D&D WASTE ESTIMATE VALIDATION

Peter C. Sanford, J.H. (Jack) Templeton PE, SAIC
405 Urban St., Suite 400, Lakewood, CO 80228

Jeffrey L. Stevens, Kent Dorr, Kaiser-Hill, LLC
Rocky Flats Environmental Technology Site
10808 Highway 93, Golden, CO 80403

ABSTRACT

Rocky Flats Closure Project (Site) includes several multi-year decontamination and decommissioning (D&D) projects which, over the next four years, will dismantle and demolish four major plutonium facilities, four major uranium facilities, and over 400 additional facilities of different types. The projects are currently generating large quantities of transuranic, low-level, mixed, hazardous, and sanitary wastes. A previous paper described the initial conceptual estimates and methods, and the evolution of these methods based on the actual results from the decommissioning of a "pilot" facility. The waste estimating method that resulted from that work was used for the waste estimates incorporated into the current Site baseline. This paper discusses subsequent developments on the topic of waste estimating that have occurred since the baseline work.

After several months of operation under the current Site baseline, an effort was initiated to either validate or identify improvements to the waste basis-of-estimate. Specific estimate and estimating method elements were identified for additional analysis based on the element's potential for error and the impact of that error on Site activities. The analysis took advantage of actual, more detailed data collected both from three years additional experience in decommissioning a second plutonium facility and from experience in deactivating certain non-plutonium facilities. It compared the actual transuranic and low-level waste generation against their respective estimates based on overall distribution and for individual media (i.e. equipment type), and evaluated trends. Finally, it projected the quantity of lead-characteristic low-level mixed waste that will be generated from plutonium building decommissioning and upgraded the decommissioning waste estimates of the non-plutonium buildings.

The results of these analyses include improved estimate factors and waste generation trends, which of the collected data proved relevant, sources of error, and waste generation changes due to improved decommissioning methods. Based on the actual completed project elements, the waste estimate was accurate overall ± 10%, with some reduction in the rate of generation of certain wastes over time. Specific details of the estimating methods will need to be modified for future estimates to reflect the work methods used to ensure that they more closely reflect the execution methods.

INTRODUCTION

Decommissioning the facilities at Rocky Flats will generate a significant portion of the transuranic (TRU) waste that will be disposed of at the Waste Isolation Pilot Plant (WIPP), and over the near term will be the largest waste stream disposed of at that facility. An accurate estimate of this waste stream is necessary to allow efficient Site and DOE weapons complex overall management of TRU waste disposal. The estimates for the generation of low-level (LLW) and low-level-mixed (LLM) waste are also important to manage those waste streams on Site, to properly contract treatment and disposal actions, and to estimate project cash flow requirements, although the impact on Site and DOE-wide activities is less than for the TRU. The process of validating, assessing the basis, and improving the accuracy of these estimates early in the project is important to optimize the management of this waste on Site and throughout the disposition process.

The standard approach for estimating the resources (i.e. cost, crafts, waste generation, etc.) required to accomplish a project is to identify the approach to some level of detail and to estimate the resources based on past practice. The Site used such an approach in developing the 2006 Closure Project Baseline waste estimates for decommissioning the Site facilities. Using physical walkdowns and drawing takeoffs, a database of the physical attributes, or "metrics," of the principle plutonium processing buildings was developed to support the cost estimating effort. These metrics were multiplied by a factor developed from the average waste generated from each of the corresponding metrics during the previous decommissioning of a "pilot" plutonium facility (Building 779). This yielded the waste estimate for the principle processing buildings. The discussion of the development of the waste estimating process is the topic of a previous paper (1).

Once the estimate was developed, we initiated an effort to track the waste generation "performance" of the building activities against their respective estimates. The principal purpose of this effort was to integrate and report the waste generation data, and provide a format to support short- and long-term waste generation projections, allowing better management of the downstream waste handling and treatment activities. The tracking effort focuses on methods to continuously collect and compare estimated waste and actual waste, present that information to management, and predict how the changes in project methods and schedule will impact future waste generation. The tracking effort is discussed in a separate session (2).

After the completion of the 2006 Closure Project Baseline, there were several issues that remained unresolved, either because of the schedule pressure to complete and implement the new baseline or because the data to resolve the problem had not yet been generated. We were concerned that the application of overall "pilot" building data to subsequent project lower-level elements and the variations resulting from differences in conditions and methods of decommissioning between buildings would result in estimate errors, both in magnitude and in time-phasing. We wanted to incorporate the effect of worker learning curve and the quantity of waste generation by media types that were under-represented in Building 779 decommissioning. We had intentionally not developed an independent LLM estimate, but had simplified the process by assuming that the generation would be a (relatively small) percentage of the LLW based on the experience in Building 779. Finally, we recognized that the LLW and LLM estimates from the non-plutonium radiological facilities were based on data generated several years ago that assumed obsolete decommissioning and waste disposition methodologies.

We therefore initiated an independent effort coordinated with the waste tracking to examine the waste generation data from the decommissioning activities most representative of the estimate to be validated or corrected. For independent data that could be applied to the plutonium building estimates, we examined the waste generation data from the completed individual elements of work ("Sets" of equipment removed) from a separate building, Building 771. The work in this building had been initiated over a year prior to our development of the 2006 Closure Project Baseline and will continue through 2004. Since the Building 771 metric data was available by Set, comparing the actual and estimated data was expected to highlight inaccuracies resulting from applying overall building data. We thus looked to validate (or identify correction factors for) the waste generation unit rates for the individual metrics, examine any trends in data over time, and identify any process or methodology problems that could be corrected in future estimates.

The Building 779 decommissioning LLM stream was relatively small, about 0.7% of the total LLW stream, so in the 2006 Closure Project Baseline the decision was made to estimate it as a factor of the overall LLW values for the plutonium buildings. However, in order to plan for possible on-Site treatment to meet Land Disposal Restriction requirements and constraints on the disposal of certain categories of mixed waste, a better estimate was needed. Since lead shielding was the bulk of the decommissioning LLM from these buildings (approximately 95%) and appeared to be related to the available metric data, the lead LLM became the focus of the effort.

