PAST, PRESENT, AND ANTICIPATED LOW-LEVEL RADIOACTIVE WASTE DISPOSAL VOLUMES AND CHARACTERISTICS AT THE NEVADA TEST SITE (NTS)

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ABSTRACT

The Nevada Test Site (NTS) has been identified in recent, 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 Complex. The potential volumes and characteristics of these wastes -- as well as their proposed shipment to the NTS -- are of particular interest and concern to stakeholders in Nevada and in potential, shipment-corridor states. As part of the independent, Nevada Risk Assessment/Management Program (NRAMP), human health risk assessments are being developed with regard to NTS disposal areas and the proposed shipments of LLW to the NTS. In support of this work, good estimations of the volumes and characteristics of the wastes, and of the anticipated number of shipments to the NTS from generator sites, are needed. This paper describes historic disposal statistics and current estimations of projected shipments of LLW to the NTS from identified generator sites, including estimated shipment volumes, the characteristics of key, projected waste streams, and current uncertainties that impact the reliability of the data.

HISTORIC PERSPECTIVE ON DISPOSAL OF LLW AT THE NTS

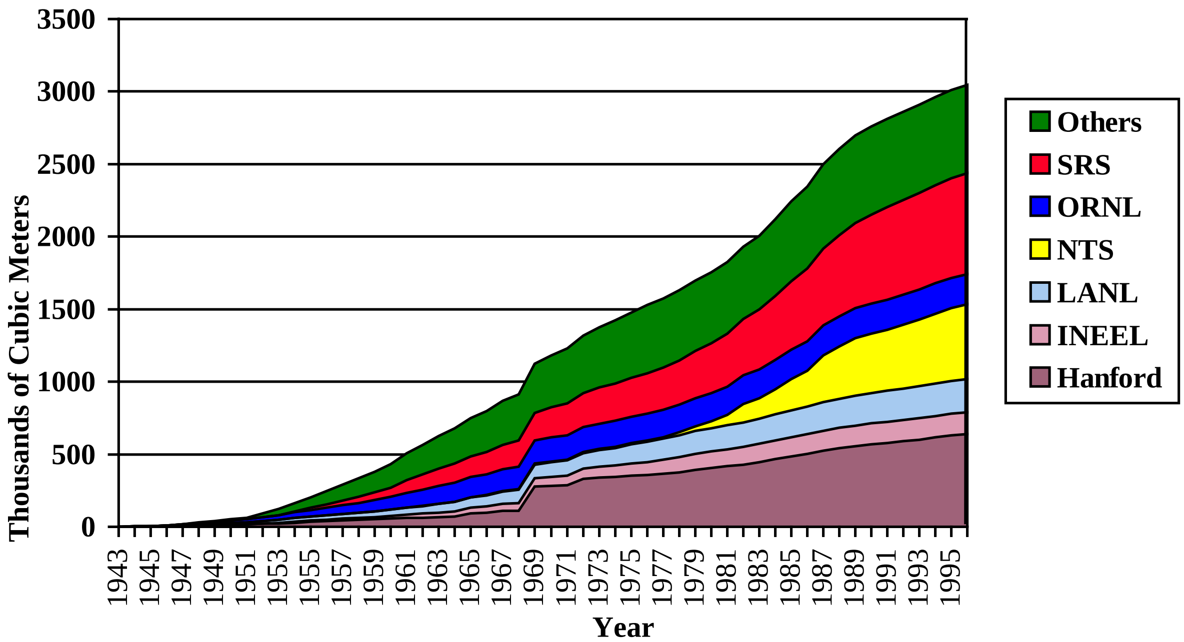
The Nevada Test Site (NTS) is the location of two Radioactive Waste Management Sites (RWMSs). The Area 3 RWMS encompasses an area of approximately 128 acres of land located in south central Yucca Flat, and utilizes subsidence craters that resulted from historic underground nuclear tests. Area 3 is currently used for the disposal of containerized bulk and packaged low-level waste from on-site and off-site DOE generators. The Area 5 RWMS is located approximately 15 miles north of the Area 3 RWMS on a dedicated 732 acre site on Frenchman Flat. Approximately 92 acres are currently being used for storage and disposal. The disposal facility currently consists of 21 landfill cells (pits and trenches) and 13 Greater Confinement Disposal (GCD) boreholes.

Historically, more than 3 million cubic meters of DOE LLW, with a total radioactivity exceeding 12.5 million curies, was disposed by shallow land disposal at DOE sites during the period 1943 - 1996. Six DOE sites (Hanford, Idaho National Engineering and Environmental Laboratory, Los Alamos National Laboratory, NTS, Oak Ridge National Laboratory, and the Savannah River Site) accepted and disposed of more than 80 % of this total volume. The volumes disposed by these six sites accounted for more than 99 % of the total cumulative radioactivity of the LLW disposed, dominated by Hanford (38 %) and the NTS (35 %).

Historically, all the major DOE disposal sites have experienced significant fluctuations in the annual volumes and radioactivity of LLW accepted for disposal. However, from 1943 through 1996, all of these sites have experienced steady increases in both the accumulated volumes and the cumulative radioactivity of LLW accepted for disposal (see **Figure 1** and **Figure 2**, below). Cumulative radioactivity at the six major DOE disposal sites has increased disproportionately as compared to accumulated volumes, with the NTS having the largest increase in cumulative radioactivity over time. Although the LLW disposed at the NTS represents only approximately 17 % of the total volume of LLW disposed at DOE sites during the period from 1943 through 1996, these wastes represent greater than 35 % of the cumulative radioactivity of such wastes as of the end of 1996.

