MEMORANDUM

Date: December 7, 1995
To: David Miller
From: Amanda Ralph
Subject: Cleanup Levels for Uranium, Radium and Thorium in Four Environmental Media

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Task: Summarize the status of existing and proposed rules (EPA, NRC, DOE, and State of Missouri - where possible) on the cleanup levels for uranium, radium, and thorium. Consider surface water, drinking water, soil, and groundwater.

1. Background

In order to determine which of the available standards to use at the St. Louis site, some background information might be useful and is included in this memorandum.

DOE and NRC

Basic authority for regulating radioactive materials is found in the Atomic Energy Act of 1954, as amended, 42 USC Section 2011 et seq. Originally, the AEA vested authority in the Atomic Energy Commission to regulate the production and utilization of radioactive materials. In 1974, the Atomic Energy Commission was abolished. In its place two agencies were established: the NRC to handle licensing and regulatory activities; and the Energy Research and Development Administration (ERDA) to, among other things, carry out the AEC's military activities. In 1977, ERDA was terminated and its military applications programs transferred to the DOE. DOE is a self-regulating entity and is not subject to the NRC licensing or regulating authority.

DOE facilities are regulated by DOE Directives and Orders. For the past two years, DOE has carried out an effort to reissue its Orders as promulgated rules. DOE Orders recognize, incorporate and mandate that all applicable Federal, state and local environmental requirements be made a part of the DOE regulatory structure.

Formerly, DOE managed its radioactive wastes according to the provisions of DOE Order 5820.2A, "Radioactive Waste Management " DOE is now carrying out a major rewrite of DOE Order 5820.2A. For cleanup levels, DOE calculated acceptable residual activity levels in accordance with provisions in DOE Order 5400.5, "Radiation Protection of the Public and the Environment." This Order has now been proposed as a rule by DOE, to be codified at 10 CFR Part 834 (58 FR 16268, March 25, 1993).

In a DOE memorandum of March 29, 1993, entitled *Nuclear Regulatory Commission (NRC) Low-Level Radioactive Waste Regulations and CERCLA Applicable or Relevant and Appropriate Requirements*, by Raymond Berube, Deputy Assistant Secretary for Environment, Mr. Berube states DOE's position that DOE is not subject to NRC requirements for low-level radioactive wastes found at 10 CFR Part 61. Mr. Berube points out that "appropriate" 10 CFR Part 61 requirements are already incorporated into DOE Order 5820.2A, which provisions DOE is legally bound to follow. However, in situations where DOE Order 5820.2A does not clearly address a specific condition at the site to ensure protection of human health and the environment, then sections of 10 CFR Part 61 can be ARARs. Extrapolating from the position stated in this memorandum, with regard to the effect of NRC rules on DOE operations, if DOE Orders or rules cover a situation during a DOE environmental restoration, then the DOE Order/rule governs. If a DOE Order or rule does not clearly address a specific condition at the site to ensure protection of human health and the environment, then DOE should look to the NRC rules for guidance.

USEPA's Role

When the USEPA was established in 1970, the AEA conferred upon it "consultative, advisory, and miscellaneous functions." (42 USC Section 2021(h)). One such function was to issue radiation standards applicable to all Federal agencies. USEPA's standards apply to DOE programs and activities as well as to NRC licensees, and once final, must be incorporated into DOE and NRC's regulatory schemes. At the time this memorandum is written, USEPA has issued final rules setting standards for radionuclides in the area of air regulation, as National Emission Standards for Hazardous Air Pollutants (NESHAPs), and in the area of drinking water, as Maximum Contaminant Levels (MCLs). USEPA has also issued MCLGs, which are goals to work toward, but are not standards that must be met.

USEPA has entered into a MOU with NRC where USEPA will take the lead in promulgating radiation protection standards and coordinate those standards for the Federal Government. However, where USEPA determines that NRC rules are adequately protective of human health and the environment, USEPA rules will not apply to NRC licensees in those particular areas. If USEPA does not agree that NRC rules are adequately protective of human health and the environment, USEPA's rules supersede NRC's rules and are legally binding on NRC licensees.