Finally, an analysis was conducted to validate and refine the waste estimate for the Site non-plutonium buildings. While detailed waste estimates based on databases of Set-specific metrics were prepared for the four plutonium buildings, the waste estimates for the remaining buildings, including major uranium-contaminated facilities, relied on parametric estimates. The decommissioning waste parametric estimates were based on the eight-year-old data, with global corrections applied to reflect the recent decommissioning project experience and "hazards reduction" activities. This corrected parametric estimate was then incorporated into the Closure Project Baseline.

As the planning and work has progressed on some of these buildings, discrepancies have developed between the actual waste generation and the parametric estimates. Part of the problem was that more detailed planning rearranged the schedules of the activities being performed, causing the waste generation profile to change. Also, a parametric estimate, even if it is correct overall, will result in some buildings or parts of buildings being estimated to generate more waste than they will actually produce, and others less. Finally, the expectation of what will constitute hazardous and mixed waste has changed since the development of the original data.

In the absence of detailed metric data for the non-plutonium buildings, an attempt was made to improve the quality of the parametric estimate based on new waste generation and schedule data. The revised approach will allow greater confidence in the estimate accuracy and allow the Site waste management organization to better optimize their operations. It will also allow better tracking of the waste data against the estimate to better predict future waste generation both for current and future building activities.

This paper is divided into five ensuing sections. The Background section provides Site-specific information to explain the circumstances and purposes that influenced the approaches used. The following three sections discuss the methods and results for each of the analyses: Plutonium Building TRU and LLW Validation, Lead Analysis, and Non-Plutonium Building Analysis. The Conclusion section provides overall impacts and discusses the lessons learned and anticipated future activities.

BACKGROUND

The Rocky Flats Closure Project has been subdivided into six "Projects," four of which are principally concerned with the demolition of each of the four major plutonium facilities. The 771 Project involves the equipment dismantlement, structural decontamination, and demolition of Buildings 771, 774, and some of the smaller adjacent structures, and is integrated with the environmental restoration of the soil under and surrounding the building. Building 771 was one of the original facilities at the Rocky Flats Site, constructed in 1952 to handle all of the plutonium purification and weapons fabrication. Building 774 was constructed at the same time to treat the liquid wastes generated in Building 771. The combined footprint of the buildings is 147,000 square feet. Although weapons fabrication operations were subsequently relocated, the plutonium purification activities remained active until the Site was shut down in 1990. The operations in the Building 771 gloveboxes and tanks used concentrated solutions of plutonium, nitric acid, hydrochloric acid, plutonium fluoride, residue incineration, and other activities dealing with concentrated radionuclides.

During the course of operations there was a major fire, numerous spills (within the building) and removal and replacement of numerous pieces of equipment. The ventilation system was upgraded several times to support new safety standards and process requirements. Operations were suspended in 1990, and the principle activity for a number of years was "Deactivation," which mostly consisted of draining the high-plutonium liquids from the tanks and connecting piping, with the eventual removal of most of this piping. Decommissioning began in 1999, and work to date has included the removal and size reduction of gloveboxes, tanks, duct, equipment, and the remaining pipe.

The decommissioning work is subdivided into "Sets" of work – essentially the scope elements that include the removal and packaging of specific pieces of highly-contaminated equipment, and "Areas" – the scope to remove the remaining less-contaminated equipment and decontaminate the structure to an unconditional release status. There are a total of 47 Sets and 13 Areas, with 18 Sets and no Areas complete as of October 2001. Deactivation was also nearly complete. The Set work will generate virtually all of the TRU and LLM, and the LLW generation will be split between the Set and Area scope. Deactivation scope generated a relatively small portion of the overall waste.

The paper presented at WM01 (1) on waste estimating at Rocky Flats first discussed the evolution of the methods of waste estimating over the different decommissioning projects, concluding with the method used for the Site baseline. That method used take-off data for Building 779 for six "metrics": glovebox volume and surface area, tank volume, pipe length, duct surface area, and a "balance" of the remaining material based on building floor area. The actual waste container data was collected and the quantities of "primary" (e.g. metal, rubble) waste were correlated with the individual metrics, and "secondary" (e.g. combustibles, plastics, supplied-air suits) were correlated with glovebox and "balance" categories. Additional correlations were developed to try to segregate the waste that would be done in the Sets and in the Areas, and to identify container packing density (net container weights) by waste type. The metric data was applied to the remaining plutonium buildings base in the belief that if the materials decommissioned and the decommissioning methods used were the same, then the resulting actual waste generated should be the same.

The D&D waste estimates generated for the baseline combined the radioactive and radioactive-mixed waste streams, e.g. TRU and transuranic-mixed (TRM), LLW and LLM. Since TRU and TRM waste are both disposed of at the WIPP, TRM does not have a separate disposition path or higher costs and need not be tracked separately. However, LLM waste must be treated and/or disposed of much differently than the non-hazardous LLW, resulting in different Site waste management requirements, disposal locations, and much higher disposition costs. In order to determine the whether the quantity and associated cost of the LLM generated from the decommissioning of the plutonium buildings was significant, an initial effort was undertaken to analyze and apply existing data. The data from Building 779 showed that the lead containing waste was 95% of the total LLM generated. Based on this the data, we decided to analyze the waste generated from Building 779 and Building 771 by waste characteristic to specifically look at the quantity of LLM waste containing lead.

One of the major sources of lead in the buildings is from glovebox shielding. Whether the lead is stripped from the glovebox or not also affects the activity of the waste, and hence its final disposition. The current disposition pathway for most of the Site LLM is to Envirocare of Utah, which has a permit limit of 10nCi plutonium per gram of waste (nCi/g). It is likely that the LLM elemental lead stripped from the outside of the gloveboxes will have a relatively low radioactivity and can be disposed of under Envirocare's permit. Similarly, the glovebox parts and light metal which have had the lead removed can be disposed of at NTS as straight low level waste up to a radioactivity level of 100nCi/g. Where the lead cannot be readily stripped from the glovebox parts, there may be a greater amount of LLM Lead waste with a radioactivity greater than the Envirocare permit limit, but less than the lower TRU limit of 100nCi/g. Waste containing between 10 and 100nCi/gram not having a clear disposition path is sometimes termed "orphan" waste.