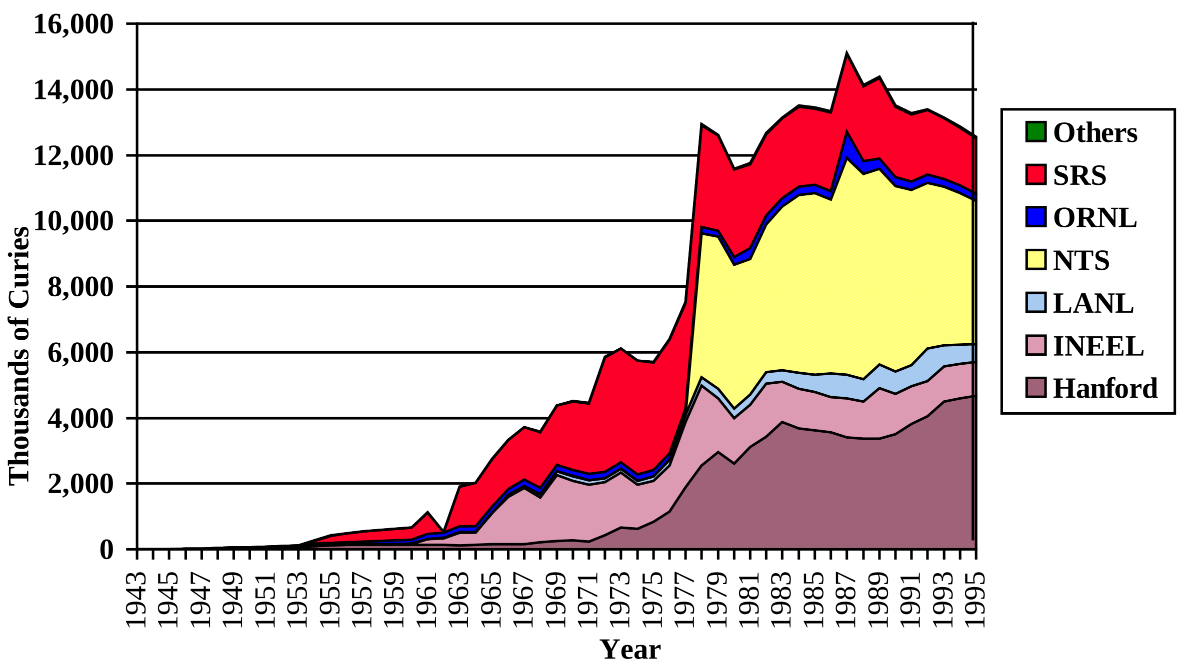
Unlike other major DOE disposal sites, the NTS did not begin accepting significant quantities of LLW for disposal until the mid-1970s. The <u>15-year period</u> beginning in 1974 and ending at the close of 1997 saw a steady increase in the volume of LLW disposed at the NTS from other DOE sites. During that period, LLW generated off-site represented approximately 55% of the total volume of LLW disposed at the NTS. That ratio, however, does not provide an accurate portrait of more recent trends. During the <u>ten-year period</u> 1988 - 1997, the percentage of off- site generated LLW disposed at the NTS increased to approximately 88% of the total volume, and over the <u>last five years</u> (1992 - 1997), the ratio of off-site LLW increased even further to approximately 95% of the total volume of DOE LLW disposed. Over the decade from 1987 through 1996, the NTS has accepted more than 41% of all LLW

Figure 1: Accumulated Volumes of LLW Disposed at DOE Sites 1943-1996



Source: E. J. Bentz & Associates from DOE data (1)

Figure 2: Cumulative Radioactivity of LLW Disposed at DOE Sites 1943-1995



Source: E. J. Bentz & Associates from DOE data (1)
disposed by shallow land disposal at DOE sites. **Table I**, below provides numerical and fractional comparisons of the annual volumes of off-site and on-site DOE-generated LLW disposed at the NTS in the period 1974 – 1997 (15 years).

Table I: Annual Volumes (in m^3) and Fractions of Off-Site and On-Site LLW Disposed at the NTS

Fiscal Year	Off-Site Volume	NTS Volume	Total Volume	% Off-Site Volume
1974	0.00	10.10	10.10	0.00%
1975	0.00	0.00	0.00	0.00%
1976	26.76	0.00	26.76	100.00%
1977	11.12	351.16	362.28	3.07%
1978	714.61	9,412.90	10,127.51	7.06%
1979	7,554.57	5,995.87	13,550.44	55.75%
1980	7,163.65	5,329.25	12,492.90	57.34%
1981	4,808.10	17,539.86	22,347.96	21.51%
1982	7,972.72	21,797.52	29,770.24	26.78%
1983	7,664.48	30,983.74	38,648.22	19.83%
1984	9,468.50	25,769.82	35,238.32	26.87%
1985	13,480.49	27,696.02	41,176.51	32.74%
1986	15,853.99	10,458.22	26,312.21	60.25%
1987	22,270.43	59,191.64	81,462.07	27.34%
1988	26,119.95	1,952.81	28,072.76	93.04%
1989	29,069.63	19,261.50	48,331.13	60.15%
1990	16,547.94	193.21	16,741.15	98.85%
1991	9,608.84	0.00	9,608.84	100.00%
1992	24,516.18	0.00	24,516.18	100.00%
1993	18,548.65	56.78	18,605.43	99.69%
1994	21,313.03	42.59	21,355.62	99.80%
1995	24,799.67	41.12	24,840.79	99.83%
1996	11,145.41	1,577.50	12,722.91	87.60%
1997	19,556.01	4,468.06	24,024.07	81.40%
Total	**298,214.73**	**242,129.67**	**540,344.40**	**55.19%**

Source: E. J. Bentz & Associates from Bechtel Nevada data (2)

Off-site generated LLW disposed at the NTS has originated from all over the DOE Complex. **Table II**, below depicts the annual volumes of LLW disposed at the NTS by generator for the period 1974 – 1997 (15 years). Off-site LLW historically shipped to the NTS for disposal has exhibited wide variances in radioactivity concentrations among the generator sites. For example, LLW disposed at the NTS Area 5 RWMS from the Fernald site (FEMP) during the period 1989-1993 (five years) accounted for approximately 50% of the total volume of off-site generated LLW disposed in that period, but only .09% of the cumulative radioactivity. Conversely, during the same period, LLW generated from the Lawrence Livermore National Laboratory (LLNL) and disposed at the Area 5 RWMS accounted for only about 2% of the total volume of LLW disposed, but fully 47% of the cumulative radioactivity (see **Table III**, below).