CERCLA

CERCLA is administered by USEPA, although DOE has been authorized to act as the lead agency in its environmental restoration program. DOE and USEPA have agreed upon a policy that any decommissioning of DOE units will proceed in accordance with CERCLA requirements as set forth in the National Contingency Plan. Cleanup levels for soil in a CERCLA action are often established in accordance with USEPA's Risk Assessment Guidance for Superfund (RAGS). While DOE must follow the administrative procedure specified by the Policy it agreed upon for decommissioning a facility, with regard to cleanup levels DOE is still bound to follow DOE Order 5400.5, until 10 CFR Part 834 is promulgated as a final rule, unless DOE has entered

into an enforcement agreement specifying otherwise for that particular site. If DOE has entered into an enforcement agreement, often the agreement will contain a provision about reconciling differences between DOE requirements and USEPA requirements. Under this kind of provision, DOE and USEPA can negotiate exactly what requirements will govern cleanup standards for the site.

If DOE has entered into an enforcement agreement, it will in all liklihood proceed under CERCLA. Under CERCLA, MCLs will be relevant and appropriate for drinking water and groundwater; uranium mill tailing standards will be relevant and appropriate for soil; the Superfund RAGS guidance will be a TBC; NRC rules will be ARARs under the conditions explained previously; and DOE Orders will be TBCs, with DOE remaining legally required to comply with the provisions of its Orders.

2. Cleanup Standards

Explanation of Different Kinds of Cleanup Standards

Cleanup standards for uranium, radium, and thorium can be expressed in several ways. USEPA has issued a working draft explaining four possibilities.

The first is as a dose or risk limit, where the radiation dose is expressed in millirems per year and corresponds to an acceptable lifetime cancer incidence risk. As USEPA assumes a linear relationship between dose and risk, this level could be expressed as a certain risk or risk range. Several rules have expressed protection standards as dose limits.

The second is as a table of radionuclide concentrations, where a generic radioactive site has default exposure scenarios developed for it, then an exposure pathway model is used to back calculate medium-specific radionuclide concentrations that correspond to an acceptable risk or dose. With this method, an owner/operator can look up on a table cleanup levels for a specific radionuclide. This is the method used in 40 CFR 192, 40 CFR 141, and 40 CFR Part 302.

The third approach would combine a table of generic radionuclide and medium-specific concentrations with a standardized pathway model to derive site specific cleanup levels. 40 Part 61 uses pathway models, as does the Superfund RAGS.

The fourth possibility USEPA has discussed is to establish technology requirements that are linked to a risk-based standard. This approach is used with the Land Disposal Restriction (LDR) program. DOE Order 5400.5 sets forth a technology-based approach (BAT) as well as health-based dose limits and ALARA process requirements.

Summary of Cleanup Standards per Media

Cleanup standards for uranium, radium, and thorium, in the medium of soil can be calculated in

accordance with the procedures specified in DOE Order 5400.5, Chapter IV, also found at proposed 10 CFR Part 834. Alternatively, under CERCLA, DOE can follow the risk-based approach prescribed by the Superfund RAGS, or use the dose limits established in 40 CFR Part 192 Subpart B.

Cleanup standards, or MCLs, for uranium, radium, and thorium, in the medium of drinking water are found in the Federal primary drinking water regulations, 40 CFR 141.15 and 141.16. Uranium is an alpha-gamma emitter, thorium is a beta-gamma emitter, and radium is an alpha-gamma emitter. The Primary Drinking Water MCLs are:

(a) for combined radium-226 and radium-228 - 5pCi/liter.

(b) for gross alpha particle activity, including radium-226 but excluding radon and uranium, - 15pCi/liter.

(c) The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/year.

(d) Except for tritium and strontium-90, the concentration of man-made radionuclides causing 4 mrem total body or organ dose equivalents shall be calculated on the basis of a 2 liter per day drinking water intake using the 168 hour data listed in "*Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure.*" NBS Handbook 69 as amended August 1963, U.S. Department of Commerce. If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ shall not exceed 4 mrem/year.

Cleanup standards for Class I or Class II groundwater (actual or potential sources of drinking water) are often set at the MCL level. Alternative levels can be calculated depending on the volume of groundwater involved, the amount of suspended solids, the background level of contamination of the actual groundwater and surrounding groundwater, future use of the groundwater, and whether the body of groundwater is hydraulically connected to any other water.

Surface water criteria are expressed as water quality standards. In order to establish a water quality standard, one must know the federal water quality criteria for the element and the present and future use of the body of water. Water quality criteria have not been established for radionuclides, so specific water quality standards have not been established for radionuclides. However, the Federal rules contain a narrative standard for toxic pollutants, and uranium is included as a toxic pollutant that must be reported if present. The narrative standard for most of the designated uses is:

> Toxic, radioactive, nonconventional, or deleterious material concentrations shall be less than those which may affect public health, the natural aquatic environment, or the desirability of the water for any use. (40 CFR 131.35).

The narrative standard for special resource water is.

