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[2] Health Physics Society, "Return to Background," published in the February 1994 *Health Physics Society Newsletter* (HPS, 8000 Westpark Drive, Suite 130, McLean, VA 22101).

Level of Protection

NRC is proposing that licensees will be allowed to release a facility for unrestricted use if the residual radioactivity, exclusive of background, which includes fallout, would not cause a dose to the average individual in the most highly exposed group to exceed 15 mrem/yr. The goal of decommissioning is to reduce the residual radioactivity to "background levels" which is defined as below 3 mrem/yr exclusive of background.

Insufficient information was supplied to support selection of these limits. These values are low compared to other standards for protecting the general public. In particular, it is not clear in the proposed rule why the 25 mrem (0.25 mSv) limits used in NRC's 10 CFR Part 60 (high-level waste regulations), NRC's 10 CFR Part 61 (low-level waste disposal regulations and EPA's 40 CFR Part 190 (uranium fuel cycle regulations) did not receive more consideration and why the value of 15 mrem/year was selected.

The Commission's (and DOE's) dose limit for members of the general public is 100 millirem per year. NRC appears willing to allocate only 3-15 % of the limit to residual radionuclides. While we have not had an opportunity to review the analyses of risks and benefits that support this position, our data suggests that a dose limit of 25 or 30 mrem/yr (committed effective dose equivalent) might be a more suitable limit for decommissioning of land and buildings. A 30-mrem limit is a value for which compliance can be demonstrated, which may not be true for a 3 mrem "goal." Such a level would still be only 25-30% of the primary dose limit recommended by the International Committee on Radiation Protection (ICRP) and the National Committee on Radiation Protection (NCRP) and would provide an adequate margin to ensure that, even for multiple sources of exposure, the primary 100 mrem dose limit would be met. It would maintain risks to levels generally within the 10^{-4} to 10^{-6} risk range. In most instances, we believe, actual post-remedial action radiological conditions will be within or below the 3 to 15 mrem in a year range; however, from a practical point of view, a slightly broader range (up to 30 mrem) might be more readily implemented at a wider variety of sites without requiring "restricted use."

In establishing the goal concept for decommissioning [draft 10 CFR 20.1402 and 20.1404 (a)], it is important that the Commission ensure that the goal does not become the *de facto* limit. These values are low compared to the variation in natural background. For many radionuclides the environmental concentrations that could produce a 3 mrem dose are indistinguishable from background levels. A precise definition of background is difficult to make, and the radiation measurements involve inherent statistical variations. Variations in the natural background dose rate at a particular location can exceed 10 millirem per year due to variations in snow cover, rainfall, wind and other factors. A 3 millirem annual dose is equivalent to a 0.3 μrem per hour dose rate[3]. The natural background dose rate for external direct dose is typically 5.8 to 24 μrem/hour.[4] Thus even a 10% variation in the external dose rate from natural sources could mask the incremental 0.3 μrem per hour dose rate equivalent to the 3 mrem/year annual dose criterion.

The DOE staff believes that the Commission should address the following considerations in its selection of the dose criteria:

- The NRC analysis does not appear to consider the costs of demonstrating compliance with such a low risk level. While a painstaking survey might differentiate an incremental increase of 3 mrem/yr above background for a few gamma emitters, demonstration of compliance for most radionuclides will require laboratory analyses. This greatly increases the cost of demonstrating compliance. The NRC needs to address the costs of surveys and other actions that are necessary to demonstrate compliance and the relationship of these costs to very low cleanup limits when demonstrating the implementability of the proposed range for the criteria.

- The NRC staff draft states that environmental pathway models will be used to demonstrate compliance under certain circumstances. We recognize that such models are often the only way to demonstrate compliance, especially at extremely low dose rates. However, available comparative studies indicate disparities among model results. Further, most environmental models have not been verified or validated. Overly conservative model results may force great expenditures for remediation that may not actually be warranted to protect public health and the environment.

ALARA and Collective Dose

The rule would require that an ALARA determination be made to define the site criterion. This analysis would have to show that the criterion for a particular site did

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3 An annual dose rate of 3 millirem is equivalent to 3,000 microrem (3000 μrem). Dividing this by 8,766 (365.24 days/year x 24 hours per day) gives an hourly dose rate of 0.34 μrem per hour.

4 The dose from terrestrial radionuclides is typically 23 mrem/year for the Atlantic and Pacific coastal states, up to 90 millirem/year in the Rocky Mountain States and averages about 50 millirem per year elsewhere in the U.S. The cosmic ray contribution varies from 28 millirem per year at sea level to over 125 millirem per year at 3200 m. This gives external dose rates from 51 to 215 millirem per year. The corresponding hourly dose rates are 5.8 to 24 μrem/hour.

not exceed 15 mrem and that it was not practicable to get to 3 mrem. Such an application of ALARA overlooks the uncertainties inherent in ALARA analyses and environmental dose assessments in general. In most cases, site-to-site variations in some of the parameters used in the dose estimation process could produce variations in the estimated dose that would exceed a range of 3-15 mrem. Furthermore, the variation of background concentrations in the soil within a region could over shadow any benefit from remedial measures taken to meet these low dose goals. For example, a concentration for uranium that gives a 3 mrem/year dose might be 6 pCi/g given a conservative scenario. Background levels of radium in soil frequently range from 0.5 pCi/g to 2 pCi/g. Consider the case where a licensee identified uranium in soil at concentrations between 6 and 50 pCi/g (averaging 18 pCi/g) over a 1000 square meter area and that background levels in this area for radium-226 was 0.8 pCi/g (a common background concentration). Consistent with the requirements of the draft rule, the licensee removes all of the contaminated soil and replaces it with soil from another area that had concentrations of radium that average 1.3 pCi/g (also a commonly measured background). Under such a scenario, the net result of the action would be to increase the potential dose to the user of the site by between 0 and 4 mrem in a year.

The discussion of ALARA appears to be based solely on the dose to an individual and not on collective dose considerations. Although cost-effectiveness can be considered for individual doses, the type of ALARA analysis envisioned by the International Commission on Radiological Protection and used in the NRC's ALARA Design Objectives for Effluents from Nuclear Power Reactors (Appendix I to 10 CFR Part 50) are based upon tradeoffs between the health detriment cost and the cost of control and the monetary equivalence of other factors.

We suspect that for certain sites with low population exposure potential, an ALARA analysis based on collective dose and considering competing risks, might indicate that decontamination to the criteria proposed may not be justifiable. Without the supporting technical documents, it is difficult to evaluate this conclusion; however, based on the Department's experience, collective dose is an important risk management tool in the decision-making process.

Cost of Implementation

The NRC draft seems to suggest that there is little increase to implementation risks and costs up to and possibly below the 3 mrem in a year goal. This is not consistent with DOE experience. Although we have encountered situations (particularly at sites where contamination is concentrated and localized) where volumes, costs and implementation risks level off after some concentration (within the proposed criteria range), most examples do not. Worker and transportation risks, costs and waste volumes tend to increase significantly at lower cleanup criteria (see examples).

Costs (and times) related to radiological surveys are also dependent on cleanup criteria. Clearly while survey cost to demonstrate compliance generally increase with decreasing criteria, these costs are typically a fraction of remedial action costs. However, there is also a point at which the survey directly effects remedial action costs. When the criteria are sufficiently low that field surveys can no longer be used with confidence to demonstrate compliance, remedial action costs as well as survey costs can increase significantly. In these cases, laboratory analysis of samples are required to confirm compliance, hence, the time required to verify compliance increases. As a result, the remedial action is effected in one of two ways. The remedial action schedule is extended to ensure compliance (the contractor must hold excavated areas open (or at least maintain ready crews) to complete additional remediation until such time as there are sufficient data to ensure compliance, or the remedial action contractor will excavate extra material (hence increasing waste volumes and disposal costs) to provide an ample safety factor and ensure additional remedial action will not be needed after the data are analyzed. The NRC needs to address clearly the cost impact of reducing the ICRP and NCRP recommendations to these low dose limits, both in dollars and in additional exposures and health risks to workers, etc., with no realistic gain in benefits to the health of the public.

As previously noted, the Department's experience indicates that there is a clear correlation between waste volume and criteria and that the volume increases in an a non-linear manner, increasing much more rapidly at low concentrations. The Commission's analysis dose not appear to have identified this relationship or at least assumes that it does not exist in the range of the proposed criteria. Without access to the technical support documents it is not possible for the Department to identify the basis for this difference. We, however, suspect that the lack of correlation between residual criteria and waste volumes/decommissioning costs may be an artifact of assumptions used by the Commission in its analyses.

