A Little Here, A Little There, A Fairly Big Problem Everywhere: Small-Quantity-Site Transuranic Waste Disposition Alternatives

Dale Luke, Idaho National Engineering and Environmental Laboratory
Lori Fritz, DOE-Idaho Operations Office
Doug Parker, Idaho National Engineering and Environmental Laboratory
John Moss, Idaho National Engineering and Environmental Laboratory
Brent Daugherty, Savannah River Site, BNFL
Ken Hladek, Waste Management Federal Services Hanford
Tom Monk, Idaho National Engineering and Environmental Laboratory
Stan Kosiewicz, Los Alamos National Laboratory

ABSTRACT

Small quantities of transuranic (TRU) waste represent a significant challenge to the waste disposition and facility closure plans of several sites in the Department of Energy (DOE) complex. This paper presents the results of a series of evaluations, using a systems engineering approach, to identify the preferred alternative for dispositioning TRU waste from small quantity sites (SQSs). The TRU waste disposition alternatives evaluation used semi-quantitative data provided by the SQSs, potential receiving sites, and the Waste Isolation Pilot Plant (WIPP) to select and recommend candidate sites for waste receipt, interim storage, processing, and preparation for final disposition of contact-handled (CH) and remote-handled (RH) TRU waste. The evaluations of only four of these SQSs resulted in potential savings to the taxpayer of $33 million to $81 million, depending on whether mobile systems could be used to characterize, package, and certify the waste or whether each site would be required to perform this work. Small quantity shipping sites included in the evaluation included the Battelle Columbus Laboratory (BCL), University of Missouri Research Reactor (MURR), Energy Technology Engineering Center (ETEC), and Mound. Candidate receiving sites included the Idaho National Engineering and Environmental Laboratory (INEEL), the Savannah River Site (SRS), Los Alamos National Laboratory (LANL), Oak Ridge (OR), and Hanford. At least 14 additional DOE sites having TRU waste may be able to save significant money if cost savings are similar to the four evaluated thus far.

INTRODUCTION

The genesis for evaluating the consolidation of TRU waste from SQS to large sites was a recommendation from a contractor-led DOE Environmental Management Integration effort(1) conducted in 1997 that identified consolidation of TRU waste as a potential cost savings opportunity for the Department of Energy. DOE embraced this effort and sponsored a workshop in October 1998 at which representatives from 11 DOE sites, including DOE personnel, reevaluated the opportunity to consolidate TRU waste from SQSs to larger sites. Using a systems engineering approach, they identified and prioritized issues, identified and screened solution alternatives, and qualitatively evaluated those solution alternatives. The workshop identified four SQSs (BCL, Mound, MURR, and ETEC) that had pressing schedule drivers that could not be met by shipping their TRU wastes directly to WIPP and were good candidates for intersite shipment to larger DOE sites with long-term TRU missions. These sites had facilitated their disposition plans based on the assumptions that (a) WIPP would be open and permitted to accept their direct shipment of waste and (b) that vendors, using mobile waste characterization and packaging systems/equipment, would be able to cost-effectively support waste characterization and certification activities at their site. The latter assumption now appears to be less valid and puts the small quantity sites at risk of not meeting their milestones and various stakeholder agreements.

At the request of DOE Headquarters (DOE-HQ), the results from the qualitative analysis performed in October 1998 were then followed by a semi-quantitative analysis specifically conducted to provide

additional levels of detail on scope, cost, schedule, and political/legal barriers to provide defensible discriminators among alternatives to support a recommendation to DOE-HQ. Level "0" (i.e., top level) lifecycle scope, cost, schedule, risk and barrier information was collected from the shipping and potential receiving sites to support development of several alternatives. Potential solutions were evaluated by a team of subject matter experts from various sites, using established criteria (technical feasibility, cost, schedule, risk, and integration benefits), using the "direct ship to WIPP" alternative as the baseline or default alternative. Recommendation Evaluation Plans (REPs) were prepared to document the results of the analyses and were presented to DOE-HQ and DOE Field Office management for use in their decision making.

EVALUATION DISCUSSION AND RESULTS

The four SQSs identified as initial high-priority candidates for intersite shipments share common characteristics: pressing, near-term schedule commitments and limited funds to characterize and certify their TRU waste for shipment to WIPP. Specific discussions on the issues facing each SQS, a description of the system engineering process used to facilitate the analysis, and individual results of the semi-quantitative analysis are presented below.

Figure 1 shows the location of the various DOE sites having TRU waste to be disposed of at WIPP. Other sites having small quantities of TRU waste are candidates for future evaluation of the benefits of consolidating waste at larger sites.

