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**Engineering Evaluation/Cost Analysis for the
Proposed Removal of Contaminated Materials
from Pad 1 at the Elza Gate Site, Oak Ridge,
Tennessee**

June 1990

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U.S. Department of Energy
Oak Ridge Operations Office
Formerly Utilized Sites Remedial Action Program

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June 1990

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prepared by

Environmental Assessment and Information Sciences Division, Argonne National Laboratory

prepared for

U.S. Department of Energy, Oak Ridge Operations Office, Formerly Utilized Sites Remedial Action Program
under Contract W-31-109-Eng-38

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NOTATION

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this document.

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EE/CA	engineering evaluation/cost analysis
EPA	U.S. Environmental Protection Agency
FR	Federal Register
FUSRAP	Formerly Utilized Sites Remedial Action Program
LSA	low specific activity
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
PL	Public Law
USC	United States Code

UNITS OF MEASURE

cm	centimeter(s)
cm ²	square centimeter(s)
dpm	disintegration(s) per minute
ft	foot (feet)
ft ²	square foot (feet)
g	gram(s)
h	hour(s)
ha	hectare(s)
L	liter(s)
μCi	microcurie(s)
μg	microgram(s)
μR	microroentgen(s)
m	meter(s)
m ²	square meter(s)
m ³	cubic meter(s)
mL	milliliter(s)
mrem	millirem(s)
pCi	picocurie(s)
s	second(s)
WL	working level(s)
yd ³	cubic yard(s)
yr	year(s)

FOREWORD

This engineering evaluation/cost analysis (EE/CA) has been prepared in support of the proposed removal action for cleanup of radioactively contaminated concrete and soil beneath a building on privately owned commercial property in Oak Ridge, Tennessee. The property, known as the Elza Gate site, became contaminated with uranium-238, radium-226, thorium-232, thorium-230, and decay products as a result of the Manhattan Engineer District storing uranium ore and ore processing residues at the site in the early 1940s. The U.S. Department of Energy (DOE) has responsibility for cleanup of the property under its Formerly Utilized Sites Remedial Action Program (FUSRAP). The DOE plans to remove the cracked and worn concrete pad and contaminated subsoil beneath the pad, after which the property owner/tenant will provide clean backfill and new concrete. Portions of the pad and subsoil are contaminated and, if stored or disposed of improperly, may represent a potential threat to public health or welfare and the environment.

The EE/CA report is the appropriate documentation for the proposed removal action, as identified in guidance from the U.S. Environmental Protection Agency. The objective of the EE/CA report, in addition to identifying the planned removal action, is to document the selection of response activities that will mitigate the potential for release of contaminants from the property into the environment and minimize the related threats to public health or welfare and the environment.

ENGINEERING EVALUATION/COST ANALYSIS FOR THE PROPOSED REMOVAL OF CONTAMINATED MATERIALS FROM PAD 1 AT THE ELZA GATE SITE, OAK RIDGE, TENNESSEE

1 SITE CHARACTERIZATION

The 8.1-ha (20-acre) Elza Gate site is located in the southeastern portion of the city of Oak Ridge, Tennessee (Figure 1). In the early 1940s, the site was used by the Manhattan Engineer District as a storage area for pitchblende (a high-grade uranium ore from Africa) and ore processing residues. Site ownership was retained by the federal government until 1972, when the site was decontaminated to levels applicable at the time and transferred to the city of Oak Ridge. The property was subsequently sold to a metal plating company and finally to the current owner in 1988. The U.S. Department of Energy (DOE) has designated the Elza Gate property for inclusion in its Formerly Utilized Sites Remedial Action Program (FUSRAP) (Fiore 1988).

The site is divided into nine parcels (Figure 2). Parcels 1 through 4 contain concrete pads, which formerly served as the foundations for warehouses in which uranium ore and processing residues were stored. Currently, only one building exists on the site; this building was erected on an existing concrete pad on parcel 1 and is leased by the property owner to a fabricator of metal boxes for storage of radioactively contaminated wastes. The total surface area of pad 1 is approximately $2,300 \text{ m}^2$ ($25,000 \text{ ft}^2$), of which about $1,000 \text{ m}^2$ ($11,000 \text{ ft}^2$) is the original pad; the remainder was added around the original pad during property development when the site reverted to private ownership.

A radiological survey of the building pad was conducted in 1989, which included:

- Direct beta-gamma and alpha radiation measurements on the pad surface, and
- Collection of near-surface soil samples from beneath the pad and analysis of the samples for uranium-238, radium-226, thorium-232, and thorium-230.

The results of the direct radiation measurements indicated that contamination exceeded DOE guidelines for allowable residual surface contamination (see Appendix B). Most of the residual contamination from the pad surface was removed during a demonstration of a portable shot-blast system for concrete decontamination (Argonne National Laboratory 1989; Baublitz 1989). After the demonstration was completed, the average residual surface contamination measured was $750 \text{ dpm}/100 \text{ cm}^2$ for alpha radiation and $4,600 \text{ dpm}/100 \text{ cm}^2$ for beta-gamma, less than the applicable surface contamination guidelines. However, the results of subpad soil measurements (Table 1) indicated that levels of radium-226 and thorium-230 exceeded residual contamination guidelines (5 pCi/g averaged over the first 15 cm of soil below the surface and 15 pCi/g for any 15 cm layer beneath the first 15 cm). Elevated levels of uranium-238 were also detected

FIGURE 1 Location of the Elza Gate Site

FIGURE 2 Plan View of the Elza Gate Site

TABLE 1 Radionuclide Concentrations in Soil Beneath Pad 1 at the Elza Gate Site^a

Radionuclide	Number of Samples	Concentration (pCi/g)		
		Maximum	Minimum	Average
Uranium-238	20	1,300.0	<2.0	146.0
Radium-226	20	45.0	0.5	8.9
Thorium-232	20	4.0	0.4	1.9
Thorium-230	20	500.0	<1.0	59.4

^aSamples were biased, i.e., taken from locations with a high probability of being contaminated.

