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Impacts of the use of institutional controls on risk assessments for U.S. Department of Energy facilities

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Abstract

This paper summarizes some of the major issues related to the use of institutional controls at hazardous waste sites under the auspices of the U.S. Department of Energy Field Office, Oak Ridge/Environmental Restoration Division (DOE-OR/ERD). In particular, the impacts that assumptions regarding institutional controls have on the results and interpretation of the risk assessment, both in the Remedial Investigation (RI) and the Feasibility Study (FS) are addressed. The approaches and assumptions relating to institutional controls focus on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), since it is the regulatory driver for hazardous waste sites at Department of Energy (DOE) facilities. In order to provide a contrast to approaches adopted under CERCLA, the Resource Conservation and Recovery Act (RCRA) and radiation regulatory authorities (i.e., Nuclear Regulatory Commission (NRC) regulations/guidance, DOE orders, and U.S. Environmental Protection Agency (EPA) standards) are briefly outlined. To demonstrate the implications of the use of institutional controls at DOE facilities, the approaches and results of a recent baseline risk assessment for Solid Waste Storage Area 6 at Oak Ridge National Laboratory (ORNL) are summarized.

1. Introduction

Currently, access by the public is prohibited at the majority of hazardous waste sites under the auspices of the Department of Energy Field Office Oak Ridge/Environmental Restoration Division (DOE-OR/ERD). Fences, armed security guards, and patrols exclude the public from on-site areas. Such remedial response actions that mitigate health risks by limiting human activities or access to the site are known as institutional controls. Institutional controls act by physically restricting land use of the site. They may also involve legal land/resource restrictions such as deed restrictions, deed notices, well-drilling prohibitions, well-use advisories, and building permits. Institutional controls do not involve reduction of the toxicity, volume, or mobility of the hazardous

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waste (although they may be used in conjunction with actions that do involve such reductions).

Though institutional controls are presently in place at many DOE-OR/ERD sites, the length of time that these sites will remain under active institutional controls is open to question. The answer might be tens, hundreds, or perhaps thousands of years. In the long run, a reasonable certainty exists, in most cases, that the human health risks at the site will diminish through time due to the natural attenuation of contaminants and radioactive decay. However, what would happen if institutional controls were removed immediately and a family hypothetically sets up residence on a DOE-OR/ERD hazardous waste site? The health risk estimates for that family would be far greater than actual current public risks with institutional controls in place, and would exceed the risks that would occur in the more likely event that institutional controls are not removed immediately, but rather in a hundred years.

The residential risk exercise just described, although hypothetical, is not a futile one. If hypothetical risks to an on-site resident are unacceptable, then a strong argument exists for DOE-OR/ERD to keep in place the very active institutional control mechanisms that prevent those risks from actually occurring. The danger lies in the fact that estimates resulting from this risk assessment approach may mislead and overly distress the general public. There may be a perception amongst the general public that they are actually subjected to the risk level estimates generated by the exercise.

2. Institutional controls under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

2.1 Institutional controls and the baseline risk assessment

According to the National Contingency Plan (NCP), which implements the regulatory requirements established under CERCLA, the baseline risk assessment must consider risk in the *absence* of any institutional controls (NCP, Section 300.430(d)) [1]. The baseline risk assessment should address the potential land use associated with the highest level of exposure and risk. Because DOE-OR/ERD sites currently have institutional controls in place, the baseline risk assessment must consider an assumed *future* land use condition in which one cannot exclude the possibility that a family takes up residence on the sites. However, the NCP does concede that the assumption of future residential land use may not be justifiable if there is only a small probability that the site will support such use. Where the future land use is unclear, risks associated with residential land use should be compared to risks associated with other land uses, such as industrial, recreational, agricultural, etc.

The Environmental Protection Agency (EPA) Region IV has also issued a baseline risk assessment guidance memorandum that addresses the exposure scenarios to be assessed under current and future land use condition [2]. Instead of attempting to define an institutional control period, this directive provides instructions which divide exposure scenarios into current and future land use (with no mention of the time frame, i.e., when the "future land use" will occur). Table 1 shows that the exposure scenarios to be considered also depend on whether the site is defined as industrial or non-industrial. EPA Region IV defines industrial sites as strictly buildings and their associated infrastructure. This definition of an industrial site means that a large number of the DOE-OR/ERD hazardous waste sites will be considered non-industrial. Therefore, under the future land use condition, the baseline risk assessment must use the on-site residential "homesteader" scenario. Furthermore, this assessment under the future land use condition must consider exposures to current contaminant concentrations, even though these concentrations are likely to decrease through time due to natural attenuation and radioactive decay.

