RISK AND DECISIONS ABOUT DISPOSITION OF TRU AND HLW: FINDINGS AND RECOMMENDATIONS OF A NATIONAL ACADEMIES STUDY

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ABSTRACT

The Department of Energy (DOE) asked the National Academies to provide advice on approaches for using risk in selecting disposition paths, including alternatives to deep geologic disposal, for some high-level radioactive waste (HLW) or transuranic (TRU) waste. This paper summarizes the findings and recommendations from the study and presents some of the reasoning supporting those findings and recommendations. The committee found that deep geologic disposal is the default disposition option for TRU and HLW, but some of this waste may not warrant disposal in a deep geologic repository, either because (1) it is infeasible to recover and dispose of every last bit of the waste, or (2) the effort, exposures, and expense associated with the repository disposition path may be out of proportion with the risk reduction achieved, if any. Three waste types contain waste streams that merit consideration for alternative disposal—(1) HLW remaining in tanks (heels); (2) low-activity products from treatment of HLW; and (3) buried TRU waste. The nation should pursue a formal, well-structured, risk-informed approach to decide which waste streams, if any, should have an alternative disposition path. The process would be more credible if an agency other than DOE had the authority to approve or reject DOE's proposals for alternate disposal paths. DOE should not attempt to adopt these changes unilaterally, but should engage regulators and others in a risk-informed decision-making process and implement the process in the context of DOE's existing or renegotiated compliance agreements. Congress, DOE, the U.S. Environmental Protection Agency, and the U.S. Nuclear Regulatory Commission should take actions as necessary to enable DOE to implement this approach effectively. Finally, the DOE risk assessments and decision processes examined by the committee do not exhibit all of the characteristics of an effective and credible risk-informed decision-making process. DOE should form an authoritative, credible, and reasonably independent group to revamp the way DOE goes about implementing risk-informed approaches applied to waste disposition decisions.

INTRODUCTION

The U.S. Department of Energy's Office of Environmental Management (DOE-EM) estimates that it has approximately 340,000 cubic meters (m^3) of high-level radioactive waste containing approximately 835 million curies (MCi) of radioactivity, and at least 287,000 m^3 of transuranic waste containing more than 3.1 MCi of radioactivity at its sites requiring some form of treatment

and disposal. DOE expects to spend several tens of billions of dollars managing and disposing of these highly varied and, in some cases, poorly characterized wastes. Deep geologic disposal is the only contemplated disposition path for some of these waste streams, but DOE is considering seeking alternative disposition paths for other waste streams. DOE-EM asked the National Academies to provide advice on technically sound approaches for using risk in selecting disposition paths, including alternatives to deep-geologic disposal, for its TRU waste and HLW. The study examined the following issues: Key elements of a risk-based approach; criteria for risk assessment; potential alternatives to geologic disposal for disposition of low-hazard waste; compatibility with current regulatory regimes; knowledge and technology gaps for implementation; and broader implications, if any, for disposition of other DOE wastes. The National Academies issued the report, Risk and Decisions about Disposition of Transuranic and High-Level Radioactive Waste [1], in March 2005. This paper presents the report's findings and recommendations along with some of the background. Portions of this paper are taken from the report, although some of the language does not mirror the report language exactly.

THE STUDY PROCESS

The committee's activities began with a meeting in Washington, DC in September 2003, and included information-gathering sessions in Idaho Falls, Idaho; Augusta, Georgia; and Richland, Washington. These meetings focused on the Idaho National Engineering and Environmental Laboratory (INEEL, now the Idaho National Laboratory), the Savannah River Site (SRS), and the Hanford Site, respectively, but allowed the committee to meet with DOE, lab scientists, cleanup contractors, federal and state regulators, tribal representatives, local community leaders, environmental public interest groups, and interested citizens. Through these interactions and through review of hundreds of documents, the committee examined the general and specific issues of controversy concerning TRU and HLW disposition. Because one of the alternative disposition options most frequently explored is near-surface disposal, the committee also examined LLW disposal policies and practices at the sites.

