COMPARISON OF PROJECTIONS OF LOW-LEVEL WASTE DISPOSAL AT THE NEVADA TEST SITE (NTS) BY NTS-APPROVED, DOE OFF-SITE GENERATORS (1998 – 2070)

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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 (WM), environmental restoration (ER), and other programs of the DOE Complex (**1**). This proposed, central NTS role in disposal of DOE LLW was recently partly confirmed by the December 10, 1999 issuance of DOE's *Identification of Preferred Alternatives for the Department of Energy's Waste Management Program: Low-level Waste and Mixed Low-Level Waste Disposal Sites* (**2**). The notice of preferred alternatives identifies Hanford and the NTS as DOE's preferred regional disposal sites for both WM LLW and mixed low-level radioactive waste (MLLW).

This paper represents a portion of the most recent findings of a multi-year effort to develop good estimations of the volumes and characteristics of the wastes projected to be disposed at the NTS from DOE LLW generators. These efforts have resulted in the development of several previous reports detailing findings regarding LLW projected to be disposed at the NTS.

The authors' *Past, Present, and Anticipated Low-Level Radioactive Waste Disposal Volumes and Characteristics at the Nevada Test Site* (Waste Management '99 Symposium) (**3**) described historic disposal statistics and current estimations of projected LLW shipments to the NTS from off-site generators, including estimated volumes, characteristics of key, projected waste streams, and uncertainties impacting reliability of the data. This paper reports progress on building upon the data gathered and analyzed in the earlier work to develop and compare projected undecayed source term estimates of LLW forecast to be disposed at the NTS.

The forecasts compared are recently-developed estimates based on DOE's Revision 1 (September 1998) of *The Current and Planned Low-Level Waste Disposal Capacity Report* (LLWDCR, Rev. 1) (**4**), and the authors' current (May 1999), site-specific and stream-specific LLW analyses (EJB&A, 1.0). Comparisons of these forecasts are made on an annual, waste-stream, and radionuclide-specific basis, from FY 1998 through estimated DOE Complex closure in FY 2070. The LLWDCR (Rev. 1) and EJB&A (1.0) include both WM and ER wastes.

The forecasts (and comparisons) provide among them a basis for multiple potential uses, both at the NTS and for the DOE complex. These potential uses include: updating source term projections required for risk-based performance assessments and composite analyses under current DOE regulations for radioactive waste management; supporting the development and evaluation of NTS LLW disposal fee calculations; and evaluating DOE-proposed LLW disposal options among DOE generator and disposal sites.

HISTORICAL PERSPECTIVE ON DISPOSAL OF LLW AT THE NTS

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 %). 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 15-year period 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 ten-year period 1988 - 1997, the percentage of off-site generated LLW disposed at the NTS increased to approximately 88% of the total disposal volume, and over the last five years (1992 - 1997), the ratio of off-site LLW increased even further, to approximately 95% of the total volume of DOE LLW disposed at the NTS. Over the decade from 1987 through 1996, the NTS has accepted more than 41% of all LLW disposed by shallow land disposal at all DOE LLW disposal sites.

DESCRIPTION OF CURRENT SOURCE TERM ESTIMATES

LLWDCR (Rev.1): *The Current and Planned Low-Level Waste Disposal Capacity Report* (LLWDCR, Rev. 1) represents DOE's first Complex-wide attempt to estimate and compare the radionuclide inventories and concentrations of LLW projected to be generated by the DOE Complex against the radiological capacities of existing DOE disposal facilities (LLWDCR, Rev. 0 contained only estimated LLW volumes). The site- and stream-specific LLW radiological profiles presented in the report were developed using data from a 1997 Waste Management Technical Data Call, the Environmental Restoration Core Database (**5**), and estimates based on other existing waste stream information, including DOE's *Paths to Closure* (**6**) volumes data. The LLWDCR (Rev. 1) was also careful to review the radiological profile data developed for the report against the WMPEIS and other relevant DOE reports (**7**).

The above-referenced *Paths to Closure* volumes estimates have been utilized by DOE to update its analysis of WMPEIS disposal configurations. As part of the WMPEIS process, states, Tribal Nations, regulators, and stakeholders requested a period of dialogue with DOE on possible LLW and MLLW disposal configurations, prior to issuance of the final Records of Decision (RODs) on LLW and MLLW disposal. To initiate this dialogue, DOE released a suite of options at a March 30, 1998 meeting of the National Governors' Association and at two inter-site workshops

involving states, stakeholders, and Tribal Nations. The options presented utilized updated volumes data from DOE's *Paths to Closure* database. The "baseline case" option represented site-specific disposition of wastes using agreements already in place among sites (**8**).