Toxic, radioactive, or deleterious material concentrations shall not exceed those found under natural conditions.

If surface water is designated as a potential or actual source of drinking water, MCLs are the appropriate cleanup levels.

For more details about specific rule standards and provisions, please see the attached Table.

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Summary of Cleanup Standards per Media

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Regulation/ Requirement	Medium	Standard or Limit	ALARA
NRC: *Radiological Criteria for Decommissioning*, Proposed Rule	Soil.	Total effective dose equivalent of 15 mrem/year for residual radioactivity distinguishable from background. Remove all readily removable radioactivity from site before decommissioning.	Yes
DOE: *Occupational Radiation Protection*, 10 CFR Part 835 and Appendix A, DOE Order 5480.11	All sources of radiation.	(1) Total effective dose equivalent of 5 rems (0.05 Sv) annually; (2) sum of the deep dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye of 50 rems (0.05 Sv); (3) lens of the eye dose equivalent of 15 rems (0.15 Sv), and (4) shallow dose equivalent of 50 rems (0.5 Sv) to the skin or to any extremity. Any member of the public exposed to radiation during direct on-site access at a DOE site or facility - 0.1 rem (0.001 Sv) total effective dose equivalent in a year.	Yes
DOE: *Radiation Protection of the Public and the Environment*, proposed 10 CFR Part 834, DOE Order 5400.5	Soil; Air and water; Water ingestion, air exposure and immersion.	Generic guidelines for residual concentrations of Ra-226, -228 and Th-230 and -232 in soil are: (1) 5 pCi/g, averaged over the first 15 cm of soil below the surface; and (2) 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface. Residual radioactive materials in soil (uranium) in excess of background concentrations averaged over an area of 100 square meters. These derivations are obtained by means of environmental pathway analysis and basic dose limits. Procedures for these derivations are given in DOE/CH-8901. Residual concentrations of radionuclides in air and water shall not exceed 100 mrem (1 mSv) per year. Exposures to members of the public from all radiation sources released into the atmosphere - effective dose equivalent of 10 mrem (0.1 mSv) per year. DCGs for water ingestion, air inhalation, and immersion in a gaseous cloud are based on a committed effective dose equivalent of 100 rem for the radionuclide taken into the body by ingestion or inhalation during one year.	Yes

Regulation and Regulating Entity	Citation and Status of Regulation	Description of Regulation	Media and Specific Standards/Dose Limits	Comments: Future Direction
USEPA: *Radiation Site Cleanup Regulations*	Advanced Notice of Proposed Rulemaking: to be codified at 40 CFR 195	This ANPR announces USEPA's intention to issue radiation site cleanup regulations and, at a later time, to issue waste management regulations. The ANPR poses many questions for which USEPA is soliciting comments.	USEPA asks the regulated community what approach to follow, and suggests the following: a single dose, a risk limit, or a range of limits; a table(s) of default media- and radionuclide- specific concentration limits based on generic site conditions; site-specific concentration limits derived from an Agency-approved pathways model based on actual site conditions; or technology-based linked to an acceptable risk level.	USEPA intends to send the rule proposal to OMB in early 1996. In the ANPR, USEPA explains that if NRC's decommissioning criteria are protective of public health and the environment, USEPA's site cleanup regulations will not apply to NRC licensees. DOD and DOE facilities remain subject to the standards.
USEPA: *Groundwater Standards for Remedial Actions at Inactive Uranium Processing Sites*	40 CFR Part 192 Subpart A Final Rule effective February 10, 1995	These regulations provide that tailings must be stabilized and controlled in a manner that permanently eliminates or minimizes contamination of groundwater beneath stabilized tailings, so as to protect human health and the environment. They also provide for cleanup of contamination that occurred before the tailings are stabilized. Standards are promulgated for two types of remedial actions: disposal and cleanup of residual radioactive material.	The limit for uranium was established at 30 pCi/liter, which is the same limit proposed to be established as the MCL for uranium in drinking water (July 18, 1991). The limit for combined radium-226 and radium-228 is 5 pCi/liter, the same as the promulgated MCL. The limit for gross alpha-particle activity, excluding radon and uranium, is 15 pCi/liter, the same as the promulgated MCL.	Under the UMTRA, USEPA was directed to be consistent with other remediation programs.

