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BENEFITS ACCRUING TO THE DOE COMPLEX ATTRIBUTABLE TO THE DISPOSAL OF OFF-SITE LOW-LEVEL WASTE AT THE NEVADA TEST SITE

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ABSTRACT

The Nevada Test Site (NTS) has been consistently identified in national U.S. Department of Energy (DOE) reports as playing a key role in the future disposal of low-level radioactive waste (LLW) originating from waste management, site remediation, and other programs of the DOE nuclear weapons complex. This key NTS role was confirmed by the December 10, 1999 *Identification of Preferred Alternatives for the Department of Energy's Waste Management Program: Low-Level Waste and Mixed Low-Level Waste Disposal Sites*. (1) The findings presented in this paper represent part of a larger effort to develop information to respond to stewardship issues that have been documented by DOE stakeholders in Nevada with regard to DOE LLW disposal at the NTS. (2)

This paper presents current findings from an ongoing effort to identify the historical and projected benefits accruing to the DOE Complex attributable to the off-site disposal of DOE LLW at the NTS, and to assess the incremental costs that may accrue to the NTS in order to realize these national benefits. Mixed waste disposal is not discussed.

The authors identify factors that affect DOE LLW disposal options and disposal costs, including both waste generator and disposal facility costs. Based on current, national DOE analyses, cost comparisons of disposal at the NTS vs. other operational DOE disposal sites are made, as well as comparisons of anticipated facility disposal limitations. The authors' present their preliminary estimates of significant historical and projected cost savings to the DOE Complex associated with LLW disposal at the NTS. The paper concludes with a discussion of the limitations of the current, DOE volumes-based cost estimates, and a discussion of the steps currently being taken in Nevada to perform waste-stream-specific analyses.

FACTORS AFFECTING DISPOSAL OPTIONS AVAILABLE TO DOE LLW GENERATORS

The primary factors governing LLW disposal options available to DOE LLW generators are the availability of on-site land for LLW disposal facilities, site-specific hydrogeologic constraints on on-site LLW disposal, applicable on-site regulatory compliance restrictions, and the limited availability and high cost of alternative, off-site commercial LLW disposal options. **Figure 1** summarizes the options available to NTS-approved DOE generator sites for LLW disposal.

Limited On-site Land Availability. The availability of on-site land for disposal of LLW is a threshold issue, which must be considered in evaluating the potential option of on-site disposal of LLW at DOE sites. Some DOE Complex sites are privately-owned (e.g. ETEC, RMI, General Atomics). In such cases, DOE has no land available on-site on which to dispose of LLW. The relatively small size of other, DOE-owned sites (e.g. Grand Junction Projects Office, ITRI, SNL/CA) also limits the availability of on-site disposal. The land available for LLW disposal at some of these small sites (e.g. ITRI, SNL/CA) is further limited by on-going requirements to support DOE missions, and the need for an adequate buffer zone (the smallest area required as controlled space for monitoring and for taking mitigative measures, as may be necessary) around disposal cells.

The small size of these DOE Complex sites is also an indirect measure of two other, associated characteristics important to the suitability of a site for LLW disposal:

- The size and proximity of potential populations at risk (larger sites exclude population growth from extensive areas and provide a larger buffer); and
- The likelihood contaminants in down-gradient groundwater would appear in publicly-accessible water sources (off-site population centers near small sites would tend to be located in closer proximity to these sites).

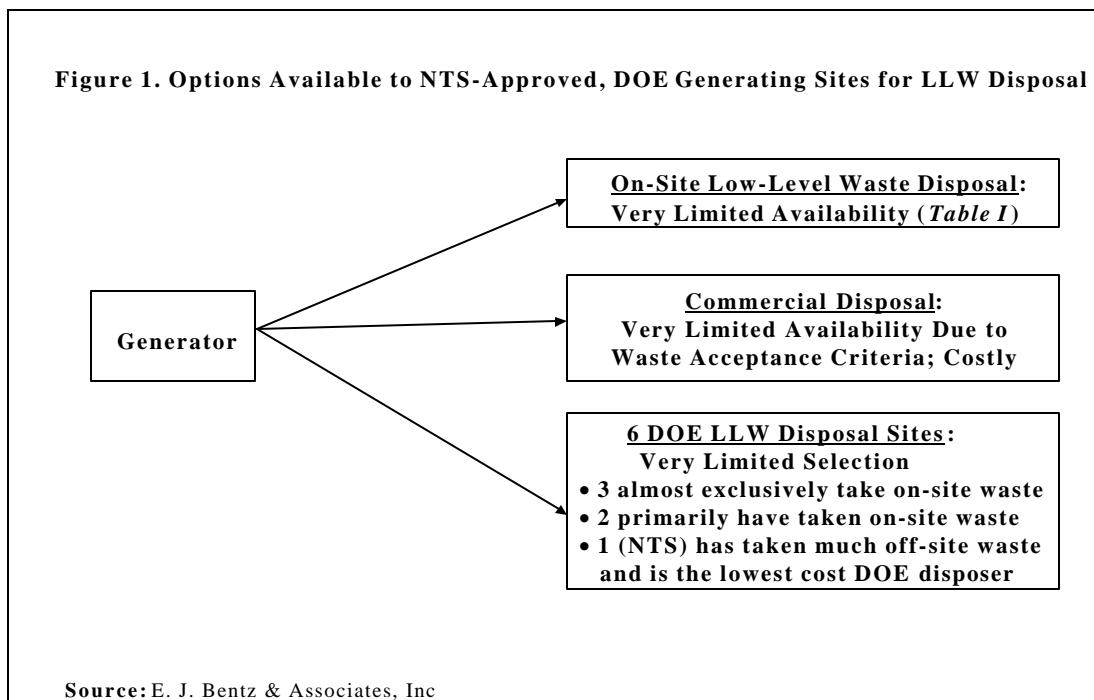


Table I provides a summary of land availability and other important factors discussed in the following sections that limit the suitability of NTS-approved generator sites for on-site disposal of LLW.

On-Site Hydrogeologic Constraints on Disposal. The siting of a LLW disposal facility is the first, and arguably the most important, step for ensuring the long-term isolation of the waste. Historically, DOE and commercial disposal facilities have relied on the site hydrogeological characteristics as the principal means to mitigate nuclide migration from disposal sites (i.e., dependence on natural isolation barriers). Therefore, site-specific hydrogeological characteristics are of primary concern in determining the suitability of DOE sites for on-site disposal. DOE Orders require that disposal sites have hydrological characteristics which will protect groundwater resources. In addition, the potential for floods, erosion, earthquakes, and volcanoes must be considered in site selection (see **Table I** with regard to potential seismic activity at certain DOE sites).

The hydrogeologic characteristics at several DOE generator sites restrict the suitability of these sites for on-site disposal of LLW (see **Table I**). Some sites are located within 100-year flood plains. Other sites (e.g. LLNL, SNL/NM) are located on, or near, seismic faults. Still other sites have shallow groundwater (e.g. ORR, Savannah River) or are located over major, sole source aquifers (e.g. Fernald, Mound).

