Nearly 50,000 m^3 of Waste and More Than 5000 Shipments to WIPP: *What Does it All Mean?*

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ABSTRACT

In 1962, the U.S. Atomic Energy Commission (AEC) began removing radioactive waste from defense facilities across the nation with the first disposal of low-level waste. Thirty-seven years later, transuranic (TRU) waste began making its way toward permanent isolation in the excavated salt drifts at the Waste Isolation Pilot Plant (WIPP) repository. Ever since, close tallies have been assigned to track the volume removed, shipped, and disposed at WIPP.

In 2007, DOE will move past the 45-year mark of progress toward meeting a much improved environmental stewardship mission. At the end of January 2007, WIPP’s contribution to this mission totals 45,214 m^3 and 5,413 shipments of TRU waste. This equates to approximately 8.5 m^3 per shipment and an average of seven hundred shipments per year since opening. Considering that the actual annual rates have consistently climbed, this appears to be very good progress since WIPP opened, and especially for the past five years. The numbers from 2006 were record setting, at over 10,000 m^3 and more than 1100 shipments. While these numbers share information on the volume received at WIPP, they do not fully portray the actual waste volume of any shipment. This paper provides an expanded view of the differences in how volume values are tracked and reported.

INTRODUCTION

The Environmental Management (EM) program was established by DOE in 1989 to focus on clean up of legacy waste and environmental contamination from DOE facility operations in a manner safe for the workers and protective of the environment. In the mid 1990’s, the DOE initiated measures, goals, and expectations for site closures [1, 2]. In 2001, the DOE implemented a tracking system in tandem with incentives for WIPP contractors. At that time, the key parameters established for tracking were number of shipments and volume of waste delivered to WIPP [3]. This approach was instrumental in helping transform the employee culture from a preparatory mode into an operational mode. The numbers are evidence of the difference made by tracking and trending these parameters. In one year, the cumulative number of shipments went up from 188 to 676, over 250% more than the previous two years [4]. Admittedly, there were regulatory hurdles and tough concessions that had to be overcome in the first two years of operating the WIPP facility, though the new approach in tracking helped to improve the average shipment volume sent to WIPP.

The success of this approach has carried through into even today. By assisting EM in meeting aggressive benchmarks, such as the closing of the Rocky Flats Environmental Technology Site (RFETS), the National TRU Program surges forward in fulfilling the commitment toward environmental stewardship.

Shipments and Volume Tracking

The most common method employed for tracking the cleanup progress at each site is captured in terms of waste volume removed, shipped, and disposed. Low-level and TRU waste cleanup activities are also gauged in terms of waste shipments per year. Values of volume and shipments are used frequently to describe the progress made at any DOE site. Initiated in 2001, acceleration and implementation of more demanding goals for all sites included increased TRU volume and number of shipments for each DOE facility. Table I provides a summary of both the goal and actual numbers for all DOE TRU waste generator sites.

Table I. Goal vs. Actual - Shipments and Volumes for CH TRU Waste [3, 4]

Fiscal Year	Goal[a]		Actual	
	Volume (m^3)	Shipments	Volume (m^3)	Shipments
2002	7134	1218	5134	861
2003	7630	1297	7542	799
2004	9550	1727	8810	964
2005	8531	1585	7657	941
2006	7043	1327	10556	1128
Five year total	**39888**	**7154**	**39699**	**4693**

One conclusion that can be drawn from examining the data provided in Table I is that the 5-year goal of removing nearly 40,000 m^3 of contact-handled (CH) waste was satisfied by using 2461 less total shipments than the projection from 2002. This represents a substantial savings of over $30 million[b], while maintaining a safe shipping record and meeting a challenging volume removal goal. Using the same familiar parameters, Figure 1 displays a more comprehensive range of data in terms of TRU waste shipments and volume emplaced at WIPP.