Source: Data from Bechtel National (1989).

in the subpad soil. The guideline for uranium-238 is developed on a site-specific basis but has not yet been developed for the Elza Gate site.

2 REMOVAL ACTION OBJECTIVES

The property owner at the Elza Gate site needs to remove the cracked, worn concrete from the building on parcel 1 and replace it with new concrete that would provide more solid footing for equipment and safer flooring for workers. Surface concrete repairs were evaluated following the pad surface decontamination demonstration, but the repairs were judged to be unreliable due to the abundance of grease, oil, and other bond-inhibiting substances present on the surface of the pad. The objective of the proposed removal action is to safely remove residual contamination in subsoil beneath the concrete pad and in joints and cracks, thereby eliminating, reducing, or otherwise mitigating the potential for exposure to radioactive contaminants. However, if the property owner performs this work outside of FUSRAP without DOE assistance, there is the potential for uncontrolled releases that could result in exposure of workers, the public, and the environment. By allowing DOE to pursue this action, the cleanup and containment of radioactively contaminated materials would be performed under strict radiological safety controls and monitoring to minimize exposures and uncontrolled releases.

The scope of the removal action will initially be focused on the removal, packaging, and interim storage of contaminated concrete and subsoil from one section of the pad. This initial action will include an area measuring approximately 20 m² (214 ft²). At a later date, other sections of the floor will be removed and replaced, as necessary, within the scope of this engineering evaluation/cost analysis (EE/CA).

2.1 STATUTORY LIMITS

Authority for responding to releases or threats of releases from a hazardous waste site is addressed in Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Executive Order 12580 delegates to DOE the response authority for DOE sites, whether or not they are on the National Priorities List of the U.S. Environmental Protection Agency (EPA). Under CERCLA Section 104(b), DOE is authorized to investigate, survey, test, or gather other data required to identify the existence, extent, and nature of the contaminants, including the extent of danger to public health or welfare and the environment. In addition, DOE is authorized to undertake planning, engineering, and other studies or investigations appropriate to directing response actions that prevent, limit, or mitigate the risk to public health or welfare and the environment.

2.2 SCOPE AND PURPOSE

The scope and purpose of the proposed removal action is the removal, packaging, and interim storage of radioactively contaminated concrete and soil from pad 1 at the Elza Gate site. The specific objectives of the action are:

- Removal of radioactively contaminated concrete and soil from the floor (pad 1) within the industrial building on parcel 1 of the Elza Gate property.
- Elimination or reduction of the radiological hazard associated with the presence of this radioactive contamination by removing all radium and thorium soil contamination exceeding applicable guidelines and all uranium contamination detectable with field instrumentation.
- Minimization of potential health hazards to on-site personnel performing the removal action.
- Collection and analysis of post-remedial soil samples and eventual certification of the decontaminated site for use without radiological restrictions.

The timely and complete removal of contaminated materials from and beneath pad 1 would contribute to the efficient performance of response actions being planned for the

entire site and the eventual permanent disposition of radioactively contaminated materials currently identified at the site.

2.3 SCHEDULE

The initial removal action at pad 1 of the Elza Gate site is scheduled to be completed in 1990. The primary scheduling objective is to complete this action in one continuous operation. This schedule provides time to survey the pad location prior to and during the proposed removal action, break up the concrete pad, excavate the contaminated materials, backfill with clean topsoil or other appropriate materials, and package and store the contaminated materials in an appropriate location on the site. On-site interim storage of these materials is consistent with and would contribute to the efficient conduct of the overall response action being planned for the Elza Gate site.

2.4 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The proposed removal action at the Elza Gate site will be carried out in accordance with all applicable or relevant and appropriate requirements (ARARs), based on interim guidance regarding compliance with ARARs provided by the EPA (1987). The EPA guidance defines *applicability* as implying that the proposed action or site circumstances satisfy all of the jurisdictional prerequisites of the requirement. *Relevant and appropriate requirements* are defined as those that address problems or situations sufficiently similar to those encountered at the site in question that their use is well suited to the particular site. Any standard, requirement, criterion, or limitation under any federal or state law -- including state regulations that are more stringent than federal regulations -- may be considered either applicable or relevant and appropriate to a specific action. A determination of applicability is made for the requirement as a whole, whereas a determination of relevance and appropriateness may be made for only specific portions of a requirement. An action must comply with relevant and appropriate requirements to the same extent as an applicable requirement with regard to substantive conditions, but need not comply with the administrative conditions of the requirement.

The preliminary identification of potential ARARs for the proposed removal action at the Elza Gate site is based on the nature of the contamination (primarily soil contaminated with uranium-238, thorium-230, radium-226, and thorium-232). The potential ARARs for the proposed action are presented in Appendix A.

3 REMOVAL ACTION TECHNOLOGIES

Alternative removal actions were identified by considering relevant technologies that might be implemented. The procedure and rationale for considering alternatives is consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and with EPA guidance regarding removal actions. The selected removal action

alternative will implement a permanent solution and, consistent with the goals of FUSRAP, real property will be certified to the extent practicable for use without radiological restrictions.

Because the contamination under pad 1 at the Elza Gate site is radioactive, the number of practicable and suitable treatment technologies that can be applied is limited. The technologies considered in selecting response action alternatives include those identified in the NCP. Additional technologies addressed in the following discussion are based on experience and information gained as a result of remedial action planning and implementation at other sites.