Unlike the waste estimates for the plutonium buildings, the waste estimates for the non-plutonium buildings were not based on recent cost estimate walkdowns and take-offs by Set. They were derived on the original waste estimates for the Site, developed in 1992-1994 as part of the Systems Engineering Analysis (SEA). This analysis conducted detailed walkdowns and drawing take-offs of a number buildings of different types to estimate the weight of equipment and structural materials that would become waste during decommissioning, including total weights and a breakdown into the transuranic, low-level, sanitary, mixed, and hazardous categories. The results of the detailed walkdowns/take-offs were then applied parametrically to all of the Site buildings based on their total floor area.

After the decommissioning of Building 779, we compared the SEA estimate for that building with the actual waste generated, and used the results of this analysis to update the estimate values provided in the SEA for non-plutonium buildings. These updated SEA values were then combined with additional data to reflect the division of the waste generation into hazards reduction activities and decommissioning activities by building, and entered into the Closure Project Baseline.

In the time since the development of the baseline, additional information has become available that could be used to refine the estimate. First, significant progress has occurred in the hazards reduction activities, so some actual data is available as to the type and quantity of waste that will be produced by a given building. Secondly, the original SEA walkdown data has been discovered for one of the major non-plutonium buildings (Building 865), which also has completed its hazards reduction activities. Using this data it is possible to identify what was originally part of the SEA estimate and the breakdowns between different materials (equipment/structural) in that estimate. Also, with a cursory building tour we could identify what had been included in the SEA estimate that has subsequently been removed and, by subtraction, what remains for the decommissioning activity. Finally, separate drawing take-offs have been developed for the structural components of the major non-plutonium buildings, which can also be independently compared with the Building 779 data to allow additional validation of the SEA data.

PLUTONIUM BUILDING TRU AND LLW VALIDATION

Method

There were three analyses that were performed as part of this effort: analysis of the TRU generation at the Set and at the "metric" level, analysis of the TRU generation trends over time, and analysis of the LLW generation. Graphs supporting these analyses are shown in Figures 1, 2, and 3, respectively.

The initial activity in developing the analysis was to identify the waste generation by Set for the 771 Project Sets. The overall waste tracking and data repository for the Site waste generation is the Waste and Environmental Management System (WEMS). However, the system does not explicitly collect the information on the Set work that generates the waste. WEMS contains information that may sometimes be related back to the Set, including the room in which the waste was packaged and a code used to identify the waste matrix for waste characterization purposes. The actual waste travelers carried data on the material in the waste container that was not recorded in WEMS (e.g. pipe, duct). Also, separate records were available tracking government "personal property" to confirm its disposal as waste, including gloveboxes and process equipment identifiers that could be traced back to a given Set.

The "Actual" WEMS data was always used as the total generation data for the whole building. Between the WEMS data, the traveler, and the property data most Standard Waste Boxes (SWBs) for TRU, crates and cargo containers for LLW, and some portion of the drums (TRU and LLW) could be assigned to individual Sets; i.e. we could trace a direct linkage between the container contents and the Set of origin. The remaining containers were "apportioned" to the Sets based on which Sets were active and the quantity of other waste being generated.

The original waste estimate by Set was created using metrics (e.g. glovebox volume, pipe length, etc.) that identified the quantities of the materials in the Set and, multiplied by the waste factor per metric, yielded the estimate. An initial attempt to get the actual waste data by metric for TRU was unsuccessful because the data on some of the metrics was too sparse for the Sets completed to date. Also, accurate identification of metric types and relative volumes within waste containers (e.g. what percentage of a crate was pipe in a crate labeled pipe, duct, and glovebox parts) was difficult for TRU gloveboxes and impossible for other metrics. As a fall-back alternative, the data was correlated at an intermediate level that approximately corresponded to the glovebox and non-glovebox wastes. The waste estimate provided the estimate data to whatever level of detail necessary – building, Set, or metric. The analysis of the actual and estimate data is discussed in the Results section.

Building 771 decommissioning had been in progress for approximately two years at the time of the initial analysis. Over that time there had been improvement in decommissioning operations, including installation of better contamination control systems and better size reduction equipment that would allow materials to be cut into smaller pieces and presumably achieve greater container density and lower total volume. To test the estimate accuracy over time, an initial analysis was performed by graphing the ratio of actual TRU waste divided by estimated TRU waste for each Set against the midpoint date of the Set activity on the 771 Project schedule. The graphed result showed the time variation of the estimate predictive capability.

An initial problem with this analysis was the impact of small Sets on the overall trending. In scatter plots of actual vs. estimate data (e.g. Figure 1) the small Sets are clustered at the lower left, which diminishes their impact on the overall result. In the plot of the actual/estimate Set values vs. time, the use of a ratio eliminates the impact of the overall Set magnitude, in effect skewing the analysis. To correct for this skewing a weighting approach was developed.

The weighting approach first identified the ratio of the sum of the Set actual TRU generation divided by the sum of the Set estimated TRU generation. The magnitude of the difference between the individual Set actual/estimate ratios from this ratio of the sums is then raised to a power that reflects the Set size. The result is a geometric weighting that emphasizes the deviations of the larger Sets from the average and suppresses the deviations of smaller Sets.

The LLW/LLM data was analyzed for the same eighteen Sets, with the actual and estimated data obtained in an identical fashion.

Results

Eighteen of the nineteen completed Sets were initially plotted directly, the actual waste volumes against the estimated volumes for the given Sets. The nineteenth Set's actual scope was different than its estimated scope, and therefore inappropriate. This plot is shown in Figure 1a. The next level of detail, i.e. the "glovebox" and "non-glovebox" TRU is shown in Figures 1b and 1c.