The committee asked some of the same questions at each site. These include the following: What alternatives for management, treatment, and disposal of radioactive waste have been examined? What are the health risks, costs, and timelines for each alternative? What kinds of risks are considered (worker, public, exposure pathways and scenarios, etc.)? What factors drive the risks for different disposal alternatives? Are those factors and the underlying mechanisms well understood? What parts of the calculations introduce the greatest uncertainties? How is the local public involved in the risk assessments? How will risk decisions be implemented? What kinds and levels of risk are considered acceptable? Are there specific examples where regulations are incompatible with or prevent DOE from pursuing an option that appears preferable from a risk perspective?

The issues of controversy are considerable. DOE has encountered skepticism and resistance as proposals and plans have been announced. Regulators, affected tribal nations, interested citizens, and public interest groups worry that short-term advantages, such as cost and schedule reductions, could lead DOE to take actions that jeopardize the long-term safety of people and the environment. Credibility is a particular challenge for anyone proposing to use risk, and more specifically risk assessment, as a basis for decisions on disposition of TRU and HLW. Despite the formulation of risk assessment as an objective tool for evaluating options for waste

disposition, assumptions and judgments are unavoidable parts of the process; some people believe one can get whatever answer one wants from a risk assessment. Disagreements and distrust threaten to paralyze the programs for processing and disposal of types of waste.

Should alternative disposition of some TRU and HLW be allowed and, if so, how should risk be used in selecting disposition options for TRU and HLW? What makes a risk assessment supporting the deliberative process on TRU and HLW useful and credible?

BACKGROUND: THE VARIED NATURE OF THE WASTES

The range of wastes that are considered TRU or HLW is quite broad. This range is illustrated qualitatively in Figure 1, which represents graphically the long-lived and short-lived radionuclide composition of HLW, TRU waste, and spent nuclear fuel. In this figure, adapted from one by Fehringer and Boyle [2], the horizontal axis represents the concentration of long-lived radionuclides of concern (e.g., americium-243) and the vertical axis reflects the concentration of shorter-lived radionuclides of concern (e.g., cesium-137). Notional representations of the radionuclide concentration limits for near-surface burial of low-level wastes (Class C limits contained in 10 CFR 61) appear as a vertical line and a horizontal line within the chart. Congress used the class C limits and the performance objectives from 10 CFR 61 as components of the 2005 Defense Authorization Act, which modified the definition of HLW. The limits are included here as reference levels only.

Among the wastes that might be, or have been, considered HLW are the cesium and strontium capsules at Hanford (these are the most concentrated radioactive material in the DOE SRS Savannah River Site; vitrified and calcined HLW (near the upper right on the figure); and the waste grouted in two tanks that were declared closed at SRS. This last waste type is displayed straddling the Class C limit because the waste is below the class C limit if one averages the concentration over the grout in the tank, but the Natural Resources Defense Council (NRDC) [3] has argued that there is not substantial mixing, and the concentration of the waste itself remains above the class C limit.

By definition TRU waste has relatively high concentrations of long-lived radionuclides or of radionuclides that will decay into long-lived radionuclides. Remote-handled TRU waste has higher concentrations of short-lived fission products and so appears higher on the chart. The concentration of radionuclides in spent nuclear fuel depends on the burnup of the fuel (i.e., how many fissions have occurred per unit fuel). Lightly irradiated fuel has relatively low concentrations of radioactivity.