On-Site Regulatory Compliance Restrictions (Land Use). Several DOE sites have been placed on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL), requiring environmental remediation consistent with the regulatory requirements of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). (3) Land use restrictions, site remediation levels, and other site-specific requirements developed through implementation of CERCLA can restrict the siting, facility design, waste acceptance criteria (e.g. radionuclides and radionuclide concentrations), and disposal volumes of on-site LLW disposal facilities. On-site disposal of LLW at the Fernald Environmental Management Project (Fernald) site provides an example of the impact of such restrictions on on-site LLW disposal.

Fernald was placed on the NPL in 1989. The Records of Decision (RODs) for environmental remediation at Fernald (developed consistent with the requirements of CERCLA) include disposal of large volumes of LLW in an on-site disposal facility (OSDF). The OSDF represents Fernald's "balanced approach" to waste management. Fernald's OSDF will contain approximately 1.9 million cubic meters of soil and debris from site remediation. An estimated 83,591 cubic meters of LLW not meeting OSDF acceptance criteria is expected to be shipped off-site to the NTS for disposal. The waste acceptance criteria for the OSDF include concentration limits on specific radionuclides and

chemicals, and prohibited items. The criteria were developed to protect the Great Miami Aquifer to EPA's maximum contaminant levels under the Safe Drinking Water Act for a period of 1,000 years.

Table I: Summary of Factors Limiting On-Site Disposal at NTS-Approved DOE Generator Sites*

Generator Site	Factors Limiting On-Site Disposal
ETEC	<ul style="list-style-type: none"> • Small site (90 acres). • Privately-owned DOE Complex site (DOE has no on-site disposal authority).
Fernald	<ul style="list-style-type: none"> • Location near Great Miami River. • Location atop a major sole source aquifer (State of Ohio waiver required). • Disposal limited to low concentrations to protect aquifer to maximum contaminant levels (MCLs) for 1000 years.
General Atomics	<ul style="list-style-type: none"> • Small site (120 acres). • Privately-owned DOE Complex site (DOE has no on-site disposal authority).
Grand Junction Projects Office	<ul style="list-style-type: none"> • Small site (56.4 acres). • Location on a river and adjacent to City of Grand Junction, Colorado. • On-site facility for limited volumes would likely not be cost-effective.
Kansas City Plant	<ul style="list-style-type: none"> • Small site (141 acres). • Location in an urban setting. • On-site facility for limited volumes would likely not be cost-effective.
LRRRI (ITRI)	<ul style="list-style-type: none"> • Small site (135 acres). • Location on an Air Force Base. • High seismic activity (with potential for damaging event every 100 years). • On-site facility for limited volumes would likely not be cost-effective.
LLNL	<ul style="list-style-type: none"> • Major faults in the area (San Andreas, Hayward, Calaveras, and Greenville). • Local faults have the potential for damaging earthquakes. • Potential for slope instability in Site 300.
Oak Ridge	<ul style="list-style-type: none"> • Climate is humid and relatively high precipitation (53.75 inches/yr.). • Depth to groundwater is shallow (less than 20 feet in some areas). • Groundwater is discharged to the surface in some areas. • Above-ground "tumulus" facility is expensive and long-term disposal use questionable.
Mound	<ul style="list-style-type: none"> • Small site (306 acres). • Location within City of Miamisburg near residential populations. • Location within ½ mile of Great Miami River. • Location atop a major sole source aquifer (State of Ohio waiver required).
Pantex Plant	<ul style="list-style-type: none"> • On-site facility for limited volumes would likely not be cost-effective.
RMI	<ul style="list-style-type: none"> • Small site (60 acres). • Privately-owned DOE Complex site (DOE has no on-site disposal authority).
Rocky Flats	<ul style="list-style-type: none"> • Relatively small (384 acres) secured area inside the buffer zone. • Proximity to large (2.1 million) population and growing residential areas.
Sandia/CA	<ul style="list-style-type: none"> • Relatively small site (413 acres). • No LLW anticipated to be generated in future.
Sandia/NM	<ul style="list-style-type: none"> • Location on an Air Force Base. • Four faults (including 2 capable of major seismic activity) cut across site. • High seismic activity (with potential for damaging event every 100 years).

* Approved non-DOE generators include Aberdeen Proving Grounds (DoD), Army Industrial Operations Command (DoD), and Defense Threat Reduction Agency (DoD).

Source: E. J. Bentz & Associates, Inc.

Limited and Expensive Commercial Disposal Options. Prior to 1979, DOE routinely utilized commercial facilities for disposal of LLW to promote the development of such commercial disposal facilities and to provide disposal capabilities for DOE sites that could not dispose of their LLW on-site. The commercial sites then available

WM'00 Conference, February 27 – March 2, 2000, Tucson, AZ

were: Barnwell, South Carolina; Beatty, Nevada; Maxey Flats, Kentucky; Richland, Washington; Sheffield, Illinois; and West Valley, New York. Due to operational problems that resulted in the closure of three of these sites between 1975 and 1978 (Maxey Flats, Sheffield, and West Valley), DOE changed its policy and practices.

“In 1979, [DOE] adopted a policy of disposing of its LLW at its sites to ensure the availability of reliable disposal capacity for wastes generated by its defense production mission and to limit its potential legal liability for claims by or against commercial disposal facility operators.” (4)

Current DOE policy on commercial LLW disposal was established under previous DOE Order 5820.2A, *Radioactive Waste Management* (September 26, 1988), which provided that LLW “shall be disposed of on the site at which it was generated, if practical, or if on-site disposal capability is not available, at another Department disposal facility.” The Order allowed for exemptions from this requirement, on a case-by-case-basis. DOE delegated authority to make decisions regarding the use of commercial facilities to its Field Office Managers, under the following guidance (5):

- The commercial facility must meet applicable Federal, State, and local requirements, and have the necessary permits, licenses, and approvals;
- The facility, based on DOE review, must have an adequate history of operational and regulatory performance;
- Disposal of these wastes at a commercial facility must be cost-effective and in the best interests of the Department;
- The waste must be sufficiently characterized and verified to meet the facility’s waste acceptance criteria;
- Appropriate National Environmental Policy Act (NEPA) review must be completed; and
- Host states and state compacts must be consulted before the exemption is approved.

Based on the results of a recent policy analysis (4), DOE has decided to continue the policy under its new DOE Order 435.1, *Radioactive Waste Management*, which replaced DOE Order 5820.2A effective September 1, 1999.

Available options for commercial disposal of DOE LLW are currently both limited and expensive (compared to DOE disposal facility costs) for all but the lowest-activity LLW. Most DOE LLW sent to commercial facilities under the current policy has been disposed at the Envirocare facility near Clive, Utah. Envirocare is the only commercial LLW disposal facility to have opened since *the Low-Level Radioactive Waste Policy Act (LLWPA)* was enacted in 1980. The Envirocare facility is not a “compact facility” (as defined by 42 U.S.C. §§ 2021(b)-2021(j) of the LLWPA). Hence, it can accept LLW from sites throughout the country. However, disposal at Envirocare is limited to very low-activity, NRC Class A waste. The site cannot accept LLW containing special nuclear materials in quantities sufficient to form a critical mass, as defined by 10 CFR §150.11. Large quantities of DOE LLW would not meet these restrictions.