The discussion focuses on source control response actions. The objective of source control response actions is to protect public health or welfare and the environment by altering the nature of the waste source (i.e., the radioactively hazardous constituents) to reduce its toxicity, mobility, or volume. Source control response actions that are potentially applicable to the proposed action at the Elza Gate site include waste removal, waste reprocessing/treatment, and interim storage.

3.1 REMOVAL

The removal of contaminated materials may involve decontamination and excavation. These technologies are reliable, can be easily implemented with standard construction equipment, and have been used extensively to control radioactive contamination similar to that associated with the Elza Gate site. Because the scope of the proposed action is limited to the cleanup of contaminated soil and concrete within an enclosed building in one isolated area of the site, excavation is the applicable removal technology.

3.2 REPROCESSING/TREATMENT

Reprocessing/treatment includes a wide range of technologies, but only a limited number of these can be implemented where radioactive contamination is present. Radioactive waste reprocessing/treatment technologies can be divided into two general categories:

- Those that remove the radioactive material from the waste matrix, and
- Those that change the form of the waste, thereby reducing its toxicity, mobility, or volume.

Treatment technologies include extraction (which involves separation of radioactive contaminants from the waste matrix), separation, and vitrification. The full-scale reprocessing/treatment of contaminated materials from pad 1 at the Elza Gate site was eliminated from further consideration because the use of these technologies has not been demonstrated for treatment of materials of this type. Moreover, the radioactive materials in the subsoil beneath the pad are present in low concentrations, making

separation by any developmental reprocessing or treatment technology difficult, time-consuming, and costly.

3.3 INTERIM STORAGE

Interim storage is the temporary placement/containment and effective control of contaminated materials to minimize exposure, pending decisions on final disposal. Examples include placement on an engineered pad (followed by covering the pad with a synthetic membrane or clay cap) or placement in suitable containers, such as drums or metal boxes. Metal boxes suitable for storing contaminated soil and concrete are fabricated in the building at the Elza Gate site. Each box has a volume of 2.7 m^3 (3.6 yd^3) and can be covered and sealed to isolate the contents from the environment. Interim storage of contaminated materials in metal boxes is preferred over a membrane-covered pad due to the small volume of waste materials anticipated and the ready availability of metal boxes (fabricated on-site). The boxes are also portable and will facilitate removal of the wastes at a later date.

3.4 SUMMARY

Based on the technologies described above and the current plans of the property owner, the most appropriate, cost-effective alternative appears to be removal (excavation) of contaminated materials and on-site, interim storage in low-specific-activity (LSA) steel boxes.* This alternative will protect against potential uncontrolled release of contaminated materials to the environment and increased worker and public exposure.

4 ANALYSIS OF THE PROPOSED REMOVAL ACTION ALTERNATIVE

The proposed removal action is an interim measure related to the overall response action planned for the disposition of wastes at the Elza Gate site. The purpose of this removal action is to safely remove and contain contaminated soil and concrete prior to planned improvements by the property owner. The removal action alternative has been evaluated in terms of its protectiveness of public health and the environment, technical feasibility, and institutional considerations.

4.1 PUBLIC HEALTH AND ENVIRONMENTAL PROTECTION

The effectiveness of an alternative is defined by its effectiveness in ensuring the protection of and minimizing the adverse effects on public health and the environment. For the proposed removal action, the contaminated concrete and soil would be excavated

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*Permanent waste disposal or waste removal to an off-site location will be analyzed in the documentation for overall site remediation and is not considered in this EE/CA.

and stored in steel boxes at the site. Excavation would disturb the contaminated materials, which might temporarily increase radioactive releases. Mitigative measures, such as spraying water on the work area during excavation, would be implemented during the action period to minimize potential releases of radioactive particulates.

To assess the potential radiological impacts associated with the proposed removal action, radiation doses to a worker at the site were estimated. Only the workers implementing the action would be affected by radiation because the site is an industrial property, and the area where the proposed action would take place is inside a building. Potential impacts to the public were not assessed because of the confinement of the proposed action within a closed building and the extremely low probability of any releases during the proposed action that could affect the public. Also, exposure of plant employees (i.e., those fabricating metal boxes) would be minimal because the removal action would be conducted during off-hours as much as possible.

The potential radiation doses to workers performing the removal action would be kept as low as reasonably achievable by standard health physics practices and by strict compliance with DOE environmental protection, safety, and health protection guidelines given in DOE Order 5480.11. The concrete pad was previously decontaminated by abrasive blasting. Because the measured exposure rate at 1 m (3 ft) above the ground is at background levels, little external radiation hazard exists for workers under current conditions. However, when the concrete pad is removed and the contaminated soil is excavated, workers could be exposed to radionuclides in the soil and to contamination present in the concrete expansion joints and cracks.

The primary pathways by which workers could incur radiation doses in excess of background exposure would be through external exposure and inhalation of airborne radioactive contaminants generated during decontamination and waste handling. The potential doses to workers would be kept low by using procedures to minimize the amount of airborne contamination, such as spraying the work area with water. Additionally, workers would wear respiratory protection equipment, if necessary, to reduce the likelihood of inhaling contaminated particulates. Workers would also wear lapel air monitors that would be analyzed every 24 hours to verify the safety of the working environment.

The potential dose to workers implementing the proposed action were calculated with the RESRAD code (Gilbert et al. 1989). Because the proposed action might be carried out gradually, two types of simulations were performed. In the first simulation (similar to the first phase of the work), it was assumed that the excavation area would be 20 m^2 (214 ft^2). Based on current subpad sampling results, the excavation is expected to extend to a depth of 0.3 m (1 ft) below the concrete pad. Calculations were performed based on the average radionuclide concentrations given in Table 1 and on the assumption that a total of 60 worker-hours (three workers at 20 hours each) would be required to excavate, package, and store the excavated materials. The predicted total dose for 60 worker-hours is approximately 1 mrem, i.e., each worker would be exposed to only about 0.33 mrem, which is indistinguishable from the background level.