DOE also included and utilized these new volume estimates in its *Information Package on Pending Low-Level Waste and Mixed Low-Level Waste Disposal Decisions* made publicly available to stakeholders on the Internet. In utilizing the new data, DOE noted that:

> *"Since the WMPEIS was issued, DOE has updated its estimates of the volume of LLW and MLLW requiring disposal over the 20-year [WMPEIS] analysis period. These new estimates are derived from the life-cycle estimates presented in 'Accelerating Cleanup: Paths to Closure' and have been used to develop the [WMPEIS ROD] options currently under evaluation."* (**9**)

The LLWDCR (Rev. 1) was prepared as part of DOE's response to the Defense Nuclear Facilities Safety Board Recommendation 94-2, Conformance with Safety Standards at DOE Low-Level Nuclear Waste and Disposal Sites. The purpose of the LLWDCR (Rev. 1) was to assess whether DOE's LLW and MLLW disposal facilities have sufficient volumetric and radiological capacities to accommodate the waste that is expected to be disposed at these facilities. The report covers a far greater time period (1998 – 2070) than the 20-year period considered by DOE's *Final Waste Management Programmatic Environmental Impact Statement* (WMPEIS). However, after acknowledging and describing the ongoing WMPEIS LLW/MLLW disposal configuration options dialogue between DOE and interested parties (discussed above), the LLWDCR (Rev. 1) states: "The conclusions and findings of this Report [LLWDCR, Rev. 1] may also be considered in the evaluation of [WMPEIS disposal] options." (**10**)

EJB&A (1.0): The EJB&A (1.0) undecayed source term estimate represents an attempt to further refine the LLWDCR (Rev. 1) data, to provide a more detailed and accurate characterization of the LLW projected to be disposed at the NTS. For the purposes of the EJB&A (1.0) estimate, NTS-approved NTSWAC (11) waste stream profiles and other site- and waste- stream-specific LLW characterization data obtained through site-specific surveys was substituted, where available, for the LLWDCR (Rev. 1) characterization data. Where more specific waste stream characterization data was <u>not</u> available, the LLWDCR (Rev. 1) characterization data was utilized.

To be conservative, the undecayed source term estimates developed by the authors includes LLW designated for disposal at the NTS under the *Paths to Closure* "base case," <u>plus</u> all LLW from the two NTS-approved generators (Oak Ridge Reservation and Grand Junction Projects Office) for which no disposal site has yet been identified (NTS is currently the only DOE disposal site approved to accept LLW from these two sites). In addition, the radiological profiles provided in the LLWDCR (Rev. 1) for ETEC and General Atomics (only one profile was provided for each of these sites) were used to characterize waste streams identified by *Paths to Closure* for which no other specific information was available. Missing characterization data for identified LLNL waste streams was estimated using data from existing, NTS-approved NTSWAC profiles for LLNL (for the reader's information, page OK-3, Appendix D, of the LLWDCR, Rev. 1 was missing from the copy of the report initially available on the Internet).

The EJB&A (1.0) forecast estimate includes LLW from 67 waste streams produced by 12 DOE off-site generators. In contrast, the LLWDCR (Rev. 1) forecast estimate includes LLW from 66 waste streams produced by 11 DOE off-site generators. The differences in generator and waste stream numbers is attributable to the inclusion of one waste stream from General Atomics in the EJB&A (1.0) estimate. Whereas, both forecast estimates utilize the same annual LLW volume projections over the forecast period (1998 – 2070) from *Paths to Closure* data, the radiological profiles for many of the waste streams differ. Twenty-three (23) of the 67 waste streams included in the EJB&A (1.0) estimate (from 7 off-site generators) have different radiological profiles from those of the LLWDCR (Rev. 1) estimate. As mentioned above, this reflects updates in the EJB&A (1.0) estimate based on site-specific surveys and on NTSWAC-approved waste stream profile submittals.

PROJECTED NTS DISPOSAL VOLUMES

Both the LLWDCR (Rev. 1) and EJB&A (1.0) source term estimates are based on volumes projected by generator disposal strategies developed under DOE's *Paths to Closure* (FY 1998 – FY 2070) guidelines. A summary breakdown of the projected disposal volumes, by generator site, is provided in Table I.

Table I: Total Projected Volumes Disposed at the NTS (1998 –2070)

Site Name	Volume (m^3)
Energy Technology Engineering Center	2,761.70
Fernald Environmental Management Project	83,589.00
General Atomics	0.88
Grand Junction Projects Office	54.60
Kansas City Plant	2.04
Lawrence Livermore National Laboratory	37,216.00
Lovelace Respiratory Research Institute	2,313.00
Mound Site	64,177.00
Oak Ridge Reservation	243,417.70
Pantex Plant	1,403.40
Rocky Flats Environmental Technology Site	65,028.30
Sandia National Laboratories (New Mexico)	5,071.40
Total	**505,035.03**

Source: E. J. Bentz and Associates, Inc., derived from sources noted

COMPARISON OF TOTAL ACTIVITIES PROJECTED BY THE SOURCE TERM ESTIMATES

The total activity of the LLW projected to be disposed at the NTS, and the proportionate contribution of each radionuclide to total activity, varies substantially between the two undecayed source term projections (See **Table II**). The LLWDCR (Rev.1) projects the greater total activity being disposed at the NTS, with a total of 13,144,945 Ci projected to be disposed

over the period FY 1998 through FY 2070. This amount is more than ten times the total 1,242,235 Ci projected to be disposed at the NTS by the EJB&A (1.0) estimate for the same period.