VOLUME TRACKING

Examining volume values at greater resolution can provide a more realistic picture of how much waste has been emplaced at WIPP by focusing on variables that can enhance or inhibit waste removal. While there are hundreds of tracked data points that can be evaluated, there are only a few that show great sensitivity toward affecting the removal of waste and cleanup of DOE sites. Although a few major factors can significantly alter the start and stop of cleanup activities (e.g. regulatory changes, safety performance, political influence, etc.), there are quantitative and qualitative values that can be tracked and evaluated periodically. These values will help to explain differences in shipped volume, dunnage volume, packaging volume, and WIPP disposal volume. This section describes some of the tracked volume values, and shows that when combined some of the more familiar values, the result can help to provide a more complete picture of WIPP shipment and repository utilization.

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[a] Source: Compiled from the National TRU Waste Management Plan; DOE, 2002

[b] At an average of $12,500 K per roundtrip shipment

Figure 1. Shipments and volume emplaced at WIPP

The values that seem to have the most influence on shaping the disposed volume and shipments from each DOE site are:

Quantitative:

- *Payload utilization*
- *Dunnage (shipped vs. emplaced)*
- *Effective Waste Volume*

Qualitative:

- *Upper and lower regulatory limits*
  - Fissile mass
  - Weight
  - Gas generation

Quantitative

The quantitative values can be measured and tracked in units that provide a direct relation to disposed waste. This section describes the values that have shown historical sensitivity to affecting the final waste volume emplaced at WIPP.

Payload Utilization

The payload utilization is the payload volume of actual waste containers utilized per shipping package (e.g. TRUPACT-II) per shipment. This information allows one to compare waste containers and dunnage containers that make up a payload. The majority of dunnage containers that are shipped to WIPP are readily configured for re-use. There are some payload configurations that include dunnage containers, and cannot be easily separated. As described below, it is important to keep these values distinct when tracking emplacements in the WIPP repository. Examining and tracking these values more closely provides a better measure of actual waste both collectively, and by individual generator site.

Dunnage

The majority of dunnage received at WIPP is returned to the generators for later use. So long as a payload of dunnage remains intact, it can be reused multiple times. A portion of the dunnage that is contained within a payload configuration is emplaced in the WIPP repository when it is impractical to parse the payload.

Tracking the dunnage volume sent to WIPP is important for multiple reasons. First, it indicates if the shipment payloads have reached one or more of the regulatory limits. These limits restrict additional quantities of waste from being sent in the same shipping package. Second, it provides information on the ability of each site to ship more than one waste stream. Sites that consistently ship dunnage are typically constrained to process from a single waste stream. Third, the amount of dunnage received over time reduces the process efficiency for sending and receiving waste. Each payload of dunnage requires radiological contamination checks, additional storage space, and adds handling time to maintain and manage dunnage containers for potential use in a future shipment. Last, and most importantly, payloads with dunnage in the container configuration contribute toward ineffective use of shipment packages, as well as premium space within the WIPP repository. The development and maintenance of repository space incurs cost to survey, mine out and handle salt, stabilize (e.g. rock bolting), setup and monitor instrumentation, forecast and respond to salt creep, maintain (i.e. removing fractured rock), ventilate, and close off filled or unused excavations.

Effective Waste Volume

The effective waste volume is the volume of waste after treatment and final packaging. This amount can differ substantially from the reported shipment volume. Treatment typically helps to reduce the amount of total shipments by consolidating or eliminating a portion of the original volume. At the Idaho National Laboratory, one of the treatment approaches reduces the input volume of debris waste by mechanical compaction and repackaging. Each 55-gallon drum that is compacted is referred to as a "puck," and is repackaged into a configuration of three 100-gallon drums per payload. With a shipment that contains forty-two 55-gallon drums, that have not been treated or repackaged, a volume of 8.8 m^3 is used. Alternatively, using mechanical compaction with a nominal value of four pucks per 100-gallon drum, and eighteen 100-gallon drums in a shipment, an equivalent waste volume at 15.1 m^3 is used. This is almost twice as much waste per shipment and almost twice the waste removed from the generator site per volume of capacity consumed at WIPP.

