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DISPOSAL OF MIXED WASTE: TECHNICAL, INSTITUTIONAL, AND POLICY FACTORS[a]

Robert D. Waters and Marilyn M. Gruebel, Sandia National Laboratories
Martin J. Letourneau, DOE/EM-33
Joel T. Case, DOE/Idaho Operations Office

ABSTRACT

In conjunction with the affected States as part of their interactions required by the Federal Facilities Compliance Act, the Department of Energy has been developing a process for a disposal configuration for its mixed low-level waste (MLLW). This effort, spanning more than two years, has reduced the potential disposal sites from 49 to 15. The remaining 15 sites have been subjected to a performance evaluation to determine their strengths and weaknesses for disposal of MLLW. The process has included institutional and policy factors as well as strictly technical factors, with each highly dependent on the other: policy decisions must be supported by technical analyses, and technical analyses must be performed within a framework which includes some institutional considerations, with the institutional considerations selected for inclusion largely a matter of policy. While the disposal configuration process is yet to be completed, the experience to date offers a viable approach for solving some of these issues. Additionally, several factors remain to be addressed before an MLLW disposal configuration can be developed.

INTRODUCTION

The Federal Facility Compliance Act (FFCAct) of 1992 [1] requires the U.S. Department of Energy (DOE) to work with its regulators and with members of the public to establish plans for the treatment of DOE's mixed low-level waste (MLLW). Although the FFCAct does not specifically address disposal of treated MLLW, both DOE and the States recognize that disposal issues are an integral part of treatment discussions. The DOE established the FFCAct Disposal Workgroup (DWG) in June 1993 to work with the States in defining and developing a process for evaluating disposal options for treated MLLW. This joint DOE-State process has currently narrowed the DOE sites for further evaluation from 49 to 15.

Several technical, institutional, and policy factors have been used throughout this project. The overriding policy factor was to enable decisions that are supported by technical analyses, that incorporate appropriate institutional factors, and that give the best value for the tax dollars spent. In this context, the technical analyses are following a phased approach in which (1) technically unacceptable candidate sites were screened from further consideration, (2) the remaining sites were subjected to a scoping analysis to identify their strengths and weaknesses for disposal of MLLW, and (3) results from the scoping analysis will be compared to actual waste streams to determine the ability of the sites to dispose of actual DOE MLLW. These and other technical analyses will provide the support to enable further policy decisions pertaining to the final disposal configuration for MLLW. The final configuration will also include consideration of institutional factors such as the existing disposal infrastructure, other on-going complex-wide assessments, and input from interested stakeholders.

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DISCLAIMER

SCREENING ANALYSES

The overriding policy of enabling decisions that are supported by technical analyses, incorporating appropriate institutional factors, and giving the best value for the tax dollars spent was first met by a screening analysis. This analysis eliminated obviously technically unacceptable candidate sites from further consideration so that resources could be focused on the more viable sites. Forty-nine sites that were identified in the first draft of the Mixed Waste Inventory Report (MWIR) [2] comprised the initial universe of potential candidates for MLLW disposal. After consultation with the States, the DWG initiated and implemented a tiered screening process to narrow the field of potential candidate sites from 49 to 15 in two phases [3]. The results of this screening process, which were reviewed and agreed to by the affected states, are illustrated in Figure 1.

insert Figure 1

After combining five sites based on geographic proximity, the initial screening eliminated 18 of the most obviously poor candidate sites based on three objective criteria with regulatory or operational basis. The site

- must not be located within a 100-year floodplain [5],
- must not be located within 61 meters of an active fault [5], and
- must have sufficient area to accommodate a 100-meter buffer zone [6].

The second phase of the screening process was based on a more refined evaluation of the remaining 26 sites [7] using several criteria grouped into three broad categories:

- technical considerations (e.g., hydrology, geology, topography, and volcanic and tectonic potential),
- potential receptor considerations (e.g., populations, significant groundwater resources, and sensitive environments), and
- practical considerations (e.g., ownership, mission, MLLW storage and generation, and regulatory considerations).