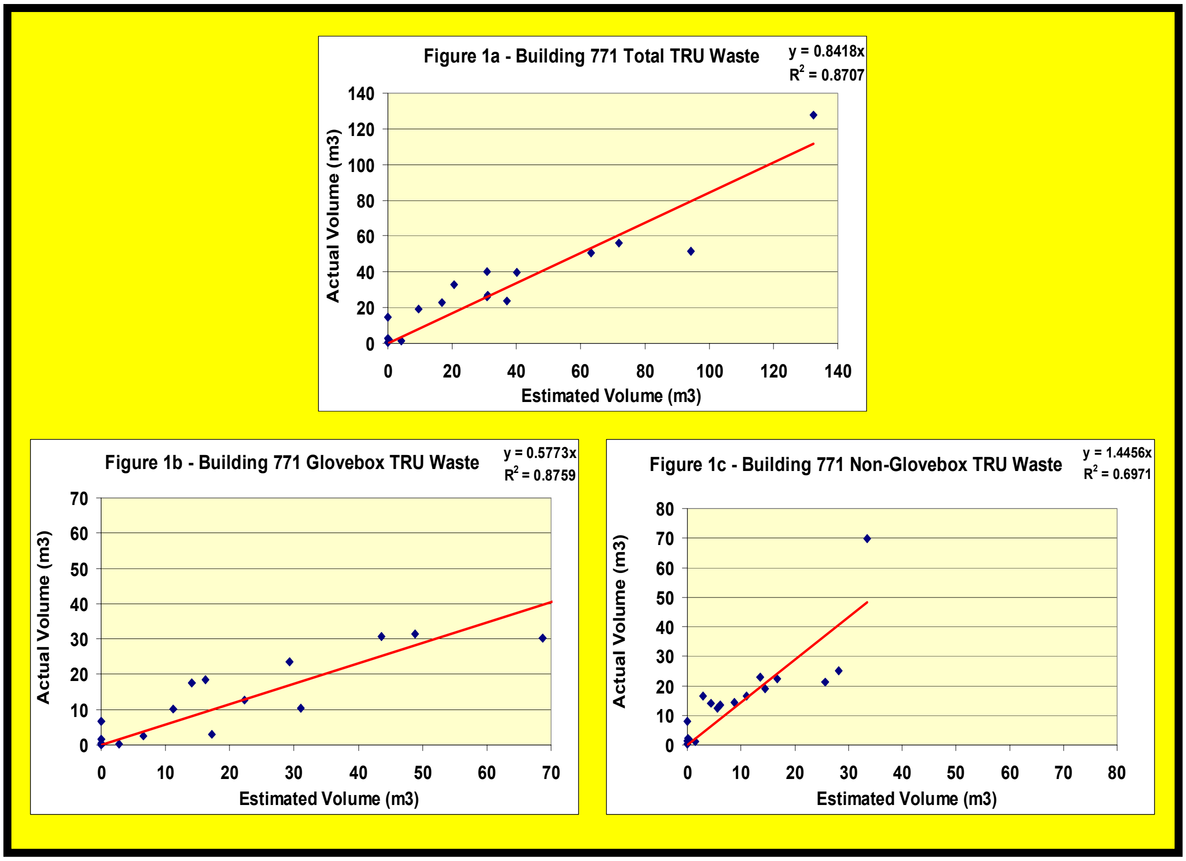

Fig. 1 – Plots of Set and Metric Actual TRU Waste Volumes vs. Estimated TRU Waste Volumes

A linear regression was performed on each group of data, with the line constrained to the origin. A slope of 1.0 would represent a completely accurate estimate. The R^2, or correlation coefficient, is a measure of the scatter of the data, with a value of 1.0 indicating all of the data is absolutely collinear. The data in Figure 1a shows a slope of 0.84 for the total TRU waste, indicating the actual Set waste is modestly less than the estimate; the R^2, at 0.87, indicates the data is relatively linear. For the glovebox TRU waste, the R^2 is approximately the same, but the slope, at 0.58, shows that the actual glovebox waste generated (or at least that which could be identified in waste containers) is significantly less than estimated. The non-glovebox waste correlated less well with the estimate on a Set-by-Set basis, but showed that the actual was greater than estimated.

The plots of the data for the thirteen most-recent Sets showing the change in the ratios of the actual/estimate data over time are shown in Figure 2.

In the time-phased data, a Set ratio of 1.0 would occur where the estimate and the actual values are equal. Figure 2a is the total unweighted data for reference. The remaining graphs show the weighted values. A trend line is used to indicate general trends, although the scatter is fairly large for all cases. There is a consistent downward slope indicating that the project is generating significantly less waste than estimated, as much as a 40% reduction over the two-year period. Both the weighted and unweighted data shows the trend, and the trends are similar for the glovebox and non-glovebox wastes, although the ratios average below and above unity respectively as would be expected based on the Figure 1 plots. We are investigating ways to better resolve both the segregation of metric data and the trending of data over time.