Conversely, the need to re-package can often increase the amount of shipments required to remove more difficult waste streams. For a directly loaded container, this is usually attributed to the internal container capacity. Figure 2 depicts a visual example of the difference between direct loading and overpacking. With this example, a standard waste box (SWB) that is directly loaded will count as a volume of 1.88 m^3 versus the volume of 0.84 m^3 derived from overpacking four 55-gallon drums. Therefore, the *shipment volume* should be compared to the *effective waste volume* to ensure more realistic results for gauging cleanup activities.

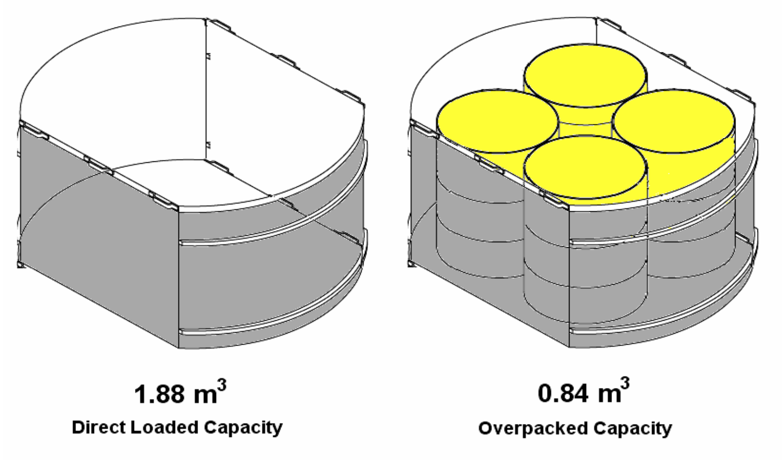

Figure 2. Volume Differences derived from two different uses of the SWB container

Qualitative

Alone, the qualitative limits are difficult to trend in a manner that directly correlates to waste removal. While the limits have actual values associated with them, the impact on payloads and shipments results in waste volume reduction compared to capacity values. When this information is paired with dunnage volumes, these qualitative values provide insight into how waste processing is being performed for a particular facility, process line, or waste stream.

Upper and lower regulatory limits

Requirements governing the different aspects of TRU waste processing and shipping were established by the U.S. Congress and are spread among the Nuclear Regulatory Commission (NRC), the Environmental Protection Agency (EPA), individual States and Tribal lands through which TRU waste is shipped, and the New Mexico Environment Department (NMED) [5]. Each entity has established requirements that must be met prior to sending TRU waste to WIPP. Listed below are the transportation-sensitive limits:

Fissile Mass (F)

When issuing a certification, NRC sets a maximum allowable fissile mass, or fissile-gram equivalent (FGE), limit for each shipping package, and that value can vary slightly based upon the inner waste confinement and containment. In practice, this nuclear criticality limit is managed in a way that can reduce the amount of waste allowed per waste container such that the limit for each package is never exceeded.

Weight (W)

The amount of weight is limited by container type, payload configuration, total payload per package, and by total shipment weight. All interstate routes in which the waste is shipped also have single and tandem axle limits that vary by state. Each weight limit is monitored and controlled throughout the waste packaging, assembly, and shipment loading processes.

Gas Generation (G)

The potential generation of gas affects waste shipping performance in two ways. First, the design pressure limit of shipping packages (e.g. 50 psig for TRUPACT-II inner cavity) must be maintained regardless of the waste type. To ensure the pressure limit will not be exceeded, the chemical, organic, and thermal properties of the waste are assessed, categorized, and packaged in accordance with the maximum gas generation potential that will stay below the package limit. Second, the same waste information restricts combinations of waste that produce gases during transport to less than flammability limits. Often these two limits, alone or combined, can result in adding dunnage to one or more packages in a shipment.