Need for Implementation Guidance

Guidance for implementing decommissioning criteria has not yet been made publicly available for review. Guidelines for performing dose assessments, could significantly affect the allowable radionuclides concentration levels and the associated cleanup costs. Several guidance documents are mentioned within the draft discussion; however, they do not appear to be available to be reviewed in conjunction with the proposed rule. Without such guidance, it is not possible to evaluate fully the feasibility and costs of implementing the proposed NRC criteria. In particular, the NRC staff's position regarding the nature and degree of inherent conservatism in the exposure scenarios is crucial to a full assessment of the NRC proposal.

Guidelines for performing dose assessments could significantly affect the translation of the dose criteria into radionuclide concentration levels and associated cleanup costs.

With these considerations in mind, the draft NRC regulatory guides and technical documents to support the implementation of these criteria should be made available for public comment sufficiently before issuance of the final rule that the public comments on the implementation guides could affect the nature of the final rule.

When calculating the Total Effective Dose Equivalent (TEDE) under draft 10 CFR 20.1403 (a), the maximum annual TEDE for the first 1000 years after decommissioning is required. A scenario may be site-specific within a generic model. Thus, modeling is crucial to the success of the approach but acceptable generic modeling isn't defined.

For us to accurately review the impact of the addition of these criteria, either guidance documents or additional information on the methods of measurements, modeling and analysis of data are needed. Specific areas where additional information would be useful are:

(1) methods for site-specific implementation of the criteria (p.27);

(2) guidance on how the As-Low-As-Reasonably-Achievable (ALARA) process will be applied (p. 29);

(3) guidance on acceptable measurements (i.e., measurement methods, extent of measurements, statistical sampling used, and calibrations applied);

(4) pathway, risk, and dose models acceptable to the NRC staff (pp.32 and 63-64);

(5) guidance on how to apply site-specific characteristics (p. 32); and

(6) guidance on acceptable methods that can be used to demonstrate that the concentrations of specific isotopes are indistinguishable from background (pages 45-46).

Probably more important than the actual protection level selected, from a practical standpoint, is the selection of radiation exposure scenarios. The major need in environmental restoration is definitive rationale for selection of exposure scenarios. In spite of numerous references made in the NRC staff draft to implementation guidance, which would include exposure scenario guides, no such guidance has been made available for review. Without knowledge of the content or regulatory approach in these exposure scenario and other guides, it is not possible to evaluate fully the NRC staff approach to decommissioning criteria. NRC should make every effort to provide such guidance on a timely basis prior to the issuance of the final rule.

Risk-Based Rules

DOE supports the NRC staff's selection of risk-based rules for decommissioning criteria. Although DOE recognizes that NRC should consider different regulatory approaches in this rulemaking, DOE continues to strongly support the risk-based approach. DOE believes that the advantages of the risk-based approach far outweigh any advantages of the other approaches. In particular, the risk-based approach provides flexibility in the remediation process which is important because of the great variety of contaminated sites and buildings. We also note that, in some cases, risks other than human health risks must be considered. We believe that the process proposed by NRC can be used to address these competiting risks.

Dose Assessment Methodology

In the past, exposure scenarios have been chosen that would lead to the greatest potential (and, in some cases, conceivable) risk to users or residents of a site. This approach leads to very low cleanup levels, to protect people under circumstances which are highly unlikely to occur. NRC has an opportunity in this rulemaking to develop realistic exposure scenarios. This contribution could significantly reduce costs of cleanup, while still assuring protection of public health and the environment. DOE believes this is one of the most important steps NRC could take in providing decommissioning criteria.

The NRC staff's selection of a "typical individual" in the critical population group as the means for implementing the radiological criteria for decommissioning is consistent with the approach advocated by the International Commission on Radiological Protection. The NRC staff provides a reasonable discussion whether the criteria should apply to the maximally exposed individual, to an average member of the most exposed group, or to some other entity. However, the NRC staff does not specify how the "typical individual" is to be identified or how exposure parameters are to be selected for members of the critical population group. More definitive guidance should be provided in the regulatory guides or technical reports accompanying the final rule.

Time Frame for Calculating Radiation Doses

A time frame of 1000 years is given for estimating future radiological impacts. Although we recognize that this time period might be inadequate to characterize the dose for a few very long-lived radionuclides[5], we also recognize the difficulty in trying

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[5] There are only a few long-lived radionuclides (uranium and thorium, for example) which will persist after a 1000 years and for which decay product ("daughter") ingrowth can produce increased doses with time.

to estimate demography and the condition of the environment beyond a few decades. We believe that very long-term risks from cleanup operations should not be calculated without also estimating the risks associated with the disposal option for a comparable period of time (i.e., how do we demonstrate that the removal and disposal operations do not create a greater risk somewhere else than they solve at the cleanup location?).

The Department supports the Commission's efforts to define a practical limit for the time period over which theoretical computations should be used in criteria selection and demonstration of compliance. For a few decades, perhaps up to a couple of hundred years, one can assume that the land use, demography and exposure pathways can be reasonably forecasted. Beyond that time, such forecasts become increasingly speculative as do any radiological impact assessments based upon them. The Department recommends that the Commission consider whether a single fixed 1,000-year cutoff will provide the Commission with sufficient flexibility to handle all types of decommissioning actions. We believe that alternative combinations of cleanup and disposal actions should be evaluated over a time period that provides usable and comparable results that can support the decision-making process[6]. In general we believe that, beyond this a few hundred years, the risk of the disposal alternatives and results of the calculations become increasingly uncertain. We recommend consideration of several time intervals as appropriate to the uncertainty in the site and disposal site related individual doses and collective doses and the nature of the radioactive materials, so that the effect of the evaluation time (with uncertainties) can be seen on the result of the analysis.

Finality in Decommissioning Standards

In Section 6 on Finality (page 22) and in proposed Section 20.1401 (c) (page 70), the commission expresses their belief that cleanup actions performed in accordance with the criteria of this rule should be considered final. Even if more prescriptive and stringent requirements are later codified, no additional cleanup actions would be required unless it can be demonstrated that, based on new information, the residual radioactivity remaining at the site could result in significant public or environmental harm. We strongly support this concept in the NRC rulemaking, as well as in the parallel EPA rulemaking on radiological cleanup standards.

Institutional Controls for Limited Use Situations

NRC has chosen, within the scope of this rulemaking, to include the release of land

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[6] Although the doses were computed for longer periods (>1000 years), the time period over which the accompanying DOE examples were evaluated was 200 years.

and buildings for restricted use, requiring the use of institutional controls to ensure protection of the public and the environment. The total costs of cleanup of land contaminated with radioactive materials are just now being appreciated. The likely consequence of these enormous costs is the additional use of institutional controls to provide protection of the public and the environment. DOE strongly supports the optional use of institutional controls.

The NRC should provide guidelines for selection of institutional controls. These guidelines should be based primarily on the effectiveness of institutional controls. An analysis of institutional control failures would provide a strong basis for institutional controls guidelines. Such an analysis would require innovative assessments and legal and societal solutions. DOE also encourages NRC to investigate the institutional control approaches that EPA has used under its National Contingency Plan rules, including the use of institutional controls in remediation actions.

Lack of Criteria for Recycle/Reuse of Materials

NRC proposes to consider separately the issues related to recycle or reuse of radioactively contaminated materials. This subject urgently needs to be addressed by the NRC in the context of these decommissioning regulations.

Criteria for Naturally-Occurring Radioactive Materials (NORM)

The NRC staff proposes to include NORM, along with other radionuclides, under the proposed risk goal. It is extremely difficult, if not possible, to distinguish the proposed exposure levels from background levels. Application of a 15 mrem/yr limit to radionuclides such as radium may be problematical due to high levels of naturally-occurring radionuclides.

DOE believes that it is essential for NRC to consider the applicability of these criteria to existing NORM sites that have been remediated and released for unrestricted use, many at great cost. DOE has remediated about 4500 vicinity properties and 20 sites under the Uranium Mill Tailings Remediation Action Program (UMTRAP), about 130 vicinity properties and 14 sites under the Formerly Utilized Sites Remedial Action Program (FUSRAP), and many other properties. EPA's Superfund program has remediated a number of NORM-contaminated sites. NRC should not ignore these facts when developing its criteria, and should address the applicability of their criteria to remediated sites that were contaminated with NORM and have been released for unrestricted use. Examples attached to these comments address remediation of naturally-occurring radionuclides for formerly-licensed sites. These examples provide some detail on the relationships between the cleanup criterion and the volume of material that would have to be removed (and, consquently, the cost of the cleanup).

Existing Guides and Rules for Decommissioning are not Adequately Discussed

DOE is concerned that NRC has inadequately considered the relationship between the proposed criteria and other environmental radiation protection standards. The NRC criteria will be used as Applicable or Relevant and Appropriate Requirements (ARAR) procedures at CERCLA sites, even for situations that the standards were not intended to apply to. The NRC staff should be consider that these criteria may have a more widespread use, such as CERCLA ARARs, than initially intended by the Commission.