Regulation and Regulating Entity	Citation and Status of Regulation	Description of Regulation	Media and Specific Standards/Dose Limits	Comments: Future Direction
USEPA: *Primary Drinking Water Regulations*	40 CFR 141.15 and 141.16	These rules establish enforceable standards for contaminants in drinking water. Contaminants are sampled at the tap. Primary Drinking Water Regulations are usually MCLs, although USEPA may specify a treatment technique if it is not possible to specify the level of contaminant.	The Federal Primary Drinking Water MCLs are: (a) for combined radium-226 - 5 pCi/l (b) for gross alpha particle activity, including radium but excluding radon and uranium - 15 pCi/l (c) average annual concentration of beta particle and photon radioactivity shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/year (d) except for tritium and strontium-90, the concentration of man-made radionuclides causing 4 mrem total body or organ dose equivalents shall be calculated on the basis of a 2 liter per day drinking water intake using the 168 hour data listed in "*Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Permissible Body Burdens and maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure.*" NBS Handbook 69 as amended August 1963, U.S. Department of Commerce. If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ shall not exceed 4 mrem/year.	MCLs are often used as cleanup levels for contaminated groundwater or surface water that is an actual or potential source of drinking water. USEPA has proposed an MCL for uranium, on July 18, 1991, of 30 pCi/l

Regulation and Regulating Entity	Citation and Status of Regulation	Description of Regulation	Media and Specific Standards/Dose Limits	Comments: Future Direction
NRC: *Standards for Protection Against Radiation: Radiation Dose Limits for Individual Members of the Public*	10 CFR Part 20 Subpart D Effective June 20, 1991 or January 21, 1994	These rules establish standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the NRC. Standards are promulgated for Occupational dose limits and Radiation dose limits for individual members of the public.	Each licensee shall conduct operations so that- (1) the total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contribution from the licensee's disposal of radioactive material into sanitary sewerage, and (2) the dose in any unrestricted area from external sources does not exceed 0.002 rem (0.02 mSv) in any one hour.	*dose equivalent* means the product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv). *effective dose equivalent* is the sum of theproducts of the dose equivalent to the organs or tissue and the wieghting factors applicable to each of the body organs or tissues that are irradiated.

Regulation and Regulating Entity	Citation and Status of Regulation	Description of Regulation	Media and Specific Standards/Dose Limits	Comments: Future Direction
NRC: *Standards for Protection Against Radiation: Occupational Dose Limits*	10 CFR Part 20 Subpart C Effective June 20, 1991 or January 21, 1994	See previous description		Occupational dose limits are given for oral ingestion and air inhalation for a "Reference man." The limits are also expressed in terms of "annual limits on intake or ALIs" and "derived air concentrations or DACs." ALI means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) (stochastic ALI) or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue (non-stochastic ALI). DAC-hour is the product of the concentration of radioactive material in air, expressed as a fraction or multiple of the derived air concentration for each radionuclide, and the time of exposure to that radionuclide, in hours. DAC values are intended to control chronic occupational exposures. A licensee may take 2,000 DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 5 rems (0.05 Sv).

SUMMARY TABLE

Regulation/ Requirement	Medium	Standard or Limit	ALARA
USEPA: *Federal Protection Guidance for Exposure of the General Public*	All sources of radiation.	Radiation Protection Guide (RPG) of 1 mSv (100 mrem) effective dose equivalent to an individual	Yes
USEPA *Radiation Site Cleanup Standards ANPR*	Soil, Water and Air	Not yet decided: USEPA will send proposed rule to OMB in early 1996	
USEPA: *Groundwater Standards for Remedial Actions*, 40 CFR 192, Subpart A	Groundwater	Uranium - 30 pCi/l Radium-226 and -228 - 5 pCi/l Gross alpha-particle activity, excluding radon and uranium - 15 pCi/l	
USEPA: *Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites*, 40 CFR 192 Subpart B	Soil	Radium-226 concentration in land averaged over any area of 100 square meters shall not exceed - (a) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and (b) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface	
USEPA: *Standards for Management of Uranium and Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended*, 40 CFR 192 Subparts D and E	Groundwater	Combined radium-226 and radium-228 - 5 pCi/l Gross alpha-particle activity (excluding radon and uranium - 15 pCi/l	Yes
USEPA: *Primary Drinking Water Regulations*, 40 CFR 141.15 and 141.16	Drinking Water; potential ground water and surface water standards	(1) Combined Radium-226 - 5 pCi/l (2) Gross alpha particleactivity, including radium but excluding radon and uranium - 15 pCi/l. (3) Average annual concentration of beta particle and photon radioactivity, annual dose equivalent to total body or any internal organ - 4 mrem/year	
NRC: *Standards for Protection Against Radiation: Radiation Dose Limits for Individual Members of the Public*, 10 CFR 20 Subpart D	All sources of radiation.	Total effective dose equivalent to individual members of the public - 0.1 rem (1 mSv)/year; 0.002 rem (0.02 mSv/hour	Yes
NRC: *Standards for Protection Against Radiation: Occupational Dose Limits*, 10 CFR 20 Subpart C	All sources of radiation.	Annual Limits on Intake (ALI) - committed effective dose equivalent of 5 rems (0.05 Sv) or a committed dose equivalent of 50 rems (0.5 Sv).	Yes
NRC: *Licensing Requirements for Land Disposal of Radioactive Waste: Protection of the General Population from Releases of Radioactivity*, 10 CFR 61.41	All sources of radiation - ground water, surface water, air soil, plants or animals.	Annual dose equivalent to 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ.	Yes