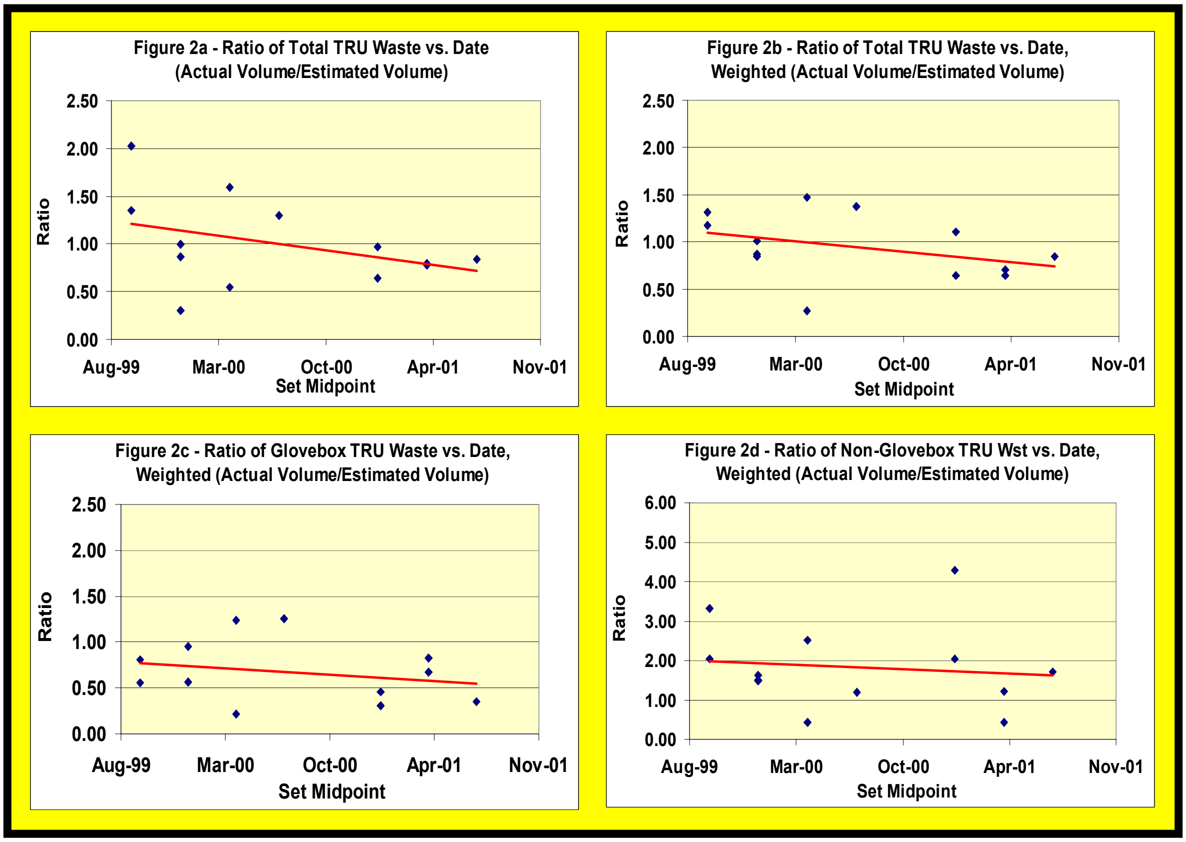

Fig. 2 – Plots of Set and Metric Actual/Estimate Ratios over Time

The LLW/LLM data is shown in Figure 3. The total actual LLW/LLM for the 18 completed Sets was 1,770 cubic meters against an estimate of 2,170 cubic meters, or an average volume ratio of 0.82 of predicted. The R^2 in Figure 3a, at 0.68 shows mediocre correlation of the actual and estimated volumes, and the fact that the slope of 0.58 deviates significantly from the average ratio is another indication of poor correlation. Data did not support resolution of actual data below the Set level.

The ratios of the actual and estimate LLW Set volumes, unweighted and weighted, were plotted in Figures 3b and 3c, respectively. The weighted trends showed generally no overall change with time, although the exaggerated impact of the large deviations in small Sets early in the process can be seen in Figure 3b. The trend line being greater than one is an artifact of the large scatter and an arithmetic (as opposed to a geometric or logarithmic) averaging.

A potential cause of the discrepancies between the LLW estimate and actual volumes was the attempt in the estimate to separate the LLW in a given room that would be removed by the D&D workers (Set) from the LLW that would be removed by a subsequent construction contractor (Area). We will continue to observe non-Set waste generation to see if the trend continues.

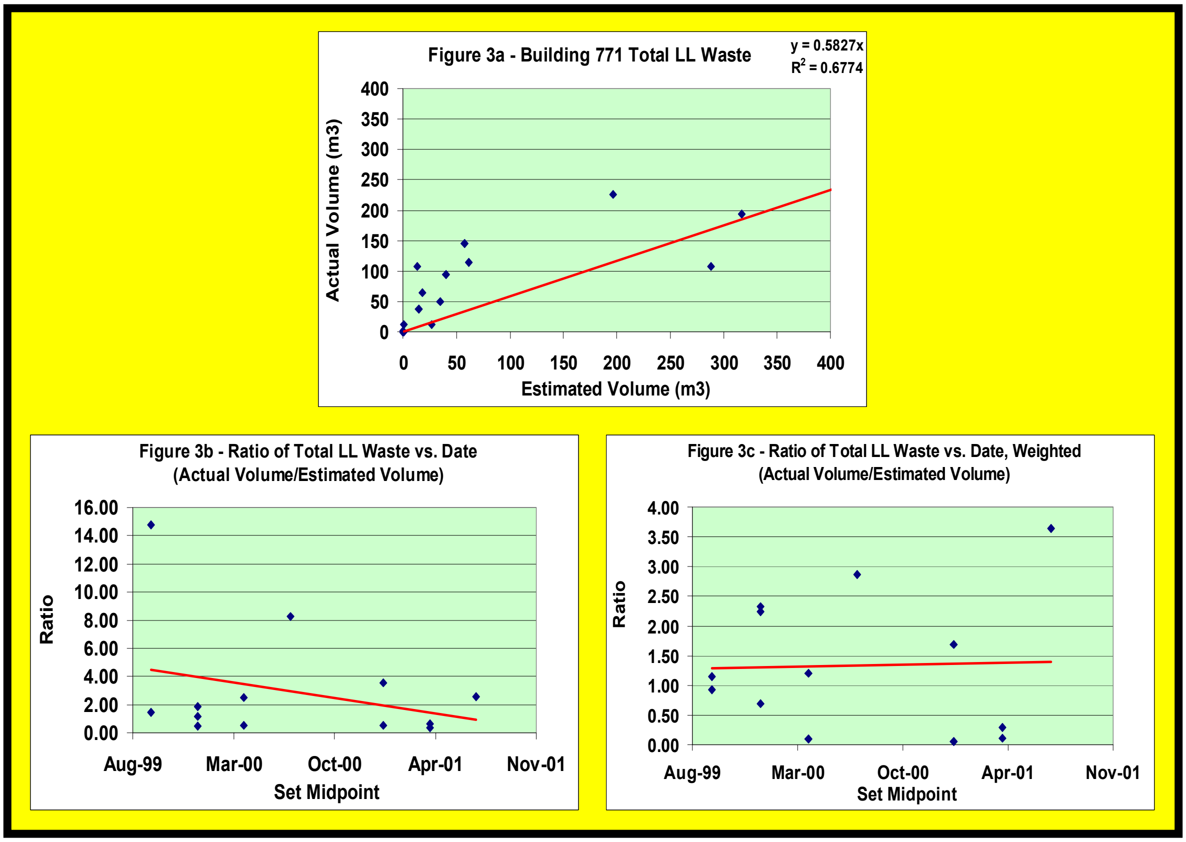

Fig. 3 – Plots of Low-Level Waste Set Data, Actual vs. Estimated Volumes and Volume Ratios vs. Time

LEAD ANALYSIS

Method

Waste data from WEMS for both the Buildings 779 and the Building 771 decommissioning projects was analyzed to develop a way to model the quantity generated of low level mixed waste containing lead. Four groupings defined within WEMS constituted the majority of the decommissioning mixed waste: Lead Shielding, Leaded Drybox Gloves, Ground/Leaded Glass, and GB Parts with Lead/LLM Light Metal/LLM Surface Contaminated Objects.