Waste Volumes are not Adequately Considered

The NRC staff needs to consider the availability of disposal capacity for hazardous wastes produced in site cleanup, including mixed wastes. The nonlinearity of the relationship between the radioactive waste volume generated versus the radionuclide concentration limits also needs to be more adequately considered. The practical implication of this relationship is that potentially huge volumes of waste would be created due to criteria with very low levels of radionuclides concentrations. These wastes must be placed somewhere else. Although the cost of placing these large volumes of contaminated soils at various sites can be estimated, there are few places willing to accept these wastes for disposal. The lack of availability of disposal capacity further justifies detailed consideration of the benefits of moving great volumes of slightly contaminated soils from one location to another.

Site Specific Advisory Boards

The concept of a Site Specific Advisory Board (SSAB) should be useful in providing greater involvement of the local public in the decommissioning process and, hopefully, alleviate some of their concerns about this process and the residual hazard after decontamination and restoration. However, it would appear that the formation and operation of a SSAB after an initial decision to decommission a facility would be preferable to waiting until the licensee intends to meet the conditions in §20.1404. This would enable the SSAB to be involved at an earlier time in the process than the NRC proposal. In addition, more details need to be provided with regard to the implementation and decision-making responsibilities of these Advisory Boards (e.g., do very small remediation projects (I.e., a room or two in a facility) need a SSAB?

Specific Comments:

1. Page 31, 1st ¶ The NRC states that, for very heavily contaminated sites, there may be a need to maintain the license indefinitely until new and more efficient technologies and resources become available. Given this possibility, it is likely that some sites will never be remediated. In such situations, what are the responsibilities of the NRC and the licensee?

2. Page 69, 3rd ¶ - The definition of "residual radioactivity" (or more properly "residual radioactive materials") could be clarified. The last sentence in the definition seems to say that residual radioactivity includes material which has been discharged from the site. Does activity outside the site boundary constitute a regulatory problem that must be addressed as part of site decommissioning?

3. Page 70, Section 20.1401 (c) - On what basis could the Commission "require additional cleanup" if the license has been terminated, (i.e., what legal authority would the Commission have over the former licensee?)

4. Page 70, Section 20.1401 (c) - Requiring additional cleanup based on new information that could result in "significant" harm should be further defined. "Significant" should also be defined.

5. Page 70, Section 20.1402 - It would be helpful if the regulation were clear on the criteria for identification of the "critical group" are.

6. Page 72, Section 20.1403 (a) - NRC indicates that calculations for the greatest annual Total Effective Dose Equivalent (TEDE) are required to be validated to the maximum extent practicalusing actual measurements. This statement is confusing. Requiring actual measurements that are to be taken at times that can be hundreds of years in the future would seem to be impractical at the outset. For example, the groundwater pathway for uranium would require sampling several hundred years in the future.

7. Page 72, Section 20.1404 (a) (2) - In this paragraph the term "average member of the critical group" is first used. The term "average member" needs to be defined. The definition of "critical group" is presented in the definitions portion of the document. Although this term is used in ICRP Publication No. 7, there has not been much guidance on selecting this critical group. More specific guidance for developing assessments in this area is needed. (See Specific Comment # 5)

8. Page 72, item(c) - Given the requirement that all readily-removable residual activity be shipped from the site or disposed of at the site, what are the

requirements for the storage/removal of any remaining wastes resulting from the decontamination and decommissioning? If there are no disposal facilities available for receiving these wastes, and extended on-site storage becomes necessary, will there be guidelines for on-site storage?

COMPARISON OF DERIVED STANDARDS AT DOE FACILITIES.

The following comparisons were made to explain the basis for derived standards applied to specific cleanups and are intended to provide examples of the impacts of cleanup criteria on waste volume, costs and dose/risk avoided. They also demonstrate the importance of collective dose as a decision-making tool. Given the time requirements, only information on sites for which data were readily available has been provided. Additional data for other sites will be discussed in supplemental information that will be provided in the future. Also, DOE is completing a more thorough review of the attached material to ensure that the analyses are based on the most recent data.

- **Colonie, NY**

Site:

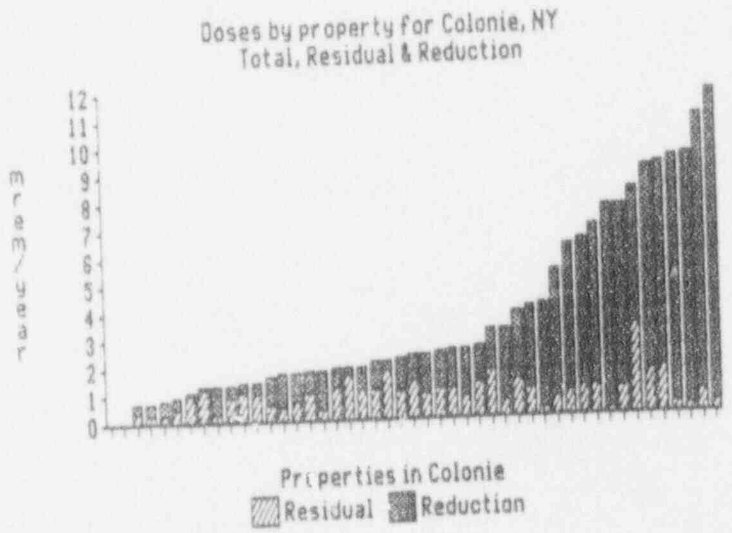
This site was a formerly (State and NRC) licensed facility that processed uranium largely for DOD use. The facility operated for period of several years without a functional gaseous radwaste treatment system. The State ultimately closed the facility and Congress directed the Department to remediate the plant and residential properties around the plant. Vicinity properties have been remediated. Remedial activities for the Colonie site area are currently underway and include the development of an engineering evaluation, cost assessment, and environmental documentation to support the selection of the preferred remedial alternative. This discussion deals primarily with the vicinity properties that were remediated in the late 1980's.

Basis for Standard:

The cleanup standard or authorized limit being used for cleanups at Colonie, NY, is 35 pCi/g for depleted uranium (U-238). This standard was derived in the early to mid-1980's using a process similar but different from that contained in DOE 5400.5 (1990). DOE conducted dose assessments that assume a residential farmer scenario (a resident gets a significant fraction of food supplied from a home garden) and determined that a 120 pCi/g concentration of depleted uranium could result in a dose of 100 mrem in a year. Based on a cost evaluation and through meetings with NY State and EPA officials, it was determined that 35 pCi/g was an appropriate ALARA-based limit. At the time of the cost analysis, only 12 properties were known to be contaminated and the incremental cost between 35 pCi/g and other alternatives was on the order of a few thousand dollars per property, hence the costs were considered to be insignificant. The supporting analysis was qualitative and included no systematic assessment of collective dose or waste volume-cost relationships. The standard ensured that maximum doses to residents would be less than about 25 mrem in a year, assuming that the contamination was uniformly over the property. For the most part, actual contamination was concentrated in areas such as near drain spouts, drip lines, or run-off areas from the pavement. Localized concentrations in these small areas exceeded 100 pCi/g. Many of the over 50 properties which were cleaned had only spotty contamination.

Results:

The final cleanup reduced maximum uranium concentrations on the properties to levels between 1.5 and 24 pCi/g. Post-remedial action dose assessments, conducted on the first 47 properties, indicated that the average maximum dose was 1 mrem in a year (an average of the doses to the maximally exposed individual from each of the properties evaluated). The maximum dose for any single property was 3.3 mrem in a year. This dose is less than 15% of the dose used to select the authorized limits for uranium at this site[1]. *[These dose estimates are generally conservative in that they are calculated assuming that the dose over the entire time period was equivalent to the dose at the time of maximum dose rate and assuming that a significant portion of the resident's diet is obtained from home gardening when, in fact, the food assumed to be grown grown may exceed the quantity that can be produced on the lots. (Although locally grown food is a minor contributor to dose, assuming a reasonably conservative mass loading factor for inhalation (a major contributor to dose), it likely over estimated dose. Further, the residential scenario for all dose estimates was assumed, despite the fact that some properties were commercial or open areas. Doses from U-234 were not estimated; however, the site was contaminated with depleted uranium, which is primarily U-238, and the contribution of the U-234 to the dose is expected to be low. Similarly, Ra-226 will eventually result be present from ingrowth but, over the 1000 year period evaluated, the contribution to dose is insignificant.]*



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[1] This is not an uncommon situation - i.e., due to the field application of the ALARA principles and the precautions taken to account for uncertainties in field radio-analytical methods and excavation techniques, post-remedial levels actually achieved routinely surpass the authorized limit. However, this decrease cannot be predicted in advance and efforts to lower pre-remedial action limits to account for this phenomenon will likely cause significant increases in waste volume, costs and impact schedules.