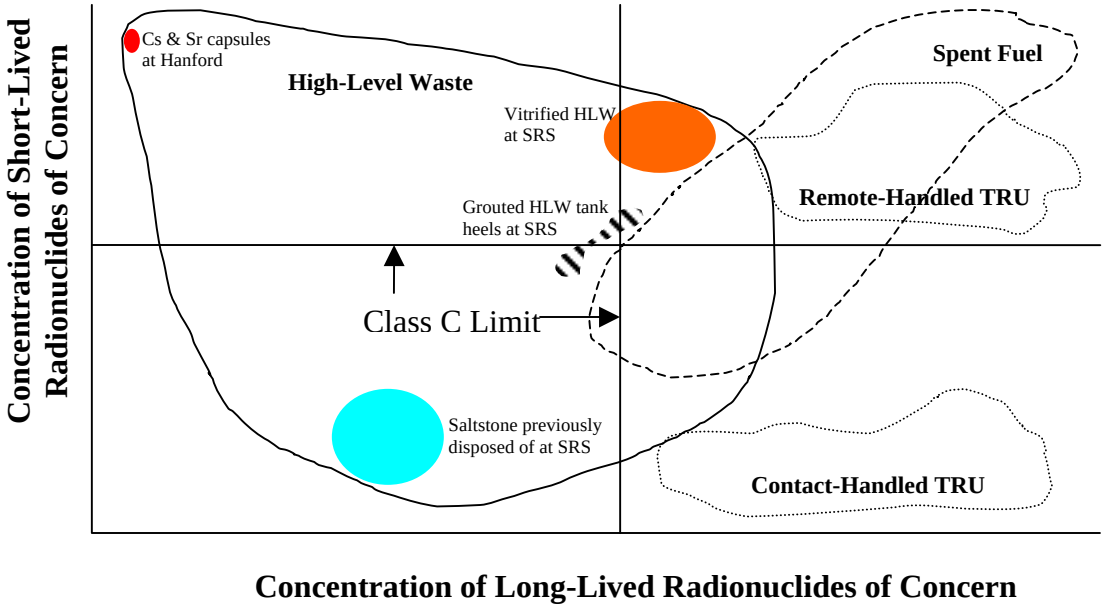

Fig. 1. Chart of the concentrations of short-lived and long-lived radionuclides for waste that might be considered HLW along with TRU waste and spent nuclear fuel. The boundary of each waste class is meant to surround the various waste streams and does not represent quantities. Class C limit demarcations represent radionuclide concentrations in low-level waste below which near-surface disposal is permitted. Note that Saltstone would not now be considered HLW (Figure 2.1 in [1]).

The committee selected three waste types—(1) HLW remaining in tanks ("heels"), (2) low-activity products from treatment of HLW, and (3) buried TRU waste[a] —to describe in detail to illustrate why some waste streams might warrant consideration for a disposition path other than deep geologic disposal. These waste types are described in some detail in the report.

FINDINGS AND RECOMMENDATIONS

Below are the committee's findings and recommendations from the final report [1].

Finding 1: Deep geologic disposal is the default disposition option for HLW and TRU waste.

There is a long history of studies supporting deep geologic disposal of long-lived radioactive wastes. Deep geologic disposal remains the nation's approach for disposal of TRU and HLW.

Finding 2: Some waste currently classified as TRU or HLW may not warrant disposal in a deep geologic repository, either because (1) it is infeasible to recover and dispose of every last bit of waste that might conceivably be classified as TRU or HLW, or (2) the effort, exposures, and expense associated with retrieval, immobilization, and disposition in a repository may be out of proportion with the risk reduction achieved, if any.

Recovery of every last gram of TRU and HLW will be technically impractical and unnecessary. Recovery of some of the waste that is hardest to retrieve may result in little reduction in risk compared to disposing of it in situ while substantially increasing other risks, impacts, and costs. Further, processing and treatment methods can separate highly radioactive material from some wastes, which greatly reduces their hazards. But because of the definition of HLW found in the law, the low-activity waste fraction, even if it contains very low concentrations of hazardous radionuclides, could also be classified as HLW and, therefore, require deep geologic disposal. Some of these wastes, then, may not warrant deep geologic disposal.

Finding 3: The committee makes no recommendation whether specific wastes should be approved for alternative disposal, but it has identified three waste types that contain waste streams that merit consideration: (1) HLW remaining in tanks (heels); (2) low-activity products from treatment of HLW; and (3) buried TRU waste (not buried in a manner that facilitates retrieval).

The nation must confront disposition decisions for each of the waste types listed. Each of these waste types spans a range of characteristics, from relatively low to high radioactivity and hazard, and volumes ranging from a few thousand liters to possibly billions of liters. The costs and risks of packaging and disposing of these wastes are very large. There is, then, the potential for a disproportion between the risk-reduction achieved and the costs and risks incurred for some wastes.

Finding 4: The nation needs a way to determine which of the wastes mentioned in Finding 3, if any, will be disposed in some manner other than deep geologic disposal.

Litigation over authority and agreements about waste disposition has left DOE's waste disposition program with substantial uncertainty concerning the path forward. Given the various disputes and the reality that not all of the waste will or can be recovered and disposed of in a deep geologic repository, an acceptable exemption process is needed.

Finding 5: Without a formal, well-structured, decision-making process, less desirable, ad hoc approaches will emerge.