DOE FORECASTS OF LLW DISPOSAL VOLUMES AT THE NTS

Nine recent DOE reports are the primary sources of data for off-site LLW volumes projected to be shipped to the NTS for disposal:

- *1996 Baseline Environmental Management Report* , June, 1996 (BEMR) (3)
- *The Current and Planned Low-Level Waste Disposal Capacity Report, Rev. 0*, July, 1996 (LLWDCR) (4)

Table II: Annual Volumes (in m^3) of Off-Site LLW Disposed at the NTS by Generator Site

FY	Aberdeen	DNA	ETEC	Fernald	GA	ITRI	LLNL	Mound	Pantex	RFETS	Others
1974	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1975	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.8	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	0.0	0.0
1978	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	0.0	706.0	0.0
1979	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	0.0	7,546.8	0.0
1980	0.0	0.0	0.0	0.0	0.0	0.0	197.2	466.7	30.8	5,972.2	496.7
1981	0.0	0.0	0.0	0.0	0.0	0.0	1,105.9	841.8	57.6	2,631.9	170.9
1982	0.0	0.0	0.0	0.0	0.0	60.7	549.2	1,011.9	120.0	6,225.6	66.1
1983	0.0	0.0	0.0	0.0	0.0	0.0	1,441.6	1,516.9	1,071.9	3,358.1	276.0
1984	0.0	0.0	0.0	0.0	0.0	0.0	1,268.7	3,063.3	63.4	4,492.5	580.6
1985	0.0	1,045.6	38.1	72.3	0.0	130.9	1,297.7	3,646.4	170.1	7,034.3	176.2
1986	0.0	0.0	171.6	3,553.9	32.7	38.9	749.6	5,446.5	35.7	5,823.6	40.5
1987	151.1	0.0	235.5	10,410.3	3,236.5	73.6	846.4	4,053.7	40.2	3,174.6	122.2
1988	0.0	0.0	135.9	13,651.6	493.0	78.2	498.1	7,943.9	0.0	3,313.9	83.5
1989	470.6	0.0	70.5	14,648.3	20.8	156.1	721.1	6,364.3	92.5	6,521.7	159.9
1990	166.1	0.0	0.0	5,784.2	0.0	94.7	473.2	1,817.4	82.6	8,106.5	117.9
1991	0.0	0.0	0.0	9,608.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	316.2	0.0	0.0	21,945.3	530.0	117.4	0.0	1,501.0	91.1	15.2	117.4
1993	321.8	0.0	0.0	15,905.6	1,508.1	93.7	0.0	430.5	203.1	0.0	179.6
1994	65.1	11.4	164.8	16,629.7	761.6	0.0	1,576.4	1,047.8	466.2	326.5	263.6
1995	145.2	0.0	180.7	20,445.7	663.6	0.0	417.7	1,946.8	166.3	364.1	469.6
1996	129.1	0.0	424.4	8,815.6	100.4	143.1	367.3	57.7	215.4	46.7	988.9
1997	105.3	0.0	273.0	15,926.3	391.3	0.0	433.9	907.2	58.3	1,290.8	169.9
Total	**1,870.5**	**1,057.0**	**1,694.3**	**157,397.4**	**7,738.0**	**987.3**	**11,943.7**	**42,118.0**	**2,965.2**	**66,951.1**	**4,479.5**

Source: E. J. Bentz & Associates from Bechtel Nevada data (2)

Table III: Accumulated Volumes and Cumulative Radioactivity of LLW Disposed at the NTS Area 5 RWMS by Off-Site Generators (1989 - 1993)

	Aberd'n	ETEC	FEMP	GA	ITRI	LLNL	Mound	Pantex	RFETS	Sandia
Volume (m^3)	1266	70	23,393	2,069	467	951	10,271	469	8,018	132
Activity (Ci)	105	0.17	94	21.9	2.86	46,938	24,000	16.2	61.9	29,650

Source: E. J. Bentz & Associates from Bechtel Nevada data (2)

- *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada*, August, 1996 (NTS EIS) (5)
- *Final Waste Management Programmatic Environmental Impact Statement*, May, 1997 (WM PEIS) (6)
- *A Contractor Report to the Department of Energy on Opportunities for Integration of Environmental Management Activities Across the Complex* , May, 1997 (Contractor Report) (7)
- *Accelerating Cleanup: Focus on 2006, Discussion Draft*, June, 1997 (Draft Accelerated Plans) (8)
- *Accelerating Cleanup: Paths to Closure,* June, 1998 (June, 1998 Accelerated Plans) (9)

- *The Current and Planned Low-Level Waste Disposal Capacity Report, Rev. 1*, September, 1998 (LLWDCR, Rev. 1) (10)
- *Information Package on Pending Low-Level Waste and Mixed Low-Level Waste Disposal Decisions*, September, 1998 (Info Package) (11)

All of these DOE reports were published during the years 1996 through 1998. Each of the reports was developed to address a different programmatic requirement or issue relevant to DOE's Environmental Management program. Hence, each report utilizes its own unique set of programmatic and technical assumptions and data, depending upon the date of the report and its particular purpose.

There are significant differences in the various reports in both the site-specific and the overall projections of the volumes of off-site LLW destined for disposal at the NTS. These forecasts of off-site LLW destined for disposal at the NTS have ranged from 189,771 m^3 (June, 1998 Accelerated Plans) to 2,386,004 m^3 (WM PEIS, Centralized Alternative No. 2). **Table IV**, below provides a summary of the projected top exporters of LLW to the NTS by volume and by their respective relative ranking by each report. Differences in the disposal projections appear to be attributable to multiple factors, including:

- Significantly different programmatic assumptions on the extent and pace of originating site clean-up, reflecting emerging policy;
- Significantly different technical assumptions concerning pre-treatment of wastes and volume reduction; and
- Use of different data sources, different vintages of source data, and different periods of forecast.