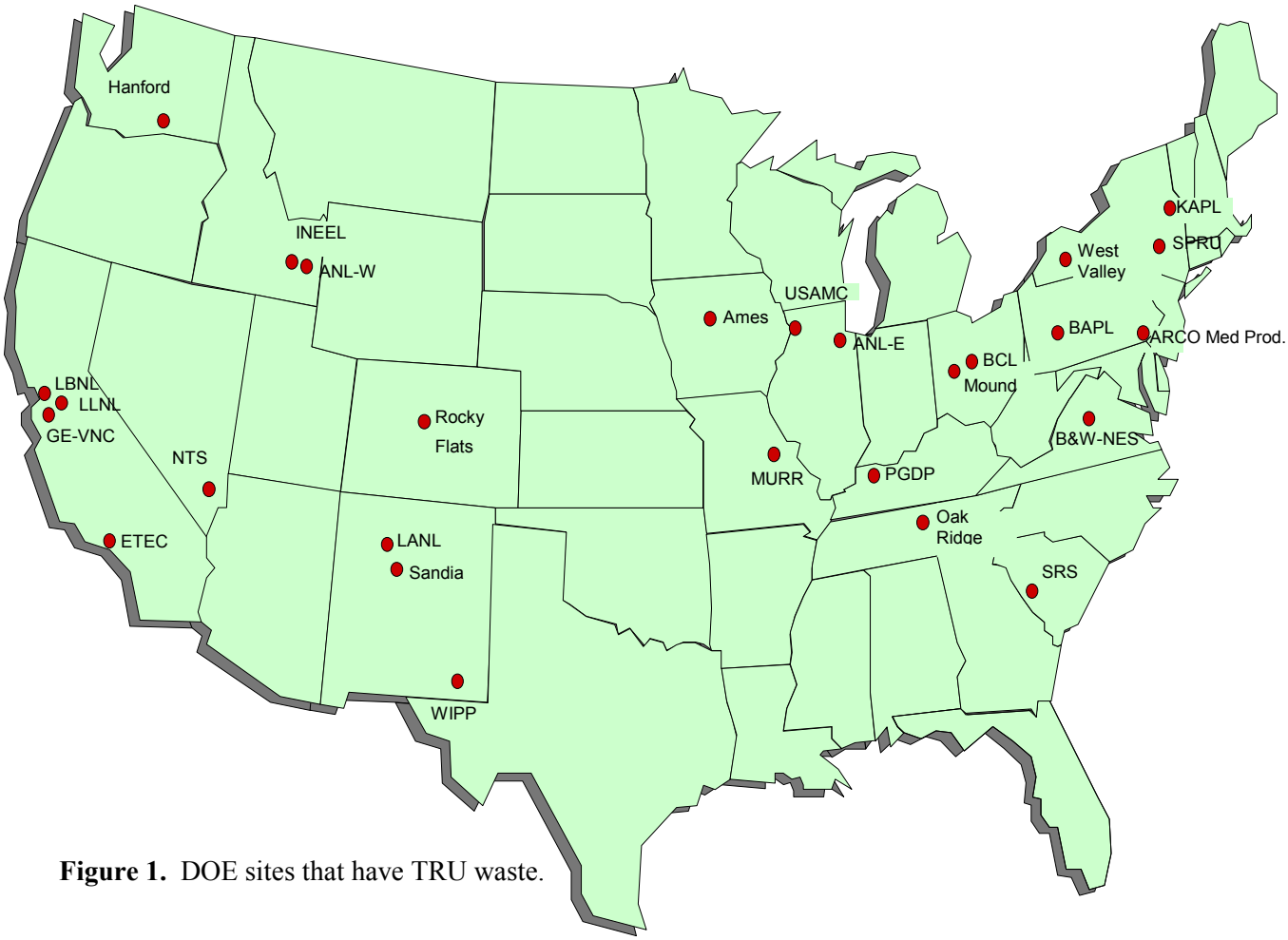


Figure 1. DOE sites that have TRU waste.

Continued from figure 1:

Ames[a]	Ames Laboratory	LLNL[a]	Lawrence Livermore National Laboratory
ANL-E[a]	Argonne National Laboratory-East	LANL	Los Alamos National Laboratory
ANL-W[a]	Argonne National Laboratory-West	Mound[a]	Mound Plant
ARCO[a]	ARCO Medical Products Company	MURR[a]	University of Missouri Research Reactor
B&W-NES[a]	Babcock & Wilcox – Nuclear Engineering Services	NTS	Nevada Test Site
		OR	Oak Ridge Reservation
BAPL[a]	Bettis Atomic Power Laboratory	PGDP[a]	Paducah Gaseous Diffusion Plant
BCL[a]	Battelle Columbus Laboratory	RFETS	Rocky Flats Environmental Technology Site
ETEC[a]	Energy Technology Engineering Center	SNL[a]	Sandia National Laboratories
GE-VNC[a]	General Electric-Vallecitos Nuclear Center	SPRU[a]	Separations Process Research Unit
Hanford	Hanford Reservation	SRS	Savannah River Site
INEEL	Idaho National Engineering and Environmental Laboratory	USAMC[a]	U.S. Army Material Command
		WVDP[a]	West Valley Demonstration Project
KAPL[a]	Knolls Atomic Power Laboratory	WIPP	Waste Isolation Pilot Plant

a. Considered to be a SQS that might take advantage of TRU waste consolidation through intersite shipment to a large quantity site for final characterization and certification prior to shipment and disposal at WIPP.