Table II: Total Projected Activities Disposed at the NTS (1998 –2070)

Estimate Source	Projected Activity
EJB&A, 1.0 (only off-site generators)	1,242,235 Ci
LLWDCR, Rev. 1 (only off-site generators)	13,144,945 Ci

Source: E. J. Bentz & Associates, Inc., derived from sources noted

As noted above, both the LLWDCR (Rev. 1) and EJB&A (1.0) undecayed source term estimates utilize the same *Paths to Closure* LLW disposal volume projections for sites anticipated to dispose of LLW at the NTS. Hence, all differences in the activities projected to be disposed by the estimates, including total activity, radionuclide-specific contributions to total activity, and the proportionate contributions of specific generator sites (to total activity and to radionuclide-specific activities) are attributable to differences in the radiological characterization profiles utilized for the wastes projected to be disposed at the NTS by the two estimates.

Table III provides a comparison, by radionuclide, of the forecast (FY 1998 –FY 2070), undecayed source term estimates derived from the LLWDCR (Rev. 1) data and the EJB&A (1.0) data. Only radionuclides with half-lives greater than 5 years are included in the **Table III** comparison. Radionuclides with half-lives less than 5 years were eliminated from consideration by most of the LLWDCR (Rev. 1) profiles, since they are expected to decay to negligible levels during the anticipated 100-year period of postclosure institutional control (radionuclides with half-lives less than 5 years were included in some of the site-wide composite profiles used by the LLWDCR (Rev. 1) - e.g. the ORR radiological profile).

Table III: Comparison of the LLWDCR (Rev.1) and EJB&A (1.0) Projected, Undecayed NTS LLW Source Terms (1998 - 2070) (Radionuclides with a Half-Life Greater Than 5 Years Only)

Radionuclide	Half-Life (Years)	EJB&A (1.0) (1998 -2070) (off-site generators only)	LLWDCR (Rev. 1) (1998 -2070) (off-site generators only)
Ac-227	21.8	7.55E+01	7.63E+01
Ag-108m	418	6.78E-02	9.64E-01
Al-26	717,000	8.06E-07	1.65E-06
Am-241	432	9.07E+01	2.33E+01
Am-243	7,370	1.49E+01	1.08E+01
Ba-133	10.5	9.04E+00	1.13E+02
Bi-207	31.6	4.01E-01	3.95E-01
C-14	5730	2.30E+01	1.01E+02
C-14m	5730	3.40E-08	6.94E-08
Ca-41	103,000	2.89E-03	2.89E-03
Cd-113m	14.1	8.83E-02	1.80E-01
Cf-249	351	3.73E-02	3.73E-02
Cl-36	301,000	1.41E+01	1.66E+02
Cm-243	29.1	2.11E-02	2.38E-02
Cm-244	18.1	2.90E+02	4.12E+03
Cm-245	8,500	6.76E-06	-
Cm-246	4,730	6.90E-06	-
Cm-248	340,000	6.76E-06	-
Co-60	5.27	1.84E+04	8.01E+04
Cs-135	2,300,000	1.72E-04	3.52E-04
Cs-137	30.1	1.05E+05	5.05E+05
Eu-152	13.5	2.00E+03	2.82E+04
Eu-154	8.6	8.23E+01	9.58E+02
H-3	12.3	5.39E+05	5.95E+06
Ho-166m	1,200	6.43E-09	9.15E-08
I-129	15,700,000	1.38E-02	2.86E-02
K-40	1,270,000,000	2.51E-01	3.13E+00
Kr-85	10.8	3.06E+05	4.35E+06
Nb-93m	16.1	4.78E-01	9.76E-01
Nb-94	20,300	2.14E-02	4.38E-02
Ni-59	76,000	6.93E+01	1.42E+02
Ni-63	100	6.91E+04	9.33E+05
Np-237	21,400,000	2.25E-01	2.87E+00
Pa-231	32,760	1.83E+01	1.84E+01
Pb-210	22.3	1.98E+03	1.98E+03
Pm-145	17.7	1.86E-01	1.86E-01