In the second simulation, the total worker dose was estimated assuming that the scope of the action would include the removal of all of pad 1 and the contaminated soil

beneath the concrete pad. Again, the calculations were based on a 0.3-m (1-ft) depth of contamination and the average radionuclide concentrations given in Table 1. An estimated maximum number of 2,400 worker-hours would be required to excavate and package the contaminated soil and put it in storage. If 14 workers were used, as currently planned, it is estimated that the work would be completed in about 170 hours. Under this scenario, the estimated total worker dose is 63 mrem and the estimated dose to each worker is 4.5 mrem. About 63% of the total dose would result from the external exposure pathway (with radium-226 accounting for most of the dose for this pathway, followed by thorium-232 and uranium-238). The dust inhalation pathway would account for 27% of the total dose (with uranium isotopes contributing about 61% of the dose for this pathway). The predicted individual dose of 4.5 mrem to each worker is only a small fraction of DOE's occupational dose limit of 5,000 mrem/yr.

Plant employees are not likely to be exposed to radiation because the removal action would be carried out primarily during off-hours. However, for a hypothetical and conservative case where a plant employee remained in the area of the removal action during its total duration, the highest predicted dose would be the same as the predicted dose for a worker involved in the removal action, i.e., 4.5 mrem.

Because the proposed action involves storing the excavated materials on-site in steel boxes, the potential dose to an intruder was also calculated. The intruder scenario assumed that access to the site would be uncontrolled and that the area where the waste would be stored lacks a fence or other barrier. The persistent intruder (for example, a worker from a nearby industrial establishment who spent each lunch hour near the boxes of wastes) was assumed to spend 5 hours per week, 50 weeks per year, near the boxes. It was estimated that the intruder might encounter a maximum gamma radiation field of 17 μ R/h from the stored canisters. The estimated dose to such an intruder is 4 mrem/yr, which is a small fraction of DOE's 100 mrem/yr dose limit (above background) for the public.

4.2 TECHNICAL FEASIBILITY

Removal (excavation) is technically feasible and has been used in the past at other properties to control the source of radioactive contamination. The technical feasibility of interim storage has been established at many FUSRAP sites. The interim storage area would be controlled to prevent contaminant releases or public exposure until the wastes were transported to a permanent disposal facility.

4.3 INSTITUTIONAL CONSIDERATIONS

Removal and interim storage is unlikely to generate any significant institutional concerns because all activities would be conducted in accordance with ARARs and to the satisfaction of the property owner. Based on the successful implementation of excavation and storage at similar properties in the past, the proposed removal action would be unlikely to encounter significant obstacles with regard to institutional issues.

4.4 SUMMARY

Based on the above analysis, the proposed removal action alternative has been identified as technically feasible, timely, protective of public health or welfare and the environment, and involving the least significant institutional concerns. Therefore, the recommended removal action for the Elza Gate pad 1 is excavation of the contaminated materials and on-site, interim storage in steel LSA boxes. The recommended removal action is consistent with and would contribute to the efficient performance of the overall response action being planned for the Elza Gate site.

5 DESCRIPTION OF THE PROPOSED ACTION

The proposed action is to break up the concrete floor of pad 1 and remove contaminated concrete and subsoil to a depth of approximately 0.3 m (1 ft), place the contaminated materials into steel LSA boxes, and transport the boxes to a prepared area at the back of the property for controlled interim storage. This action would include the following activities:

- Break up the concrete pad and survey the rubble to segregate contaminated from clean materials to the extent practicable;
- Stockpile the clean rubble and package the contaminated rubble;
- Excavate and package the contaminated soils/materials;
- Seal the contaminated materials in steel LSA boxes and transport the boxes to a prepared control area at the back of the property;
- Survey the excavation area to verify that cleanup guidelines have been met;
- Restore the pad foundation with new/clean fill and gravel in preparation for relaying a new concrete floor (by the property owner);
- Certify the decontaminated area for release without radiological restrictions.

6 REFERENCES

Argonne National Laboratory, 1989, *Action Description Memorandum, Demonstration of the Effectiveness of Abrasive Blasting Techniques for Decontaminating Concrete Pads at the Elza Gate Site, Oak Ridge, Tennessee*, prepared by Energy and Environmental Systems Division, Argonne, Ill., for U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, Tenn., May.

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U.S. Environmental Protection Agency, 1987, *Superfund Program; Interim Guidance on Compliance with Other Applicable or Relevant and Appropriate Requirements*, Federal Register, 52(166):32496-32499, Aug. 27.

7 LIST OF CONTRIBUTORS

This EE/CA has been prepared by the U.S. Department of Energy with contractual assistance from Argonne National Laboratory and Bechtel National, Inc. The following individuals contributed to the preparation of this report.

Name	Education/Expertise	Contribution
<u>Argonne</u>		
Nicholas J. Beskid	M.S., Geology 18 yr experience, including 15 yr in environmental assessment	Proposed action, and potential requirements for proposed action
Jas S. Devgun	Ph.D., Physical Chemistry/ Photon Physics; P.D.F., Chemical Engineering 12 yr experience in radio- active waste management/ nuclear engineering/envir- onmental assessment	Project Leader, radiological characterization and environmental impact analysis
<u>Bechtel National, Inc.</u>		
Steve D. Liedle	Ph.D., Environmental Engineering Several years experience as Project Manager with Bechtel National Inc.	Site description

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APPENDIX A:
POTENTIAL REQUIREMENTS FOR THE PROPOSED ACTION

TABLE A.1 Potential Contaminant-Specific Requirements

Requirement	Citation	Content	Pertinence to Proposed Action
Clean Air Act, as amended; National Primary and Secondary Ambient Air Quality Standards	42 USC 7401-7642; 40 CFR 50	National Ambient Air Quality Standards are established for certain pollutants, including particulate matter (not to exceed a 24-hour average concentration of $150 \mu\text{g}/\text{m}^3$ or an annual arithmetic mean of $50 \mu\text{g}/\text{m}^3$). (See also National Emission Standard for Asbestos and Radionuclides.)	Pertinent to decontamination, dismantlement, and temporary storage activities.
National Emission Standards for Radionuclide Emissions from Department of Energy Facilities	40 CFR 61, Subpart II	Air emissions of radionuclides other than radon-220 and radon-222 and their decay products from DOE facilities must not exceed an amount that causes a dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to the critical organ of any member of the public.	Pertinent to decontamination, dismantlement, and temporary storage activities.