The attached figure shows the pre-remedial action doses, the post-remedial action doses, and the dose reduction resulting from the remedial action. The comparison is summarized in the following table.

SUMMARY OF DOSE, COLLECTIVE DOSE, AND RISK AVERTED

	Pre-Cleanup	Post-Clean	Reduction (Risk or Dose Averted)	
Individual				
Average Dose	4.2 mrem/y	1.0 mrem/y	3.2 mrem/y	
Annual Risk (cancer)	2 in 1,000,000	5 in 10,000,000	2 in 1,000,000	
Lifetime Risk (30 yrs exposure)	6 in 100,000	1 in 100,000	5 in 100,000	
Collective Integration time	person-rem	person-rem	person-rem	Cancers Averted
Annual	0.2	0.05	0.2	0.00008
50 year period	10	2	8	0.004
200 year period	40	10	30	0.02

It is of interest to note that the pre-remedial action doses for these properties ranged from about 1 mrem to 15 mrem per year. In other words, although the generic dose assessment used to develop the standard assumed that the potential dose on the contaminated properties could be as high as 25 mrem in a year, given the actual use of the properties, the actual distribution of radionuclides, and site-specific parameters, none of the 47 properties studied were likely to approach that dose even prior to remedial action[2]

Annual individual risk of cancer, given residential use of the property, was reduced from $2x10^{-6}$ to $5x10^{-7}$. Assuming individuals spend 30 years at a property (EPA data suggests

[2] Conservative assumptions routinely result in over-estimates of dose. Generic modelling conducted (in the early 1980's) to develop dose-based authorized limits for remediation of this site produced doses that were greater than those that were more firmly based on site-specific data.

that most individuals spend on average 7 years at a given property and 95% of the population spends less than 30 years at a given property) the lifetime incremental risk of fatal cancer was reduced from $6x10^{5}$ to $1x10^{5}$ (6 in 100,000 to 1 in 100,000).

Assuming an average of 4 persons per household, collective doses for pre-remedial action conditions, post-remedial action conditions and collective dose avoided by the action were estimated for 1 year, 50 years and 200 years and are presented in the summary table. The estimated collective dose avoided over the 200 year period was 30 person-rem. At a cost of about $200,000 for vicinity property cleanup, this equates to about $6,700 per person rem avoided. The total number of health effects avoided, over a 200 year period, by these remedial actions was 0.02 (this is effectively no cancers). The estimated cost per health effect averted for the project is about $10,000,000.

- **Elza Gate Site, TN**

Site:

This site was a former storage site for waste and contaminated material. It was remediated to standards in effect in the 1970's. The property is now an industrial park that includes about 20 acres. The primary radionuclides of concern are Ra-226, Th-230, and uranium. The criteria for Ra-226 and Th-230 was 5 pCi/g for the top 15-cm layer of soil and 15 pCi/g in subsequent 15-cm layers. A standard for uranium was derived under Order DOE 5400.5.

Basis for Uranium Standard:

The authorize limits for cleanup at Elza Gate was 35 pCi/g for U-238 and 5 pCi/g surface and 15 pci/g subsurface for the combined activities of radium and thorium isotopes. The uranium standard was developed independent of the radium standard[3]. A dose assessment was completed for several scenarios and a uranium concentration that would meet a dose limit of 100 mrem in a year were calculated for each:

- Industrial use (current & likely use) - 1800 pCi/g (Uranium)
(if used as an indicator for measurement) 880 pCi/g (U-238)

- Recreational use - 4000 pCi/g (Uranium)
(U-238 as indicator) 2000 pCi/g (U-238)

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[3] The radium/thorium and uranium standards are not truly independent of each other. Selection of a lower or higher radium standard, for example, could impact the residual uranium levels and vice versa. In many cases, the standard development process deals with all radionuclides at once. However, because radium is treated separately in DOE standards (i.e., as low as reasonably achievable below the concentration limit) and all other radionuclides are dose-based (plus ALARA requirements), development is typically done separately and dose analyses integrate the doses later.

♦ Residential use[1] (worst-case use - 470 pCi/g (Uranium)
(U-238 as indicator) 230 pCi/g (U-238)

An analysis of the relationship of the authorized limit (soil concentration of U-238) to volume of waste (a surrogate for cost) was completed (see attached figure). The analysis indicated that costs began to increase dramatically between concentrations of 30 and 40 pCi/g U-238. Given that the estimated individual dose in this concentration range for the likely use of the site was about 4 mrem in a year which, as recommended by DOE guidance, was well below the 100 mrem in a year dose limit for all sources, and the worst-case future use scenario dose was about 15 mrem in a year, a cleanup standard of 35 pCi/g was selected for U-238 (about 70 pCi/g total uranium).

Results:

Pre- and post-remedial action concentrations (in pCi/g) were:

PRE-REMEDIAL ACTION CONCENTRATIONS

Radionuclide	Measured Average	Average Backgnd	Average Net
U-238*	146	1.0	145
Ra-226	8.9	1.3	7.6
Th-232	1.9	1.5	N/A
Th-230	59	1.0	58

POST-REMEDIAL ACTION CONCENTRATIONS

Radionuclide	Measured Average	Average Backgnd	Average Net
U-238*	5.9	1.0	4.9
Ra-226	1.0	1.3	N/A
Th-232	1.3	1.5	N/A
Th-230	2.5	1.0	1.5

* U-235 and U-234 were estimated on the basis of U-238 concentrations.

[1] Another residential scenario that was evaluated was rejected because the groundwater pathway was inappropriate [i.e. inappropriate assumptions and parameters]. Even for the residential scenario results that were reported here, unrealistic assumptions were used for water use: it was assumed that an on-site pond provided drinking water and irrigation water despite the fact that the site is adjacent to a river and has a relatively steep slope.

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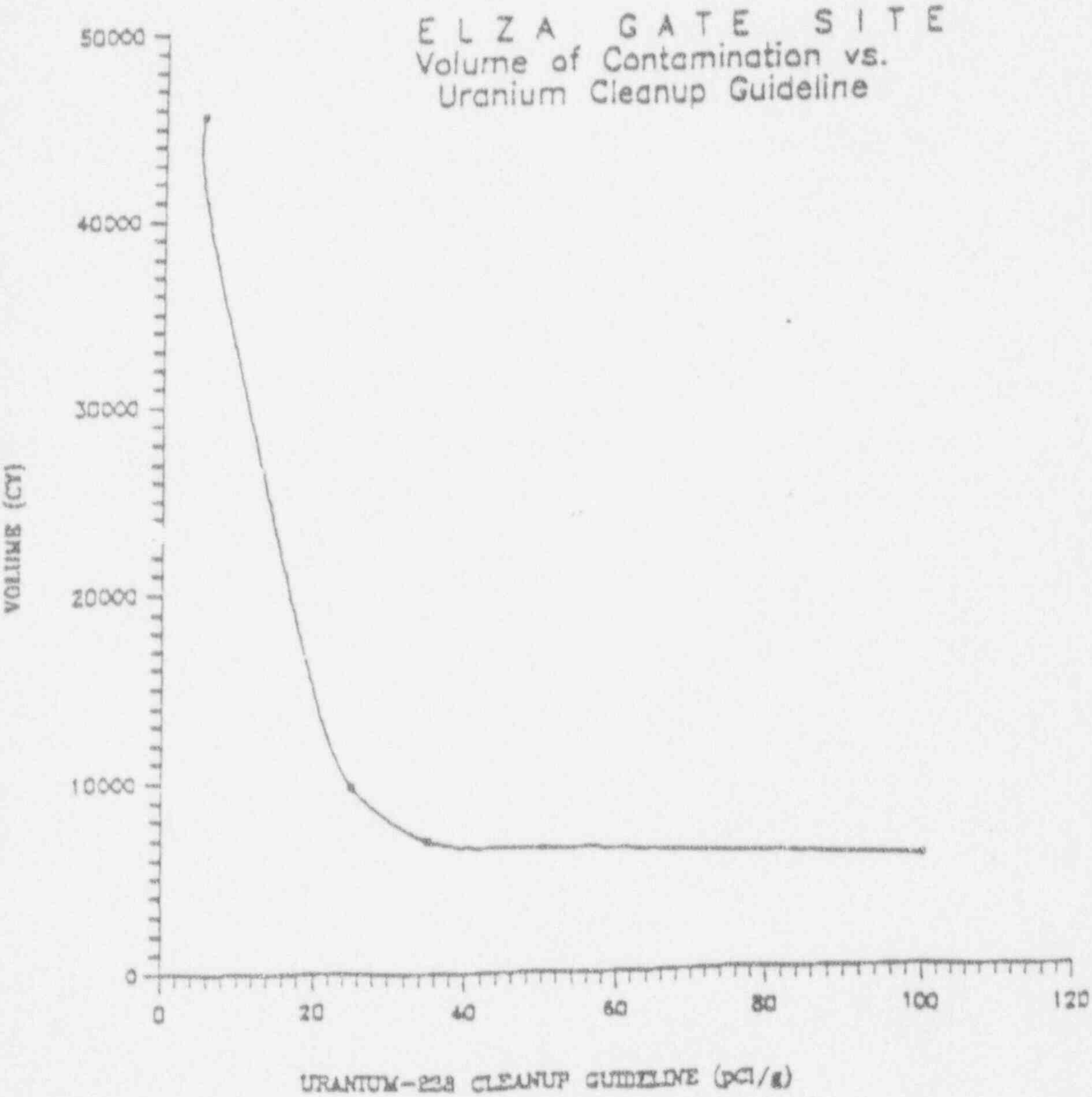