Table IV: Top Projected Exporters of LLW to the NTS by Volume in Cubic Meters (Relative Ranking by DOE Report)

Site	BEMR (1996)	LLWDCR Rev. 0 (1996)	NTS EIS Pref. (1996)	WM PEIS No Action (1997)	WM PEIS Centrl. 2 (1997)	Draft Accl. Plans (1997)	Contract. Report (1997)	Accel. Plans (1998)**
FEMP	57,330 (2)	57,000 (1)	84,177 (4)	180,000 (1)	180,000 (4)	406,915 (1)	112,185 (1)	83,591 (1)
Hanf.*	-	-	170,571 (2)	-	89,700 (7)	-	-	-
INEEL*	-	-	106,934 (3)	-	245,000 (3)	-	-	-
LANL*	-	-	41,773 (7)	165,000 (2)	165,000 (5)	32,102 (4)	-	-
LLNL	4,429 (7)	4,950 (6)	1,928 (19)	3,600 (7)	3,600 (19)	5,173 (7)		37,216 (4)
Mound	1,390 (10)	32,000 (4)	60,027 (6)	41,100(5)	41,100 (12)	11,173 (5)	-	64,177 (3)
ORR	349,870 (1)	-	26,607 (8)	-	279,000 (2)	70,625 (2)	26,987 (3)	-
Ports.*	-	-	63,512 (5)	-	97,100 (6)	-	-	-
RFETS	32,522 (4)	56,000 (2)	14,000 (9)	77,000 (4)	77,000 (9)	66,797 (3)	65,494 (2)	65,028 (2)
RMI	-	-	5,528 (10)	81,000 (3)	81,000 (8)	-	-	-

Sandia	45,104 (3)	36,000 (3)	570 (24)	38,500 (6)	38,500 (13)	2,549 (8)	8,715 (4)	5,071 (5)
SRS*	-	-	243,901 (1)	-	910,000 (1)	-	-	-

* Denotes a generator not currently approved for LLW disposal at the NTS.

** LLWDCR (Rev. 1, September, 1998) and Info Package (September, 1998) both use volumes data from *Paths to Closure* (1998 Accelerated Plan).

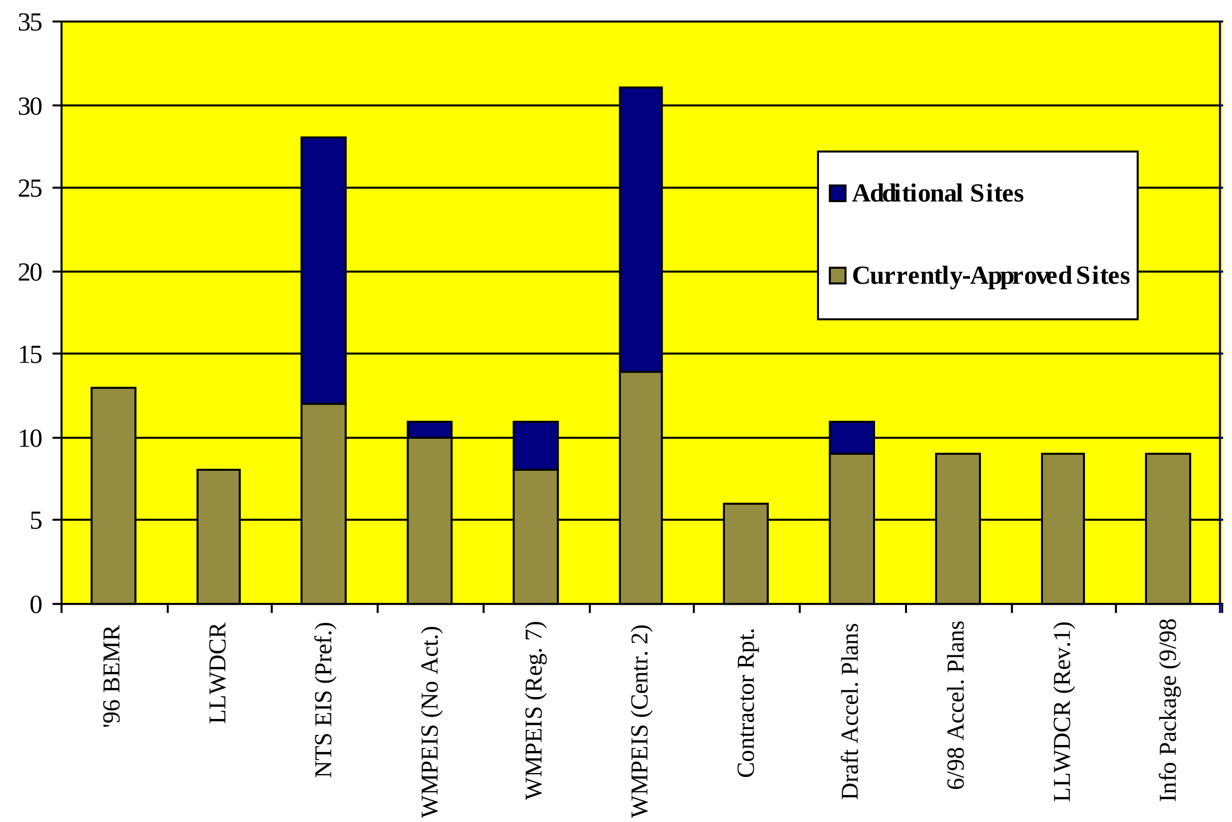
Source: E. J. Bentz & Associates from data derived from the cited reports

Significant differences in the projections among the reports result from the inclusion or non-inclusion of currently-unapproved (by DOE-Nevada) generator sites in NTS off-site LLW disposal projections; the reports vary from considering six of the currently-approved generators to over 31 generators, many of which are not currently approved for NTS LLW disposal (see **Figure 3**, below). Currently, there are 12 NTS-approved generators planning (or assumed by the authors to be planning) disposal of LLW at the NTS. This number excludes the NTS itself, and five sites (two DOE and three DOD sites) which are approved, but which do not currently plan any disposal at the NTS. These 12 generators are ETEC, Fernald, General Atomics, Grand Junction Projects Office, Kansas City Plant (Allied Signal), LLNL, LLRI (ITRI), Mound, Oak Ridge, Pantex Plant, Rocky Flats, and Sandia (NM).