Existing and Proposed Rules about Cleanup Levels for Uranium, Radium and Thorium

Regulation and Regulating Entity	Citation and Status of Regulation	Description of Regulation	Media and Specific Standards/Dose Limits	Comments: Future Direction
USEPA: *Federal Radiation Protection Guidance for Exposure of the General Public*	Proposed Recommendations, request for written comments, and notice of public hearing	This action proposes 7 recommendations: 1. No exposure of the general public to ionizing radiation unless it is justified by the expectation of an overall benefit. 2. Make a sustained effort to ensure that doses to individuals and the public are maintained ALARA. 3. Combined radiation doses incurred in any single year should not exceed a Radiation Protection Guide (RPG) of 100 mrem effective dose equivalent. 4. Authorized limits for sources should be established to ensure that individual and collective doses in current and future populations satisfy the objectives of this guidance. Authorized limits for sources should limit doses to a fraction of the RPG for all sources combined. 5. Risks associated with exposure of the general public to radiation that may occur due to Federal agency decisions, and the policies upon which these actions are based, should be made known to the public as part of the decision process. 6. Assessments and records should be maintained of doses to the exposed population. 7. Exceptions to Recommendation #3 for planned exposure to radiation should be made only for highly unusual circumstances, and should be a matter of public record.	The combined radiation doses incurred in any single year from all sources of exposure covered by these recommendations should not normally exceed a Radiation Protection Guide (RPG) of 1 mSv (100 mrem) effective dose equivalent to an individual. The RPG applies to the sum of the effective dose equivalent resulting from exposure to external sources of radiation during a year and the committed effective dose equivalent incurred from the intake of radionuclides during that year. Effective dose equivalent is a derived quantity defined as the risk-weighted sum of dose equivalents to specified organs and tissues. Dose equivalent is the product of the absorbed dose and a quality factor which varies with the energy and type of radiation. The effective dose equivalent incurred in a given period of time is the sum of the effective dose equivalent received from external exposure in that period and the committed effective dose equivalent incurred from the intake of radionuclides during that period.	USEPA anticipates that these recommendations will be published in final form in late Spring 1996. These recommendations will replace guidance issued by the Agency in 1960 and 1961 for protection of the general public. The main changes in the recommendations are that: (1) the RPG is expressed in terms of a single weighted sum of doses to organs rather than as separate RPGs for individual organs; (2) the current RPG of 500 mrem whole body dose is replaced by a single RPG of 100 mrem effective dose equivalent received by or committed in a single year from all sources combined; (3) doses from individual sources are limited to a fraction of the RPG; and (4) increased emphasis is given to the principle that all exposure should be maintained as low as reasonably achievable (ALARA), within the RPG.

Regulation and Regulating Entity	Citation and Status of Regulation	Description of Regulation	Media and Specific Standards/Dose Limits	Comments: Future Direction
USEPA: *Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites*	40 CFR Part 192 Subpart B	These standards are promulgated to address lands and buildings that are part of any processing site designated by the Secretary of Energy under Section 102 of the UMTRA.	Remedial actions shall be conducted so as to provide reasonable assurance that, as a result of residual radioactive materials from any designated processing site: (1) The concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than- (a) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and (b) 15 p Ci/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.	In a CERCLA action, these standards would be potential ARARs.
USEPA: *Standards for Management of Uranium and Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended*	40 CFR 192 Subparts D and F.	These standards regulate the management of uranium and thorium byproduct materials during and following processing of uranium and thorium ores, and to restoration of disposal sites following any use of such sites under the Atomic Energy Act.	The groundwater protection standard for uranium and thorium is given as: (1) combined radium-226 and radium-228 - 5 pCi/l (2) gross alpha-particle activity (excluding radon and uranium) - 15 pCi/l.	