Each category was evaluated for each site and assigned a ranking as either a major problem, moderate problem, or a minor problem [3]. Based on this analysis, the States agreed to eliminate an additional 5 sites from further consideration and to assign a lower priority to another 6 sites. The lower priority sites were to continue to be considered for on-site disposal and would be considered for disposal of wastes from off-site only if a disposal configuration could not be defined with the remaining 15 sites.

SCOPING ANALYSES

A more technically detailed performance evaluation (PE) was conducted on the remaining 15 sites (Figure 1) to estimate their strengths and weaknesses for disposal of MLLW [4]. The PE evaluated the water and atmospheric transport pathways and inadvertent intruder scenarios for 58 radionuclides expected to be in DOE MLLW for trench and tumulus disposal facility types. The permissible radionuclide concentrations in grouted waste were estimated based on site-specific data and on performance objectives determined from DOE Order 5820.2A [8]. These "permissible waste concentrations" (i.e., the radionuclide concentrations in waste in a disposal facility that do not exceed the performance criteria specified at the performance boundary) were estimated for each pathway and for each radionuclide. The smallest of these values represents the limiting concentration for each radionuclide at each site. The methodology and results of the PE were reviewed by both internal and external review panels as well as DOE Headquarters, the affected sites, and the States.

A summary of the results of the analysis are shown in Table I. This table presents the radionuclides that were limited by the water or atmospheric pathway for each of the 15 sites. Blank cells indicate that the radionuclide was limited by a human intrusion scenario at the site. Fourteen radionuclides were limited by intrusion at all sites, and an additional 27 radionuclides were limited by intrusion at 13 or 14 of the 15 sites. The results of the PE demonstrated that the intrusion scenarios selected for evaluation, which were based on performance assessments (PAs) of DOE low-level waste (LLW) disposal facilities [9,10], provided the most limiting permissible waste concentrations for most radionuclides at most sites.

insert Table I

The water pathway limited several of the more environmentally mobile radionuclides at sites located primarily in the more humid region of the country (Table II). With the exception of C-14, each of these radionuclides is long-lived relative to the 10,000-year period of performance. All the radionuclides have high or medium environmental mobility [4], indicating that they would migrate to the 100-meter performance boundary within the 10,000-year period and, therefore, would not decay appreciably. The number of sites limited by the water pathway is an indication of the relative mobility and persistence of the radionuclides, with Tc-99 and I-129 being the most mobile and persistent of the radionuclides evaluated.

insert Table II

The atmospheric pathway was evaluated only for the volatile radionuclides tritium (as tritiated water) and carbon-14 (as carbon dioxide gas carrying the C-14 isotope). This analysis indicated that tritium would not be limited by the atmospheric pathway at any site and that C-14 would be limited by the water pathway at about half of the sites.

Although the purpose of the PE was not to eliminate sites from further consideration, the analysis indicated that several radionuclides can be disposed of at the more arid sites at higher permissible concentrations than at the more humid sites. The PE analysis revealed that engineered barriers offer no long-term advantages for the disposal of wastes containing long-lived radionuclides; their benefits are for containing shorter-lived radionuclides while they decay to insignificant levels. The analysis also identified key parameters characterizing both the sites and the wastes and identified several indicator radionuclides which can be used to represent the behavior of broad classes of radionuclides.

The permissible radionuclide concentrations in waste estimated by the PE will be compared with estimates of radionuclide concentrations in treated MLLW streams to determine the ability of the 15 sites to dispose of actual DOE MLLW. The radionuclide concentrations in treated MLLW will be estimated by using existing waste stream and treatment train databases and process knowledge to estimate the concentration changes due to the various treatment processes. Other information that will be provided by this analysis includes the estimated volume of MLLW after treatment and the usefulness of the existing DOE MLLW databases.

Upon completion of this analysis, the technical capability of the 15 sites for disposal of DOE's MLLW will be presented to the States. Before further progress can be made in refining the MLLW disposal configuration, the incorporation of institutional and policy factors will be required.