Given the costs and difficulties of sending all waste that could be classified as HLW or TRU waste to a deep geologic repository, some approach will arise for deciding what waste gets geologic disposal and what does not. A formal, well-structured exemption process is needed regardless of the outcome of the various lawsuits and appeals concerning these wastes. The alternative to a reasoned, planned process is an ad hoc one, which could lead to inconsistent or poorly thought-out decisions that are not in the public interest.

Finding 6: Human health risk is a good basis or starting point for considering whether a waste stream should be granted an exemption, but it is not a sufficient basis for deciding these questions. At a minimum, costs, work-related risks, risks to ecosystems, technical feasibility, cultural and societal impacts, land use implications, preexisting agreements, and other, site-specific factors are also relevant in what is called a risk-informed approach.

Risk-informed approaches are necessary to include all valuable information in an exemption process. Human health risk is an essential consideration for exemptions because (1) risk reflects

one of the basic values being protected—human health—and therefore is a sensible starting point; and (2) risk analysis is a powerful, structured, well-developed way of considering human health effects, and its strengths and weaknesses are well established. This report focuses on human health risk because it is of concern for all of the waste streams and because it has traditionally been studied in risk analysis. However, the committee does not mean to imply that other risks, such as ecological or cultural risks, are unimportant. A proper risk analysis should identify and consider all of the relevant risks at a given site. The process of performing a risk assessment is useful, too, because it draws attention to the critical assumptions and focuses thought on the most significant contributors to risks. The question of how such decisions should be reached, including the roles of these factors and ethical considerations, is critically important, but is entirely a policy question that is beyond the task statement of this technical committee.

Finding 7: The credibility of DOE's planning and decision making is reduced by the apparent conflict of interest created by DOE's authority both to propose and to approve disposition plans for radioactive waste.

The burden of proof for departing from the default disposition option must be on the petitioner seeking alternative disposition. Allocating the burden of proof to DOE is meaningful only if DOE is not also the decision maker. That is, the burden of proof would be weak indeed if it was simply a matter of DOE convincing itself that it is right. DOE's status as a self-regulating agency is problematic because of the perceived and real conflict of interest: DOE is both petitioner and decision maker. Outsiders might reasonably question whether DOE is able to separate these functions so that the agency is neutral in the latter role. Having DOE's application for exemption subject to the judgment of an independent arbiter would make the process more credible to skeptics, of which, in this area, there are many.

Therefore, the burden of proof implies, and the committee here makes it explicit, that a separate federal entity is needed as the regulatory decision maker for exemption purposes. DOE is, of course, regulated by a number of different federal and state entities. Persuasive arguments could be made for either the U.S. Environmental Protection Agency (U.S. EPA) or the U.S. Nuclear Regulatory Commission (U.S. NRC) as regulator, because both have significant expertise in the regulation of radioactive materials. The committee does not have a basis for making a recommendation for either agency but offers some observations on the merits of each for this role.

The U.S. EPA would appear to be the most obvious regulator for TRU waste, because it is already the decision maker identified by law and has worked extensively with such waste at the WIPP facility. U.S. EPA also has been the principal regulator for cleanup at the sites at which HLW and TRU waste is found and U.S. EPA has extensive experience with stakeholder interaction under several statutes; probably more experience than U.S. NRC has. The U.S. NRC, on the other hand, is the agency mentioned in the current definition of HLW. U.S. NRC will rule on DOE's license application for a HLW repository and is the regulator for the cleanup of waste, including HLW, at DOE's West Valley site, which is perhaps the experience that is technically most similar to the management and cleanup of HLW at Hanford, Savannah River, and INEEL. Also, U.S. NRC is legally an independent agency and has some distance from the administration in power. At the same time, however, U.S. NRC is perceived by some to be a captured regulator, serving the interests of the nuclear industry. Further, coming as it does from the same parent

agency (the Atomic Energy Commission), U.S. NRC is perceived by some as being too close to DOE and therefore having an institutional bias for DOE.

Recommendation 1: The nation should pursue a formal, well-structured, risk-informed approach to decide which specific waste streams within the waste types enumerated in Finding 3, if any, should be disposed in some manner other than deep geologic disposal.