Issue Descriptions

Battelle Columbus Laboratory

The BCL facility, located in West Jefferson, Ohio, is expected to generate approximately 25 m^3 of remote-handled (RH) TRU waste during decontamination of the JN-1 hot cell facility. The decontamination and demolition of this facility is critical path for final decontamination and project closure of BCL by a target date of 2003. Lack of established criteria to dispose of RH TRU at WIPP and the fact that WIPP is not scheduled to dispose of RH TRU waste until late 2002, at the earliest, led the team to recommend shipment to another DOE site as a viable alternative to meet BCL's site closure schedule.

Energy Technology Engineering Center

ETEC, located near Los Angeles, California, has a small inventory of contact-handled (CH) and RH TRU waste generated during hot cell operations, reactor fuel decladding, decontamination, and D&D operations. The site has a contractual milestone to remove all TRU waste by October 2002 to facilitate site closure by September 2006. WIPP's schedule to receive RH TRU waste no earlier than 2002, limitations in mobile vendor's technical capabilities to characterize and certify RH and CH TRU waste, and lack of adequate funding indicated that shipment of ETEC's TRU waste to an alternative DOE site would be the most likely strategy to support their site's closure milestone.

Mound Plant

Mound currently has 135 m^3 of CH TRU waste that must be removed from the site by September 2001 to support the decontamination of the T-Plant, which is an activity on the critical path to support site closure prior to September 2004. Mound is required to meet the 2004 site closure date to meet contractual obligations to turn the site over to a commercial owner. Mound does not have repackaging, characterization, or certification capabilities to prepare the waste for shipment to WIPP. Therefore, shipment to another DOE site with an existing or planned TRU waste certification program offers a cost-effective alternative for Mound to meet its site closure schedule.

University of Missouri Research Reactor

MURR is currently storing seven drums of CH TRU waste that are owned by the DOE and must be removed to close the agency's legal/regulatory obligations at the university. Because the university does not have characterization or certification capabilities or financial resources to develop these capabilities, shipment to another DOE site would satisfy the obligation to the State of Missouri to remove the waste and meet the DOE's objective to close out all obligations associated with continued management of this waste at MURR.

THE SYSTEMS ENGINEERING PROCESS

Figure 2 presents the systems engineering process used to identify issues and evaluate potential solutions relating to the disposition of TRU waste. The process was developed in accordance with proven systems engineering principles and consists of:

1. Issues identification and prioritization
2. Solution alternatives identification and screening
3. Qualitative evaluation of solution alternatives
4. Semi-quantitative evaluation of solution alternatives
5. Detailed formulation of the recommended solution alternative.

Execution of each process step, which provides an increasing level-of-detail used during the evaluation, is described below.