Institutional and Policy Factors

The major institutional and policy factors that remain to be addressed before a final disposal configuration for MLLW can be proposed can be grouped into three categories: integration of MLLW into the larger picture of low-level waste disposal; the disposal facility infrastructure; and the evolving regulatory landscape. Each will require one or more supporting technical analyses.

Perhaps the most pressing complex-wide initiative for integration of MLLW disposal issues is DOE's response to the Defense Nuclear Facilities Safety Board's (DNFSB) Recommendation 94-2 [11] pertaining to the DOE's management of low-level waste. One of the most important recommendations of the DNFSB is that the effects of nearby source terms and existing contamination be considered when analyzing the impacts of operations of planned LLW (including MLLW) disposal facilities. Prior to this recommendation, each disposal facility was evaluated according to specific performance objectives independently of nearby facilities or contamination.

Incorporation of existing disposed waste and contamination is problematic in terms of technical issues as well as institutional issues. One of the main technical problems to be addressed is that the inventories of past disposal activities or accidental releases are generally poorly known. This lack of knowledge introduces uncertainty into the analysis that may overshadow the deleterious effects of the wastes to be disposed of. Until characterization of the existing *in situ* waste and contamination can be characterized, they must be treated in a conservative fashion that may tend to limit the capability of planned disposal facilities. Scoping-level technical analyses can aid formulation of a coherent policy that will in turn result in clear direction for more detailed technical analyses.

One of the important institutional problems this new approach introduces is the distinction between the PA methodology for LLW and MLLW and the risk assessment methodology specified under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [12]. The approaches to evaluating risk and performance, the timeframes of the analyses, and the endpoints for analyses are different for PAs and CERCLA risk assessments. These issues must be resolved before significant progress can be made. Again, scoping-level technical analyses, such as the process described above, can be used to help formulate policy for addressing these issues.

Another complex-wide initiative for integration of MLLW disposal activities is DOE's Programmatic Environmental Impact Statement (PEIS) [13]. A PEIS is required to provide National Environmental Policy Act (NEPA) coverage for major federal programmatic actions and includes a Record of Decision which is issued to support the selected alternative. As currently envisioned, the analyses used to support the planning process for MLLW disposal will be incorporated into the PEIS documentation so that NEPA coverage will be provided for the recommended configuration decision.

Integrating the MLLW disposal configuration process into the existing LLW disposal facility infrastructure is another important institutional factor and is interrelated with the 94-2 and PEIS considerations. Because the nearby existing source terms and contamination will now be considered in the performance assessments of disposal facilities, the future LLW and MLLW disposal volumes must compete for a finite disposal capacity at some sites. The estimates of treated MLLW volume are an important piece of technical data that will factor into the analysis; however, longer-term projections of expected waste volumes are difficult to justify with any accuracy, especially when considering highly uncertain environmental restoration waste volumes.

There are still several institutional issues that must be addressed. Some of the more important questions are the following: How will commercial disposal factor into the analysis? How will the input from the States and stakeholders influence the decision-making process? What changes in operating practices will be required for existing disposal facilities? What factors are the most important in selecting new disposal sites? Are the current disposal sites the most appropriate ones for continued disposal? Technical analyses will provide the basis for answering many of these questions, but some policy decisions will also be required to provide direction to those technical analyses.

In addition to the resolution of the internal DOE policy issues mentioned above, at least one external regulatory change is expected to occur that will influence MLLW disposal: the Environmental Protection Agency's Hazardous Waste Identification Rule (HWIR) modifications to the Resource Conservation and Recovery Act (RCRA)[14]. The HWIR is expected to establish "exit levels" for listed RCRA wastes that pass a test for leachability. The mixed wastes that pass this test are not required to be disposed of in a RCRA Subtitle C-type disposal facility, and therefore, these wastes can be disposed of in a LLW DOE disposal facility. Presently, listed RCRA wastes remain classified as hazardous even after they have been treated. The HWIR may have the effect of reclassifying some MLLW as strictly LLW in terms of disposal, but it will not reduce the total combined volume of MLLW and strictly LLW to be disposed of.