Even considering the above, however, the differences in the report projections are not so easily explained. Historic DOE LLW forecasts have been undertaken with no uniform, DOE-wide guidance or methodology, and appear beset with such uncertainties as to provide limited confidence in the data. (For a more complete discussion of findings regarding DOE’s NTS LLW disposal volume projections and uncertainties, see *Comparative Analysis of Current DOE Report Projections of Nevada Test Site Low-Level Radioactive Waste Disposal Volumes* (12)). DOE’s recently-developed *Low-Level Waste Projection Program Guide* provides a new, standardized approach and methodology for development of LLW projections and the improvement of projected data quality. Implementation of the program may result in more uniform, accurate, and detailed projections of LLW generation for use in analyzing both the programmatic planning requirements associated with the treatment, storage, transportation, and disposal of LLW and the risks associated with those activities.

It is important to note that, despite the current uncertainties regarding the final disposal configuration of DOE’s LLW management system and regarding the accuracy of projections of LLW that will be generated by specific DOE sites, all of the disposal configuration options currently under serious consideration by DOE would require disposal of substantial volumes of off-site generated DOE LLW at the NTS.

Figure 3: Number of Originating Sites Projected to Ship LLW to the NTS



See Note ** in **Table IV**.
Source: E. J. Bentz & Associates from data derived from the cited DOE reports

DOE FORECASTS OF LLW RADIOLOGICAL CHARACTERISTICS

Adequate LLW characterization data is an essential element in DOE decision-making regarding the disposal of LLW and in the analysis of associated risks. The characteristics of LLW anticipated to be shipped from generator sites to the NTS must be demonstrated to be acceptable under the NTS Waste Acceptance Criteria (NTSWAC) (13). LLW must be characterized with sufficient detail and accuracy to permit proper segregation, handling, and disposal of the wastes. At minimum, such data must include the volume and weight of the waste (total of the waste and any solidification or absorbent media); its physical and chemical characteristics; the quantity and concentration of each major radionuclide present; and any other data necessary to demonstrate compliance with the NTSWAC. To date, DOE efforts at Complex-wide characterization of LLW appear to be of limited and, in some cases, insufficient detail and beset with too many uncertainties to demonstrate compliance with these requirements. This warrants the need for site-specific characterization efforts underway. Also, many of the reports identified above were developed for programmatic purposes, and not for site-specific waste acceptance purposes. To quote from DOE's *Information Package on Pending Low-Level Waste and Mixed Low-Level Waste Disposal Decisions:*

> *The WM PEIS analyses are screening level assessments, focusing mainly on alternatives addressing national-level strategic issues related to waste management. …DOE will follow these broad decisions with an analysis of narrow proposals for the implementation of the programmatic decisions, in related site-specific NEPA reviews. …Also in the actual siting and design of a disposal facility, more detailed, site-specific analyses would be conducted in accordance with the requirements for a performance assessment as specified in DOE Radioactive Waste Management Order 5820.2A. …Such studies investigate these issues more rigorously than could a programmatic document.*

Two DOE reports have attempted to describe the radiological characteristics of the LLW streams forecasted to be disposed at the NTS. Early efforts (April, 1995), in support of the WM PEIS, relied on generic, and at times inconsistent, approaches to describing radiological characteristics. In addition, these efforts were limited to Waste Management streams only. Recent efforts, resulting in Revision 1 of *The Current and Planned Low-Level Waste Disposal Capacity Report* (September, 1998), provided the first comprehensive attempt to provide Complex-wide radiological characterization information for forecasted LLW streams. Both of these efforts are discussed below.

WM PEIS LLW Characterization

Most of the DOE reports discussed above contain little or no characterization data for LLW projected to be shipped to the NTS for disposal, since they were developed for programmatic purposes. Both the WM PEIS and the NTS EIS analyses utilize LLW characterization data from an ANL report (14) specifically developed to support the analyses in the WM PEIS. The ANL report uses waste stream information contained in DOE's Waste Management Information System (WMIS) (15) database to characterize LLW by treatability category and handling characteristics for use in the WM PEIS analyses (see discussion below).

Waste generation quantities and form descriptions provided in the WMIS were used to identify treatability categories for each waste stream for each of 16 major DOE sites. The WMIS also indicates radionuclides present in each waste stream. Ten waste treatability categories (Combustible, Noncombustible-Noncompactible, Noncombustible-Compactible, Surface-Contaminated Bulk Metal/Equipment, Activated Bulk Metal/Equipment, Sludge/Resin, Other, Small-Volume Dilute/Aqueous, Liquids Containing Organic Materials, and Remote-Handled) were defined for LLW, and all LLW was considered to be either contact-handled (CH) non-alpha waste or CH alpha waste.

The LLW was further categorized, within each of the ten treatability categories, by assigning the waste one of six generic radiological profiles (Uranium/Thorium, Fission Products, Induced Activity, Tritium, Alpha, Other) previously identified and defined in the 1992 Integrated Data Base Report (16). The representative radionuclide compositions of these profiles were developed by Oak Ridge National Laboratory, based on historic source term and process flowsheet data, along with process knowledge.

The above-described profiles are <u>limited to LLW in Waste Management streams</u>. <u>No characterization of ER LLW was attempted for the WM PEIS</u>. At the time the WM PEIS LLW profiles were developed (April, 1995), the WMIS apparently represented the best data available on a Complex-wide basis. However, according to the ANL report itself, the quality of underlying WMIS data is unknown, and the data presented are inconsistent across the sites reporting. Hence, the profiles may not be consistent with the actual wastes generated by a specific site.

The Current and Planned Low-Level Waste Disposal Capacity Report (Rev. 1, September, 1998)

The recent Revision 1 of *The Current and Planned Low-Level Waste Disposal Capacity Report* (LLWDCR) represents the first Complex-wide attempt by DOE to estimate and compare radionuclide inventories and concentrations in projected LLW against the radiological capacities of DOE's existing Waste Management Program disposal facilities (Revision 0 only included volume estimates).

The site- and stream-specific LLW radiological profiles discussed in the report were developed using data from a 1997 Waste Management Technical Data Call (to the field), the 1997 Environmental Restoration Core Database, and estimates based on known information. Waste volume data used by the report were based on past disposal volume data provided by the disposal sites and projected disposal volume data from DOE's *Paths to Closure* (June, 1998). For the Data Call, sites were requested to report the radiological profile(s) of their LLW based on 49 key radionuclides.