Data on the number of containers, total volume and total weight was collected for each grouping and then arranged into data sets for LLM only, the TRM waste only, and the combined mixed waste (sum of LLM and TRM). The volume and surface area of the gloveboxes which were the source of the LLM were determined as potential metrics, since all of these items were related to glovebox dismantlement and size reduction. For each grouping and waste type the actual waste volume and weight were divided by a potential metric to obtain generation volume per unit metric factors. Table I shows the example of the lead shielding on the outside of the gloveboxes.

The results from the two buildings were compared to determine which factor more closely agreed and could represent the waste generation for each grouping. The best factor for the lead shielding on the outside of the gloveboxes is the waste volume of the total lead (LLM and TRM) divided by the surface area of the gloveboxes. When the Building 779 and Building 771 data is combined for this factor it yields, 0.012 cubic meters of TRM/LLM lead per square meter of glovebox surface area. The percentage of the lead shielding waste which is LLM averages 93.6% by volume, yielding 0.011cubic meters of LLM lead per square meter of total glovebox surface area.

Table I – Lead Shielding Factor Development

IDC	Waste QTY	Waste Vol (m^3)	Waste Wt (lb.)	Waste Vol by GB Vol	Waste Vol by GB Area	Waste Wt by GB Vol	Waste Wt by GB Area
LLM							
779	79	16.6	29,671	0.042	0.012	75.306	21.073
771	18	3.8	7,039	0.012	0.009	21.782	16.968
TRM							
779	2	0.4	693	0.001	0.000	1.759	0.492
771	5	1.0	1,563	0.003	0.003	4.837	3.768
LLM/TRM							
779	81	17.0	30,364	0.043	0.012	77.065	21.565
771	23	4.8	8,602	0.015	0.012	26.619	20.736

Performing a similar analysis for each grouping yields the factors for LLM shown in Table II. The factor is calculated based on the weighted average of the waste generated by the two buildings. The unit/metric identifies the decommissioning metric (e.g. glovebox surface area) that provided the best fit. The range is not a statistical calculation, but provides the average values for each of the two buildings and is an indication of uncertainty based on only two points of data. Based on these factors the LLM generation from gloveboxes can be calculated for the other plutonium buildings.

Table II – Low Level Mixed Lead Factors for Gloveboxes

Grouping	Factor	Unit/metric	Range
Lead Shielding	0.011	m^3 generated waste / m^2 total GB In-place	0.011-0.012
Drybox Gloves	0.002	m^3 generated waste / m^3 LL GB In-place	0.001-0.003
Leaded Glass	0.007	m^3 generated waste / m^3 Total GB In-place	0.007-0.009
GB Parts w/ Lead, Metal, SCO	0.183	m^3 generated waste / m^3 Total GB In-place	0.062-0.227

In addition to obtaining an estimate for the LLM generated from the gloveboxes, it is important to understand how much of the mixed waste is orphan waste. In order to identify the potential for waste containing between 10 and 100 nCi/gram plutonium, the isotope data in WEMS was analyzed. The grams of plutonium and total transuranic isotopes were multiplied by their specific activity, and divided by the net weight in grams to yield nCi/g waste (net). As only LLM waste containers were analyzed (<100 nCi/g), values greater than 10 nCi Pu/g waste (net) would indicate orphan waste.

Due to different segregation methods used, more orphan waste was generated in Building 779 than in Building 771. The percentage of LLM that was orphan waste for each grouping was determined by combining both buildings together and then separately to provide a range.

Table III – Orphan Waste Estimation

Grouping	Orphan %	Range
Lead Shielding	21.8	11.1-24.0
Drybox Gloves	100	NA
Leaded Glass	100	NA
GB parts with lead, light metal, SCO	24.8	3.1-90.3

Results

The described method provides reasonable estimates for the quantity of low level and orphan waste generated from dismantlement and size reduction of gloveboxes. However, to provide an accurate Site estimate, we also needed to add other lead sources and specialty waste forms present in a building. The two major additional lead sources were the Building 707 X-Y retriever and the Building 371 Central Storage Vault, both of which have lead-lined storage containers. No other significant sources were identified. Assuming that all of these containers will be LLM and none of them are characterized as orphan, the total estimated quantities for the plutonium buildings are as follows.

Table IV – Estimated Lead LLM and Lead Orphan Wastes

Building	LLM Estimate (inclusive) (m^3)	Orphan Waste Only (m^3)	LLM Estimate Range (m^3)		Orphan Waste Estimate Range (m^3)	
			LLM High	LLM Low	Orphan High	Orphan Low
707	301	80	364	143	236	23
771/4	165	44	199	79	128	13
776/7	353	94	428	166	279	27
371/4	223	60	270	103	178	17
Total	1,041	278	1,262	492	820	80

The values provided in the "range" columns, while not statistically-based, provide a general indication of the accuracy of the estimate, which is adequate for planning given that the approaches used to dismantle the gloveboxes are also subject to change in ways that may impact the LLM generation.

Regarding the non-lead LLM generated from decommissioning, our original analysis indicating that this waste stream will be minor has been validated by the Building 771 data to date. The LLM such as that resulting from the dismantlement of systems that handled carbon tetrachloride, in addition to being a minor contributor at the Site, is very location-specific. Thus, an estimate approach based on evaluating the equipment dimensions and estimating the volume fitting into waste containers, perhaps after treatment, is more appropriate even though such approaches have been shown to yield less accurate results on larger scale estimates.