SUMMARY

Significant progress has been made toward developing a process for determining the disposal configuration for DOE's MLLW. The number of DOE sites being considered has been reduced from 49 to 15, performance evaluation of these 15 sites has been completed, and additional technical analyses are being conducted to determine the technical capabilities of the 15 sites for disposal of treated DOE MLLW. However, several institutional and policy factors must still be addressed. Some of these factors include (1) integrating MLLW disposal with other complex-wide assessments of LLW disposal practices, (2) MLLW and LLW competing for a finite disposal capacity, (3) evaluating the impact of potential changes in the regulations affecting MLLW disposal, and (4) developing a fair and equitable process for determining the MLLW disposal configuration. Each of these factors has components that are technical in nature and that additional technical analyses can help solve. However, there will always be an intimate relationship between the policy guidance necessary for establishing appropriate technical analyses and the technical analyses that will be used to support policy.

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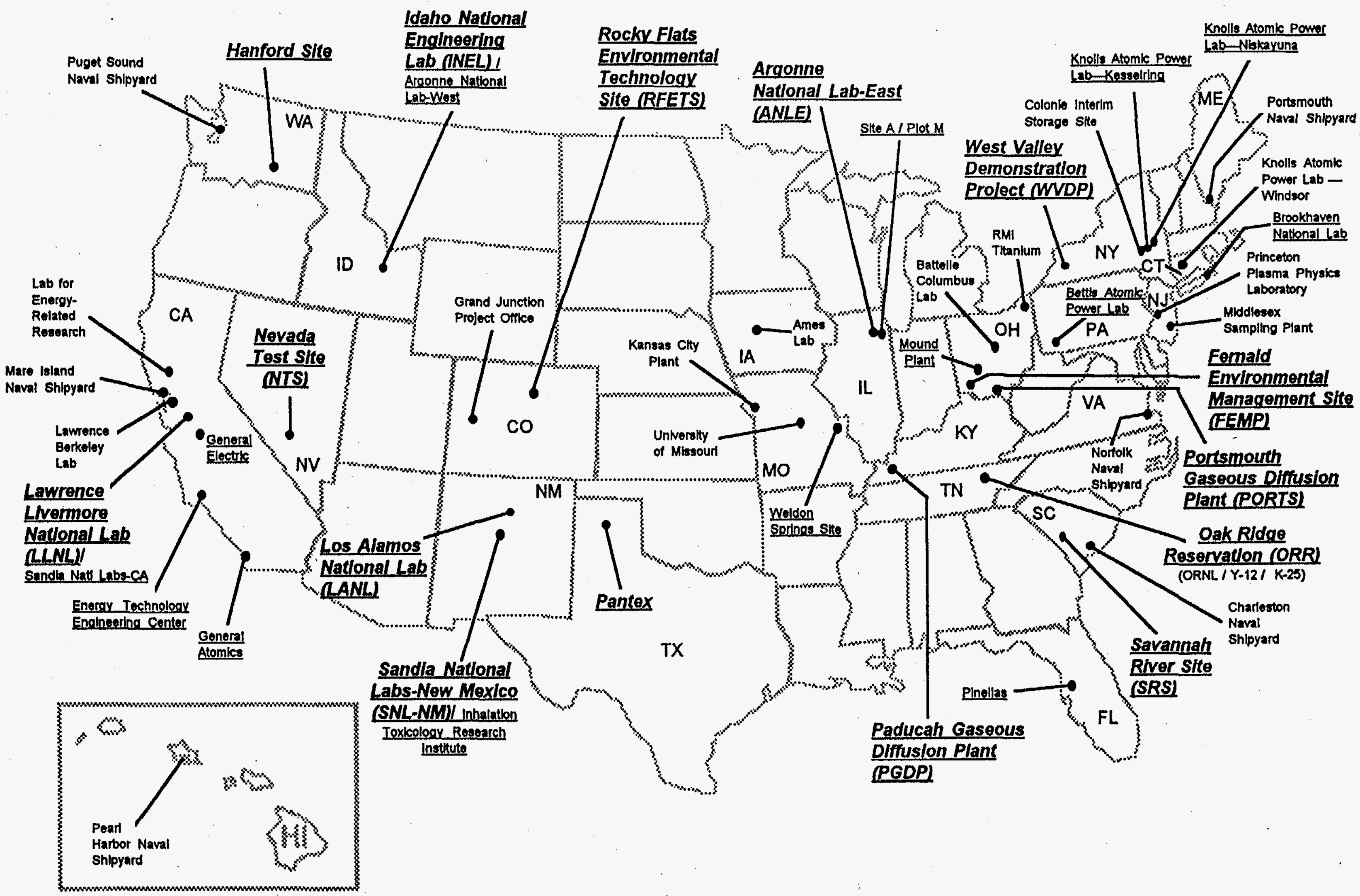