TABLE A.2 Potential Action-Specific Requirements

Requirement	Citation	Content	Pertinence to Proposed Action
Occupational Safety and Health Administration General Industry Standards	29 CFR 1910	Health and safety standards are established for hazardous waste operations, including limits for exposure to noise and certain hazardous materials. (See also discussion of 29 CFR 1910 in Table A.3.)	Pertinent to specific exposure management activities (e.g., for noise) and general worker health and safety.
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings	40 CFR 192	Permissible concentrations of radium, thorium, radon, and gamma radiation are limited. ^a	Although the Elza Gate site is not a uranium mill tailings site, certain parts of these requirements are pertinent to the proposed action because of contaminant similarities.
Radiation Protection Derived Concentration Guides	DOE Order 5480.1B (Chapter XI, as amended -- see Vaughan [1985] and subsequent updates of Derived Concentration Guides)	A basic dose limit is established for nonoccupationally exposed individuals: 100 mrem/yr committed effective dose equivalent above background. Further, all radiation exposures must be reduced to levels as low as reasonably achievable. In addition, derived concentration guides are identified for various contaminants in water and air, as are requirements for occupational exposure and on-site controls.	Although not promulgated, these constitute "to be considered" requirements for the proposed action.

TABLE A.2 (Cont'd)

Requirement	Citation	Content	Pertinence to Proposed Action
Radiation Protection for Occupational Workers	DOE Order 5480.11	Standards and program requirements are established for worker protection from ionizing radiation, including derived air concentration guides for inhalation and immersion. Additionally, this order establishes that the basic dose limit of 100 mrem/yr (see DOE Order 5480.1B) also applies to any member of the public entering a controlled area.	Although not promulgated, these constitute "to be considered" requirements for the proposed action.
Standards for Protection Against Radiation	48 FR 20721	The standard for uranium-238 in inhaled air is 3×10^{-12} $\mu\text{Ci/mL}$ daily, 1×10^{-12} $\mu\text{Ci/mL}$ weekly; the standard for thorium-232 in inhaled air is 4×10^{-15} $\mu\text{Ci/mL}$ weekly and 8×10^{-15} $\mu\text{Ci/mL}$ yearly; the standard for thorium-230 in inhaled air is 2×10^{-14} $\mu\text{Ci/mL}$ yearly; and the standard for radium-226 in inhaled air is 9×10^{-13} $\mu\text{Ci/mL}$ weekly.	Although not promulgated, these constitute "to be considered" requirements for the proposed action.
Comprehensive Environmental Response, Compensation, and Liability Act, as amended.	42 USC 9601 (PL 96-510) et seq. (e.g., PL 99-499)	Authority and responsibility for implementing environmental response actions are identified, including procedural requirements.	Pertinent to all aspects of the proposed action.

TABLE A.2 (Cont'd.)

Requirement	Citation	Content	Pertinence to Proposed Action
Occupational Safety and Health Administration Standards for Hazardous Waste Operations and Emergency Response	29 CFR 1910	General worker protection requirements are established, as are requirements for worker training and the development of an emergency response plan and a safety and health program for employees. In addition, procedures are established for hazardous waste operations -- including decontamination of radioactive waste, shipping and transport, and drum/container handling.	Pertinent to decontamination, dismantling, temporary storage, and transport activities.

^aThe soil concentration of radium or thorium averaged over an area of 100 m² must not exceed the background levels by more than 5 pCi/g averaged over the first 15 cm of soil below the surface and 15 pCi/g averaged over subsequent 15-cm layers. In any occupied or habitable building, the annual average (or equivalent) radon decay product concentration (including background) must not exceed 0.02 working level (WL) or a maximum of 0.03 WL. In any occupied or habitable building, the level of gamma radiation must not exceed the background level by more than 20 μ R/h. Radon releases to the atmosphere from tailings piles must not exceed an average rate of 20 pCi/m²-s or increase the annual average concentration in air outside the site by more than 0.5 pCi/L. Finally, the annual dose equivalent from sources other than radon and its short-lived decay products must not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the general public.

Source: Data from Vajda (1989).

REFERENCES (APPENDIX A)

Vajda, G.F., 1989, *Position Paper, ARARs for WSSRAP Chemical Plant/Raffinate Pits Area*, prepared by Dames and Moore for U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri (March).

Vaughan, W.A., 1985, *Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities*, memorandum from W.A. Vaughan (U.S. Department of Energy, Assistant Secretary for Environment, Safety and Health) to distribution (Aug. 5).

APPENDIX B:
DOE GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL

APPENDIX B:

DOE GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL

[reproduced from U.S. Department of Energy, 1987, *U.S. Department of Energy Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites* (Revision 2, March 1987)]

A. INTRODUCTION

This document presents U.S. Department of Energy (DOE) radiological protection guidelines for cleanup of residual radioactive material and management of the resulting wastes and residues. It is applicable to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and remote sites identified by the Surplus Facilities Management Program (SFMP).^{*} The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactive material, and requirements for control of the radioactive wastes and residues.