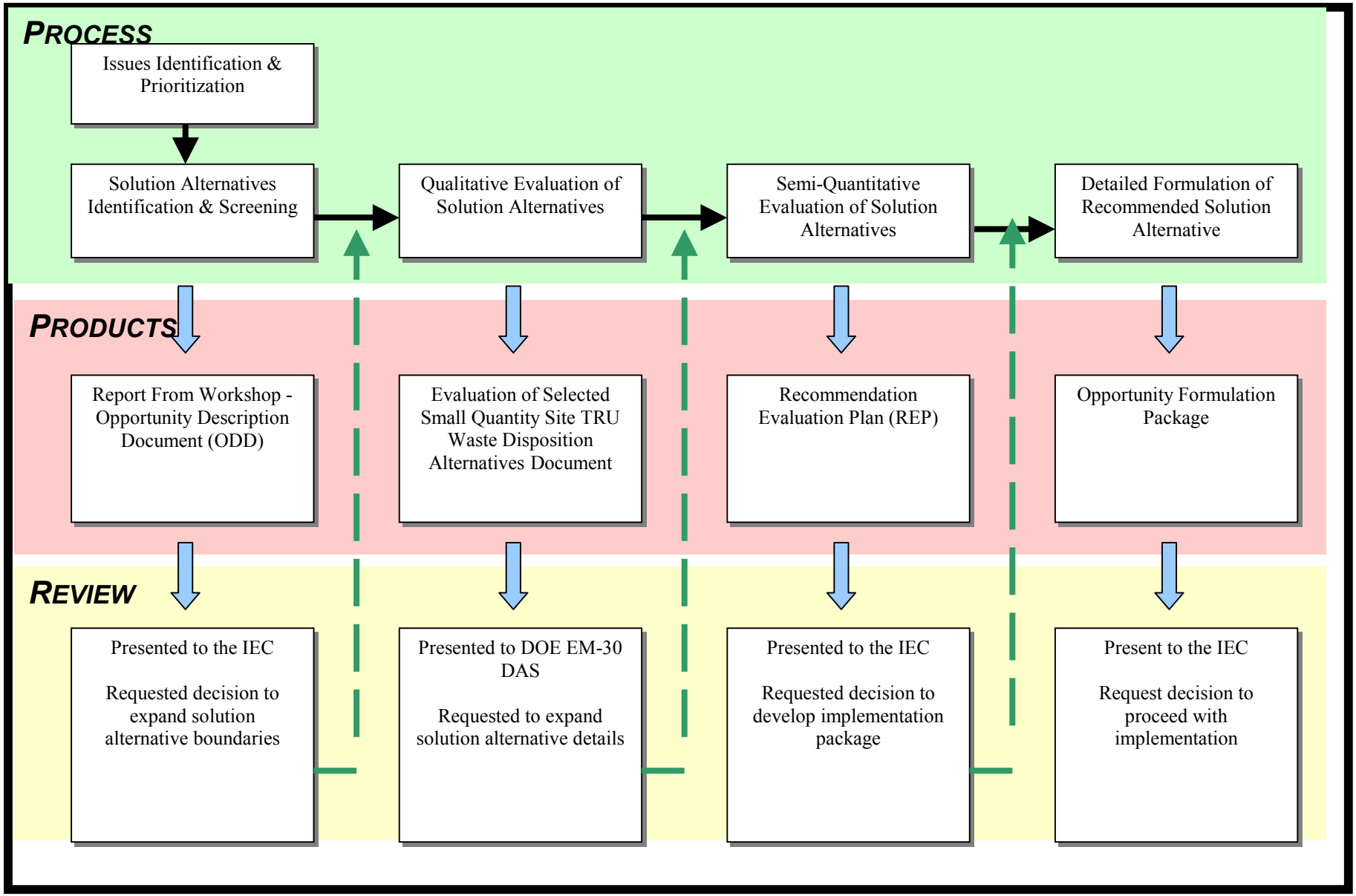


Figure 2. TRU Storage and Treatment PAIT evaluation of selected small quantity sites TRU waste disposition alternatives process description.

ISSUES IDENTIFICATION, PRIORITIZATION, AND ALTERNATIVES IDENTIFICATION

A workshop was held in October 1998, with representatives from most of the sites (or DOE field offices) that have appreciable quantities of TRU waste. The key purposes of the workshop were to identify and screen the issues and the solution alternatives. A representative from each site or field office was given the occasion to present:

- Unresolved site-specific requirements concerning TRU waste storage, characterization, treatment, transportation, or unique disposal problems, for example, determining a site that will accept for interim storage the waste of a facility or site slated for closure
- Existing or planned capabilities that could be available to other sites to minimize costs or to meet schedule commitments (for example, treatment, characterization, or certification)
- Barriers specific to a given site that must be overcome to utilize complex-wide existing or planned capabilities to solve a particular site's need (e.g., permit changes or stakeholder approvals that must be obtained before the capability can be utilized).

The issues, requirements, and possible solutions were gathered electronically (using GroupSystems by Ventana Corporation) and discussed. Drivers, advantages, and barriers for the proposed solution were identified and addressed for each *marriage* (potential sending site *married* to a potential receiving site). The workshop participants then scored each recommendation against criteria to determine which should be pursued immediately. This activity identified a preliminary "preferred" solution for each need. Workshop participants decided that the four aforementioned sub-recommendations (i.e., sending TRU waste from BCL, ETEC, Mound, and MURR to a larger site(s)) were the ones that should be pursued in the near term.

An Opportunity Description Document (ODD) for each of the four recommendations was prepared that describes the issues, the potential alternatives, and a path forward for resolution of the issues. A summary of the document was presented to the Integration Executive Committee (IEC) for a decision to proceed into the next phase, where a more detailed evaluation of various options would be performed. The IEC consists of the head of the DOE Environmental Management (EM) organization and the DOE site manager from INEEL, Hanford, Oak Ridge, Savannah River, and Rocky Flats Field Offices. The IEC approved going forward with all four recommendations. However, the DOE Deputy Assistant Secretary (DAS) EM-30, requested that a more detailed analysis be performed to re-examine some of the potential receiving sites. Specifically, the request was made for additional analysis to support the mixed/low-level waste Record of Decision (ROD) decision-making process.

Qualitative Evaluation of Solution Alternatives

In response to the DOE EM-30 DAS's request, each opportunity was evaluated applying the criteria established by a DOE integration oversight team (Integration Core Team) to specific disposition alternatives. Sending sites and potential receiving sites answered evaluation questions concerning:

- Capability implementation (technical feasibility, operational authorization basis, facilities/processes/infrastructure, and waste minimization) cost and schedule
- Disposition (storage, characterization/certification, packaging, and preparation for transportation) cost and schedule
- Human health and safety risk.

Participating sites differentiated alternatives by selecting the best choice among multiple options based on qualitative information supplied. Answers that reflected greater readiness for a potential

receiving site to accept and disposition waste from a sending site were given a higher score. Alternatives indicating lower vulnerability of human health and safety risk also received higher scores.

The alternatives evaluation was based on summary-level information and constituted an initial screen for selecting candidate sites for receipt, interim storage, processing, and preparation for final disposition of small quantity sites' TRU waste.

The team gave all evaluation criteria and answers to specific questions equal weight. Criteria were not given more weight based on the value of the question or answer. Nor was a sensitivity analysis performed during this qualitative evaluation.

All disposition paths were considered without regard to the actual disposition processes. Several sites have plans to treat waste for disposal, while others plan to accomplish the same end without treatment. An assumption was made that each site's plan to disposition its waste, and the schedule to perform that disposition, will be successful.