The DOE waste shipped to Envirocare has, in general, been of very low activity. In fact, most of the DOE waste disposed at Envirocare has been Section 11(e)(2) byproduct material generated during cleanups undertaken pursuant to the Formerly Utilized Sites Remedial Action Program (FUSRAP). These wastes are of such low activity that they are generally excluded from both the NRC and DOE definitions of LLW. DOE contracts with Envirocare for disposal of these low-activity wastes have experienced charges ranging from \$170 - \$600 per cubic meter of waste.

Only two commercial LLW disposal facilities are currently licensed by the NRC to accept LLW classified as greater than NRC Class A: the facility operated by U.S. Ecology at Richland, Washington (U.S. Ecology facility) and the facility operated by Chem-Nuclear, LLC, at Barnwell, South Carolina (Barnwell facility). Only the Barnwell facility accepts LLW from generators outside of a regional compact.

The U.S. Ecology facility is a “compact facility” which serves the Northwest and the Rocky Mountain Compacts. As a compact facility, the State of Washington and the Northwest Compact must approve the disposal of DOE waste at the facility. (6) The State of Washington has made approval of disposal of DOE LLW at the facility subject to certain conditions. Among the conditions are: 1) that only waste from DOE’s Hanford site could be disposed at the facility; and 2) that U.S. Ecology must establish that disposal of the Hanford waste at the facility “would result in cost savings when compared to available disposal options.” (7) According to available information, U.S. Ecology charges between \$1,000 and \$3,000 per cubic meter for the disposal of LLW. A comparison of LLW disposal cost

ranges at commercial and DOE WM disposal sites is provided in **Table II**. Under current rates, it is unlikely that disposal of Hanford waste at the facility would satisfy the conditions imposed by the State.

Table II: Ranges of LLW Disposal Costs for Commercial and DOE Sites (\$/cubic meter)

Commercial LLW Disposal Facility Rate Ranges		DOE LLW Disposal Facility Rate Ranges	
Envirocare (UT)	\$170 - \$600	NTS (NV)	\$350 - \$650
U. S. Ecology (WA)	\$1,000 - \$3,000	LANL (NM)	\$450 - \$700
Barnwell (SC)	\$8,000 - \$14,000	Hanford (WA)	\$500 - \$850
Ward Valley (CA) (proposed)	\$5,000 - \$21,000	Savannah River (SC)	\$800 - \$1,200
		INEEL (ID)	\$1,000 - \$2,400
		Oak Ridge (TN)	\$2,500 - \$3,500

Source: E.J. Bentz & Associates, Inc. derived from U.S. Department of Energy, *Commercial Disposal Analysis for Low-Level and Mixed Low-Level Wastes* (March 1999).

The Barnwell facility was one of the original “compact facilities” developed under the LLWPA. However, on July 1, 1995, South Carolina withdrew from the Southeast Compact and removed the prohibitions it had imposed on Barnwell concerning the disposal of waste from states outside the compact. Barnwell currently extends access to generators from all states except North Carolina. Barnwell has not participated in any DOE competitive procurement for LLW disposal. Disposal charges at the facility are very expensive (\$8,000-\$14,000 per cubic meter) compared to DOE WM facility disposal costs. The Barnwell rates include components based on both weight/volume and curie content, as well as a state-imposed disposal tax of \$8,300 per cubic meter. (8) Although the high cost of disposal has prevented DOE from making extensive use of the facility, Barnwell has been utilized by DOE for disposal of small amounts of LLW with activity levels that precluded disposal at other facilities. For example, in 1997, DOE shipped 45 cubic meters of LLW from Brookhaven National Laboratory (BNL) to Barnwell for disposal (BNL is not an NTS-approved generator). **Table III** summarizes general waste acceptance restrictions at currently-operating, commercial LLW disposal facilities.

Table III: Restrictions on LLW Acceptance at Commercial (NRC Licensed) LLW Disposal Facilities

Commercial Site	Restrictions on Waste Acceptance
Envirocare (Utah)	Limited to very low-level NRC Class A waste.
Barnwell (South Carolina)	Can accept greater than NRC Class A waste.
U.S. Ecology (Washington)	Can accept greater than NRC Class A waste, but is limited to LLW from Northwest and Rocky Mountain Compact generators.

Source: E. J. Bentz & Associates, Inc.

FACTORS WHICH AFFECT THE COST OF DISPOSAL OF LLW AT DOE WM DISPOSAL SITES

Within the DOE Complex, DOE maintains operational Waste Management (WM) facilities for disposal of LLW at six DOE sites: the NTS, Hanford Site, Idaho National Engineering and Environmental Laboratory (INEEL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), and Savannah River Site (SRS). Three of these sites (INEEL, LANL, and ORNL) almost exclusively dispose of on-site generated LLW. Of the remaining three sites, Hanford and Savannah River have primarily accepted on-site generated waste for disposal, although they have the capability to accept off-site LLW if the waste meets site-specific acceptance criteria (stringent for Savannah River – see **Table IV**).

In addition, DOE’s Environmental Restoration (ER) program operates CERCLA -regulated LLW disposal facilities at certain sites. These CERCLA facilities are limited to disposal of wastes generated from on-site environmental restoration activities, which meet facility-specific acceptance requirements. At present, there are two of these cells in operation -- one at Hanford (the ERDF) and the other at Fernald (the OSDF). Two additional DOE CERCLA disposal cells dispose of waste other than LLW. These cells (at the Weldon Spring Site in Missouri and the Monticello Site in Utah) are used for disposal of Section 11(e)(2) byproduct material generated by on-site cleanup

activities pursuant to FUSRAP. DOE is considering construction of two additional CERCLA disposal cells (at INEEL and Oak Ridge); a decision as to whether to build these cells will be made pursuant to the CERCLA process.

The total cost to DOE for LLW disposal at the various DOE LLW disposal sites is affected by several factors, including the availability of disposal facility volumetric capacity and potential for expansion, the cost to operate and maintain a facility, and the cost incurred by generators to prepare and ship LLW for disposal at a facility. DOE's July 1997 *Low-Level Waste Disposal Cost Comparison Report* (1997 Cost Comparison Report) (9) analyzes the current and projected costs to operate, maintain, and manage LLW disposal facilities within the DOE Complex during Fiscal Years 1996 through 1998. The report also analyzes the costs to be incurred by DOE LLW generators to characterize, package, certify, and receive approval to disposal of LLW at the six WM disposal facilities during one year (FY 1997). All of the cost estimates provided in the report are based on then-current site baseline strategies and assumptions (including LLW volumetric assumptions) developed for the DOE *Accelerating Cleanup: Focus on 2006 Discussion Draft*. (10)

DOE Disposal Facility Capacity Limitations. The six DOE LLW disposal facilities currently accepting DOE Complex LLW are each uniquely different from the others. The DOE 1997 Cost Comparison Report found that the physical differences among the facilities account for a portion of the disposal cost variations among them. Primary physical differences among the facilities which drive cost include the volumetric capacity available for expansion and the limitations on use of the available volumetric capacity.

Only three of the WM disposal facilities (NTS, Hanford, and Savannah River) currently accept substantial amounts of LLW for disposal from off-site generators. The facilities at INEEL and ORNL are very limited in their expansion capability, and accept only on-site generated waste. At LANL, the expansion capacity is limited by the size of the mesa upon which it is located. The available expansion capacity at LANL is dedicated to supporting the LLW disposal needs of the on-site Defense Programs and National Laboratory missions.