ELZA GATE SITE
Volume of Contamination vs.
Uranium Cleanup Guideline
50000
40000
30000
20000
10000
0
VOLUME (CY)
0
20
40
60
80
100
120
URANIUM-238 CLEANUP GUIDELINE (pCi/g)

Post-remedial action doses were estimated for use of the site using the net average residual concentrations of the above radionuclides and estimating U-234 and U-235 (and decay products) as a standard ratio to U-238. For the likely use of the site (industrial use) the maximum individual dose was estimated to be 1.5 mrem in a year (less than 40% of the modeled dose[5]). Potential doses for recreational use of the property was estimated at less than 1 mrem in a year and the worst-case use dose for the resident farmer scenario (using an onsite pond for drinking water and irrigation[6]) was estimated to be about 12 mrem in a year. Individual risk under the likely use of the property (industrial) is estimated to be about $7.5x10^{-7}$ annually and $2x10^{-5}$ (2 in 100,000) for lifetime risk assuming a worker spends 25 years at the site. Use under the residential-farmer scenario (worst case) would suggest potential lifetime risks on the order of $2x10^{-4}$ (2 in 10,000).

Assuming a 20 acre industrial site could maintain a work force of 150 persons, the collective dose and estimated number of associate cancers for 1, 25, 50, and 200 years for continued use of the site under pre- and post remedial action conditions was estimated and are presented in the following table:

INDUSTRIAL SCENARIO ANALYSIS

Years Integrated	Collective Dose (person-rem)	Estimated Cancers (fatal)
Pre-remedial Action		
1	11	0.006
25	290	0.2
50	590	0.3
200	2340	1.2

Years Integrated	Collective Dose (person-rem)	Estimated Cancers (fatal)	Collective Dose Averted (person-rem)	Cancers Averted
Post-remedial Action				
1	0.2	0.0001	11	0.006
25	5	0.003	285	0.2
50	10	0.006	580	0.3
200	40	0.02	2300	1.2

5 Due to in-field ALARA applications and the uncertainties in radio-analytical methods and excavation techniques, post-remedial levels achieved routinely surpass the authorized limit for a site. However, because this reduction is highly dependent on field conditions, it cannot be predicted and pre-remedial action designation of this reduction as a specific goal would be likely to significantly increase volumes of waste.

6 Extremely unlikely assumption due to slope and proximity to river.

Based on current use of the site (industrial/commercial), and assuming pre-remedial action radiological conditions, dose to the reasonable maximum exposed individual at the site was estimated to be about 78 mrem in a year. An individual working at the facility and receiving this dose for 25 years would incur a potential incremental lifetime individual risk of about 1 in 1000 (about $1x10^{-3}$). It is highly unlikely that any individual would receive this dose for 25 years. Similarly, it is highly unlikely, if not impossible, that a large number of the employees would be exposed to this dose; however, for the purposes of assessing collective dose, it was assumed that all 150 workers were exposed to this dose.

The total cost of this remedial action was about $5,000,000. The cost per person-rem averted for this project is $2200 for 200 years of operation and $18,000 for the 25-year period. This equates to about $4,200,000 per potential cancer averted over the 200 year integration period. This excludes risks associated with worker dose and fatal accidents. However, there were no fatal accidents on this project.

Based on our assessment of this remedial action, residual radioactive material was reduced such that the site, under likely use, surpassed (was less than) the proposed NRC goal of 3 mrem in a year. Doses under the residential scenario (worst-case) were greater than the goal but about equal to the limit. However, to illustrate the relationship between dose criteria and cost/benefit, consider the following figure which shows waste volume to concentration relationships. It is apparent that increasing the uranium limit from 35 to 80 pCi/g would have decreased waste volume by less than 10% and, hence, would result in little cost savings. However, decreasing the authorized limit from 35 to 20 pCi/g would produce a 2.4 increase in volume of the waste and a corresponding increase in costs. The collective dose reduction for this additional remedial action would be on the order of 17 person-rems over 200 years. This incremental action would result in a cost per unit of collective dose avoided on the order of $400,000 per person-rem (about $800,000,000 per cancer averted) compared to $2,200 per person-rem for the entire project using the standard actually selected.

- **Ventron, MA**

Standard Approved: 100 pCi/g total uranium (about 48 pCi/g U-238 and U-234, and 4 pCi/g U-235)

Site:

The former Metal Hydrides site in Beverly, MA, processed uranium compounds and scrap to produce uranium for the MED and AEC. Operations contaminated portions of the buildings and grounds onsite plus some of the properties around the site.

The site is presently used for industrial applications and is owned and operated by Notron International. It is about 3 acres in size.

Basis for Standard:

The authorized limit for cleanup of this site was developed consistent with DOE 5400.5 requirements and guidelines. An assessment of potential doses was completed for industrial use, recreational use, and the resident farmer scenario. The analysis indicated that the 100 mrem in a year dose limit would not be exceeded if total uranium concentrations were less than 1800 pCi/g, 3100 pCi/g, and 480 pCi/g for the industrial, recreational, and farmer scenarios, respectively.

To select an authorized limit that was as far below the derived 100 mrem in a year equivalent concentration guideline values as is reasonably achievable, an analysis was performed of the relationship between concentration and waste volume (a surrogate for cost) was performed. This analysis indicated that waste volumes (and costs) were generally constant to about 60 pCi/g of U-238 (120 pCi/g total uranium). On this basis, an authorized limit of 100 pCi/g total uranium was approved. This limit would ensure that doses under the expected use of the property would be less than 5.5 mrem in a year to the most exposed individual. Lifetime risk of a fatal cancer for a worker continuously exposed (for 25 years) to this dose would be about $7x10^{-5}$ (7 in 100,000). If the site were to continue to be operated as an industrial facility, residual collective dose would be less than 0.2 person-rem per year or about 8 person-rem and 33 person-rem integrated over 50 and 200 years respectively. This assumes that the facility employed 30 persons for the entire integration period and all persons receive the 5.5 mrem/year estimated for the maximally exposed individual. Assuming a linear no-threshold relationship between dose and health effects, the residual radioactive material on site after the cleanup would result in a potential 0.02 fatal cancers over 200 years of operation. However, it is expected that post-remedial action concentrations of uranium will be below the approved authorized limit and hence, potential doses and associated risks will be lower as well.