Qualitative Analysis Results

Results indicated that (a) OR and Hanford are essentially equally prepared technically to receive and complete disposition of BCL TRU waste; (b) both the INEEL and SRS are technically feasible treatment sites for Mound waste, having similar cost estimates, capabilities, and political impacts; (c) INEEL, LANL, OR, and Hanford are technically feasible processing sites for ETEC waste, with similar cost estimates, capabilities, and political impacts; and (d) INEEL, LANL, and Hanford are technically feasible processing sites for MURR waste, with similar cost estimates, capabilities, and political impacts. Detailed information for waste characterization, packaging, transportation, and processing for final disposition that would identify better discriminators between alternatives such that a recommended receiving site could be identified was not available during this qualitative evaluation.

Semi-Quantitative Analysis

After examining the qualitative analysis, the DOE EM-30 DAS requested that the solution (disposition) alternatives be further evaluated to recommend a path forward. Further evaluation to obtain defensible discriminators to support a recommendation required more complete and detailed information, including specific scope, cost, schedule, and political and legal barriers. In addition, the DOE EM-30 DAS requested that the "direct ship to WIPP" alternative be included as a disposition alternative in order to validate the original recommendation to consolidate TRU waste from the small quantity sites to larger sites. The objectives of the more detailed evaluation were twofold:

1. Does it make sense to consolidate TRU waste at a larger site?
2. If so, which large site(s) should receive TRU waste for interim storage and processing for final disposition?

To obtain additional information, workshops were conducted at three of the four shipping sites during March 1999—participated in by all four shipping sites. To prepare for the workshops, each disposition alternative was broken down into summary-level functions (for example, storage, characterization, processing, packaging, and transportation) and both sending and potential receiving sites were requested to arrive at the workshop with formulated scope, cost, schedule, political/legal barriers, and significant assumptions for each function. To enable potential receiving sites to complete their assignments, sending sites gave the potential receiving sites the following waste source term data:

- Acceptable knowledge information (process knowledge)
- Physical characteristics (e.g., volume, waste form, similar waste types)
- Chemical characteristics (regulated and non-regulated materials)
- Radiological characteristics (e.g., radiation levels, isotopic inventory)
- Packaging characteristics (e.g., packaging layers, container types)
- Defense-generated vs. non-defense-generated determination
- Unknowns (e.g., ability to complete shipping documentation).

Sending and receiving sites developed disposition alternative implementation information using existing constraints (e.g., political and legal barriers) without assuming success when formulating schedule information. Implementation information for each process step consisted of:

- Description and definition of scope required to accomplish each step (function) of the disposition process
- Cost and schedule (at "planning level" detail) to accomplish each step (function) of the disposition process
- Description of technical, political, and legal barriers, including site-specific National Environmental Policy Act of 1969 (NEPA) issues affecting disposition alternative implementation at both sending and receiving sites
- Description of assumptions to implement/accomplish each step (function) of the disposition process.

The participants discussed implementation information for each process function and for each disposition alternative, from both the sending and potential receiving site perspectives. Using the evaluation criteria and the previously prepared homework, workshop participants generated summary information for each process function associated with each disposition alternative.

Cumulative information was formulated to provide life-cycle information relative to each disposition alternative. Potential solutions were evaluated by workshop participants using the evaluation criteria and using the "direct ship to WIPP" alternative as the baseline, or default, alternative. Evaluation results were presented in a "Consumer Report" format. Figure 3 is an example. A report was constructed for each of the four *marriages.*

Results of the Semi-Quantitative Analysis

The workshops and subsequent analyses for each of the shipping sites led to the following conclusions:

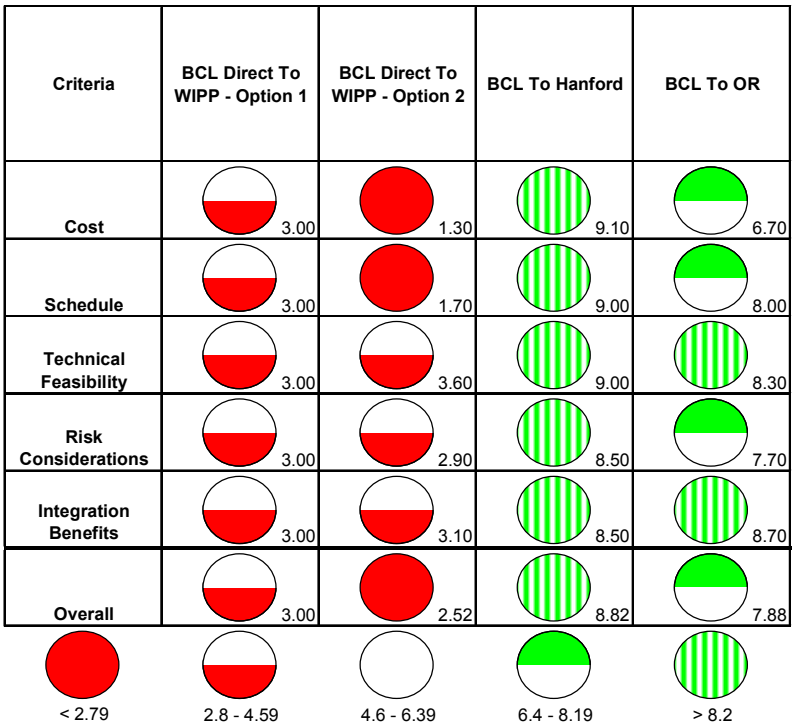


Figure 3. Evaluation results in "Consumer Report®" format (scale ranges from 0-10, with 10 being the best).