The adoption of a formal, well-structured, risk-based approach cannot be the work of one institution alone. DOE must take the initiative, but it is constrained by legislation, the regulation of multiple federal agencies, state regulation, and formal and informal agreements with states, American Indian nations, and other stakeholders. Each of these has a role in the adoption and implementation of such an approach. The committee has recommended that DOE's exemption applications be reviewed and approved or rejected by an independent regulator (or decision maker). Where it is possible and appropriate to identify a particular actor who should be responsible for a particular part of the process described herein, the committee has done so. However, in several settings, the choice of a regulator and their authority is essentially a political one, and beyond the committee's mandate.

Recommendation 2: DOE should *not* attempt to adopt these changes unilaterally. Likewise, the exemption process that the committee recommends must be implemented in the context of DOE's existing or renegotiated compliance agreements.

Put another way, if DOE wants to renegotiate its compliance agreements, it must make a case for renegotiation that is informed by risk, sets out clear criteria for an exemption, comprehensively addresses health risks (including worker, transportation, and long-term risk), and follows a transparent process that allows and enables meaningful public input.

Recommendation 3: DOE and its regulators for HLW and TRU waste should adopt a six-step process for risk-informed decision making: (1) initiate the process, laying out viable options and potential decisions; (2) scope the information and analysis; (3) collect data and refine models; (4) prepare refined risk assessment; (5) develop additional analyses and data collection, as needed, to support decisions; and (6) finalize the decision.

Finding 8: An effective and credible risk-informed-decision-making process has several characteristics. It is (1) participatory; (2) logical; (3) consistent with current scientific knowledge and practice; (4) transparent and traceable; (5) structured with reasonable independence of the decision authority from the petitioner; (6) subjected to thorough, independent peer review; (7) technically credible, with believable results; and (8) framed to address the needs of the decision process.

A risk-informed process that fails to meet any of these eight essential characteristics would likely be ineffective. In order to be effective, a risk-informed approach must be trusted. The eight characteristics listed above are intended not only to ensure a *result* that can be trusted, but *equally importantly* to create a process that can be trusted. For example, a technically credible risk-based approach that lacks participation or transparency would likely not be trusted and, therefore, would likely be ineffective in supporting a waste exemption process.

In summary, Findings 7 and 8 describe the key elements of a risk-informed approach as being a well-structured, participatory, and transparent process with an independent decision maker that uses current scientific knowledge and practice to address human health risk but also takes into account other impacts to reach a decision. In the report, the committee describes these characteristics and provides an example of such a process that is compatible with existing regulations, but does not prescribe a specific process.

Finding 9: The biggest challenges to developing a meaningful risk-informed decision process, such as recommended herein, are minimizing disruption to existing laws, regulations, and agreements; creating buy-in to the approach; and enabling meaningful participation by participants who have few resources.

Disrupting existing laws, regulations, and agreements (e.g., changing the rules to allow potentially unsafe practices to proceed without due process) will tend to cause resistance and unintended consequences of an exemption process. Any meaningful decision process that involves stakeholders such as the risk-informed process recommended here will require finding ways to implement an exemption process in the least disruptive manner possible with regard to existing laws, regulations, and agreements. This process is difficult but important to maintain predictability, to create fewer unintended consequences, and to avoid destabilizing the policy equilibrium that has been reached as people have acted in reliance on the existing framework. The committee does not know how many exemptions DOE might seek or a regulator might approve. Assuming that the number will be relatively few, the committee has recommended exemptions because they can minimize disruption while preserving the desirable features of a risk-informed approach.

Recommendation 4: Congress, DOE, U.S. EPA, and U.S. NRC should take actions as necessary to enable DOE to implement effectively the risk-informed approach recommended here. Specifically, they should provide for a formal, well-structured exemption process, institute technical review of the risk analysis independent of the agency producing the analysis, give decision-making authority to an agency outside DOE, and ensure that sufficient resources are reliably available for regulators, American Indian nations, and stakeholders to participate meaningfully in the process from the outset.

The committee did not develop detailed actions for each entity/agency for the steps necessary to implement this recommendation. There are many possible distributions of responsibilities; what one agency might contribute toward implementation of the recommendations depends heavily on what others would contribute. The implementation of the recommendation should be achieved jointly by the entities involved, without attempting to define in advance of inter-agency discussions what each should contribute.