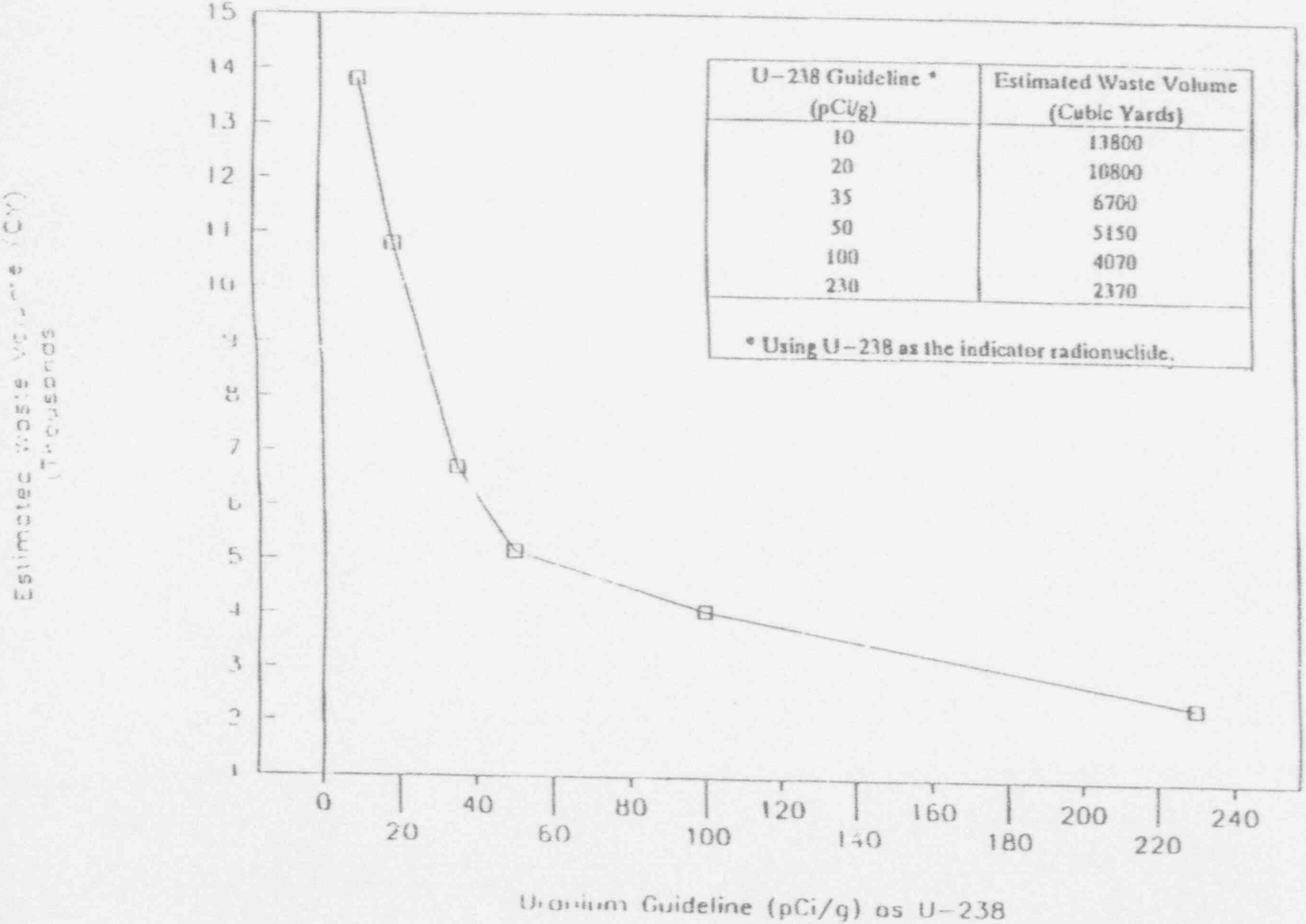
In the unlikely event that the site is used in a manner similar to the conditions set forth for the resident-farmer scenario[7] the maximum dose would be less than 21 mrem in a year. This represents a $3x10^{-4}$ lifetime risk of cancer. Continuous exposure to such a dose (assuming the site could support 6 persons under the resident-farmer scenario) would produce a maximum collective dose of 0.1 person-rems/year or an integrated dose of about 25 person-rems over 200 years. Assuming the linear relationship between collective dose and health effects, 0.01 cancers over 200 years may be calculated.

A more likely potential use for the site is a condominium complex, which is not unusual for this type of property in this region. Given a 3 acre lot, assuming a maximum of

[7] This is a good example of unrealistic and conservative exposure scenarios and assumptions used in many guidelines development efforts. The Ventron Site is a small 3 acre site in a heavily developed area that directly abuts Massachusetts Bay (actually the mouth of the Danvers River) on 2 sides. The resident-farmer scenario was still evaluated assuming 100% of the milk/meat/fish and 50% of the produce was produced on site. These are extremely conservative assumptions.

Guideline VS. Estimated Waste Volume

for the Ventron Site, Beverly, MA



U-238 Guideline * (pCi/g)	Estimated Waste Volume (Cubic Yards)
10	13800
20	10800
35	6700
50	5150
100	4070
230	2370

* Using U-238 as the indicator radionuclide.

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about 15 dwellings per acre and 4 residents per unit; the area could house a maximum of about 180 individuals. A reasonably conservative dose assessment indicates that the maximum dose to individuals living on the first floor of a condominium would be about 9 mrem/year (individual lifetime risk about 1.5 in 10,000) and for higher floors about 1.5 mrem/year (individual risk of about 1.5 in 100,000) assuming the 3 acres were uniformly contaminated to 100 pCi/g total uranium (a very conservative assumption as average concentrations following cleanup are normally many times less than the standard). The annual collective dose would be 0.07 person-rem which integrated over a 200 year period would be less than 11 person-rem (hypothetical 0.06 fatal cancers in 200 years).

The summary of collective doses from the various scenarios is reported in the following table.

VENTRON EXPOSURE SCENARIO COLLECTIVE DOSE ANALYSES

Years	Collective Dose (person-rem)	Total Cancers
	Industrial Use Scenario	
25	4	0.002
200	33	0.02
	Residential Use Scenario	
25	3	0.002
200	25	0.01
	Condominium Complex	
25	18	0.009
200	144	0.07

This remedial action has not been completed; however, preliminary engineering estimates at the proposed uranium criteria indicate the cost of the project will be on the order of $20,000,000. This cost includes building remedial action and renovation as well as soil cleanup. As noted above, it is anticipated that residual levels of uranium at the site will be below those used in the dose assessments reported above and hence, the actual potential doses and associated risks will also be lower.

The two likely use scenarios (Condominium and Industrial) evaluated are expected to result in doses that are less than the NRC proposed dose limit. However, if the residential-farmer scenario were used, the action would not comply with the 15 mrem in a year limit. If additional remedial measures were implemented to reduce the potential dose for the residential scenario from 21 to 15 mrem in a year, the uranium criteria of 100 pCi/g (48 pCi/g U-238) would be reduced to about 70 pCi/g (35 pCi/g U-238). This would increase the expected waste volume by about 1550 cubic yards (see attached figure). This would incur an additional cost of about $530,000 for waste disposal and transportation (assuming $220/cu.yd. for disposal and $120/cu.yd. for transportation). This would equate to a 10, 7 and 42 person-rem reduction and a cost per person-rem avoided of $53,000, $76,000, and $12,000 for the industrial, residential-farmer and condominium scenarios respectively (over the 200 year integration period). This is equivalent to a cost per cancer avoided of between $27,000,000 and $130,000,000.

- **Weldon Spring Site, MO**

Standard Approved:

Ra-226, Ra-228, Th-230, Th-232, and daughters in soil (0-60 cm)---5 pCi/g.
U-238 (natural U) in soil---30 pCi/g

Site:

This 226 acre AEC-site (now DOE) was originally part of 17,000 acres of land acquired by the US Army to construct an ordinance works. Uranium and thorium ore concentrates were processed from 1957 to 1966. Many buildings were constructed to house the processing equipment. Waste streams, including raffinates from the refinery and washed slag from the U recovery process, were piped to the raffinate pits and the decanted liquids were drained through sewers to the Missouri River via a 2.4 km natural drainage channel. The site contamination is extremely non-homogeneous, with a few highly concentrated areas which extend to a depth of a few 10s of centimeters and the bulk of the soil area relatively lightly contaminated on the surface only. The sludge, which is in four raffinate pits and two ponds, is highly contaminated but confined. Contaminated surface water runoff is contained in a quarry. The estimated volume of contaminated media is presented in the following Table:

VOLUME OF CONTAMINATED MEDIA.