Radionuclide	Half-Life (Years)	EJB&A (1.0) (1998 -2070) (off-site generators only)	LLWDCR (Rev. 1) (1998 -2070) (off-site generators only)
Pu-238	87.7	9.36E+00	2.65E+01
Pu-239	24,100	1.79E+02	1.82E+02
Pu-240	6,570	2.37E+00	1.78E+01
Pu-241	14.4	1.77E+01	1.96E+01
Pu-242	373,000	4.15E-03	8.08E-03
Pu-244	80,800,000	3.73E-04	3.73E-04
Ra-226	1,600	3.80E+03	3.84E+03
Ra-228	5.75	2.83E+00	4.81E+00
Se-79	1,130,000	1.32E-04	2.69E-04
Sm-151	90	1.07E+00	2.18E+00
Sn-121m	55	1.43E-01	2.93E-01
Sn-126	100,000	9.03E-06	1.84E-05
Sr-90	28.8	8.92E+04	1.85E+05
Tc-99	211,100	2.30E+01	2.01E+01
Th-229	7,340	6.27E-03	4.24E-05
Th-230	76,000	1.14E+03	1.14E+03
Th-232	14,000,000,000	1.64E+02	1.61E+02
U-232	68.9	5.48E-02	4.44E-02
U-233	160,000	3.32E-01	2.95E+00
U-234	246,000	1.06E+04	1.05E+04
U-235	704,000,000	8.28E+03	8.27E+03
U-236	23,500,000	1.55E+00	3.48E-02
U-238	4,470,000,000	3.75E+03	2.85E+03
Zr-93	1,530,000	1.83E-02	3.74E-02
Total (radionuclides with half-lifes ≥ 5 years)		**1.16E+06**	**1.21E+07**
Total (all radionuclides)		**1.24E+06**	**1.31E+07**

Source: E. J. Bentz & Associates, Inc., derived from sources noted.

COMPARISON OF RADIONUCLIDES PROJECTED BY THE SOURCE TERM ESTIMATES

A total of 60 radionuclides with half-lives greater than 5 years are identified between the two source term estimates as contributing to the total activity of LLW projected to be disposed at the NTS. The number and identity of radionuclides contributing to overall activity varies only slightly between the two estimates. The EJB&A (1.0) estimate includes activities from all 60 of the radionuclides identified. The LLWDCR (Rev. 1) estimate includes activity from 57 of the 60 radionuclides. The only radionuclides contributing activity to the EJB&A (1.0) estimate which do not contribute activity to the LLWDCR (Rev. 1) estimate are Cm-245, Cm-246, and Cm-248.

The total activity represented by the three radionuclides with half-lives greater than 5 years that are not found in the LLWDCR (Rev. 1) estimate is minute compared to the total projected received activities over the period to closure (see **Table IV**). Further, the contribution to total undecayed activity associated with the radionuclides with half-lives greater than 5 years, as compared to the total activities for all radionuclides, is significantly dominant for both forecast estimates. The respective ratios are: 94% for the EJB&A (1.0) estimate and 92% for the LLWDCR (Rev. 1) estimate.

Table IV: Comparison of Estimated Activity Levels

Comparison	EJB&A (1.0) (1998-2070) (off-site generators)	LLWDCR (Rev. 1) (1998-2070) (off-site generators)
Total No. of Radionuclides Considered	142	125
Total No. of Radionuclides, Half-Life Greater Than 5 years	60	57
Total Activity of all Radionuclides	1,242, 235 Ci	13,144,945 Ci
Total Activity of Radionuclides, Half-Life Greater Than 5 years	1,163,026 Ci	12,072,040 Ci
Total Activity of Radionuclides, Half-Life Life ≥ 5 years not found in LLWDCR (Rev.1)	2.04E-05 Ci	NA
Ratio: Total Activity of Radionuclides, Half-Life ≥ 5yrs/Total Activity of all Radionuclides	94%	92%

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

COMPARISON OF RADIONUCLIDE-SPECIFIC ACTIVITIES PROJECTED BY THE SOURCE TERM ESTIMATES

The total activity and proportionate contribution of each radionuclide projected by each of the two undecayed source term estimates varies substantially in many cases. However, the differences in the radionuclide-specific activities projected by the undecayed source term estimates does not follow anything proximate to a fixed ratio consistent with the previously-described disparity in total activities projected to be disposed.

Table V provides a summary comparison of the relative ranking of the activities of the 60 identified radionuclides between the two estimates. While the total activity in the LLWDCR (Rev. 1) and EJB&A (1.0) estimates is the same, or roughly equivalent, for several radionuclides, the total activity for some key radionuclides differs substantially (see discussion below). In most instances (43 out of 60), the LLWDCR (Rev. 1) radionuclide-specific estimates exceed the EJB&A (1.0) estimates. This appears to be due primarily to the conservatism built into the LLWDCR (Rev. 1) waste stream radiological profile development. The large disparity in the

total activity projected to be disposed by the two estimates suggests that for several radionuclides, the LLWDCR (Rev. 1) may be much too conservative. However, it should be noted that for 14 radionuclides, the more waste-stream-specific data used by the EJB&A (1.0) estimate exceeds the LLWDCR (Rev. 1) estimate, suggesting that for certain radionuclides, the LLWDCR (Rev. 1) estimates may not be conservative enough.

Table V: Summary Comparison of the Total Activities of Identified Radionuclides

Source Term Estimate	Activities < LLWDCR	Activity < EJB&A (1.0)	Activities Equal	Activity > LLWDCR	Activity > EJB&A (1.0)
LLWDCR		14	3		43
EJB&A (1.0)	43		3	14	

Source: E. J. Bentz and Associates, Inc., derived from sources noted.