Figure 1. Forty-nine sites originally considered by the DWG in the screening process. The 26 underlined sites are those that remained after the initial screening. The 15 sites in bold italics are those for which performance evaluations were conducted. [4]

Table I. Radionuclides Limited by the Water Pathway for the Generic Trench Only (o), for Both the Generic Trench and Tumulus (•), and for the Atmospheric Pathway for Both Facility Types (x) [4]

Nuclide[a]	LLNL	Hanford	NTS[b]	INEL	RFETS	SNL	LANL	Pantex	ANLE	PGDP	FEMP	PORTS	ORR	SRS	WVDP[c]	Nuclide
H-3		o			o				o	o	o	o	•	•		H-3
C-14	x	x	x	x	•	x	x	x	•	x[d]	•	•	•	•	•	C-14
Si-32														•		Si-32
Cl-36		•			•				o	•	•	•	•	•		Cl-36
K-40				•	•				o	•	•	•	•	•		K-40
Ni-59												o				Ni-59
Se-79		•									o	o	•	•		Se-79
Zr-93														•		Zr-93
Nb-93m														•		Nb-93m
Nb-94													o			Nb-94
Tc-99	•	•		•	•	•	•	•	•	•	•	•	•	•	•	Tc-99
Pd-107										o	•	•	•	•		Pd-107
Sn-126												o	•			Sn-126
I-129		•		•	•				•	•	•	•	•	•	•	I-129
Cs-135		•										o		o		Cs-135
Ra-226												o				Ra-226
Th-229													•			Th-229
Th-230													•			Th-230
Th-232													•			Th-232
Pa-231		•												•		Pa-231
U-232		•									•					U-232
U-233		•								•	•	•	•	•		U-233
U-234		•								•	•	•	•	•		U-234
U-235		•								•	•	•	•	•		U-235
U-236		•								•	•	•	•	•		U-236
U-238		•								•	•	•	•	•		U-238
Np-237					•				•	•	•	•	•	•		Np-237
Pu-238												•	•	•		Pu-238
Pu-239													•	o		Pu-239
Pu-240													•	o		Pu-240
Pu-241					o				o				•	o		Pu-241
Pu-242													•	o		Pu-242
Pu-244													•	o		Pu-244
Am-241					o				o			o	•			Am-241
Am-243													•			Am-243
Cm-243													•	o		Cm-243
Cm-244													•	o		Cm-244
Cm-245													•			Cm-245
Cm-246													•			Cm-246
Cm-247													•			Cm-247
Cm-248													•			Cm-248
Cf-249													•			Cf-249
Cf-250													•			Cf-250
Cf-251													•			Cf-251

a Fourteen radionuclides not listed--all intruder limited (Al-26, Co-60, Ni-63, Sr-90, Ag-108m, Cd-113m, Sn-121m, Ba-133, Cs-137, Sm-151, Eu-152, Eu-154, Pb-210, and Ra-228)

b No water pathway analysis was performed at this site

c Only 18 on-site radionuclides were evaluated

Table II. Properties of several radionuclides limited by the water pathway.

Radionuclide	Half-life (years)	Environmental Mobility	No. of sites limited by water pathway
C-14	5730	High	7
Cl-36	3.01E5	High	8
K-40	1.28E9	High	8
Tc-99	2.13E5	High	14
I-129	1.57E7	High	10
U-233 - U-236, U-238	1.59E5 - 4.47E9	Medium	6
Np-237	2.14E6	High	7