The LLWDCR attempted to link the LLW streams identified by *Paths to Closure* to the radioactivity data from the above data sources. With regard to projected disposal at the NTS (excluding the NTS itself), the LLWDCR (Rev. 1) base case reports 43 waste streams originating from eight NTS-approved sites. This includes both WM and ER program LLW streams. The base case does not include 17 waste streams originating from Oak Ridge Reservation (ORR), and two waste streams originating from the Grand Junction Projects Office – destination to be determined (both are NTS-approved generators). In addition, the LLWDCR (Rev. 1) does not include characterization information from the following NTS-approved sites for certain waste streams which have been identified in the *Paths to Closure* (volumes only) report: ORR (two waste streams); ETEC (one waste stream); General Atomics (one waste stream); and LLNL (four wastes streams). Nor does it include information on five additional NTS-approved sites (two DOE and three DOD sites) from which there are no currently-anticipated shipments to the NTS (Sandia (CA); Reactive Metals, Inc.; Defense Nuclear Agency; Army Industrial Operations Command; and Aberdeen Proving Grounds).

Unfortunately, data for many of the waste streams was insufficient or unavailable. For these streams, DOE estimated radionuclide profiles by combining and volume-weighting the radionuclide concentrations of known LLW streams presented in the data sources, and applied those estimated profiles to *Paths to Closure* waste stream volumes. These composite profiles were based, whenever possible, on known waste streams generated at the same site, with similar physical and radiological characteristics. For example, for the Pantex site, Pantex has identified and reported 19 LLW streams. Of these, isotopes have been reported for only three of the waste streams, and only two of those have included isotopic concentration data. The isotope profile (with concentrations) used for the composite stream (combining all 19 LLW streams) utilized by the LLWDCR (Rev. 1) analyses was a composite developed from profile information of the two waste streams that have known isotopic concentrations.

Several sources of uncertainty exist in the estimation and projection procedures used for developing the radiological profiles for the LLWDCR. The most significant sources of uncertainty arise from: 1) estimating radionuclide concentration profiles for waste streams with no profiles, as described above; 2) limitations relevant to radiological data from the Environmental Restoration Core Database (discussed below); and 3) because no long-term radiological profiles were available, estimating composite radionuclide concentration profiles for LLW generated to the year 2070 by projecting current estimated radiological profiles. The above uncertainties are more prominent for ER wastes, due to the current, relatively limited characterization data – in contrast with WM wastes already in storage.

For example, with regard to ER wastes, data from the 1997 Environmental Restoration Core Database used in development of the LLWDCR radiological profiles have the following limitations that contribute to the uncertainty associated with those profiles:

- *Identification of Contaminants*: The database generally identifies only those radionuclides that are important in determining response decisions (e.g. a value for total U is given, with no separate data on the various U isotopes) and, for some waste streams, the database does not provide any radionuclide concentration data. The identified radionuclides typically are only a subset of the radionuclides actually present.

- *Waste Density:* Contaminant concentrations in the Core Database are almost always provided on a weight basis. To convert to a volume concentration basis (which was needed for the LLWDCR analysis and is needed for many waste acceptance applications), a waste density must be used. Because the Core Database contains limited waste density data, a uniform waste density of 1.6 MT/m (about the same as soil) was assumed for the LLWDCR analysis.

- *Average Contaminant Concentrations:* For some contaminants in some waste streams, the Core Database contains only maximum contaminant concentrations instead of the average concentrations. In these cases, the maximum concentration was used in the LLWDCR analysis, but may not be representative of, and may overestimate, the average concentration across the waste stream.

Although the LLWDCR (Rev. 1) has the above-identified limitations, it does serve a valuable role in establishing an initial benchmark for providing radiological characterization for projected WM and ER inventories. With regard to disposal at the NTS, the following observations, derived from the report, can be made:

- For the 49 radionuclides projected by the LLWDCR (Rev. 1) to be disposed at the NTS in the period 1998-2070, three radionuclides account for 99% of the cumulative curie content in 2070. They are H-3 (69% of total); Sr-90 (26% of total); and Co-60 (4% of total). The remaining 46 radionuclides collectively account for 1% of the cumulative curie content in

2070, dominated by U-238, -234, and -235; Ni-63 and -59; Ra-226; Th-230 and -232; Eu-154 and -152; and Pu-241, -238, -239, and -242.

- Several radionuclides projected to be disposed at the NTS constitute a prominent fraction of the total curies for that radionuclide projected to be disposed at all DOE sites. For key radionuclides, **Table V**, below provides the projected percentage of NTS-disposed curies compared to the total curies disposed at all DOE sites for the

Table V: Radionuclides Projected to be Disposed at the NTS with Curie Contents Exceeding 15% of the Total Curie Contents of those Radionuclides Disposed at all DOE Sites (1998-2070)

Radionuclide	% of Total DOE Disposed Curies	Half-Life (Years)
H-3	15.3%	12.3
C-14am	100.0%	5,730
Ra-226	97.4%	1,602
Ra-228	49.0%	6.7
Th-230	100.0%	80,000
Th-232	94.7%	14,000,000,000
Pa-231	100.0%	32,500
U-234	57.6%	247,000
U-235	31.5%	710,000,000
U-238	84.6%	4,510,000,000
Pu-238	24.5%	86.4
Pu-240	15.6%	6,580
Pu-241	39.3%	13.2
Pu-242	100.0%	379,000

Note: With reference to the previous observation: SR-90, 4.2 %, 28.1 years; Co-60, 0.6 %, 5.3 years.
Source: E. J. Bentz & Associates, derived from the LLWDCR (Rev. 1)

period 1998-2070, as well as their respective half-lives. Note the long half-lives of many of these radionuclides, indicating a projected need for long-term monitoring and maintenance of the NTS disposal site.