NON-PLUTONIUM BUILDING ANALYSIS

Method

The non-plutonium building waste analysis was envisioned as a way to materially improve the waste estimate for these buildings without conducting detailed walkdowns and gathering new data on the buildings to be decommissioned. It included activities to:

- compare the different Building 865 data to develop revised data for that building,
- correlate the three groups of data (SEA, structural take-offs, and hazards reduction actual) for the remaining buildings,
- correlate the data for the remaining buildings with relevant actual data from the completed Building 779 and Building 123 projects, typically waste generation per unit area,
- extrapolate the actual hazards reduction waste generation and compare with FY02 hazards reduction estimates,
- determine the number of waste containers and total volume that will be generated by the weights of material in the estimates, and
- identify the appropriate quantities of waste that will be generated from some of the smaller buildings not covered in the detailed estimate.

The Building 865 analysis first compared the SEA walkdown data (for "equipment" only, not structural materials) against the equipment remaining in the building. The weight of the removed equipment was compared against the recorded weight of the low-level, low-level-mixed, and sanitary waste generated by the building since 1993. The SEA structural weight was compared against the more recent drawing takeoffs. Finally, the SEA breakout between the waste types was compared against the actual results from the hazards reduction activities for the building and also the ratios for Building 779 and 123.

The basic analysis for the remaining buildings (Buildings 886, 883, 881, and 444, and their immediate contaminated outbuildings such as filter plenums) began by comparing the structural data. This SEA element was the biggest concern since no data was available on the methodology or assumptions, only that the values for Building 865 were comparable. The approaches that will be used to determine how much concrete will remain in the ground after demolition, the methods for surface decontamination and waste generation from that decontamination, etc. have become much clearer since the SEA assumptions.

It was therefore decided to use the drawing takeoff data as modified for the Building 779 experience, both for the total structural waste weight, and for the split of the overall waste between the LLW, sanitary waste, and recycled material categories. The SEA values were used for the total equipment weights, but the splits between the LLW and sanitary categories were based on hazards reduction splits for the appropriate building. The Building 444 equipment value was increased due to its extremely low waste weight/ square foot (0.013 tons/sq. ft. vs. greater than 3 for the other process buildings).

The estimates of the remaining waste that will be removed by hazards reduction activities from this analysis were compared against the estimates provided by the staff planning the work. These were evaluated to establish that the scopes of work being estimated were similar, and rolled into the overall values.

The density (i.e. the sum of the packages net weights divided by the sum of the container volumes) of the waste generated as a result of the hazards reduction activities for all of the buildings and for Buildings 779 and 123 were calculated.

Finally, the baseline waste estimates for the remaining buildings in the non-plutonium area of the Site were reviewed. In some cases there has been characterization performed on the buildings; in other cases, the parametric values were applied based on an inaccurate description of the facility's history. The review consisted principally of eliminating or reducing the waste estimate values from those buildings where they were unrealistically high.

Results

The results of the Building 865 analysis are shown in Table V.

Table V – Comparison of Data Sources

	SEA	Actual	Drawing take-offs	Ratio (Actual/SEA)	Ratio (Takeoffs/SEA)	tons/sq. ft. (SEA)
Equipment Removed	437 tons	430 tons	N/A	0.984	N/A	0.010
Equipment Remaining	883 tons	N/A	N/A	N/A	N/A	0.028
Structural Materials	5,824 tons	N/A	5,722 tons	N/A	0.983	0.134

These results showed excellent comparison between the SEA and the new data for the weights of the materials. While there was no way to make a direct comparison between the waste types for the SEA vs. the actual waste types generated, the SEA estimated ratio of 4% sanitary vs. LLW/LLM against the actual 3%.

Where the SEA was significantly different was in the ratio of LLM/LLW, which the SEA had at 155% (986tons LLM/634tons LLW) but which the value for the actual waste generated to date was 0.2% (1.0tons LLM/419tons LLW). Further investigation revealed that the SEA had assumed that beryllium contamination would result in the waste being considered hazardous or mixed, which is not the case. Since most of the mixed waste is typically generated in the hazards reduction activity, and the actual data in other non-plutonium buildings is similar, this ratio can be conservatively applied to other buildings.

The overall results of the data revision are shown in Table VI.

The most significant change in the overall estimate is in the total quantity of LLM anticipated to be generated. The baseline estimate gives a total of 10,565 cubic meters of LLM that would be expected to be generated by these buildings. The revision predicts a total of 437 cubic meters, of which 165 have been generated to date. The ratio of total LLM/LLW is 0.8% which, when compared with the comparable value for Building 779 (0.26% without including glovebox lead), is conservative.

The second change in the overall estimate is the LLW estimates by the buildings and total. The total LLW estimate per building varies, with some increasing and some decreasing. The two individual buildings that increased (Building 886 and Building 881) were not individually walked down during the SEA, but used parametric values that had been developed for other, presumably similar, buildings applied to them. The remaining buildings showed a decrease in estimate, particularly after the waste that has already been removed from the building was applied. The final revised value of 50,082 cubic meters compares with the baseline value of 71,809 cubic meters, a reduction of more than 20,000 cubic meters, although most of the reduction comes from the elimination of waste generation quantities from buildings that should have minimal generation (13,179 cubic meters).

CONCLUSION

The overall basis of the estimating approach used for the 2006 Closure Project Baseline was that if the materials being decommissioned were similar and the decommissioning methods were the same, then the waste generation should be predictable.

The results of the plutonium building validation show that for Building 771 the TRU estimates were reasonably predictive, within 10-15%, of the actual TRU that was generated by the initially completed Sets. Isolating the glovebox TRU and the non-glovebox TRU estimates and generation showed that the estimate components overestimated the glovebox waste and underestimated the non-glovebox waste. The reduced glovebox waste may be due to a difference in the size reduction methodology with more gloveboxes being decontaminated to LLW, with savings in both TRU metal and also secondary wastes (e.g. supplied-air suits). The cause of the increased non-glovebox waste is unknown at this time, although we are investigating the possibility that additional duct is being removed that was not included in the original estimate scope for those Sets. Differentiation between glovebox and non-glovebox waste was difficult due to inability to identify what materials (and how much of them) were in the waste boxes; there was no way to reliably update the estimate metrics based on the data available during this study. Greater use of cargo containers contributed to this difficulty for LLW.