COMPARISON OF KEY RADIONUCLIDES PROJECTED BY THE SOURCE TERM ESTIMATES

Six key radionuclides can be identified from the undecayed source term estimates as contributing greater than one percent (1.0%) of the total activities estimated by one or both of the estimates. In **Table VI**, these radionuclides are identified, and their activity and proportionate contribution to total activity are described.

Table VI: Comparison of Key Radionuclides

Radionuclide	Half-Life (years)	EJB&A (1.0)		LLWDCR (Rev. 1)	
		Curies	% Total Ci	Curies	% Total Ci
Co-60	5.27	1.84E+04	1.48%	8.01E+04	0.61%
Cs-137	30.1	1.05E+05	8.47%	5.05E+05	3.85%
H-3	12.3	5.39E+05	43.47%	5.95E+06	45.42%
Kr-85	10.8	3.06E+05	24.68%	4.35E+06	33.21%
Ni-63	100	6.91E+04	5.58%	9.33E+05	7.11%
Sr-90	28.8	8.92E+04	7.19%	1.85E+05	1.41%
Total		**1.15E+06**	**91%**	**1.20E+07**	**91%**

Source: E. J. Bentz and Associates, Inc., derived from sources noted

These six radionuclides constitute more than 90% of the total activities projected to be disposed at the NTS by each of the estimates. However, the activity and proportionate contribution of the radionuclides to each undecayed source term estimate varies substantially between the estimates. The activity of tritium accounts for the largest portion of the total activity of both estimates. It accounts for approximately 45% of the total activity of the LLWDCR (Rev. 1) estimate, and a slightly lower 43% of the EJB&A (1.0) estimate.

The activities of Co-60, Cs-137, Ni-63, Kr-85, and Sr-90 also account for a significant portion of the total activities of both the LLWDCR (Rev. 1) and EJB&A (1.0) estimates. Kr-85 accounts

for approximately one-third of the activity projected by the LLWDCR (Rev. 1). Kr-85 also contributes the second highest portion of the total activity of the EJB&A (1.0) estimate, however, the relative contribution is significantly less, at only 25% of the total activity.

In addition to tritium and Kr-85, Cs-137 and Sr-90 are key radionuclides that contribute the most significant amounts to the total activity estimated by the EJB&A (1.0) estimate. Together, these two radionuclides account for almost 15% of the total activity projected by the EJB&A (1.0) estimate, while Cs-137 and Sr-90 account for only a little more than 5% of the total activity projected by the LLWDCR (Rev. 1). Ni-63 contributes a significant 7.11% to the total activity of the LLWDCR (Rev. 1) estimate, and approximately 5.58% of the EJB&A (1.0) estimate. **Figure 1** and **Figure 2** graphically depict the differences in activities and contribution to total activities for the identified key radionuclides between the source term estimates.

The contribution to total undecayed activity of very long-lived radionuclides (greater than 1,000 years) is very small for both forecast estimates (approximately 2% of EJB&A, 1.0 activity and .2% of LLWDCR, Rev. 1 activity). A comparison of the highest activity, long-lived radionuclides is provided in **Table VII**.

Table VII: Comparison of Key, Long-Lived Radionuclides (Curies)

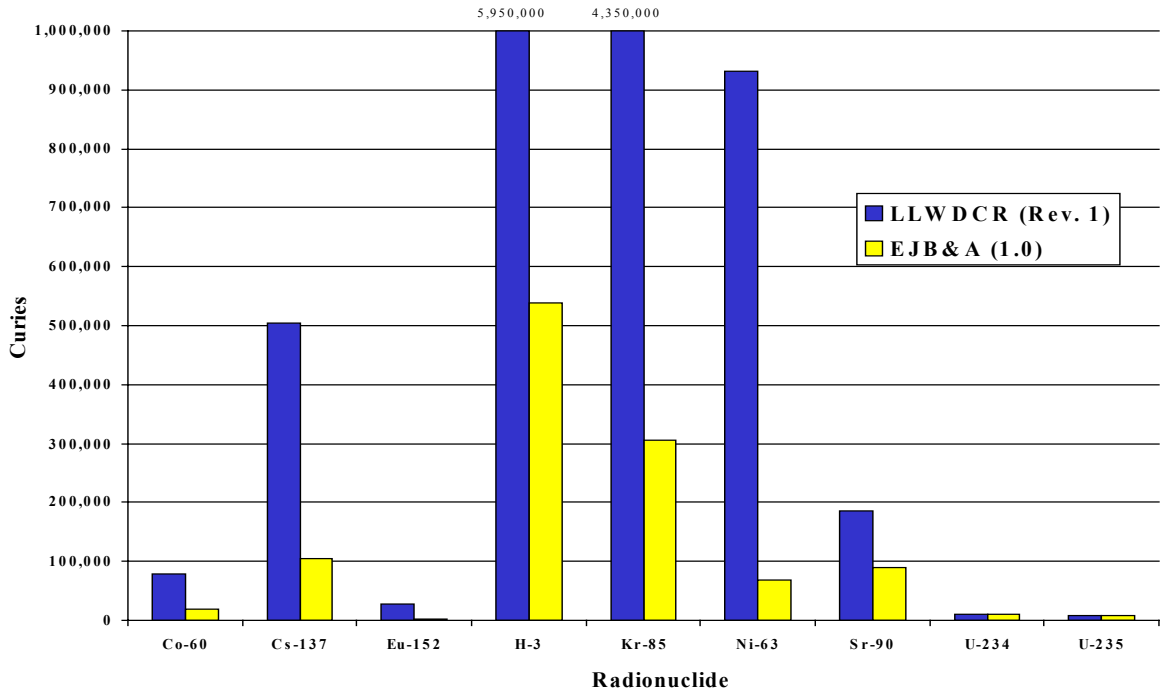
Radionuclide	Half-Life (yrs.)	EJB&A (1.0) (off-site generators)	LLWDCR (Rev. 1) (off-site generators)
Ra-226	1600	3,800	3,840
Th-230	76,000	1,140	1,140
U-234	246,000	10,600	10,500
U-235	704,000,000	8,280	8,270
U-238	4,470,000,000	3,750	2,850