DISCUSSION

Looking at the last eight years of volume tracking, categorized by DOE facility, Table II shows the variation in the payload usage for all shipments divided into waste and dunnage. This information can be used to evaluate trends across the complex, as well as trends that can be traced to a specific process or waste stream.

Table II. TRU Waste Shipping by Payload Utilization [4]

DOE Facility	Shipments	Waste Payloads	Dunnage Payloads	Percent Utilized by Payload
INL	1955	9077	638	93%
SRS	727	4249	90	98%
ANL-E	14	69	3	96%
NTS	48	272	5	98%
LANL	234	948	401	70%
LLNL	18	99	8	92%
RFETS	2045	9151	1435	86%
Hanford – RL	306	1451	165	90%
ALL	**5347**	**25316**	**2744**	**90%**

Table III provides more information on the use of dunnage for each site, comparing dunnage that is returned to the facility for re-use to that which is part of a waste payload and subsequently emplaced in the WIPP repository.

Table III. Dunnage Returned vs. Emplaced [4]

DOE Facility	Returned Dunnage Volume (m^3)	Emplaced Dunnage Volume (m^3)
INL	946	112
SRS	169	0
ANL-E	3	1
NTS	6	2
LANL	473	133
LLNL	10	2
RFETS	2070	111
Hanford – RL	226	16
ALL	**3903**	**376**

More than 90% of all shipped dunnage is returned to the originating site. Figure 3 shows the percentage of limit-induced uses of dunnage containers. Prior to June 2002, there were no tracking controls to limit the use of dunnage. The majority of the 32% shown below as 'unspecified' occurred prior to initiating the tracking of these limits. Since that time, dunnage usage is only permissible when it can be attributed to a shipping or containment limit.