Protocols for identification, characterization, and designation of FUSRAP sites for remedial action; for implementation of the remedial action; and for certification of a FUSRAP site for release for unrestricted use are given in a separate document (U.S. Department of Energy 1986) and subsequent guidance. More detailed information on applications of the guidelines presented herein, including procedures for deriving site-specific guidelines for allowable levels of residual radioactive material from basic dose limits, is contained in "A Manual for Implementing Residual Radioactive Material Guidelines" (U.S. Department of Energy 1987), referred to herein as the "supplement".

"Residual radioactive material" is used in these guidelines to describe radioactive material derived from operations or sites over which DOE has authority. Guidelines or guidance to limit the levels of radioactive material and to protect the public and the environment are provided for (1) residual concentrations of radionuclides in soil,** (2) concentrations of airborne

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^{*}A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE research and development or production area.

^{**}"Soil" is defined herein as unconsolidated earth material, including rubble and debris that may be present in earth material.

radon decay products, (3) external gamma radiation levels, (4) surface contamination levels, and (5) radionuclide concentrations in air or water resulting from or associated with any of the above.

A "basic dose limit" is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined by the International Commission on Radiological Protection (ICRP 1977, 1978). The basic dose limits are used for deriving guidelines for residual concentrations of radionuclides in soil. Guidelines for residual concentrations of thorium and radium in soil, concentrations of airborne radon decay products, allowable indoor external gamma radiation levels, and residual surface contamination concentrations are based on existing radiological protection standards (U.S. Environmental Protection Agency 1983; U.S. Nuclear Regulatory Commission 1982; and DOE Departmental Orders). Derived guidelines or limits based on the basic dose limits for those quantities are used only when the guidelines provided in the existing standards cited above are shown to be inappropriate.

A "guideline" for residual radioactive material is a level of radioactivity or radioactive material that is acceptable if use of the site is to be unrestricted. Guidelines for residual radioactive material presented herein are of two kinds: (1) generic, site-independent guidelines taken from existing radiation protection standards and (2) site-specific guidelines derived from basic dose limits using site-specific models and data. Generic guideline values are presented in this document. Procedures and data for deriving site-specific guideline values are given in the supplement. The basis for the guidelines is generally a presumed worst-case plausible-use scenario for the site.

An "authorized limit" is a level of residual radioactive material or radioactivity that must not be exceeded if the remedial action is to be considered completed and the site is to be released for unrestricted use. The authorized limits for a site will include (1) limits for each radionuclide or group of radionuclides, as appropriate, associated with residual radioactive material in soil or in surface contamination of structures and equipment, (2) limits for each radionuclide or group of radionuclides, as appropriate, in air or water, and, (3) where appropriate, a limit on external gamma radiation resulting from the residual material. Under normal circumstances, expected to occur at most sites, authorized limits for residual radioactive material or radioactivity are set equal to guideline values. Exceptional conditions for which authorized limits might differ from guideline values are specified in Sections D and F of this document. A site may be released for unrestricted use only if site conditions do not exceed the authorized limits or approved supplemental limits, as defined in Section F.1, at the time remedial action is completed. Restrictions and controls on use of the site must be established and enforced if site conditions exceed the approved limits, or if there is potential to exceed the basic dose limit if use of the site is not restricted (Section F.2). The applicable controls and restrictions are specified in Section E.

DOE policy requires that all exposures to radiation be limited to levels that are as low as reasonably achievable (ALARA). For sites to be released for unrestricted use, the intent is to reduce residual radioactive material to levels that are as far below authorized limits as reasonable considering technical, economic, and social factors. At sites where the residual material is not reduced to levels that permit release for unrestricted use, ALARA policy is implemented by establishing controls to reduce exposure to levels that are as low as reasonably achievable. Procedures for implementing ALARA policy are discussed in the supplement. ALARA policies, procedures, and actions shall be documented and filed as a permanent record upon completion of remedial action at a site.

B. BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr. The internal committed effective dose equivalent, as defined in ICRP Publication 26 (ICRP 1977) and calculated by dosimetry models described in ICRP Publication 30 (ICRP 1978), plus the dose from penetrating radiation sources external to the body, shall be used for determining the dose. This dose shall be described as the "effective dose equivalent". Every effort shall be made to ensure that actual doses to the public are as far below the basic dose limit as is reasonably achievable.

Under unusual circumstances, it will be permissible to allow potential doses to exceed 100 mrem/yr where such exposures are based upon scenarios that do not persist for long periods and where the annual lifetime exposure to an individual from the subject residual radioactive material would be expected to be less than 100 mrem/yr. Examples of such situations include conditions that might exist at a site scheduled for remediation in the near future or a possible, but improbable, one-time scenario that might occur following remedial action. These levels should represent doses that are as low as reasonably achievable for the site. Further, no annual exposure should exceed 500 mrem.

C. GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL

C.1 Residual Radionuclides in Soil

Residual concentrations of radionuclides in soil shall be specified as above-background concentrations averaged over an area of 100 m². Generic guidelines for thorium and radium are specified below. Guidelines for residual concentrations of other radionuclides shall be derived from the basic dose limits by means of an environmental pathway analysis using site-specific data where available. Procedures for these derivations are given in the supplement.

If the average concentration in any surface or below-surface area less than or equal to 25 m² exceeds the authorized limit or guideline by a factor of $(100/A)^{1/2}$, where A is the area of the elevated region in square meters,

limits for "hot spots" shall also be applicable. Procedures for calculating these hot spot limits, which depend on the extent of the elevated local concentrations, are given in the supplement. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

Two types of guidelines are provided, generic and derived. The generic guidelines for residual concentrations of Ra-226, Ra-228, Th-230, and Th-232 are:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface
- 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface

These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the appropriate guideline is applied as a limit to the radionuclide with the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that (1) the dose for the mixtures will not exceed the basic dose limit or (2) the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity"). Explicit formulas for calculating residual concentration guidelines for mixtures are given in the supplement.