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

COMPARISON OF PROJECTED DOE SITE-SPECIFIC CONTRIBUTIONS TO TOTAL VOLUMES AND ACTIVITIES

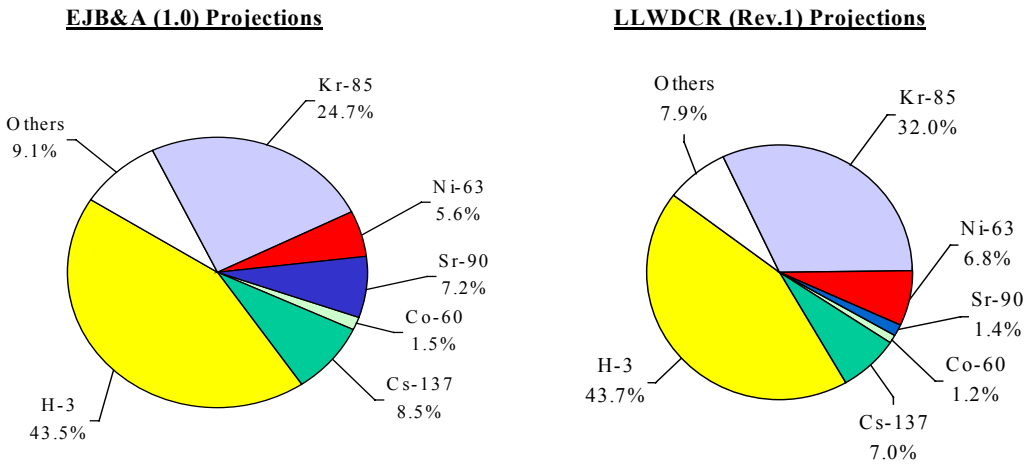
The disparity in the total and radionuclide-specific activities estimated by the two source term projections is attributable to differences in the radiological profiles of the LLW projected to be disposed at the NTS. **Table VIII** provides a summary comparison of the proportionate contribution of generator sites to total volume and undecayed

Figure 1. Comparison of Key Radionuclides by Total Activity (Ci)



Source: E. J. Bentz and Associates, Inc. derived from the sources noted

Figure 2. Comparison of Key Radionuclides by Percentage of Total Activity



Source: E. J. Bentz and Associates, Inc. derived from the sources noted

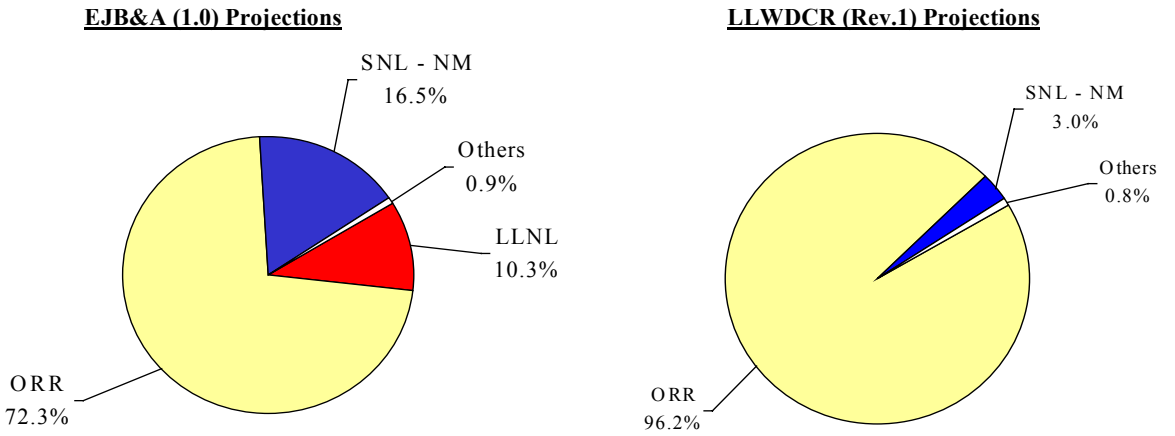
activity as projected to be disposed by the LLWDCR (Rev. 1) and EJB&A (1.0) source term estimates. **Figure 3** graphically depicts the projected major contributors to total activity projected for each of the sources term estimates.