At Savannah River, the site hydrogeology permits the use of slit trenches only for slightly contaminated soil, rubble, and oversized equipment/packages. The use of engineered vaults allows disposal of a wide range of radionuclides. However, this is a much more costly method of disposal, and facility expansion costs would be much higher than for slit trench disposal. Both the NTS and Hanford have the expansion capacity and capability to dispose of large volumes of LLW with a wide range of radionuclides. **Table IV** provides a summary of the DOE-estimated expansion capacity at the six DOE LLW disposal facilities, and important factors restricting use of that capacity.

Table IV: DOE-Estimated Expansion Capacity at the Six DOE WM LLW Disposal Sites

Site		Est. Expansion Capacity (m ³)	Important Restrictions on Capacity Use
Nevada Test Site		"Unlimited"*	None.
Hanford Site		14,200,000	None.
SRS	Low-Level Vaults	34,000	LLW radiating less than 200 mR/hr 5 cm from surface of metal containers.
	Intermediate-Level Vaults	7,650	Tritium-bearing intermediate LLW radiating more than 200 mR/hr 5 cm from surface of metal containers.
	Slit Trenches	290,000	Accepts only slightly contaminated soil, rubble, equipment.
LANL		3,700,000	Accepts primarily on-site LLW; off-site LLW is accepted only in special cases from Defense Program sites
ORNL		5,382	Accepts only on-site LLW (only from ORNL -- not from Y-12 Plant or ETPP).
INEEL		33,000	Accepts only on-site LLW; scheduled to close by 2006.

* No volumetric limitations; only radionuclide concentration limits.

Source: U.S. Department of Energy, *Low-Level Waste Disposal Cost Comparison Report*, July 15, 1997.

As noted in **Table IV**, Hanford and the NTS are the only DOE LLW disposal facilities without significant restrictions. However, DOE documents indicate a prominent role for Hanford in disposing of its own wastes. DOE

projections (*Information Package on Pending Low-Level Waste and Mixed Low-Level Waste Disposal Decisions*) (11) call for the Hanford LLW disposal facility to primarily service on-site generated LLW. ER-generated, on-site LLW at Hanford is projected to be approximately 3,400,000 m³, all of which is projected to be disposed on-site. LLW projected to be disposed at Hanford from DOE WM operations and from transfers of LLW to WM from the ER program is expected to total approximately 172,030 m³. Of this total, approximately 148,500 m³ (86 %) is projected to be generated on-site at Hanford. Only 23,530 m³ out of the total 3,572,030 m³ of LLW projected to be disposed at Hanford over the next twenty years is anticipated to come from off-site generators. This represents less than 1 % of the total LLW projected to be disposed at Hanford during that period.

Facility Disposal Costs. The DOE 1997 Cost Comparison Report found that the costs to operate and maintain a LLW disposal facility are comprised of both fixed costs and variable costs:

- Fixed costs are loosely defined as those costs that are independent of waste volumes disposed. Fixed costs are recurring costs that do not vary with the rate of waste disposal activities, “such as labor and material costs to maintain the capability to receive and dispose of the first cubic meter of LLW. Examples of fixed costs are permitting, monitoring, training, and program management.”
- Variable costs are defined as those costs that are incurred relative to the amount of waste disposed, “such as labor, materials, and contract costs, above and beyond fixed costs necessary to dispose of LLW.” The variable factor having a key impact on a facility’s cost of disposal is presumed to be the volume disposed. Variable costs are considered to increase or decrease as the volume of LLW disposed increases or decreases. “Most disposal operations, maintenance, and trench development costs are a function of volume disposed and are, therefore, variable costs. For example, if each trench has a capacity of 10,000 m³ and the facility disposes of 20,000 m³ one year and 10,000 m³ the next year, the facility will incur the cost of the development of two trenches the first year and the cost of one trench in the second year.” The authors of this paper propose that variable costs are also highly dependent on the characteristics of the wastes being disposed, as is reflected in commercial disposal pricing schedules.

The 1997 Cost Comparison Report analyzes the total disposal costs (fixed and variable) for each DOE WM facility for the years FY 1996 – FY 1998. Facility unit disposal costs are calculated by dividing the annual disposal costs by the annual volumes disposed (or anticipated to be disposed) at each facility. The 1997 Cost Comparison Report did not investigate cost impacts attributable to waste characteristics. A summary of the historical FY 1997 disposal facility unit costs is provided by **Table V**. **Figure 2** depicts the FY 1997 unit costs in relation to the volume disposed for each of the six DOE WM disposal facilities.

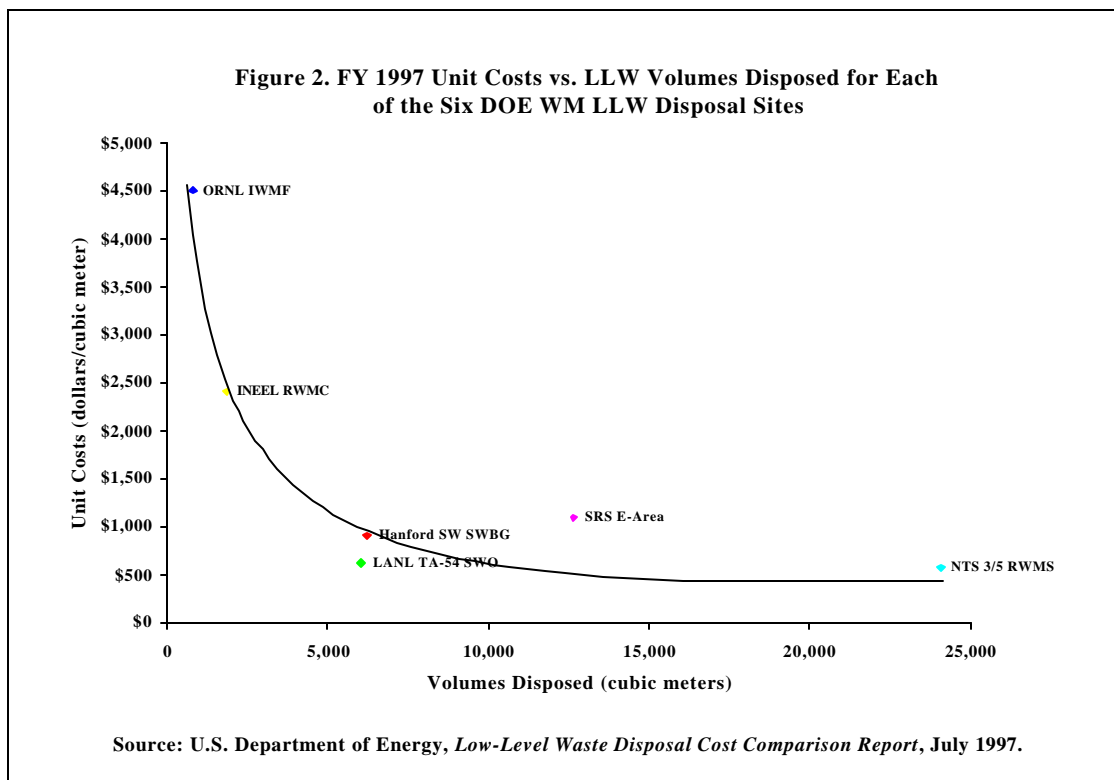
Table V: Comparison of FY 1997 Costs for Disposal at the Six DOE WM LLW Disposal Sites

Site	Vol. Disposed FY 1997 (m ³)	Total Cost in FY 1997 (thousands of \$)	Unit Cost in FY 1997 (\$/m ³)
NTS	24,073	\$13,718	\$570
Hanford	6,242	\$5,688	\$911
SRS	12,651	\$13,860	\$1,096
LANL	6,034	\$3,747	\$621
ORNL	772	\$3,553	\$4,502
INEEL	1,813	\$4,358	\$2,404

Source: U.S. Department of Energy, *Low-Level Waste Disposal Cost Comparison Report*, July 15, 1997.