2.2 Institutional controls and the feasibility study

During the feasibility study, remedial action alternatives are developed, screened, and analyzed with respect to their ability to protect human health and the environment and other criteria, so that decision makers can select the appropriate alternative for the site. The NCP describes a number of expectations related to the role of institutional controls in selecting the remedial alternative [1]. The NCP states that institutional controls may be used as a supplement to engineered controls but may not substitute for Active Response Measures (ARMs) unless (1) ARMs are not practicable, as determined by remedy selection criteria, or (2) institutional controls are the only means available to provide protection of human health (NCP, Sections 300.430(a)1 (iii)(d) and 300.430(e)3(ii)). If institutional controls are used as a sole remedy,

TABLE 1

Land use assumptions for baseline risk assessments (from EPA Region IV Baseline Risk Assessment Guidance)

Type of site	Current land use	Future land use
On-site non-industrial[a,b]	Off-site residential On-site occupational[c] Inadvertent intruder	On-site residential
On-site industrial	Off-site residential On-site occupational Inadvertent intruder	Off-site residential On-site occupational Inadvertent intruder

[a] "On-site" means those areas that are fenced and patrolled.
[b] "Industrial" sites are strictly buildings and their associated infrastructure.
[c] The on-site worker is a worker not involved with the investigation and remediation of the site.

special precautions must be taken to ensure institutional controls will remain reliable and in place.

Public comment on the NCP urged an expanded role for institutional controls if they could provide a similar level of protection at lower costs (particularly for federal sites). However, the EPA disagreed and refused enhancement or enlargement of the role of institutional controls.

3. Institutional controls under other authorities

3.1 The Resource Conservation and Recovery Act (RCRA)

RCRA does not explicitly acknowledge the use of institutional controls in the RCRA Facility Investigation, although the permitting requirements generally include a 30-year post-closure active control period. The RCRA process involves setting media cleanup target levels at a point of compliance that is negotiated early in the process. RCRA does allow remedial action alternatives that include measures that are not directly related to media clean-up, source control or waste management (e.g., measures to control exposures) as long as the alternative is protective of human health and the environment, reduces or eliminates further releases, and complies with management standards [3].

3.2 Radiation regulatory authorities

Radiation-specific regulations are more explicit and tolerant about the use of institutional controls than are CERCLA or RCRA. Radiation requirements for the disposal and management of waste generally involve setting acceptable doses to the public and equivalent concentrations that are calculated assuming a given period of institutional control [4]. Specific regulations and associated institutional control periods are described as follows and summarized in Table 2.

3.2.1 Nuclear Regulatory Commission (NRC) regulations/guidance

The NRC Part 61 requirements for the near-surface disposal of radioactive waste identify three classes of radioactive waste [5]. The concentration limits depend on specific disposal requirements and assumed scenarios for inadvertent intrusion for the different classes. Waste with the highest activities are designated as Class C waste. For these wastes, an active institutional control period of 100 years is assumed. After 100 years, it is assumed that active institutional controls are removed and the public may intrude on the site, but that the specific requirements for disposal of Class C waste (capping, burial at depths below 5 m) prevent direct exposure for an additional 400 years.

An active institutional control period of 100 years is also assumed for Class A and B wastes. However, because of their lower activities, there are no specific disposal requirements that would prevent direct exposure after institutional controls are terminated.

TABLE 2

Assumed periods of institutional control under different radiation regulatory authorities

Standard	Reference	Type of facility	Assumed period of institutional control
NRC Part 61	[5]	Near-surface disposal of radioactive waste	Class C waste: 100 years active control 400 years passive control Class A and B waste: 100 years active control
DOE Order 5820.2A	[6]	Near-surface disposal of low level waste	100 years active control
EPA CFR Part 191	[7, 8]	Groundwater protection standards for disposal of high level waste	1,000 years (no direct intrusion [7]) 1,000 or 10,000 years (no direct intrusion [8])

3.2.2 DOE Orders

DOE Order 5820.2A for the management of low level waste specifies limits on annual doses for inadvertent intruders after loss of active institutional controls at 100 years after disposal [6].

3.2.4 EPA standards for disposal of high level radioactive waste

The EPA 40 Code of Federal Regulations (CFR) Part 191 groundwater protection requirements for management and disposal of spent nuclear fuel, high-level and transuranic waste set annual dose limits and concentration limits for 1000 years after disposal, assuming undisturbed performance (e.g., no direct human intrusion) [7]. However, the First Circuit Court vacated these requirements, finding them arbitrary in limiting the duration of the requirement to 1000 years. The EPA apparently plans to propose alternative time periods of 1000 and 10,000 years for the application of the requirements [8].