Table VIII: Proportionate Contribution of Generator Sites to Total Volume and Total Undecayed Activity of LLW Projected to be Disposed at NTS by the LLWDCR (Rev. 1) and EJB&A (1.0) Source Term Estimates

Generator Site	LLWDCR (Rev. 1) Projections (1998-2070)		EJB&A (1.0) Projections (1998–2070)	
	% of Total Volume Disposed	% of Total Activity Disposed	% of Total Volume Disposed	% of Total Activity Disposed
ETEC	0.55%	0.0002%	0.55%	0.03%
Fernald	16.55%	0.10%	16.55%	1.09%
General Atomics	0.00017%	0.000004%	0.00017%	0.00005%
Grand Junction	0.01%	0.0000001%	0.01%	0.000001%
Kansas City Plant	0.0004%	0.00000000002%	0.0004%	0.0000000002%
LLNL	7.37%	0.98%	7.37%	10.32%
ITRI	0.46%	0.0003%	0.46%	0.05%
Mound Site	12.71%	0.0002%	12.71%	0.001%
Oak Ridge	48.20%	96.18%	48.20%	72.26%
Pantex Plant	0.28%	0.00001%	0.28%	0.0005%
Rocky Flats	12.88%	0.0021%	12.88%	0.02%
Sandia (NM)	1.00%	2.96%	1.00%	16.45%
Total	**100%**	**100%**	**100%**	**100%**

Source: E.J. Bentz and Associates, Inc., derived from sources noted

Figure 3. Proportionate Contribution of Generator Sites to Total Activity of LLW Projected to be Disposed at the NTS



Source: E. J. Bentz and Associates, Inc. derived from the sources noted

Based on historic data on generator sites, almost 50% of the LLW volume disposed at the NTS Area 5 Radioactive Waste Management Site (RWMS) has been originated by Fernald. The other major historic contributors to the total volume at Area 5 have been Mound (approximately 22%) and Rocky Flats (approximately 17%). Together, these three sites account for almost 90% of the historic total volumes disposed at the NTS Area 5.

By contrast, the LLWDCR (Rev. 1) and EJB&A (1.0), using DOE's *Paths to Closure* volumes data, project that almost 50% of the LLW will originate from the Oak Ridge Reservation (ORR), a site that has not historically disposed of LLW at the NTS. The three generators which have historically contributed almost 90% of Area 5 RWMS waste (Fernald, Mound, and Rocky Flats) are projected to contribute more than 80% of the remaining LLWDCR (Rev.1) source term volume. However, their relative contribution to the total projected volume is estimated to be more equally proportionate than the historic data, with Fernald (16.6%) contributing somewhat more volume than Rocky Flats (12.9%) and Mound (12.7%).

Historically (FY89 – FY93), three sites have contributed approximately 97% of the total activity disposed at the Area 5 RWMS: LLNL (46.3%), Sandia-CA (29.3%), and Mound (21.4%). Both the LLNL and Sandia-CA LLW has been low volume, high-activity, laboratory-generated waste. Historically, the Mound LLW included high specific-activity tritium wastes. However, under DOE's *Paths to Closure*, no future shipments of LLW from Sandia-CA to the NTS are projected.

In addition, most of the future LLW expected to be shipped to the NTS from Mound is expected to be lower-activity, contaminated soils and D&D debris from environmental remediation.

The total activity projected to be disposed by both the LLWDCR (Rev.1) and EJB&A (1.0) estimates is dominated by the ORR. (The ORR is an NTS-approved generator site for which no disposal site has been identified.) The ORR LLW contributes more than 96% of the estimated total activity projected to be disposed at the NTS by the LLWDCR (Rev. 1) estimate, and more than 72% of the activity projected to be disposed by the EJB&A (1.0) estimate. Sandia National Laboratories, New Mexico (SNL-NM) is the second largest contributor to total activity in both these estimates. Approximately 3% of the total LLWDCR (Rev. 1) activity estimate, and 16.5% of the EJB&A (1.0) activity estimate, are attributed to waste from SNL-NM. LLNL contributes approximately 1% of the total activity of the LLWDCR (Rev. 1) estimate, and approximately 10% of the EJB&A (1.0) total activity estimate.