The disposal facility fixed and variable costs were collected for the 1997 Cost Comparison Report in five general categories:

- Waste Documentation for, and Acceptance or Certification by, Disposal Facilities. These activities include “verification/characterization when required for disposal such as monitoring or assays for radioactivity, RCRA compliance sampling and analysis, visual container inspections, weight, dose rate, truck survey and vehicle release survey.”

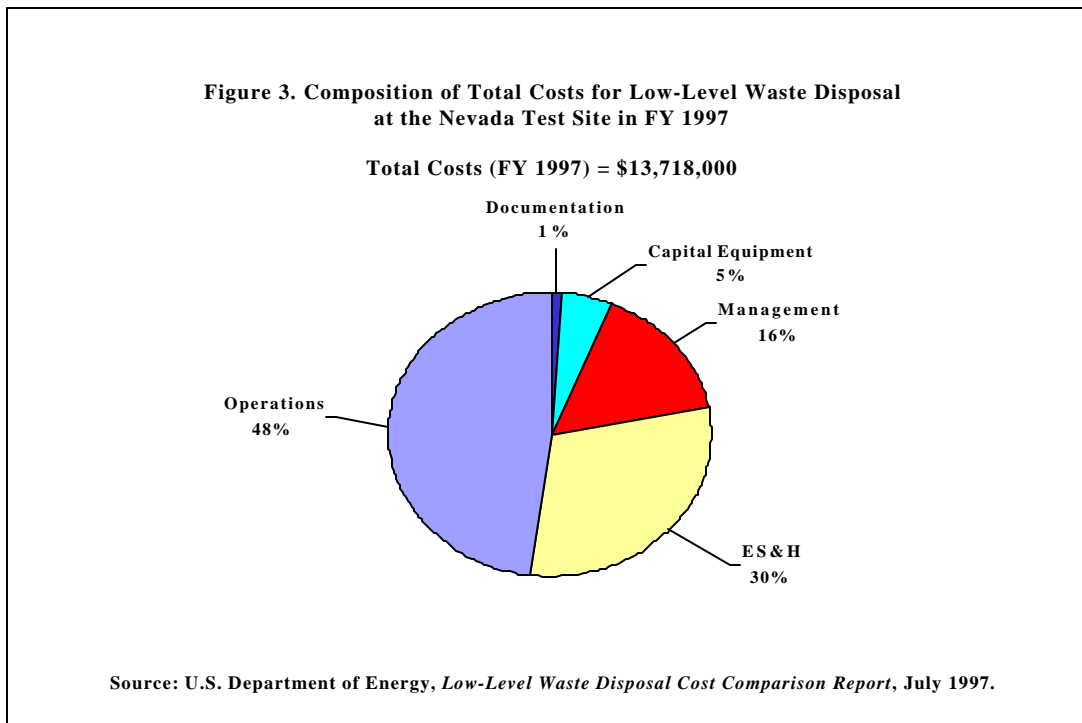


- Operations/Surveillance and Maintenance (Preventative and Corrective). These activities include “inspections, repackaging, spill cleanup, waste containers, record keeping, assays packaging or repackaging materials, and closure activities.”
- Environmental, Safety and Health (ES&H) Activities. These activities include “conduct of operations, NEPA, procedures, training, permits, quality assurance, SARs, ORPs, technical support, and performance assessment activities.”
- Capital Equipment. This category includes “general plant projects to upgrade and/or maintain disposal facilities.”
- Management Costs. These activities consist of “planning and budgeting, directly attributable to disposal facilities.”

Figure 3 provides a summary breakdown of total disposal costs at the NTS by the five general activity categories for FY 1997.

Generator Disposal Costs. The DOE 1997 Cost Comparison Report also recognized the importance of including generator costs in its analysis and comparison of DOE LLW disposal costs. Variance in generator disposal cost data from site to site may be attributable, in part, to sites relying on different degrees of process knowledge and sampling to characterize wastes. However, disposal site waste acceptance criteria and strategies can also have an important impact on generator costs. The criteria and strategies at some disposal sites may be more or less stringent or protective (with respect to risk management), based on disposal site characteristics and/or other relevant factors. For example, due to the proximity of the Columbia River, and in order to meet Performance Assessment groundwater pathway dose criteria, the solid waste acceptance criteria (WAC) for the Hanford LLW disposal facility (12) requires that certain wastes (Category 3 – based on radionuclide concentration limits) can be disposed only if the waste is:

- Stabilized by packaging in a High Integrity Container (**HIC**) meeting specified requirements;
- Stabilized in concrete or other stabilization agents to meet the leach index and compression strength criteria of the NRC Technical Position Paper on Waste Form; or
- Inherently stable waste that meets the stability requirements of 10 CFR 61.56 and the NRC Technical Position Paper on Waste Form.



In addition, if the concentration of any mobile radionuclide (^3H , ^{14}C , ^{36}Cl , ^{79}Se , ^{93}Mo , ^{99}Tc , ^{129}I , ^{187}Re , Total U, and ^{237}Np) exceeds limits prescribed by the Hanford WAC, stabilization may be required. The NTS Waste Acceptance Criteria (13) (NTSWAC) contain no similar requirements. Hence, generator costs to dispose of such wastes at Hanford would likely exceed generator costs for disposal of the same wastes at the NTS.

Disposal cost data for generators disposing at each of the six DOE LLW disposal facilities was collected by the 1997 Cost Comparison Report in the following ten categories separately for contact-handled (CH) and remote-handled (RH) waste:

- Characterization
- Packaging, Waste Approvals, Certifying
- Facility Operations
- Environmental, Health, and Safety/Conduct of Operations
- Management/Technical Support
- Chargebacks/Fees Charged by Disposal Facility
- Surcharges
- Taxes (State and local)
- Treatment
- Transportation