Battelle Columbus Laboratory

Development and implementation of a TRU waste certification program at BCL utilizing mobile vendor services and a self-certification approach were evaluated as the baseline. This approach was the most costly one, due to the requirements of certifying the waste at BCL for shipment to WIPP. BCL did not have these capabilities in place.

Cost for preparing, certifying, and shipping the waste to WIPP ranges from $29 to 54 M, depending on the number and nature of infrastructure improvements required. Shipping to WIPP will not meet BCL's schedule. Shipping the waste directly to WIPP would require new infrastructure at BCL, which would extend the current completion schedule. Construction of new interim storage capability would also necessitate an Environmental Assessment, and a Part B Permit under the Resource Conservation and Recovery Act (RCRA). Requisite regulatory actions drive costs up significantly. These environmental activities are some of the key factors in the large costs associated with shipment directly to WIPP.

Shipping the waste to an offsite interim facility for processing is the most attractive option for the following reasons:

- Shipping the TRU waste to Hanford meets the BCL schedule for removal of its waste. The contract agreement for the BCL Decommissioning Project is a cost-share effort. Any delay forces costs up significantly

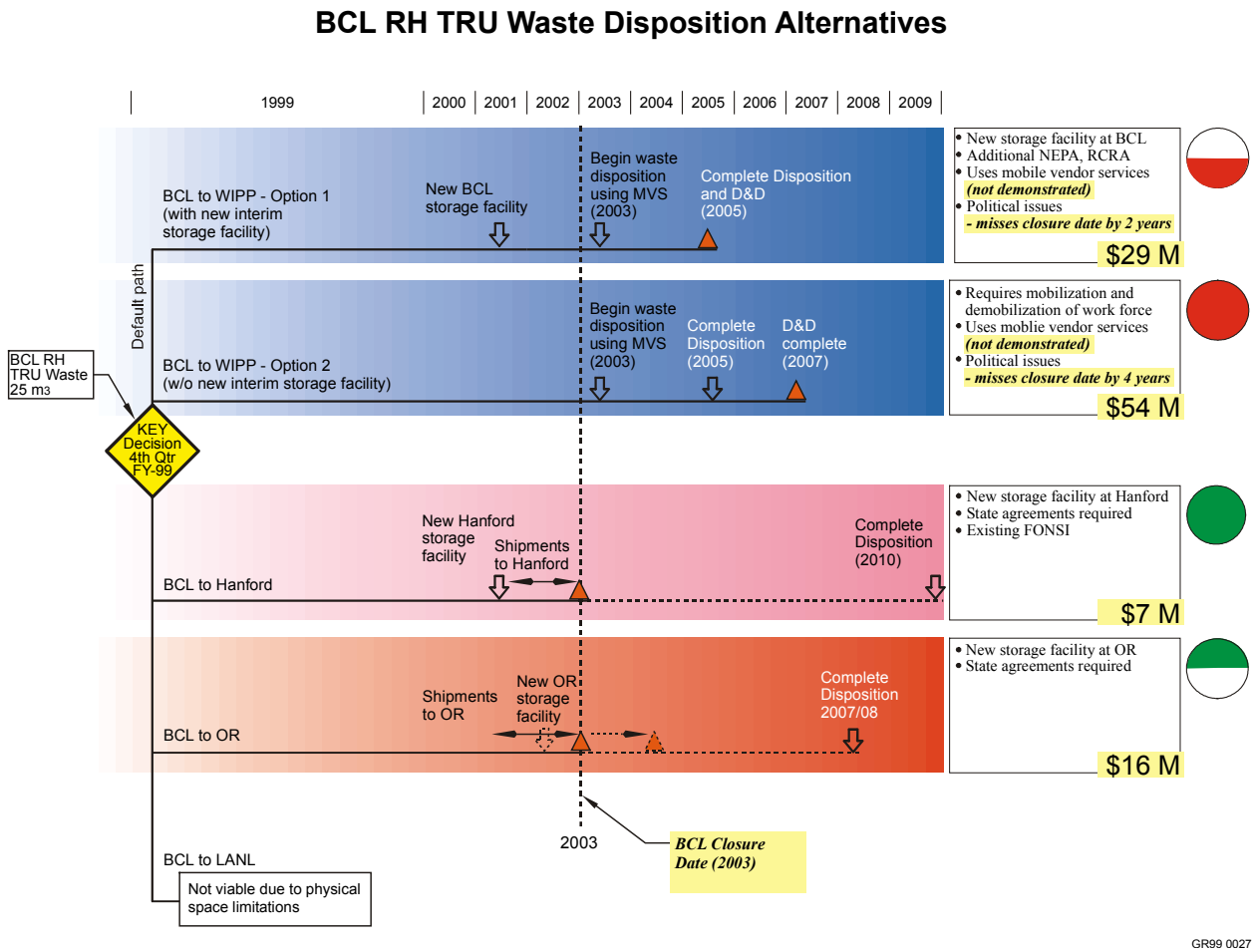
- Hanford will not need to make changes in its regulatory authorization basis, which is a large cost driver for the WIPP and OR options
- The Hanford option involves significantly fewer infrastructure concerns (e.g., less construction)
- Shipping directly to WIPP requires license amendments at BCL from the NRC in order to extend the currently approved licensee decommissioning plan date
- No new infrastructure or authorization is required at BCL to implement intersite shipment.