The radiological profiles used by the LLWDCR (Rev. 1) for both the ORR LLW and the SNL-NM LLW are very conservative, site-wide composite profiles for all wastes. The site-wide, generic ORR profile was based on isotopes and concentrations from only 2 (out of 18 *Paths to Closure*) LLW streams. The SNL-NM profile used for the LLWDCR (Rev. 1) estimate is a DOE-wide surrogate isotope profile for LLW. Hence, the EJB&A (1.0) estimates, which apply stream-specific profiles (where available), should provide a more accurate estimate of total activity and the proportionate contribution of these two sites to total activity. As more site- and stream-specific radiological profile data becomes available, these estimates can be further refined.

COMPARISON OF PROJECTED SITE-SPECIFIC RADIOLOGICAL PROFILES

Comparison of the site-specific radiological profile data developed for each site by the undecayed source term estimates was also performed. For each major isotope (i.e., greater than 3% of total generator activity), and for isotopes of which the generator site contributes a significant portion of the total NTS activity, the following analyses were performed:

- Determination of the percentage contribution by the site to the total activity disposed at the NTS for each isotope; and
- Determination of the percentage contribution by each isotope to the total activity disposed at the NTS by the generator.

Review of the data revealed that there are substantial differences between the profiles for the same site in the identity of the major isotopes and/or in the proportionate contribution of each isotope to the total activity projected to be disposed by the generator. For example, both of the ETEC profiles identify Co-60, Cs-137, and Sr-90 as major isotopes. However, the proportionate contribution of each of the isotopes to the total projected site-specific activity varies substantially. The percentages of total activity represented by Co-60/Cs-137/Sr-90 are 80.1%/14.3%/5.6%, respectively, for the LLWDCR (Rev. 1) profile; and 3.5%/53%/26.7%, respectively, for the EJB&A (1.0) profile. In addition, EJB&A (1.0) identifies U-238 as an additional major isotope contributing to 14.4% of the total activity of ETEC waste.

Similarly, both of the estimate profiles identify tritium, Th-232, and U-238 as major isotopes contributing to the total activity projected to be disposed at the NTS from the Pantex Plant. However, the proportionate contribution of each of the isotopes to the total projected site-specific activity again varies substantially. The percentages of total activity represented by tritium/Th-232/U-238 are 76.8%/11.6%/10.4%, respectively, for the LLWDCR (Rev. 1) profile; and 13.2%/70.7%/12.7%, respectively, for the EJB&A (1.0) profile.

The differences in the LLWDCR (Rev. 1) and EJB&A (1.0) profiles are the result of EJB&A's more detailed, site- and waste-stream-specific data being substituted, where available, for across-site composite profile data. The radiological profiles of twenty-three (23) out of the sixty-seven (67) waste streams projected by the EJB&A (1.0) estimate differ from the radiological profiles used by the LLWDCR (Rev. 1) estimate. Of these 23 waste streams, 9 waste streams originating from one site (ORR) account for approximately 98% of the total difference in activity between the two forecasts. As previously noted, the LLWDCR (Rev. 1) uses a generic radiological profile for all ORR waste streams.

FLUCTUATIONS IN PROJECTED ANNUAL LLW DISPOSAL VOLUMES AND ACTIVITY CONCENTRATIONS

Both the EJB&A (1.0) and LLWDCR (Rev. 1) forecasts assume a non-uniform receipt rate (in both volume and activity), with significant annual fluctuations, based on analysis of individual-generator disposal schedules over the period to closure (to 2070). These significant annual fluctuations in total volumes, total activities, and individual radionuclide activities, will place considerable demands on NTS management preparations and disposal operations.

Significant differences exist, however, in the estimated annual activity of the LLW projected to be received at the NTS between the two forecasts. Averaged over the entire period to closure (1998 – 2070), the average annual concentration of LLW to be received at the NTS under the EJB&A (1.0) estimate is 2.46 Ci/m^3. The average annual concentration of LLW to be received at the NTS under the LLWDCR (rev. 1) estimate is 26.03 Ci/m^3.

IMPLICATIONS OF FINDINGS

The information provided in the current forecast findings offers the opportunity to update existing source term estimates. In addition, the information provided in the current forecast findings will provide guidance in the planning for the disposal at the NTS of anticipated shipments. This will include guidance supporting operations, scheduling, and the development of cost estimates (capital costs; operations fixed and variable costs; ES&H costs; and closure costs). A concurrent Waste Management 2000 Symposium paper, *Benefits Accruing to the DOE Complex Attributable to the Disposal of Off-Site Low-Level Waste at the Nevada Test* Site (**12**), indicates that such disposal (in addition to generator) cost analyses are sensitive to forecast findings of LLW disposal volumes and radiological characteristics.

NEXT STEPS

With issuance of the forthcoming Record of Decision on DOE Complex-wide LLW disposal, the forecasts will need to be updated to reflect potential, additional off-site DOE generators and additional waste streams. In addition, as more of the generating sites finalize characterization efforts, radiological profiles are anticipated to be updated.

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