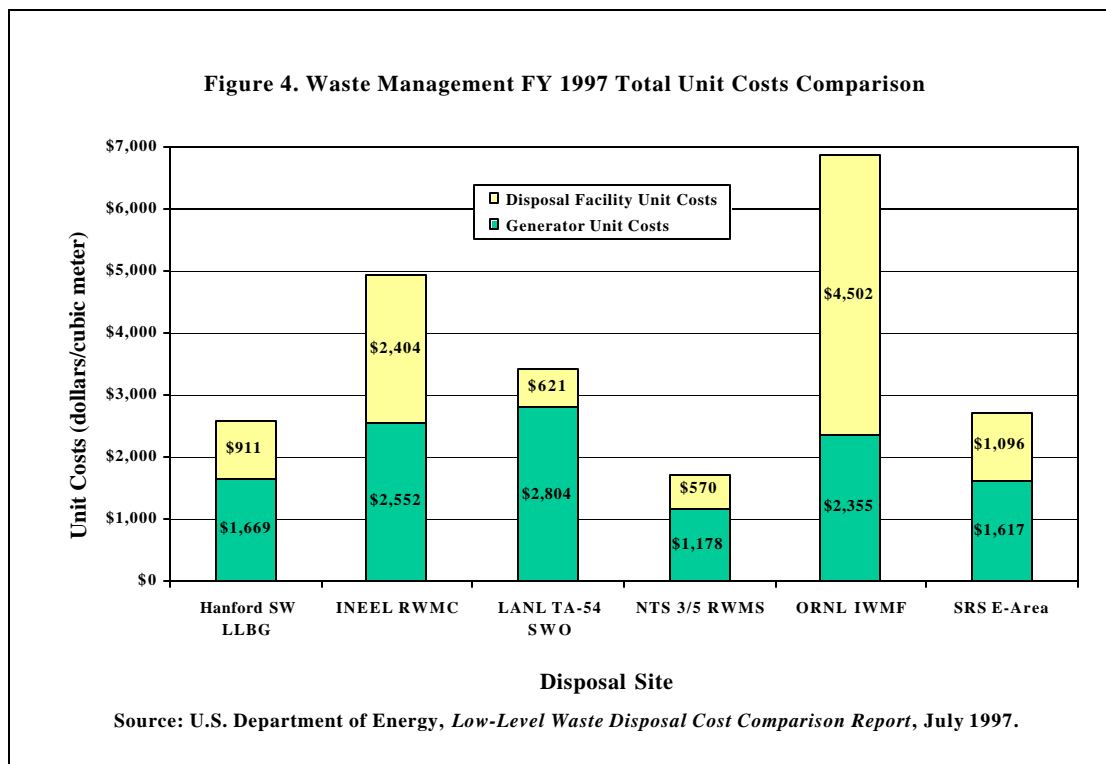
The cost data collected indicate that generator disposal costs are, in general, higher than disposal facility costs. This supports the approach used by the DOE 1997 Cost Comparison Report to capture generator costs as part of total disposal costs in the Complex-wide analysis. **Figure 4** graphically depicts the disposal facility unit costs, generator unit costs, and total unit costs for each of the six DOE WM disposal facilities.

Summary Observations. The data collected for and analyzed in the DOE 1997 Cost Comparison Report support the following observations:

- The economies of scale (total volumes received and rates of shipment) have the most impact on LLW facility disposal costs. This supports the cost findings of the WMPEIS, and a more centralized approach to LLW

disposal. LLW disposal facilities generally have a high fixed infrastructure cost, and must dispose of large volumes of LLW to reduce their total unit cost of disposal.

- With the exception of FY 1996 (during which the NTS incurred an unusual cost of more than \$3 million associated with completion of an initial Performance Assessment), disposal facility unit costs (\$/m³ disposed) for NTS LLW disposal were lower than disposal facility unit costs for both Hanford and the Savannah River Site (the other DOE LLW disposal facilities currently accepting off-site shipments of LLW, subject to the restrictions described previously).



- From the limited cost data collected, generator unit disposal costs (\$/m³) for NTS-approved generators appear to be significantly lower (by more than \$400/m³) than the generator unit disposal costs for any other DOE WM disposal facility. Since, as noted above, the 1997 Cost Comparison Report considers generator disposal costs to represent the greater portion of total disposal costs, this alone provides the NTS with a significant cost advantage over the other WM LLW disposal sites.
- A comparison of the projected, total unit disposal costs (adding disposal facility and generator unit costs) of WM LLW disposal facilities for FY 1997 indicates that the projected, total unit disposal cost at the NTS (\$1,748/m³) is significantly less (by more than \$800/m³) than the projected, total unit disposal costs at the next lowest-cost facilities – Hanford (\$2,580/m³) and Savannah River (\$2,713/m³).

COST SAVINGS TO THE DOE COMPLEX ATTRIBUTABLE TO USE OF THE NEVADA TEST SITE FOR LLW DISPOSAL

Historical Cost Savings. Utilization of the NTS for DOE LLW disposal has resulted in considerable costs savings to the DOE Complex overall, and to DOE generating sites in particular. Approximately 3,011,459 cubic meters of DOE LLW, with a total cumulative radioactivity of approximately 12,549,521 curies, were disposed by shallow land disposal at DOE sites during the period 1943 through 1995. During this period, all the major DOE disposal sites experienced fluctuations in the annual volumes and radioactivities of LLW accepted for disposal. However, from 1943 through 1995, all the DOE disposal sites generally experienced steady increases in both accumulated volumes and cumulative radioactivity of LLW accepted for disposal.

WM'00 Conference, February 27 – March 2, 2000, Tucson, AZ

The cumulative radioactivity of the LLW disposed at the six major DOE disposal sites has increased disproportionately among the sites, as compared to accumulated volumes, with the NTS having the largest increase in cumulative radioactivity over time. Although the volume of LLW disposed at the NTS during this period (approximately 501,332 cubic meters) represents only approximately 17% of the total volume of LLW disposed at DOE sites, these wastes represent approximately 35% (4,632,808 curies) of the total cumulative radioactivity of such wastes as of the end of 1995. (14)

The cost benefit to the DOE Complex of this disposal of cumulatively higher activity LLW at the NTS during the period 1943 through 1995 is difficult to precisely estimate. However, a rough comparative estimate in today's environment can be demonstrated using the current pricing schedule for Chem-Nuclear Systems' Barnwell, South Carolina commercial LLW disposal facility. As previously noted, the Barnwell facility is the only commercial LLW disposal facility currently accepting LLW classified as greater than Class A from non-compact state generators (from all states except North Carolina). The Barnwell facility Pricing Schedule includes both a weight/volume charge and a "millicurie" charge in its Base Disposal Charge. The current millicurie charge at Barnwell is \$.30 per millicurie. In addition, a Dose Rate Surcharge is applied, based on the dose level of the LLW (a multiplier, determined by the dose rate, is applied to the base weight/volume charge).

A rough estimate of the economic benefit to the DOE Complex from the disposal of cumulatively higher activity LLW at the NTS during the period 1943 through 1995 can be made using only the commercial millicurie charge and the following equations:

- $12,549,521$ (total Ci for the period 1943-1995) \times 18% (% by which NTS Ci exceeded the NTS % of the total DOE LLW volume disposed) = $2,258,914$ Ci (total disproportionate disposal of Ci at NTS).
- $2,258,914$ Ci \times 1000 = $2,258,914,000$ millicuries (mCi).
- $2,258,914,000$ \times \$.30/millicurie = $\$667,674,000$.

Hence, the cost benefit to the DOE Complex from the disposal of cumulatively higher activity LLW at the NTS during the period 1943 through 1995 is estimated to be in excess of \$667 million, based on current commercial LLW "per millicurie" disposal charges. This estimate, while based on current disposal charges, is on the conservative side, since it does not include the commercial Dose Rate Surcharge, and since the number of millicuries is based on estimated DOE LLW radioactivity decayed through 1995. The actual number of millicuries at the time of disposal, and the resulting estimated cost benefit, would have been much higher.