4. Case study: Solid Waste Storage Area (SWSA) 6

SWSA 6 is part of Waste Area Grouping (WAG) VI at the Oak Ridge National Laboratory (ORNL) [9]. SWSA 6 is approximately 2.9 km southwest of the ORNL Main Plant, covers an area of 15 acres, and occupies most of the total acreage of WAG VI. Since 1969, low level radioactive and chemically hazardous wastes from operational and research activities conducted at ORNL have been deposited at SWSA 6. These include contaminated soil, laboratory equipment, protective clothing, mechanical equipment, construction materials,

TABLE 3

Significant SWSA 6 receptor scenarios[a]

Potential receptors	Period of institutional control		
	Controlled (Operational: 0–10 y and post operational: > 10–110 y)		Uncontrolled [1] (Non-operational > 110 y)
	On-WAG	Off-WAG	WAG 6 area
WAG 6 [2] Boundary-hunter receptor		• Ingestion-fauna (R, C)	
WAG 6 [2] Boundary-fencepost receptor		• Inhalation-air (R, C) • Direct radiation-soil (R)	
WAG 6 [3] ORNL Employee	• Inhalation-air (4) (R, C) • Direct Radiation-soil (R)		
On-WAG [5] homesteader	• Direct radiation-soil (R) • Inhalation-air, GW (R, C) • Ingestion-GW, Biota (R, C) • Incidental ingestion-soil, SW, sediment (R, C)		• Direct radiation-soil (R) • Inhalation-air, GW (R, C) • Ingestion-GW, Biota (R, C) • Incidental ingestion-soil, SW, sediment (R, C)
Off-WAG [5, 6] Clinch River homesteader		• Direct radiation-soil (R) • Inhalation-air [7] (R, C) • Ingestion-SW, biota (R, C) • Incidental ingestion-soil (R, C)	

[a]Key:
GW = Groundwater.
SW = Surface water.
R = Assessed for radionuclide components.
C = Assessed for chemical components.
1 = WAG 6 area in uncontrolled period, no WAG boundaries exist.
2 = The boundary receptors (deer hunter and fencepost receptor) are present only in areas that are not contiguous with other WAGs (i.e., WAG 2); for WAG 6 this includes areas to the west and north of the WAG; there are no surface water drainages exiting the WAG from these areas, therefore no surface water/sediment exposures are anticipated for this receptor.
3 = Assume normal working conditions and no accident scenarios.
4 = Includes inhalation of volatiles and particulates for all air exposure routes.
5 = In addition to the time frames indicated, maximum concentrations associated with the identified exposure routes and the year they occur will also be provided.
6 = Off-Oak Ridge reservation receptor located downstream from WAG 6 next to Clinch River. Includes contamination to specific media through irrigation using contaminated Clinch River surface water.
7 = Assessed for tritium only.

filter media and resins, radioactive waste, and animal remains. Packaging of wastes ranged from no packaging to stainless steel drums. Since May 1986, radioactive wastes have been stored in underground concrete silos.

SWSA 6 is fenced and regularly patrolled by armed security guards. There is no public access. The entrance is continually guarded and access is limited to DOE and Martin Marietta Energy Systems, Inc. employees and their subcontractors with clearance for entering the specific area.

Table 3 shows the exposure scenarios that were used in the baseline risk assessment conducted for SWSA 6. As required under CERCLA, the baseline risk assessment included an evaluation of risk in the absence of institutional controls. Thus, the risk assessment included an on-site residential exposure scenario — the "on-WAG homesteader" scenario [9]. Using estimates of current contaminant levels, the main source of risk for this hypothetical exposure scenario was from external exposure to europium-154 while excavating the soil to build the house. Estimates of current risk from this pathway alone approached unity (i.e., almost a 100% probability of developing cancer). Estimates of risk 110 years later for the same pathway and for europium-154 alone were similar to current risk estimates, but risks 500 years later had essentially disappeared due to the radioactive decay of europium-154. (Risks from other pathways and contaminants were on the order of 10^{-3} after 500 years.) Clearly, this case study suggests that the DOE should keep active institutional control measures in place for at least 500 years.

5. Impacts of institutional control at DOE facilities

The issue of institutional controls is having, and will continue to have, a direct impact at DOE-OR/ERD sites, both in assessing baseline risks and in selecting feasible remedial action alternatives. Other DOE facilities should expect similar impacts. Institutional control assumptions determine the individual human receptor used to define the reasonable maximum exposure scenario. If the baseline risk assessment considers risks in the absence of institutional controls as the NCP requires, then the reasonable maximum exposure would be defined by a family setting up residence on the hazardous waste sites, conceivably growing crops and raising livestock there. The ultimate magnitude of the resulting hypothetical risk estimate is in many cases likely to be alarmingly high, as the SWSA 6 case study shows.