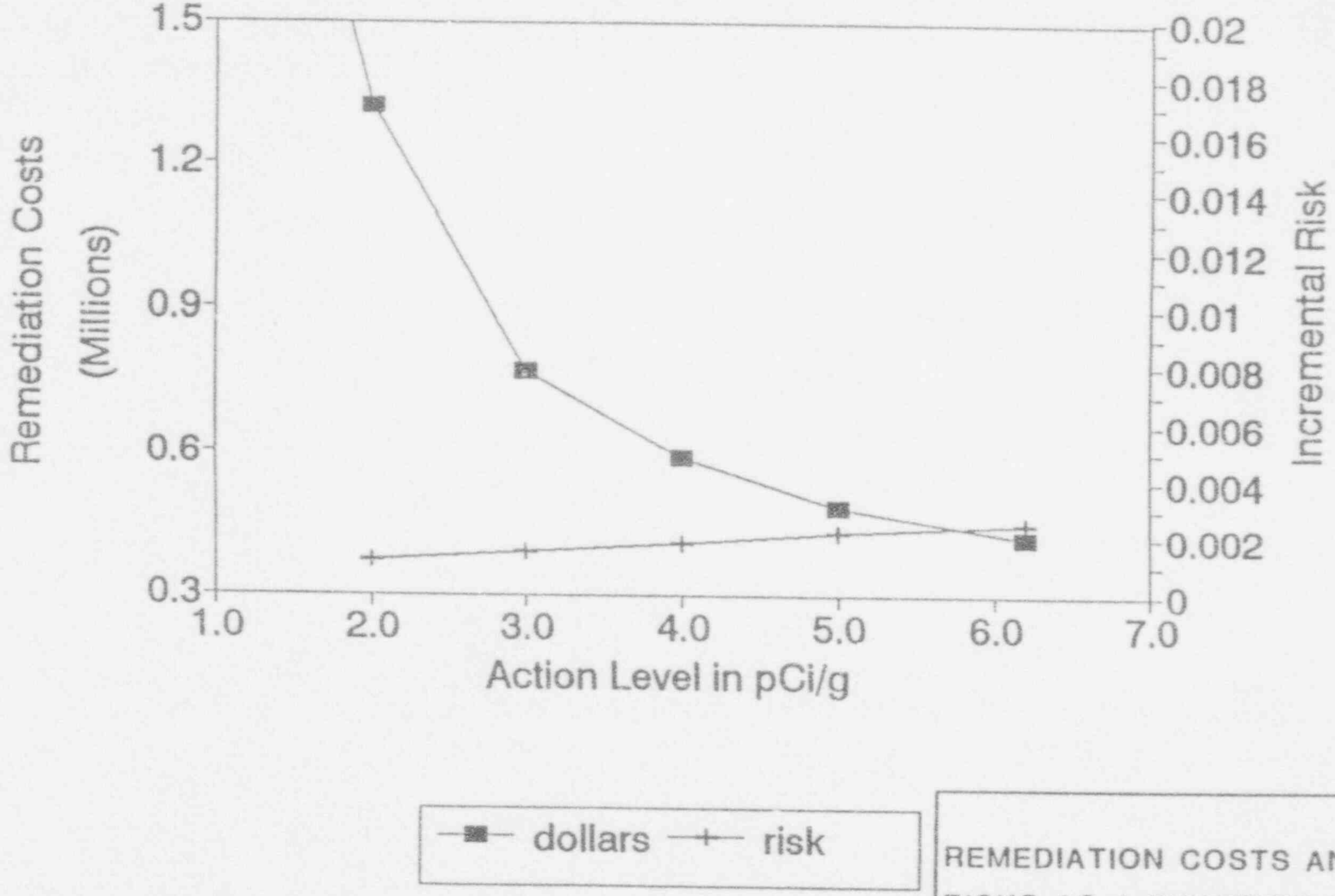
Media	Volume (yd^3)
Sludge	220,000
Sediment	119,800
Soil	339,000
Structural material	169,600
Process chemicals	3,960
Vegetation	30,650
	883,000

Basis for Standard:

The site is being cleaned in compliance with CERCLA and NEPA. The standard was derived in 1991, using a site-specific process similar to that required by Order DOE 5400.5. Contaminated debris from buildings and equipment constitute the bulk of the volume (and cost) to be disposed and the soil, regardless of the level selected, will comprise a relatively small fraction of the total. When the contamination is highly concentrated in the hot-spots, there is relatively little difference in the volume of soil which must be removed to reduce the residual to a small fraction of the initial concentration. Hence, relatively more restrictive cleanup standards could be justified in this case through ALARA considerations. Nevertheless, the lifetime risks could not be reduced to the EPA "target" range of 10^{-6} to 10^{-4}, due to exposures to radon. A dose limit of 25 mrem/y, which EPA has used for several source-specific regulations including management of U and Th by-product material, was also considered, but could not be achieved for the residential site-specific scenario in all site locations. Cleanup targets for radium and thorium (Ra-226, Ra-228, Th-230, and Th-232 concentrations in surface soil of 6.2 pCi/g (background is 1.2 pCi/g) and 16.2 pCi/g in subsurface soil were considered. An ALARA goal of 5 pCi/g was selected for all depths, including background, because it is the lowest concentration that can be reasonably achieved without excavating significant quantities of clean soils and without incurring costs that are disproportionally high for the corresponding risk reduction (see the following Figure). The cost for excavation and disposal of soil is $55/yd^3. The EPA acceptable indoor radon level of 4 pCi/L was considered. The average U-238 concentration in soil is 190 pCi/g. The calculated annual dose to a farmer in the ash pond area is 42 mrem/y, which represents a risk of 3×10^{-5}/y. Doses were calculated for concentrations in soil of 120, 60, 30, and 15 pCi/g for U-238. Removal of contaminated soil and backfill with clean soil would reduce and delay the dose after remediation due to shielding and erosion. The following Table indicates the variation of dose with concentration and cost for a range of U-238 concentrations in soil. For uranium, a soil cleanup target of 120 pCi/g without backfill (which would yield a calculated dose of 25 mrem/y) was selected, with an ALARA goal of 30 pCi/g.

RELATIONSHIP OF TARGET U-238 CONCENTRATIONS IN SOIL TO COST AND DOSE

Concentration pCi U-238/g	Volume yd^3	Backfill ft.	Cost $M	Annual Dose mrem/y
120	--	0.5	--	20 @ 400 y
120	11,000	0	0.58	25 @ present
60	26,000	1.0	1.4	6.7 @ 800 y
30	--	2.0	--	1.5 @ 10,000 y
30	37,000	0	2.0	6.7 @ present
15	50,000	2.0	3.0	0.38 @ 10,000 y



WELDON SPRING, MO

REMEDIATION COSTS AND INCREMENTAL RISKS AS A FUNCTION OF ACTION LEVEL

REPORT NO:	DOE/OR/21548-247		EXHIBIT NO:	A/PI/256/1291	
ORIGINATOR: DH		DRAWN BY: SRS		DATE: 12/91	

Results:

The primary cleanup effort to date has been directed toward remediating buildings and equipment, which will be the major cost item. A water treatment facility is planned for decontaminating the water from the quarry prior to disposal in the river. The site is adjacent to a large recreation area and that is the most likely use for the property after remediation. The potential doses to persons who may use the site for a variety of purposes, including rangers, visitors, recreational, residential, farming, etc., were estimated. It is anticipated that the ALARA goals for concentrations in soil will be achieved. The incremental radiological risk to a resident would range from 0 to 6×10^{-3} with a median of 8×10^{-6} across the site. Background for radium in soil is 1.2 pCi/g and a small increment of 0.075 pCi/g corresponds to a risk of 1×10^{-4}. This reflects the difficulty in achieving either the target risk range or annual dose limit of 25 mrem for residential scenarios for the areas of high contamination. However, the EPA acceptable indoor radon level of 4 pCi/L is likely to be met at all site locations. Dose projections for the site have focused on individual doses at various locations and times and not on collective doses to the population. State and EPA personnel have been involved with the proposed site cleanup plan.

- **Maywood, NJ**

Site:

This site includes a former thorium processing facility and properties in the vicinity that contain residual radioactive material from the operation and the facility. Thorium and rare earth ores, primarily for commercial uses, were processed at the facility. Many of the most contaminated properties have been remediated. This discussion addresses remedial action at the remainder of the vicinity properties and the site proper. Details on previous vicinity property cleanup is contained in the DOE certification docket for the Maywood remedial actions.

The primary contaminant of concern is Th-232. Radionuclides present in lesser amounts include U-238, U-234 and Ra-226. The site is located in an industrial area and the vicinity properties include primarily neighboring residences. The site is being remediated by DOE and it is on the CERCLA national priority list (NPL).

Basis for Standards:

The cleanup criteria being used for the remedial action is the DOE 5400.5 guidelines for radium and thorium. That is, to reduce the concentrations to levels to, or below, 5 pCi/g for the first 15 cm depth of soil (surface) and 15 pCi/g for subsequent layers (subsurface) including application of the ALARA process. The project is in the feasibility study phase and the Department is working with EPA to develop the final remediation goals. The following table provides project costs and individual and collective doses integrated over 200 year associated with no action and various cleanup goals (all of the alternatives except no action assume that post-remedial action concentrations on the soil surface total 5 pCi/g with the ratio of Th-232 and progeny concentrations being 4 times the concentration of Ra-226 and its progeny).

On the basis of these data, cost per dose and cost per cancer averted can be estimated. Decontamination of these properties to 30 pCi/g will reduce collective doses by 11,000 person-rems at a cost of $61,000,000. The incremental reduction to 15 pCi/g will avert an additional 440 person-rem and cost an additional $61,000,000. Remediating to 5 pCi/g will avert an additional 280 person-rem and cost from $30,000,000 to $120,000,000[8] additional. The incremental cost per person-rem avoided under each alternative cleanup level are $5,500, $140,000 and $110,000 to $430,000 for the 30 pCi/g, 15 pCi/g and 5 pCi/g cleanup alternatives, respectively. This equates to about $9,000,000 per cancer avoided at the 30 pCi/g level, $230,000,000 per cancer averted for the 30 to 15 pCi/g

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[8] The cost of the 5 pCi/g alternative is uncertain because measurement on these radionuclides is sufficiently near to background that the actual volume of waste to be removed cannot be adequately defined with normal survey data.

increment, and between $180,000,000 and $270,000,000 per cancer avoided for the 15 to 5 pCi/g increment .