A more recent estimate of the significance of these cost savings can be provided by evaluating LLW disposal at the NTS Area 5 Radioactive Waste Management facility during Fiscal Years 1989 through 1993 (five fiscal years). During this period, a total volume of $47,200$ m³ of LLW was disposed, representing 101,290 curies. Using the above-identified Barnwell commercial facility millicurie charge and the recent (1997) NTS volume-based disposal cost (\$570/m³), we obtain the following cost comparison:

- NTS volume-based disposal costs: $47,200$ m³ \times $\$570/\text{m}^3$ = $\$26,904,000$.
- Additional, comparative commercial "millicurie" charges: 101,290 curies \times \$.30/millicurie = $\$30,387,000$.

In this case, the additional millicurie charges (reflecting radioactivity) would be greater than the entire NTS facility disposal costs, and represents a significant avoided cost to the DOE Complex.

For each of the ten principal DOE off-site generators disposing of LLW at NTS Area 5 during the period, this foregone "millicurie" charge represents the realized savings shown in **Table VI**. Those generators with high curie content, low volume LLW are realizing significant savings, versus the more modest savings realized by generators with large volumes of low curie content LLW.

**Table VI: LLW Disposal Charges at NTS Area 5 (FY1989 - FY1993)
(Principal DOE Off-Site Generators Representing Over 99 % of Disposal Volume)**

Generator Site	Volume (m ³)	NTS Area 5 Volume Charge (\$) (1)	Activity (Ci)	Foregone Additional Activity Charge (\$) (2)
Aberdeen	1,266	\$721,620	105	\$31,500
ETEC	70	39,900	0.17	51
Fernald	23,393	13,334,010	94	28,200
General Atomics	2,059	1,173,630	21.9	6,570
LLNL	951	542,070	46,933	14,079,900
ITRI	467	266,190	2.86	858
Mound Plant	10,271	5,854,470	24,000	7,200,000
Pantex Plant	469	267,330	16.2	4,860
Rocky Flats	8,018	4,570,260	61.9	18,570
Sandia (CA)	132	75,240	29,652	8,895,600

Source: E. J. Bentz & Associates, Inc.

(1) Computed at 1997 NTS volume-based disposal cost (\$570/m³).

(2) Computed at 1998 Barnwell commercial millicurie charge (\$.30/millicurie). Note that Barnwell equivalent total charges (including activity charges) have been estimated at \$8,000 - \$14,000/m³.

Projected Cost Savings. All recent DOE reports projecting LLW disposal at the NTS show a significant increase in volumes. (15) However, the *Final Waste Management Programmatic Environmental Impact Statement (WMPEIS)* (16) provides the only recent, Complex-wide DOE cost projections and analytical comparisons of the projected costs of disposing of current and projected inventories of DOE LLW at DOE facilities under alternative treatment and disposal scenarios.

The WMPEIS LLW Disposal Cost Analysis. The costs evaluated in the WMPEIS for LLW are life-cycle costs of facilities required for each of the LLW treatment/disposal alternatives considered. For each site and each alternative, wastes were hypothetically routed through the waste management process (using projected volumes and waste stream characterization profiles). Life-cycle process modules (treatment and disposal) were then individually sized to handle the different processing requirements of each alternative considered.

A summary of the estimated costs by WMPEIS alternative and cost category is depicted in Table 7.14-2 of Volume 1 of the WMPEIS. Total facility costs are depicted twice: as Life-Cycle costs and as Process Breakout costs. Total Costs, as depicted, add Truck Transport costs to Life-Cycle costs. Hence, Total Costs are equal to the sum of Life-Cycle costs and Truck Transport costs and also to the sum of Process Breakout costs and Truck Transport costs.

From the cost data depicted in Table 7.14-2 of the WMPEIS, the following general observations can be made:

- As waste treatment and disposal is consolidated at fewer sites, costs for treatment and disposal decrease, reflecting the economies of scale of using larger and fewer facilities.
- Volume reduction costs are approximately twice as high as minimum treatment costs, and are not offset by the savings achieved in lowered disposal costs from less waste being disposed.
- Although the quantity of waste requiring transport is at its maximum in the WMPEIS alternatives that centralize functions at the NTS or Hanford, the relative proportion of transportation costs remains relatively small, at less than 21% (for truck transport).
- The higher transportation costs for the Centralized alternatives would shrink substantially, to a maximum of less than 5% of total costs, if the use of rail transport were maximized.

Hence, highly centralized disposal of LLW, minimizing treatment, and maximizing rail transportation, would be the most economical alternative for DOE LLW disposal, according to the WM PEIS cost data.

From the WMPEIS cost data table it can be seen that for the DOE Complex, from a purely economic standpoint, centralized disposal of all LLW at the NTS under Centralized Alternative 2 (minimum treatment, disposal at NTS) is the most attractive of the WMPEIS alternatives considered. At \$11.1 billion, the cost of this alternative is over \$1

billion less than the next-least-expensive alternative (Centralized Alternative 1: minimum treatment, disposal at Hanford) over the 20-year period covered by the analyses.

Under the cost data provided by the WMPEIS, the NTS, as a centralized disposal facility, enjoys a disposal cost advantage of approximately \$0.9 billion over Hanford for minimum treatment wastes, and of \$0.75 billion for volume reduction wastes treated at regional facilities. The principal source of this cost advantage is lower operations and maintenance (O&M) costs. O&M costs consist of annual operations labor and material, maintenance labor and equipment, utilities, contractor supervision and overhead, and related project management and contingencies.

The only advantage of Hanford as a centralized facility as compared to the NTS is that volume reduction could also be centrally located at the Hanford site (Centralized Alternative No. 5). However, as noted above, volume reduction costs are approximately twice as high as minimum treatment costs, and these costs are not offset by lowered disposal costs from less waste being disposed.

The cost savings estimated by the WMPEIS between the No Action Alternative and Centralized disposal of LLW at the NTS is enormous, at \$7 billion over the 20-year period analyzed. This savings primarily results from a \$8.7 billion decrease in disposal costs by using the NTS (an additional \$1.5 billion savings is realized in other cost categories). The advantage is partially offset by a \$2.2 billion increase in transportation costs. However, if the use of rail transport were maximized, this increase in transportation costs would be reduced to \$360 million (a strong economic argument for development of the intermodal transfer facility proposed by the DOE Nevada Operations Office for use by NTS-bound LLW). **Table VII** summarizes the cost savings of the least expensive – minimum treatment - WMPEIS disposal alternatives over the No Action Alternative.

**Table VII: DOE Projected Life-Cycle Costs Savings to the DOE Complex (in billions of dollars)
(For alternative, least expensive - minimum treatment – LLW
disposal options as compared to the No Action Alternative)**

WMPEIS Alternative	Destination Disposal Site(s)	Treatment	Total Cost (1)	Cost Savings From No Action Alt.
Decentralized	16 sites (including the NTS) (2)	All sites - minimum treatment	\$16.8	\$1.3
Regionalized 1	12 sites (including the NTS) (3)	All sites - minimum treatment	16.4	1.7
Regionalized 3	6 current disposal sites (4)	All sites - minimum treatment	14.9	3.2
Regionalized 6	Hanford, Savannah River	All sites - minimum treatment	13.0	5.1
Regionalized 7	NTS, Savannah River Site	All sites - minimum treatment	13.9	4.2
Centralized 1	Hanford	All sites - minimum treatment	12.2	5.9
Centralized 2	Nevada Test Site	All sites - minimum treatment	11.1	7.0

Source: E. J. Bentz & Associates, Inc. derived from DOE WMPEIS, Volume 1, Table 7.14-2.