However, the concept of assessing baseline risks in the absence of institutional controls is a valid one. The assessment predicts what possible risk levels *could be* if the current institutional controls were to be removed. However, it is important that the general public are not given the impression that they are actually subjected to the estimated risk levels. Therefore, DOE-OR/ERD risk assessments should also include an assessment of risks with the present institutional controls (fences, guards, patrols, etc.) in place, as well as future risks when the institutional controls are removed after some period of time. For the assessment of future risks, one needs to define the period of time over which we expect the institutional controls to remain in place, as the radiation regulators have done. In general, the longer the time period, the lower the eventual risks when controls are removed because of natural attenuation of contaminants and radioactive decay.

The role of institutional controls in selecting feasible alternatives will also have an impact at DOE-OR/ERD and other DOE sites. The NCP emphasizes the use of engineered alternatives for remediation. Institutional controls are intended to supplement, but not replace, such active response measures. However, perhaps the current institutional control measures at DOE-OR/ERD sites are more effective in terms of overall protection of human health and the environment than are present-day engineering technologies. The SWSA 6 case study suggests that an appropriate period of institutional controls would be on the order of 500 years due to the presence of long-lived radionuclides.

6. Current DOE-OR/ERD approaches

The DOE-OR/ERD risk assessment program has discussed these issues and recommends the following approaches:

(1) Adhere to the NCP's requirement for assessing risks in the absence of institutional controls in the baseline risk assessment. Follow EPA Region IV's definition of industrial and non-industrial sites (Table 1) immediately, and consider the appropriate exposure scenarios under the current and future land use conditions as summarized above. Under the future land use condition for non-industrial sites, the on-site resident homesteader will hypothetically be exposed to the current contaminant concentrations in most cases. However, if fate and transport models predict that contaminant concentrations may increase through time, then the predicted concentrations would be used rather than the current concentrations. All exposure scenario assumptions will be qualified in the "uncertainties" section of the baseline risk assessment.

(2) In addition to estimating risks in the absence of institutional controls, calculate current risks with institutional controls in place, and future risks when institutional controls are removed. Under the future land use condition, use fate and transport models to provide realistic estimates of future exposures. Present collectively in the baseline risk assessment all risk estimates for the different exposure scenarios along with assessments of the likelihood of the scenarios occurring.

(3) For future exposure scenarios define the period of time over which we expect the institutional controls to remain in place based on approaches similar to those used by radiation regulators. Time periods could be developed on a generic basis or they could be determined on a site-specific basis, but they must be fully justified.

(4) Consider the validity of problems involved with DOE's stewardship authority of lands and facilities for periods longer than 100 years. Because the presence of long-lived radionuclides at many of the DOE-OR/ERD sites means that 100 years will not be sufficient, as the SWSA 6 case study shows, the DOE has two alternatives:
(A) Examine the DOE's authority to commit to perpetual stewardship/guardianship of the sites.
(B) Propose alternative time periods for DOE's commitment to keeping institutional controls in place. Time periods could be developed on a generic basis or they could be determined on a site-specific basis.

References

1 U.S. Environmental Protection Agency, National Oil and Hazardous Substance Pollution Contingency Plan. The Federal Register 55, No. 46, Washington, DC, 1990.
2 U.S. Environmental Protection Agency, Region IV. Baseline Risk Assessment Guidance. U.S. EPA, Atlanta, GA, 1990.
3 U.S. Environmental Protection Agency, Corrective Action for Solid Waste Management Units at Hazardous Waste Management Facilities, Proposed Rule. The Federal Register 55, No. 27, Washington, DC, 1990.
4 D.C. Kocher, Applicable or Relevant and Appropriate Regulatory Requirements for Remediation of Radioactively Contaminated Waste Disposal Sites. Oak Ridge National Laboratory (ORNL/ER-31), Oak Ridge, TN, 1991.
5 U.S. Nuclear Regulatory Commission, Part 61 — Licensing Requirements for Land Disposal of Radioactive Waste, In: Code of Federal Regulations, Title 10, Parts 51 to 199, U.S. Government Printing Office, Washington, DC, 1989, p. 93.
6 U.S. Department of Energy, Management of low level waste, In: Radioactive Waste Management, U.S. DOE, Washington, DC, 1988, Order 5820.2A, Chap. III.
7 U.S. Environmental Protection Agency, Part 191 — Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Waste, In: Code of Federal Regulations, Title 40, Parts 190 to 399, U. S. Government Printing Office, Washington, DC, 1988, p. 7.
8 U.S. Environmental Protection Agency, Part 191 — Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Waste, In: Code of Federal Regulations, Title 40, Parts 190 to 399, Working Draft 1, June 2, Washington, DC, 1989.
9 Martin Marietta Energy Systems, Inc., RCRA Facility Investigation Report for Waste Area Grouping 6 at Oak Ridge National Laboratory, Oak Ridge, TN, Vol. 2, 1991.