The waste trending data showed a significant trend for a reduction in TRU waste generation over time. The LLW data showed much more scatter than the TRU data. Since the analysis effort concentrated in the TRU area, no additional analysis has yet been performed on the LLW data, although the data warrants further study.

Table VI – Non-Plutonium Building Analysis Results

	Building 123		Building 779		Building 865		Building 886		Building 883		Building 881		Building 444		Total	
	Weight	Volume	Weight	Volume	Weight	Volume	Weight	Volume	Weight	Volume	Weight	Volume	Weight	Volume	Weight	Volume
Hazards Reduction through 10/1/01																
LLW					420	1,177	83	291	345	644	445	2,951	694	3,594	1,987	8,656
LLM					1	3	1	2	14	35	25	101	13	24	54	165
San					10		16		0		114		5		145	N/A
Recycle					33		0		0		0		7		40	N/A
Asbestos							6								6	N/A
Subtotal					463	1,180	106	293	359	679	584	3,052	719	3,618	2,232	8,822
Hazards Reduction post 10/1/01																
LLW							20	72	614	2,233	941	3,420	652	2,369	2,226	8,095
LLM							0	1	6	23	10	35	7	24	22	82
San									10		168		10		188	
Recycle									5				10		15	
Asbestos					27				42		120		96		285	
Subtotal					27		20	73	677	2,256	1,238	3,455	774	2,393	2,736	8,177
Decommissioning																
LLW	106	509	2,316	8,489	1,526	5,547	236	858	2,156	7,842	3,621	13,168	2,720	9,891	10,259	37,307
LLM	0	1	31	58	8	28	1	3	11	40	19	67	14	51	52	190
San	1,755		1,422		822		511		693		2,892		2,610		7,528	
Asbestos	44	195														
Recycle Conc	0		8,295		4,871		3,887		4,087		14,856		15,573		43,274	
Recycle Metal	122		673	153	380		137		327		1,158		1,214		3,215	
Subtotal	2,027	704	12,737	8,699	7,606	5,576	4,772	861	7,274	7,882	22,545	13,235	22,131	9,943	64,329	37,497
Total																
LL/LLM	106	510	2,347	8,546	1,954	6,755	341	1,226	3,147	10,816	5,060	19,743	4,100	15,955	14,602	54,495
Asbestos	44	195	0	0	27		6		42		120		96		291	
Non-Rad	1,877		10,390	153	6,116		4,551		5,122		19,187		19,429		54,405	
Total	2,027	704	12,737	8,699	8,097	6,755	4,898	1,226	8,311	10,816	24,367	19,743	23,625	15,955	69,297	54,495
Comparison to the Baseline																
BEST input for Buildings						9,344		140		15,902		11,099		22,145		58,630
Other 400/800 BEST LL/LLM																13,179
Total 400/800 BEST																**71,809**
Difference by Building						-2,589		1,086		-5,086		8,644		-6,190		-4,135
Difference since 7/00						-3,173		827		-5,765		8,559		-8,996		-8,547
"Revised BEST"																50,083
Average LLW/M #/CM		417		549		717		580		1,120		358		397		488
Notes:																
1)All Sanitary waste values beginning 1998 (before that went to Site landfill)																
2)All weights in short tons, all volumes in cubic meters																
3) The "Revised BEST" case does not include waste prior to 7/00, no 460, 440, 441 etc., revised major Bldg numbers (includes actual generation 7/00-10/01 - 4,413 CM)																

There were a number of sources of error identified in this analysis. Even at the Set level it was difficult to definitively track and correlate between the material in the Sets and the waste packages. This led to the "allocation" of the unidentified waste to Sets, which by its very nature injects subjectivity into the process. The walkdown and takeoff data that provided the original material quantities was also sometimes questionable. Of particular concern is the issue of duct being removed that was not included in the estimate take-offs. Another source of error in the estimate is that the stripout waste included in the Set LLW estimate also included some debris waste that should probably be part of the Area estimate. Since the physical locations of the Sets and Areas overlap, it is necessary that the accurate allocation of the estimated waste between the two scopes await the completion of the initial Areas.

One area of ongoing work is the effect of aggressive glovebox decommissioning on TRU volume reduction and orphan LLM generation. As more gloveboxes are dismantled in this fashion additional waste data will be available to anticipate variances. We are also identifying scope items that were either left out or misplaced in the original estimate. Finally, we are identifying different correlation method to attempt to extract better metric factors from the data available.

The lead analysis demonstrated that the waste estimate methodology can be extended to a smaller constituent part of the estimate if that component is consistent across the buildings and the dismantlement methodology is the same. Additional data, particularly from different buildings, should allow us to better quantify the uncertainties and replace the range approach used to date.

The non-plutonium building analysis argues for a major reduction in both the LLM (96%) and in the total LLW (30%). The reduction in LLM is a result of a better understanding of the original estimate assumptions, and the changes in the waste characterization and generation approaches to be used. The reduction in LLW is a result of a better estimate of the waste in the major buildings, and the elimination of estimated waste expected in the baseline to be generated from buildings that current characterization data suggest are clean.

The overall estimate revision is a good interim measure to support an improvement in Site waste projections. Continued effort need to be made to coordinate the estimate with current work, integrate additional walkdown data from buildings as it becomes available, and compare the estimated values with the actual generation as it occurs. Of particular interest is the data that will be generated by the upcoming characterization efforts. Facility characterization data is expected to be generated on a number of non-plutonium buildings, both those with controlled areas for uranium and beryllium contamination and those with some history of contaminant use, but expected to be almost completely suitable for unrestricted release. The results of these characterizations will support or allow the correction of some of the estimate revisions.

REFERENCES

1. P.C. SANFORD, J.H. TEMPLETON PE and K. DORR, "D&D Waste Projections: Experience From the Rocky Flats Site" Proceedings WM'01, February 25-March 1,2002, Abstract 458
2. P.C. SANFORD, J.H. TEMPLETON PE and J.L.STEVENS, "D&D Waste Tracking at the Rocky Flats Site", Proceedings from WM'02, February 24-28,2002, Abstract 192