Finding 10: The DOE risk assessments and decision processes examined by the committee do not exhibit all of the characteristics of an effective and credible risk-informed decision-making process, listed in Finding 8. Other bodies have made similar recommendations on how DOE should incorporate risk into environmental decision making, and DOE has made progress, but institutional factors appear to have interfered and perhaps undermined attempts to implement these approaches. This implies that changes are needed at DOE to address internal and external impediments to the risk-informed approach.

In its site visits the committee requested that DOE present its best examples of risk assessment informing waste disposition or cleanup decisions. Through DOE's presentations to the committee and the committee's review of documents, the committee examined many risk assessments and decision processes. DOE and its contractors have performed technically complex risk assessments, and in many cases have performed risk assessments as part of regulatory processes that lead to cleanup decisions with stakeholder input. Yet the cases examined by the committee do not meet the needs identified and described in this report for the following reasons. The complex analyses were not decision oriented and were not carried out in a transparent manner needed for meaningful participation by those outside DOE. The actions supporting regulatory decisions in many cases also were lacking—the steps in the processes appeared to have been performed simply to meet procedural requirements and most did not appear to have taken the kind of cooperative approach that the committee sees as essential to reach credible decisions and to foster buy-in by other relevant parties.

That the risk assessments examined by the committee do not exhibit all of the characteristics of an effective and credible risk-informed decision-making process does not imply that DOE has been derelict. These are technically difficult cleanup problems being addressed in a complex political and social environment. DOE has stabilized into safe, although temporary, conditions dangerous wastes and facilities across the complex, and in most cases has an enviable safety record in its cleanup program. Working toward effective and credible risk-informed decisions on these issues is very difficult. Further, many of the risk assessments examined by the committee were addressing smaller although significant problems, and so may not have warranted the effort recommended in this report. Also, the risk assessments were not necessarily aimed to fill the role described in this report. But on the latter point, the committee notes that numerous studies summarized in Appendixes A and B make recommendations consistent with those made in this report on how to incorporate risk into environmental decision making. DOE has made progress, but these approaches still have not permeated DOE's decision-making apparatus. It appears that institutional factors both inside and outside DOE have impeded attempts to implement risk-informed approaches. These factors include a tradition of internal rather than open decision making, incentive structures that favor distorting or ignoring risk, and a public wariness or mistrust of DOE's use of risk assessment to justify proposed actions.

The committee's role is to help DOE to bring the best practices to bear on the challenges DOE is addressing on the nation's behalf. DOE's difficulty in adopting risk-based or risk-informed approaches recommended previously by other committees and observers implies that DOE needs to make changes and perhaps changes are needed more broadly in the nation's approach toward managing risks at DOE sites.

Recommendation 5: To address the challenges of implementation and acceptance, DOE should form an authoritative, credible, and reasonably independent group to revamp the way DOE goes about implementing risk-informed approaches applied to waste disposition decisions.

These are enormously complex problems with numerous parties involved and a great deal of institutional inertia (as evidenced by unsuccessful previous attempts to change). The committee sees a need to break out of old approaches, so DOE needs an action-oriented group that provides advice and identifies alternatives, but also assists with implementation and draws in major stakeholders to get buy-in. The group must be credible, and to be credible the group must be

authoritative on the issues it addresses and independent so as to be unbiased and free of conflicts of interest. Before implementing this recommendation, it would be useful to consider the extensive experience of a variety of federal agencies with outside advisory committees, including the committees' roles and effectiveness.

CONCLUSION

In short, the nation needs a mechanism for considering alternatives to deep geologic disposal for those wastes that may not warrant such isolation based on the risks they pose and the risks and costs involved in retrieving and disposing of them. Risk is a good starting point for such considerations, but other factors may be at least as important deciding what disposition path to use, so a risk-informed decision process should be used. Such decisions, and the analyses and discussions that support those decisions, should involve DOE, regulators, and interested and affected outside parties in an iterative and cooperative decision process. The process would be more credible if an agency other than DOE had the authority to approve or reject DOE's proposals for alternate disposal paths. DOE should form an authoritative, credible, and reasonably independent group to revamp the way DOE goes about implementing risk-informed approaches applied to waste disposition decisions.

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