C.2 Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR Part 192) is: In any occupied or habitable building, the objective of remedial action shall be, and a reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.* In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions by DOE are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive material is not the cause.

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*A working level (WL) is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

C.3 External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 $\mu\text{R/h}$ and shall comply with the basic dose limit when an appropriate-use scenario is considered. This requirement shall not necessarily apply to structures scheduled for demolition or to buried foundations. External gamma radiation levels on open lands shall also comply with the basic dose limit, considering an appropriate-use scenario for the area.

C.4 Surface Contamination

The generic surface contamination guidelines provided in Table 1 are applicable to existing structures and equipment. These guidelines are adapted from standards of the U.S. Nuclear Regulatory Commission (NRC 1982)* and will be applied in a manner that provides a level of protection consistent with the Commission's guidance. These limits apply to both interior and exterior surfaces. They are not directly intended for use on structures to be demolished or buried, but should be applied to equipment or building components that are potentially salvageable or recoverable scrap. If a building is demolished, the guidelines in Section C.1 are applicable to the resulting contamination in the ground.

C.5 Residual Radionuclides in Air and Water

Residual concentrations of radionuclides in air and water shall be controlled to levels required by DOE Environmental Protection Guidance and Orders, specifically DOE Order 5480.1A and subsequent guidance. Other Federal and/or state standards shall apply when they are determined to be appropriate.

D. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVE MATERIAL

Authorized limits shall be established to (1) ensure that, as a minimum, the basic dose limits specified in Section B will not be exceeded under the worst-case plausible-use scenario consistent with the procedures and guidance provided or (2) be consistent with applicable generic guidelines, where such guidelines are provided. The authorized limits for each site and its vicinity properties shall be set equal to the generic or derived guidelines except where it can be clearly established on the basis of site-specific data -- including health, safety, and socioeconomic considerations -- that the guidelines are not appropriate for use at the specific site. Consideration should also be given to ensure that the limits comply with or provide a level of protection equivalent to other appropriate limits and guidelines (i.e., state or

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*These guidelines are functionally equivalent to Section 4 -- Decontamination for Release for Unrestricted Use -- of NRC Regulatory Guide 1.86 (U.S. Atomic Energy Commission 1974), but they are applicable to non-reactor facilities.

TABLE 1 SURFACE CONTAMINATION GUIDELINES

Radionuclides ^b	Allowable Total Residual Surface Contamination (dpm/100 cm ²) ^a		
	Average ^{c,d}	Maximum ^{d,e}	Removable ^{d,f}
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000 α	15,000 α	1,000 α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 β - γ	15,000 β - γ	1,000 β - γ

^a As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

^b Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

^c Measurements of average contamination should not be averaged over an area of more than 1 m². For objects of less surface area, the average should be derived for each such object.

^d The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

^e The maximum contamination level applies to an area of not more than 100 cm².

^f The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm² is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

other Federal). Documentation supporting such a decision should be similar to that required for supplemental limits and exceptions (Section F), but should be generally more detailed because the documentation covers the entire site.

Remedial action shall not be considered complete unless the residual radioactive material levels comply with the authorized limits. The only exception to this requirement will be for those special situations where the supplemental limits or exceptions are applicable and approved as specified in Section F. However, the use of supplemental limits and exceptions should be considered only if it is clearly demonstrated that it is not reasonable to decontaminate the area to the authorized limit or guideline value. The authorized limits are developed through the project offices in the field and are approved by the headquarters program office.

E. CONTROL OF RESIDUAL RADIOACTIVE MATERIAL AT FUSRAP AND REMOTE SFMP SITES

Residual radioactive material above the guidelines at FUSRAP and remote SFMP sites must be managed in accordance with applicable DOE Orders. The DOE Order 5480.1A and subsequent guidance or superceding Orders require compliance with applicable Federal and state environmental protection standards.

The operational and control requirements specified in the following DOE Orders shall apply to interim storage, interim management, and long-term management.

- a. 5000.3, Unusual Occurrence Reporting System
- b. 5440.1C, Implementation of the National Environmental Policy Act
- c. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations, as revised by DOE 5480.1 change orders and the 5 August 1985 memorandum from Vaughan to Distribution
- d. 5480.2, Hazardous and Radioactive Mixed Waste Management
- e. 5480.4, Environmental Protection, Safety, and Health Protection Standards
- f. 5482.1A, Environmental, Safety, and Health Appraisal Program
- g. 5483.1A, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities
- h. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements
- i. 5820.2, Radioactive Waste Management

E.1 Interim Storage

- a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years.
- b. Above-background Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not exceed (1) 100 pCi/L at any given point, (2) an annual average concentration of 30 pCi/L over the facility site, and (3) an annual average concentration of 3 pCi/L at or above any location outside the facility site (DOE Order 5480.1A, Attachment XI-1).
- c. Concentrations of radionuclides in the groundwater or quantities of residual radioactive material shall not exceed existing Federal or state standards.
- d. Access to a site shall be controlled and misuse of on-site material contaminated by residual radioactive material shall be prevented through appropriate administrative controls and physical barriers -- active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These control features should be designed to ensure, to the extent reasonable, an effective life of at least 25 years. The Federal government shall have title to the property or shall have a long-term lease for exclusive use.

E.2 Interim Management

- a. A site may be released under interim management when the residual radioactive material exceeds guideline values if the residual radioactive material is in inaccessible locations and would be unreasonably costly to remove, provided that administrative controls are established to ensure that no member of the public shall receive a radiation dose exceeding the basic dose limit.
- b. The administrative controls, as approved by DOE, shall include but not be limited to periodic monitoring as appropriate, appropriate shielding, physical barriers to prevent access, and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactive material or cause it to migrate.
- c. The owner of the site or appropriate Federal, state, or local authorities shall be responsible for enforcing the administrative controls.