The difference in cost between Hanford and OR is preparation of an environmental impact statement (EIS) supplement, required by the Foster Wheeler contract (a private contract to treat OR TRU waste to enable shipment to WIPP for disposal). Cost differences and potential for not meeting the BCL closure schedule led the team to recommend shipping the BCL waste to Hanford.

Subsequent presentation of the recommendation to the IEC resulted in the committee directing the team to pursue implementation planning of the BCL to OR option owing to state equity considerations being addressed in the Waste Management Programmatic Environmental Impact Statement (WMPEIS)/Record of Decision (ROD). The option chosen by the IEC was identified by the team as a technically feasible alternative to the BCL to Hanford option.

Figure 4 presents the results of the evaluation (which typifies the graphic summaries prepared for all of the alternatives for the other small quantity site *marriages*).

Figure 4. Summary overview of results of evaluation of BCL alternatives



Energy Technology Engineering Center

Development and implementation of a TRU waste certification program at ETEC using mobile vendor services with subsequent shipment to WIPP was evaluated as the baseline alternative. This approach was the most costly and time consuming, due to the requirements of certifying the waste at ETEC for shipment to WIPP. The technical expertise to perform TRU waste certification activities does not exist at ETEC. Using mobile vendors to characterize, package, and transport CH and RH TRU wastes has not been demonstrated. Shipping directly to WIPP does not meet ETEC's current schedule to remove the waste, which presents potential problems with the State of California and local stakeholders. The significant cost savings and the delay in removing the waste if it were to go directly to WIPP makes shipping to an interim site for processing the best option.

Alternatives to shipping ETEC TRU waste to these interim sites for processing and subsequent shipment to WIPP were evaluated as possible solutions to meet ETEC's waste removal milestone. All require negotiation with state regulators.

The evaluation showed that shipping the ETEC CH and RH TRU waste to Hanford would save the DOE approximately $4 to 27 M over shipping the waste directly to WIPP. ETEC's closure milestones could also be met. The ETEC waste is compatible with other waste forms being processed at Hanford, and ETEC is an approved Hanford waste generator.

The evaluation also indicated that shipping the CH and RH TRU waste to OR, INEEL, or LANL would save approximately $10 to 22 M over shipping directly to WIPP. However, ETEC's closure milestones could not be met with these alternatives. Cost differences and potential for not meeting the ETEC closure schedule led the team to recommend shipping the ETEC waste to Hanford.

Subsequent presentation of the recommendation to the IEC resulted in the IEC directing the team to pursue implementation planning of the ETEC RH waste to OR and the ETEC CH waste to the INEEL due to state equity considerations being addressed in the WMPEIS/ROD. The options chosen by the IEC were identified by the team as technically feasible alternatives to the ETEC to Hanford option.

Mound Plant

The evaluated baseline was to develop and implement a TRU waste certification program at Mound using mobile vendor services (MVS).

Best-case scenarios (early start dates) for this alternative resulted in failure to meet Mound's milestone to remove TRU waste by at least two years and relied almost entirely on undemonstrated MVS capabilities. The implementation cost for the 'direct ship to WIPP' alternative was estimated at $11 M.

Alternatives to ship Mound TRU waste to the INEEL or SRS for interim storage and processing for final disposition were evaluated as possible solutions to meet Mound's milestone to remove TRU waste. Both alternatives require negotiation with state regulatory authorities and rely on intersite shipments using railcars [Atomic Materials Rail Transfer (ATMX)]. Renewal of the ATMX railcar Department of Transportation (DOT) exemption and refurbishment of the existing railcars was considered achievable with minimal project risk based on current information from DOE's National Transportation Program personnel. Mound subject matter experts were confident ("80%") that the existing waste configuration (packaging) could be shipped in ATMX railcars using available characterization information (i.e., minimal repackaging and characterization will be required).

Both potential receiving sites are planning capabilities to process ^{238}Pu waste forms. The INEEL has permitted waste storage space available, whereas SRS requires a new storage pad to accommodate the Mound inventory. Costs for preparing the Mound waste for shipment and subsequent treatment at SRS range from $5.4 to $7.0 M. Costs for shipping Mound waste to the INEEL range from $1.6 to 1.8 M. Shipping Mound waste to either SRS or the INEEL meets the Mound closure schedule. The INEEL and SRS are currently storing Mound waste. The potential for not meeting the Mound closure schedule led the team to recommend shipping the Mound waste to SRS.

Subsequent presentation of the recommendation to the IEC resulted in the committee directing the team to pursue implementation planning of the Mound waste to the INEEL due to state equity considerations being addressed in the WMPEIS/ROD. The option chosen by the IEC was identified by the team as a technically feasible alternative to the Mound to SRS option.