PREDICTED COSTS, RADIATION DOSES AND COLLECTIVE DOSES FOR VARIOUS CRITERIA

Alternative Remedial Action Criteria	Total Project Cost ($ Million[9])	Residual Dose to Exposed Individual (mrem/yr)	Residual Collective Dose (person-rem) for 200 years[10]	Remediation Worker Collective Dose (person-rem) for 200 years
No Action	$ 16	12 - 2800	12,000	
30 pCi/g	$ 77	3.6 (Res[11]) 8.2 (Com[12])	880	18
15 pCi/g	$ 138	1.8 (Res) 4.1 (Com)	440	24
5 pCi/g	$ 168 to 258	0.6 (Res) 1.4 (Com)	160	30

As in the other examples, risks associated with the remedial actions have not been taken into account in these analyses. The table above lists the estimates for collective dose to workers due to the remedial action and is used as a basis for the risk estimates in the following table of "Related Remediation Risks." The following table also presents the risks of fatal accidents for remedial workers and due to transport of the waste as well as the risk averted in the analysis above. The worker and transportation related risk are

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[9] Detailed Cost analysis is presented in the Feasibility Study for No Action alternative and Phased Action with 15 pCi/g subsurface criterion. The costs for 30 pCi/g and 5 pCi/g alternatives were scaled with the estimated change in waste volume. The waste volume for the 30 pCi/g criterion was estimated to be 56% of the waste from the 15 pCi/g alternative. The 5 pCi/g alternative was estimated to increase waste volume by 20 to 80%. The No Action alternative assumes continued environmental monitoring ($480,000 per year) and 5 year remedy reviews ($200,000 each) for 30 years.

[10] An integration period of 200 years is assumed in the estimates of collective dose from exposure to residual radioactive material (evaluation beyond this time would require assessments of waste disposal alternatives and associated collective doses); implementation times for remedial action workers were assumed to be 9, 12, and 15 years for the 30, 15, and 5 pCi/g alternatives respectively.

[11] Estimated for expected conditions following remediation at residential properties (current use).

[12] Estimated for expected conditions following remediation at commercial/industrial properties (current use).

insignificant at the 30 pCi/g criteria but they reduce the incremental risk averted from lowerin the criteria from 30 pCi/g to 15 pCi/g by as much as 50%. Depending on the volume of wastes resulting from the last increment (15 pCi/g to 5 pCi/g) the impact of the transportation and worker risks could range from that of reducing the benefit (0.14 cancers averted over 200 years) by only a few percent to that of generating more risk than is averted by the incremental cleanup level.

COMPARISON OF RISK AVERTED TO WORKER AND TRANSPORTATION RISK

Remedial Action Criteria	Incremental Transportation Accident Risk[13] (fatalities)	Incremental Remediation Worker Accident Risk (fatalities)	Incremental Excess Fatal Cancers due to remediation Worker Exposure[14]	Incremental Cancers Averted by Remedial Action to Criteria
No Action	-	-	-	-
30 pCi/g	0.004 rail 0.1 truck	0.005	0.009	5.5
15 pCi/g	0.002 rail 0.1 truck	0.009	0.003	0.22
5 pCi/g	0.002 - 0.003 rail < 0.2 truck	0.001 - 0.01	0.003	0.14

The analyses above are based on the Department assessment of the site and environs "expected conditions." It considers likely use of the properties and takes credit for soil cover and shielding. In the Department's negotiations with EPA to establish cleanup criteria for this phase of the Maywood project, EPA has proposed that the analysis be conducted for a worst case scenario and giving no credit for soil cover. The average individual doses for residential and industrial/commercial uses and residual and averted

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13 Transportation risks include risks associated with transport of the waste from the site to a commercial disposal site by rail, and transportation of borrow soil from an off-site borrow area to the site (Risk associated with disposal or management of the waste at the disposal site are not included). Both waste volume and borrow soil volume requirements are assumed proportional to the estimates of soil requiring excavation under each criterion.

14 Fatal cancers were estimate by multiplying the collective dose (person-rem) by a risk factor of $5x10^{-4}$ cancers/person-rem for workers. A factor of $6x10^{-4}$ cancers/person-rem was used for members of the general public (e.g., residential use scenarios).

collective doses for this worst case scenario are presented below. No 30 pCi/g alternative was assessed for the EPA scenario. The cost per person-rem for the 15 pCi/g alternative was estimated to be between $24,000 and $55,000/person-rem averted. This equates to between $41,000,000 and $92,000,000 per cancer avoided. Similar estimates for the 15 pCi/g to 5 pCi/g increment indicated that this additional cleanup would cost between $5,000 to $26,000 per person-rem averted or $7,500,000 and $43,000,000 per cancer avoided. The general decrease in the cost for collective dose (or health effects) between the 15 pCi/g criteria and the incremental reduction to 5 pCi/g may be an artifact of the assumptions. under this scenario material that was buried under the No Action alternative was assumed to be at the surface in the 15 pCi/g scenario. This has the effect of artificially reducing the effectiveness of the first increment (e.g., it compares a realistic No Action alternative scenario to a conservative scenario for the remedial action). It is extremely difficult to compare alternatives under such conditions and demonstrates the importance of using scenarios that are similar for all alternatives.

PREDICTED POST-REMEDIAL ACTION DOSE, COLLECTIVE DOSE, AND COLLECTIVE DOSE AVERTED BY CRITERIA

Remedial Action Criteria	Residual Individual Dose (mrem/year)	Residual Collective Dose (person-rem)	Collective Dose Averted (Cancers Averted)
15 pCi/g	122 (Res[15]) 66 (Com[16]) 189 (Future[17])	9,800 7,000[18]	2,200 person-rem 5,000[18] person-rem (1.1 cancers) (2.5[18] cancers)
5 pCi/g	40 (Res) 22 (Com) 61 (Future)	3,200 2,400[18]	8,200 person-rem 4,600[18] person-rem (4.1 cancers) (2.3[18] cancers)

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[15] Estimate for worst-case conditions following remediation of residential properties.

[16] Estimate for worst-case conditions following remediation at commercial/industrial properties, assuming continued commercial/industrial use.

[17] Estimate for worst-case conditions following remediation at commercial/industrial properties assuming residential use.

[18] Assumes all properties are residential in the future.

In any case, the comparison of these two analyses (expected scenario analysis and worst-case analysis) demonstrate the need to clearly define the process for selecting comparable scenarios. Although in both analyses the cost per dose or health effect averted is relatively high, the use of one or the other of these analyses could very easily result in the selection of a different cleanup criteria.

The Department believes that it is critical that risk or dose assessments used in these types of comparisons represent the best estimates of expected risks that can be calculated. Bounding assessments can be of value when considering the uncertainty of best estimates. Although, if time and resources permit, a probabilistic risk assessment would be preferable for estimating uncertainty because bounding estimates developed to quantify 95 percentile risks can significantly overestimate the risks. In general, worst-case scenarios should only be applied for screening purposes and never in relative risk comparisons. They are prone to biasing the results in a manner that is not readily detectible and are difficult to compare to competing non-health risks.

This example also illustrates another important factor related to the need to define the process for selecting the comparative scenarios. Under the expected use scenario (as defined in the DOE analysis) all remediation criteria alternatives (30 pCi/g, 15 pCi/g and 5 pCi/g) achieve the NRC proposed dose limit and the 5 pCi/g criteria achieves the NRC proposed goal (though at great cost per person-rem averted). However, in the EPA scenario, none of the alternatives achieve the dose limit. The waste volume data for the 5 pCi/g criteria are very uncertain because of the difficulty in adequately characterizing radium and thorium at these low concentrations. If the concentration limit was reduced by 1/3 or 1/4 to ensure compliance with the NRC's proposed 15 mrem/year limit (under the worst-case scenario) survey costs and remedial action costs would be further increased, not only as a function of waste volume but also as a result in added survey costs, extensions of schedules to await verification of compliance from laboratory analyses and, possibly, extra excavation to ensure compliance. Although they were not considered in these analyses, it is not clear that some of these factors would not effect the cleanup under the 5 pCi/g criteria.

- **Nevada Test Site**

A draft of a detailed benefit/cost assessment for remediation of the Nevada Test Site is provided for your information.