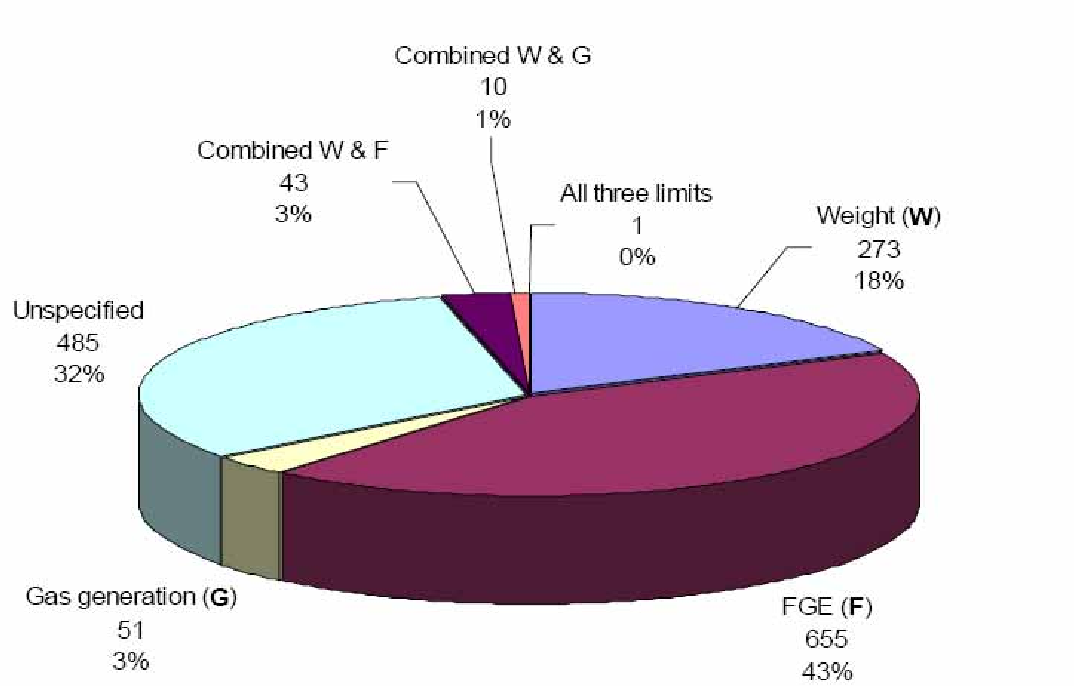

Figure 3. Shipments with dunnage attributed to regulatory limits

Currently, the volume that is reported as disposed is payload container volume. Since WIPP is limited by total waste disposal volume, it is important to provide accurate information with respect to the waste volumes. The effective volume shown in the forth and fifth columns of Table IV is a value that more closely represents the waste volume disposed at WIPP. This value removes the artificial volume from overpack containers (e.g. SWB-overpack, as shown in Figure 2). The way containers are loaded greatly affects repository and shipping values. This is most evident when comparing the shipped volume values to the effective waste volume. The three different volume values in Table IV illustrate the impact of removing the packaging layers that are often counted as waste volume values. In many instances over the last eight years, descriptions of WIPP disposal volumes have used values reflecting a shipped volume, which is always a larger number than that which is actually disposed.

The values in Tables II, III, and IV provide insight on how waste has been managed across the complex. While this discussion is limited to summary values over the last eight years, it is important to examine the trends in packaging, shipping, and receiving over time to better understand how this picture is affected by processing changes. The applied lessons-learned in the first few years of operations have shaped the management of both the waste generator side and the waste receiving end to promote more efficient packaging, better use of materials, and a reduction in shipments to remove the same amount of TRU waste.

Table IV. TRU Waste Volume Value Comparison [4]

DOE Facility	Shipped Volume (m^3)	Volume (m^3) Emplaced at WIPP [c]	Effective Waste Volume (m^3) at WIPP [d]	Effective Waste Volume (m^3) per shipment
INL [e]	16879	15821	10599	5.4
SRS	9305	9135	4500	6.2
ANL-E	125	121	92	6.6
NTS	413	405	391	8.1
LANL	2089	1483	1345	5.7
LLNL	158	146	144	8.0
RFETS	17243	15062	11490	5.6
Hanford – RL	2769	2526	1647	5.4
ALL	**48980**	**44701**	**30207**	**6.2**

Future improvements are targeted towards reducing the dunnage per shipment, continuing to maximize the waste volume per shipment, and maximizing the utilization of the WIPP repository. As mentioned in the Volume Tracking Section, one potential improvement would be to utilize containers for direct loading of waste, rather than overpacking. Another potential improvement is to pursue proven treatment methods that could safely reduce the input volume. Some regulatory and process changes will have to be made to implement these improvements but, in the long-term, these will have a large impact on cost reductions and risk avoidance (i.e. less total miles traveled).

CONCLUSION

Tracking volume and shipments values has been helping DOE to evaluate trends across the complex, and site-specific trends that can be traced to a processing activity, or down to an individual waste stream. By slightly expanding the field of tracked volume values, the categorized shipment and volume data can help show a more realistic picture of the waste disposal progress, as well as providing insight on ways to improve site closure plans and timelines for completion. Likewise, by using volume categorization and tracking, the efficiency of shipments can be routinely monitored and adjusted to the respective waste process.

The WIPP repository capacity has a stipulated limit of 175,600 m^3 for TRU waste disposal [5]. The tracking of volume values discussed in this paper can provide a basis for DOE to make adjustments to WIPP repository planning and utilization. Using the payload container volume as equivalent to TRU waste volumes, the third column of Table IV indicates that the WIPP repository already contains about 25% of the allowable volume, leaving remaining capacity of about 133,000 m^3. If the effective waste disposal volume were reported, as in the forth column

[c] Inclusive of unoccupied packaging volume
[d] Volume of waste after discounting container volume from overpacking
[e] A more representative INL waste volume is 13,650 m^3 and 7.0 m^3/shipment if considering the consolidated volume due to supercompaction at an average of 4.2 pucks per 100-gallon drum

of Table IV, the remaining volume would be about 145,000 m^3. The DOE can use the data collected to continue improving repository management plans and shipping utilization.

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