E.3 Long-Term Management

Uranium, Thorium, and Their Decay Products

- a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years.
- b. Control and stabilization features shall be designed to ensure that Rn-222 emanation to the atmosphere from the wastes shall not (1) exceed an annual average release rate of 20 pCi/m²/s and (2) increase the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates is not required.
- c. Prior to placement of any potentially biodegradable contaminated wastes in a long-term management facility, such wastes shall be properly conditioned to ensure that (1) the generation and escape of biogenic gases will not cause the requirement in paragraph b. of this section (E.3) to be exceeded and (2) biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph a. of this section (E.3).
- d. Groundwater shall be protected in accordance with appropriate Departmental Orders and Federal and state standards, as applicable to FUSRAP and remote SFMP sites.
- e. Access to a site should be controlled and misuse of on-site material contaminated by residual radioactivity should be prevented through appropriate administrative controls and physical barriers -- active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These controls should be designed to be effective to the extent reasonable for at least 200 years. The Federal government shall have title to the property.

Other Radionuclides

- f. Long-term management of other radionuclides shall be in accordance with Chapters 2, 3, and 5 of DOE Order 5820.2, as applicable.

F. SUPPLEMENTAL LIMITS AND EXCEPTIONS

If special site-specific circumstances indicate that the guidelines or authorized limits established for a given site are not appropriate for a portion of that site or for a vicinity property, then the field office may request that supplemental limits or an exception be applied. In either case, the field office must justify that the subject guidelines or authorized limits are not appropriate and that the alternative action will provide adequate

protection, giving due consideration to health and safety, the environment, and costs. The field office shall obtain approval for specific supplemental limits or exceptions from headquarters as specified in Section D of these guidelines and shall provide to headquarters those materials required for the justification as specified in this section (F) and in the FUSRAP and SFMP protocols and subsequent guidance documents. The field office shall also be responsible for coordination with the state or local government of the limits or exceptions and associated restrictions as appropriate. In the case of exceptions, the field office shall also work with the state and/or local governments to ensure that restrictions or conditions of release are adequate and mechanisms are in place for their enforcement.

F.1 Supplemental Limits

The supplemental limits must achieve the basic dose limits set forth in this guideline document for both current and potential unrestricted uses of a site and/or vicinity property. Supplemental limits may be applied to a vicinity property or a portion of a site if, on the basis of a site-specific analysis, it is determined that (1) certain aspects of the vicinity property or portion of the site were not considered in the development of the established authorized limits and associated guidelines for that vicinity property or site and, (2) as a result of these unique characteristics, the established limits or guidelines either do not provide adequate protection or are unnecessarily restrictive and costly.

F.2 Exceptions

Exceptions to the authorized limits defined for unrestricted use of a site or vicinity property may be applied to a vicinity property or a portion of a site when it is established that the authorized limits cannot be achieved and restrictions on use of the vicinity property or portion of the site are necessary to provide adequate protection of the public and the environment. The field office must clearly demonstrate that the exception is necessary and that the restrictions will provide the necessary degree of protection and will comply with the requirements for control of residual radioactive material as set forth in Section E of these guidelines.

F.3 Justification for Supplemental Limits and Exceptions

Supplemental limits and exceptions must be justified by the field office on a case-by-case basis using site-specific data. Every effort should be made to minimize use of the supplemental limits and exceptions. Examples of specific situations that warrant use of the supplemental standards and exceptions are:

- a. Where remedial action would pose a clear and present risk of injury to workers or members of the general public, notwithstanding reasonable measures to avoid or reduce risk.

- b. Where remedial action -- even after all reasonable mitigative measures have been taken -- would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.
- c. Where it is clear that the scenarios or assumptions used to establish the authorized limits do not, under plausible current or future conditions, apply to the property or portion of the site identified and where more appropriate scenarios or assumptions indicate that other limits are applicable or necessary for protection of the public and the environment.
- d. Where the cost of remedial action for contaminated soil is unreasonably high relative to long-term benefits and where the residual radioactive material does not pose a clear present or future risk after taking necessary control measures. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this risk. Remedial action will generally not be necessary where only minor quantities of residual radioactive material are involved or where residual radioactive material occurs in an inaccessible location at which site-specific factors limit their hazard and from which they are costly or difficult to remove. Examples include residual radioactive material under hard-surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. A site-specific analysis must be provided to establish that it would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in Section B, and a statement specifying the level of residual radioactive material must be included in the appropriate state and local records.
- e. Where there is no feasible remedial action.

G. SOURCES

Limit or Guideline	Source
<u>Basic Dose Limits</u>	
Dosimetry model and dose limits	International Commission on Radiological Protection (1977, 1978)
<u>Generic Guidelines for Residual Radioactivity</u>	
Residual concentrations of radium and thorium in soil	40 CFR Part 192
Airborne radon decay products	40 CFR Part 192
External gamma radiation	40 CFR Part 192
Surface contamination	Adapted from U.S. Nuclear Regulatory Commission (1982)
<u>Control of Radioactive Wastes and Residues</u>	
Interim storage	DOE Order 5480.1A and subsequent guidance
Long-term management	DOE Order 5480.1A and subsequent guidance; 40 CFR Part 192; DOE Order 5820.2

H. REFERENCES

- International Commission on Radiological Protection, 1977. Recommendations of the International Commission on Radiological Protection (Adopted January 17, 1977). ICRP Publication 26. Pergamon Press, Oxford. [As modified by "Statement from the 1978 Stockholm Meeting of the ICRP." Annals of the ICRP, Vol. 2, No. 1, 1978.]
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