University of Missouri Research Reactor

The evaluated baseline was to develop and implement a TRU waste certification program at MURR using mobile vendor services (MVS) as the baseline alternative. Best-case scenarios (early start dates) for this alternative resulted in failure to meet MURR's agreement to remove TRU waste by at least one year and relied almost entirely on undemonstrated MVS capabilities. Implementation cost for the 'direct ship to WIPP' alternative was estimated at $3 M.

Alternatives to ship MURR TRU waste to INEEL, Hanford, or LANL for interim storage and processing for final disposition were evaluated as possible solutions to meet MURR's agreement to remove TRU waste. All alternatives require negotiation with state regulatory authorities and rely on intersite shipments using a currently NRC-approved shipping container (i.e., the TRUPACT-II). The seven drums of MURR TRU waste have been characterized for shipment using TRUPACT-II. All potential receiving sites are planning capabilities to process similar waste forms. The INEEL and Hanford sites have permitted waste storage space available, whereas LANL requires a RCRA, Part B Permit modification prior to receiving mixed waste from off site. Cost differences and potential for further delaying the MURR closure schedule led the team to recommend shipping the MURR waste to Hanford.

Subsequent presentation of the recommendation to the IEC resulted in the committee directing the team to pursue implementation planning of the MURR waste to the INEEL owing to state equity considerations being addressed in the WMPEIS/ROD. The option chosen by the IEC was identified by the team as a technically feasible alternative to the MURR to Hanford option.

Risk

Studies conducted using the DOE Center for Risk Excellence Simplified Risk Model during the qualitative analysis indicated no impacts. These results were also deemed valid for the semi-quantitative analysis. There were also no differences in risk among the options.

Sensitivity Analysis

The team performed a sensitivity analysis on the criteria scoring, and the results clearly indicated that weighting the criteria would make no difference in the outcome of the 'direct ship to WIPP' alternative. 'Ship to WIPP' was always the least attractive alternative.

The results of the semi-quantitative analysis were documented in a REP for each of the four sites and a summary(2) was presented to the IEC. The IEC redirected which sites should be the receiving sites and approved proceeding with preparation of the implementation planning.

Implementation Planning

A series of meetings was held in September 1999 at the Battelle Columbus Laboratory (BCL) facilities at West Jefferson, Ohio to prepare opportunity formulation packages (i.e., implementation plans). Participants included representatives from the four small-quantity sites that need to disposition their TRU waste, and the two receiving sites designated by the IEC for this waste. Subject matter experts (SMEs) from other sites also attended for peer review and to help build the plans. The participants looked at what activities are required to ship TRU waste from (a) Mound to the INEEL; (b) from BCL to OR; (3) ETEC RH TRU waste to OR; (4) ETEC CH TRU waste to the INEEEL; and (5) from MURR to the INEEL. The team developed logically linked, integrated schedules showing all key activities required to prepare the TRU waste for shipping to and processing at each receiving site, followed by shipment to the Waste Isolation Pilot Plant (WIPP) for final disposal. The integrated schedules also identified the costs associated with these activities and noted who were responsible for completing the activities on the schedule.

The meetings were very successful and developed realistic, supportable schedules to facilitate change control actions at each of the sites that will be shipping or receiving the TRU waste. The exchange of information by the site representatives in the workshop helped resolve potential problem areas rapidly and amicably. Peer review by the SMEs from other sites contributed valuable input based on actual experience at the other sites.

The results(3) from this work and from the analyses previously published lead to the conclusion that consolidating the wastes at the larger sites for processing and shipping to WIPP is the most cost-effective option. It is also the only path identified for these sites to meet their closure dates.

To implement the recommendations to send the TRU waste from these four sites to selected larger sites for processing and subsequent shipment to WIPP, the following barriers must be overcome:

- Receiving states must agree to receive the TRU waste from the particular small quantity sites
- DOE Headquarters must issue a Supplement to the TRU waste ROD to allow intersite shipments of SQS TRU waste
- Funding must be identified for the sending and receiving sites to support the preparation, shipment, receipt, and processing of the TRU waste
- RH TRU waste transportation issues (characterization, packaging, acceptance criteria) must be successfully resolved.

The path forward to implement these recommendations is as follows:

- The IEC must accept the implementation planning as a basis to complete change control packages at the sending and receiving sites
- The IEC must assign champions to complete the following actions, thereby initiating the path forward:
  - Process a TRU ROD Supplemental Analysis (DOE-HQ) providing for intersite shipments
  - Start negotiations with the states affected by transfer of the SQS TRU waste
  - Identify and make funding available to the sending and receiving sites to support any baseline changes that require additional funding

CONCLUSIONS

By developing a suite of alternatives and conducting an in-depth analysis, the team was able to weigh each solution against predetermined criteria and choose the optimal disposition pathway for these wastes. The definition and analysis was so complete that the subsequent addition of another decision-making criterion did not derail the effort, but rather led to the choice of another, technically defensible solution with no additional expenditure of effort and money. This paper describes the decision-making effort and process, showing how systems engineering processes lead to important solutions that remove barriers to waste disposition, accelerate cleanup and closure of DOE sites, and save significant money for the taxpayer.

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3. *Report on Small Quantity Sites Integrated Product Team Implementation Planning Meetings, Columbus Ohio, September 13-17, 1999 (Discussion Draft),* dated October 1999