- As previously noted in discussion of the volume projections, the above-described estimates do not include consideration of waste streams that the authors anticipate may originate from certain sites such as Oak Ridge (an NTS-approved generator). The addition of these waste streams would result in a significant increase in the curie contents described above. The June, 1998 *Paths to Closure* volume projections on which the LLWDCR is based are limited to a conservative number (eight, base case) of NTS-approved generators. Other DOE reports call for a significant increase in the number of approved generators and resulting LLW volumes (see previous **Table IV** and **Figure 3**). As such, the above-discussed LLWDCR

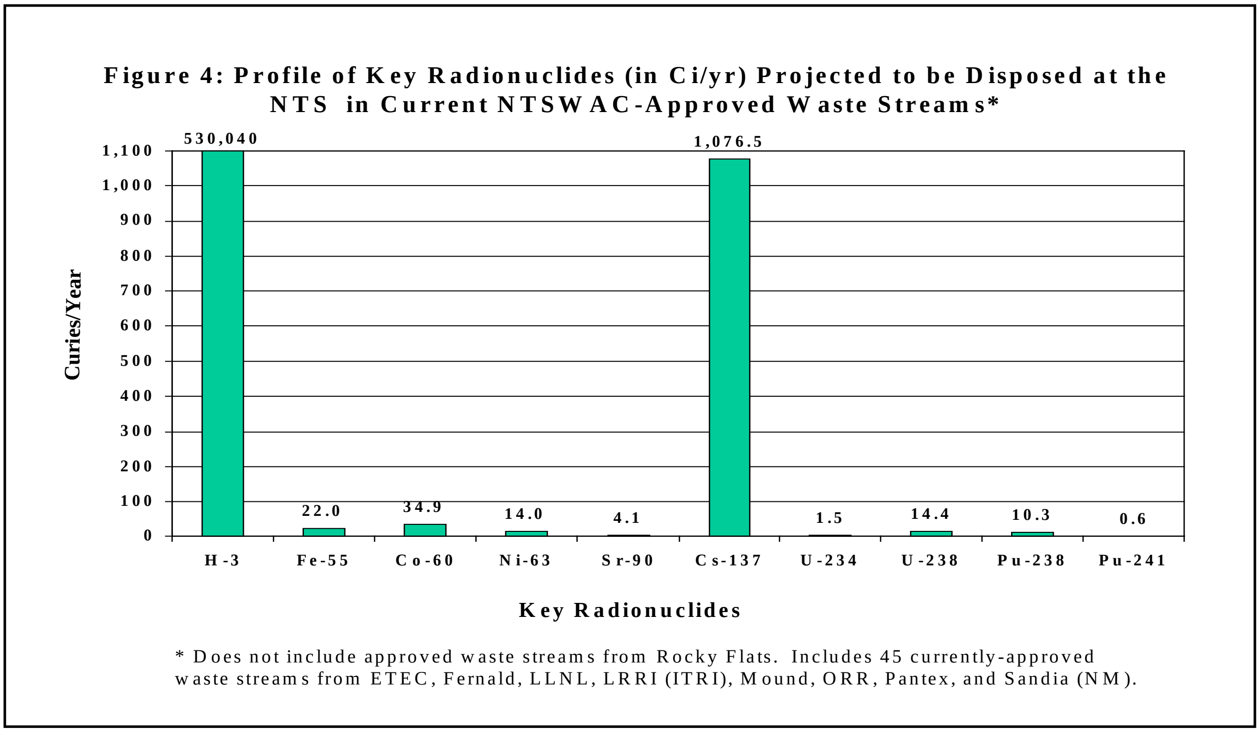
(Rev. 1) findings should be viewed as a very conservative estimate of disposal volumes and curie content potentially destined for the NTS.

RADIOLOGICAL PROFILES OF NTSWAC-APPROVED WASTE STREAMS

The *Nevada Test Site Waste Acceptance Criteria* (NTSWAC) requires that LLW generators properly characterize waste destined for disposal at the NTS. Prior to shipping any LLW to the NTS for disposal, LLW generators must prepare, submit, and obtain approval of a Waste Profile for each waste stream to be disposed at the site.

The radiological characterization required by the NTSWAC Waste Profile includes a list of the “reportable radionuclides” with data on both the estimated activity concentration ranges and the activity concentration estimated to be representative of the final waste form for each radionuclide. The term “reportable radionuclide” is defined by the NTSWAC as all radionuclides with activity concentrations in the final waste form exceeding 1% of “action levels” specified in the NTSWAC, and all radionuclides with activity concentrations in the final waste form exceeding 1% of the total activity concentration.

The characterization methods and procedures employed by the generator are required to ensure that physical, chemical, and radiological characteristics of the wastes are known and recorded during all stages of the waste management process. Characterization methods must undergo a peer review by personnel with appropriate expertise. Waste characterization may be conducted using process knowledge, sampling and analysis, or a combination of both. The acceptability of a generator’s characterization plan is based on a determination that the level of effort is appropriate, given the potential of the waste stream to exceed applicable concentration action level limits and considering physical characteristics of the waste stream. **Figure 4**, below depicts a profile of the key radionuclides projected to be disposed under current NTSWAC-approved waste streams. Note the dominant role of H-3 and Cs-137. **Table VI**, below provides a summary breakdown of the number of current NTSWAC-approved LLW waste streams by site (excluding Rocky Flats, from which information could not be obtained) and program (WM or ER).



Source: E. J. Bentz & Associates from data provided by the cited DOE sites

Table VI: Current NTSWAC – Approved LLW Waste Streams

Generator	Approved No. of Streams	WM Streams	ER Streams
ETEC	1	0	1
Fernald	11	0	11
ITRI	1	1	0
LLNL	10	10	0
Mound	6	0	6
Oak Ridge	4	3	1
Pantex	7	7	0
Sandia	5	5	0
TOTAL	**45**	**26**	**19**

Source: E. J. Bentz & Associates from data provided by the cited DOE sites

COMPARATIVE ANALYSIS OF THE LLW CHARACTERIZATION DATA

Based on our review of the characterization data presented in the DOE resources noted above, for LLW streams projected for disposal at the NTS, there appear to be significant differences in both the identification of key radionuclides and in radionuclide concentrations forecast by the WM PEIS and the LLWDCR, and with respect to both as compared with the NTSWAC Waste Profiles. The following discussion will focus on comparing the NTSWAC Waste Profiles with the more recent LLWDCR (Rev.1).