Notes to Table VII:

- (1) Total costs include process treatment, truck transport, and disposal; in billions of 1994 dollars.
- (2) ANL-East, BNL, FEMP, Hanford, INEL, LANL, LLNL, NTS, ORR, PDGP, Portsmouth, Pantex, RFETS, Sandia/NM, SRS, and West Valley.
- (3) FEMP, Hanford, INEL, LANL, LLNL, NTS, ORR, PDGP, Portsmouth, Pantex, RFETS, and SRS.
- (4) Hanford, INEEL, LANL, NTS, ORR, and SRS.

As noted above, the use of the NTS for disposal offers significant projected cost savings to the DOE Complex. In addition, as discussed previously, the “runner-up” sites offering cost savings – Hanford and Savannah River – are expected to primarily dispose of on-site-generated LLW. We further note that disposal capacity is not considered to be an issue at the NTS. *The Current and Planned Low-Level Waste Disposal Capacity Report* (Rev. 1) (17) indicates that total available LLW disposal capacity at the NTS is 3,150,000 m³, and that the site has the capability of expanding disposal operations to accommodate disposal of larger volumes of LLW. In fact, the report found that “given the site conditions and performance attributes of the disposal facilities at the Nevada Test Site, the maximum expandable volumetric capacity is limited only by the size of the usable disposal land at the Nevada Test Site.”

Confirmation: Office of the Inspector General Audit Report. The observations and conclusions regarding cost savings to the DOE Complex discussed above are reinforced by a September, 1998 Audit Report: *Disposal of Low-Level and Low-Level Mixed Waste (18)* by DOE's Office of the Inspector General (IG). The IG report concluded that DOE did not dispose of LLW in a cost-effective manner during the period FY 1993 through FY 1996, and that DOE had incurred approximately \$5.3 million in unnecessary disposal costs for LLW during that period.

Among the specific findings of the report were that DOE had incurred \$27.1 million to build LLW disposal facilities at Savannah River (Low Activity Vaults) and Oak Ridge (IWMF), but that off-site disposal would be more cost-effective. The report noted that if Savannah River's Low Activity Waste Vaults were used to capacity, DOE would spend a total of \$73.4 million on the LLW disposal. However, the report found that the same amount of waste could be disposed at a total cost of \$29.5 million, had Hanford been used for the past disposal (past disposal at NTS had been barred by a State of Nevada lawsuit), and if the remaining LLW were disposed at the NTS. The analysis demonstrated a lack of cost-effectiveness in operating the IWMF at Oak Ridge in a similar fashion. Actual cost savings were underestimated, since the \$27.1 million in "sunk" construction costs for both facilities were excluded from the disposal cost analyses.

The IG report further found that the Savannah River, Oak Ridge, Portsmouth, and Rocky Flats sites could save approximately \$12.5 million in disposal costs over the next 5 years, if those sites used the NTS for LLW disposal instead of on-site disposal or disposal at the Hanford site. It recommended that DOE's Office of Environmental Management revise the Department-wide strategy for disposal of LLW to require justification and a cost-benefit analysis before constructing any additional, on-site disposal facilities, and that implementation of the Department-wide strategy be periodically reviewed and evaluated to ensure disposals are made in a cost-effective manner.

INCREMENTAL COSTS TO THE NTS TO REALIZE BENEFITS TO THE DOE COMPLEX

Incremental costs to the DOE Nevada Operations Office from LLW disposal operations at the NTS would be expected to increase substantially as a result of the projected increased use of the NTS for DOE LLW disposal. Increases in both the fixed and variable costs associated with LLW disposal at the NTS would be anticipated.

In order to realize the above, significant projected benefits to the DOE Complex -- and in order to meet DOE nuclear safety requirements for disposal of the projected LLW streams -- the NTS is expected to experience the following additional costs:

- Increased ES&H fixed costs to certify, monitor, test, and document new LLW waste streams.
- Increased ES&H fixed costs to perform safety and performance assessments associated with a variety of new radionuclides and new LLW waste streams.
- Increased operations fixed and variable costs to handle greater LLW waste stream volumes and rates of disposal.
- Increased management fixed costs to handle a larger number of generators and greater volumes and rates of disposal.
- Increased capital costs to accommodate new LLW waste streams and greater volumes and rates of disposal.
- Increased closure costs to accommodate larger and more varied LLW waste stream volumes.

NEXT STEPS

Limitations and Qualifications on Current DOE LLW Disposal Cost Estimates. There are important limitations and/or qualifications on the DOE disposal cost estimates developed for both the WMPEIS and the 1997 Cost Comparison Report. First, the DOE cost bases are entirely driven by estimated volumes disposed. Unlike for commercial disposal operations (e.g. Barnwell), there has been no accounting for the activity level of wastes to be accepted for disposal, or for wastes containing radionuclides of special concern. As was depicted in **Table VI**, this disproportionately increases the benefits of NTS LLW disposal to DOE generators of higher-activity wastes, as compared to generators of lower activity LLW, since higher-activity wastes and wastes with radionuclides of special concern account for a greater portion of the estimated overall and incremental costs of LLW disposal (e.g. ES&H cost elements).

In addition, the volumes-driven WMPEIS cost estimates are based on outdated programmatic assumptions and volumetric projections. The LLW volume projections used for the WMPEIS were developed from 1991 and 1993 vintage data that have been superseded by more recent data projections developed as part of DOE's accelerated cleanup planning efforts. They also consider only the 20-year time period covered by the WMPEIS. The authors' ongoing analyses have concluded that the WMPEIS volumes projected for some sites and waste streams underestimate waste stream volumes, while other waste stream volumes are overstated.

The 1997 Cost Comparison Report cost estimates are based on concurrent site baselines and assumptions (including volumes) developed for the *Accelerating Cleanup: Focus on 2006 Discussion Draft*. Hence, they provide a more current, detailed breakdown and analysis of actual DOE Complex disposal costs by disposal site (including the capture of generator costs). However, the report provides only a "snapshot" of actual and projected disposal facility costs over a limited period (FY 1996 – FY 1998), and the estimates of captured generator disposal costs (projected to exceed disposal facility costs) are provided for only FY 1997. The 1997 Cost Comparison Report provides no long-range projections of estimated total disposal costs.

Step(s) Being Taken to Remedy the Identified Weaknesses in the Current DOE Cost Estimates. In order to remedy the identified weaknesses in the current DOE LLW disposal cost estimates, the following steps are being taken in Nevada:

- A waste-stream-specific analysis is being undertaken, using recent NTS-approved generator-site estimates of the annual volumes of LLW projected to be shipped to the NTS for disposal, and using available data regarding the radiological characteristics of these identified streams. This analysis includes data developed for the 1998 LLWDCR (Rev. 1) and data obtained by direct, site-specific surveys.
- Improved cost estimates will be developed, utilizing the waste stream volume and radiological characteristics data gathered by the above analysis, to describe both the cost savings afforded the DOE Complex from disposal of LLW at the NTS and the increased costs to the NTS that are anticipated to be attributable to such activities.

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