Table VII, below provides a broad summary of differences between the LLWDCR (Rev. 1) and NTSWAC LLW

Table VII: Summary Comparison of all Actual NTSWAC-Approved LLW Streams vs. Projected, LLWDCR (Rev. 1) Radiological Profiles of LLW Destined for Disposal at the NTS

Site	Number of Isotopes Identified					Isotopes with NTSWAC Conc. > LLWDCR	Isotopes with NTSWAC Conc. < LLWDCR
	NTSWAC Total	LLWDCR Total	By Both	NTSWAC Only	LLWDCR Only		
ETEC	5	3	3	2	0	3	0
FEMP	19	14	10	9	4	2	8
ITRI	39	7	7	32	0	0	7
Mound	10	10	7	3	3	7	0
ORR	10	105	10	0	95	1	8
Pantex	11	5	5	6	0	5	0
Sandia	36	47	23	13	24	5	8

Source: E. J. Bentz & Associates from data provided by the cited DOE sites

waste stream profiles for NTSWAC-approved sites. Note the lack of commonality in the number of identified isotopes between the actual and projected data.

Among the site-specific isotopes identified in common by each source, there are significant differences regarding isotope concentrations. Twenty-three isotopes identified by both sets of data have NTSWAC profile concentrations greater than the concentrations projected by the LLWDCR; thirty-one isotopes identified by both sets of data have NTSWAC profile concentrations less than the concentrations projected by the LLWDCR. **Table VIII**, below summarizes data by site and by waste stream for commonly-identified isotopes with NTSWAC concentrations greater than the projected LLWDCR waste stream profiles.

Table VIII: NTSWAC-Approved Streams with Isotope Concentrations Greater than the LLWDCR (Rev.1) Radiological Profile for the Same Site-Specific Isotope (as measured in curies/year)

Site	Waste Stream(s)	Isotope	NTSWAC Waste Profile	LLWDCR Rad. Profile	Amt. NTSWAC Profile > LLWDCR
ETEC	BNRCDD2000005	Co-60	2.964E-02	1.46E-02	1.508E-02
ETEC	BNRCDD2000005	Sr-90	2.224E-01	1.08E-01	1.140E-01
ETEC	BNRCDD2000005	Cs-137	4.440E-01	2.83E-01	1.608E-01
FEMP	ONLO000000011	Th-228	8.00E-02		
	ONLO000000101		4.19E+00		
	ONLO000000106		6.06E-02		
	ONLO000000107		3.15E-04		
	Total		**4.33E+00**	1.07E+00	3.26E+00
FEMP	ONLO000000006	U-235/236	9.31E-01		
	ONLO000000010		6.52E-04		
	ONLO000000011		3.49E-04		
	ONLO000000015		4.07E-02		
	Total		**9.73E-01**	1.38E-01	8.35E-01
Mound	AMDM-000000012	Th-228	4.044E-02	3.214E-02	8.30E-03
Mound	AMDM-000000012	Th-230	1.586E-02	3.286E-04	1.55E-02
Mound	AMDM-000000012	Th-232	3.886E-02	5.631E-03	3.32E-02
Mound	AMDM-000000012	U-234	1.824E-02	6.771E-04	1.76E-02
Mound	AMDM-000000012	U-238	1.348E-02	7.376E-04	1.27E-02
Mound	AMDM-000000012	Pu-238	1.031E+01	2.266E+00	8.04E+00
Mound	AMDM-000000012	Am-241	5.551E-03	3.420E-04	5.21E-03
Pantex	AMHP00000094	H-3	5.435E-02		
	AMHP00000094B		4.522E-06		
	AMHP00000094C		3.780E-02		
	Total		**9.220E-02**	8.411E-02	8.09E-03
Pantex	AMHP00000007N	Th-232	3.941E-01		
	AMHP00000094		6.957E-03		
	AMHP00000094B		9.455E-05		
	AMHP00000094C		3.782E-02		
	Total		**4.390E-01**	1.262E-02	4.26E-01
Pantex	AMHP00000094	U-234	5.870E-04		
	AMHP00000094B		7.811E-06		
	AMHP00000094C		7.975E-03		
	Total		**8.570E-03**	1.059E-03	7.51E-03
Pantex	AMHP00000094	U-235	1.065E-04		
	AMHP00000094B		1.316E-06		
	AMHP00000094C		1.316E-03		
	Total		**1.424E-03**	1.821E-04	1.24E-03
Pantex	AMHP00000094		6.522E-03		

Site	Waste Stream(s)	Isotope	NTSWAC Waste Profile	LLWDCR Rad. Profile	Amt. NTSWAC Profile > LLWDCR
	AMHP00000094B	U-238	8.633E-05		
	AMHP00000094C		8.222E-02		
	Total		**8.883E-02**	1.142E-02	7.74E-02
Sandia	ASLA000000003	H-3	1.700E+03		
	ASLA000000006		2.340E+01		
	ASLA000000011		1.100E-01		
	Total		**1.724E+03**	1.458E+02	1.58E+03
Sandia	ASLA000000011	Pa-231	1.430E-01	2.752E-03	1.40E-01
Sandia	ASLA000000006	Th-232	1.430E-01		
	ASLA000000011		4.050E-07		
	Total		**1.430E-01**	3.038E-04	1.43E-01
Sandia	ASLA000000006	U-234	5.590E-05		
	ASLA000000011		6.900E-02		
	Total		**6.906E-02**	4.268E-02	2.64E-02
Sandia	ASLA000000006	U-238	1.240E+01		
	ASLA000000011		1.170E-01		
	Total		**1.252E+01**	9.932E-02	1.24E+01

Source: E. J. Bentz & Associates from data provided by the cited DOE sites

SUMMARY

- Historically, the NTS has played a key role in the safe and efficient disposal of LLW for the DOE Complex.

- We have also demonstrated that this role is anticipated to grow, with more approved generators, larger disposal volumes, a greater variety of radionuclides, and higher curie contents; all of the disposal configuration options currently under serious consideration by DOE would require disposal of substantial volumes of off-site generated LLW at the NTS.

- Adequate LLW characterization data will be an essential element in DOE decision-making regarding the disposal of LLW and in the analysis of associated risks, while currently-projected LLW radiological profiles include a number of sources of uncertainty. This warrants the need for continued site-specific characterization efforts by originating sites and continued diligence in performing risk assessments associated with DOE LLW transportation and disposal.

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