ORNL/M-4693

OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

Feasibility Study for Processing ORNL Transuranic Waste in Existing and Modified Facilities

Management Summary
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MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL/M-4693

FEASIBILITY STUDY FOR PROCESSING ORNL TRANSURANIC WASTE IN EXISTING AND MODIFIED FACILITIES

MANAGEMENT SUMMARY

SEPTEMBER 15, 1995

Prepared for
Lockheed Martin Energy Systems, Inc.
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Forward

This independent Feasibility Study was commissioned by LMES, under DOE direction, in April 1995. The study evaluates the use of existing facilities at ORNL to process its legacy of transuranic waste. The study was performed by non-stakeholders in order to produce truly objective conclusions and recommendations.

The Management Summary is a brief standalone document which provides an overview of the project, its methods, and its conclusions. Volume I of the Feasibility Study is a technical summary and includes an introduction providing the purpose and scope, background information, a summary of approach, and conclusions. Following the introduction, descriptions are given of candidate transuranic waste processing processes and how they were selected. Important features of existing facilities evaluated by the study are then presented, including interfaces with the site infrastructure. Feasible alternatives of installing processes into facilities are shown. Preliminary assessments are made; methods of accomplishment are addressed, including business methods that may provide significant cost saving for the taxpayer; an overall assessment of processes, facilities, and compliance issues is made leading to selected strategies. Selected strategies for processing and disposing of the transuranic waste are detailed with schedules, cost estimates, life cycle cost estimates, uncertainties, and a summary of risks. Conclusions, both financial and for business models, are then drawn.

Volumes II through V are building specific and provide the details to support Volume I:

Volume II	Building 3517, Fission Product Develop Laboratory
Volume III	Building 3525, Irradiated-Fuel Evaluation Laboratory
Volume IV	Building 7860, New Hydrofracture Facility
Volume V	Building 7930, Thorium-Uranium Recycle Facility

Building 7877, Low Level Solidification Facility, was added to the Feasibility Study scope in August 1995 as a special case for in-liner cementation and is described as appropriate in Volume I and its appendix.

The TRU Waste Feasibility Study Project team; Parallax Incorporated, Delta-21 Resources Incorporated, and Foster Wheeler Environmental Corporation; takes this opportunity to thank all organizations and individuals providing technical information, without which this study could not have been completed. We are also thankful to the vendors and outside consultants that provided information and performed technical reviews to improve this study.

MANAGEMENT SUMMARY

1 INTRODUCTION

In April 1995, Lockheed Martin Energy Systems, Inc. (LMES), under the direction of the U.S. Department of Energy Oak Ridge Operations Office (DOE–ORO), chartered an independent study of the feasibility of using existing facilities to process transuranic (TRU) wastes* at the Oak Ridge National Laboratory (ORNL). Such waste will be processed for shipment and long-term storage at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. The feasibility study was conducted to determine a cost-effective approach to complying with federal hazardous waste requirements and with commitments made to the Tennessee Department of Environment and Conservation in the *Proposed Site Treatment Plan for the Oak Ridge Reservation*. This report describes the existing waste-processing facilities and technologies considered, the business management methods evaluated for cost-effectiveness, processing schedules, life cycle cost estimates, and final recommendations.

The Oak Ridge National Laboratory, located 25 miles west of Knoxville, Tennessee, is operated for DOE by LMES. It has a legacy of over 50 years of TRU waste generation in connection with atomic energy and basic research. Generation of the waste, as both solids and sludge, began in 1944 when plutonium was first separated from irradiated graphite reactor fuel as part of the Manhattan Project, and it continues under the current mission of the laboratory. The TRU solid waste encompasses materials from gloveboxes, hot cells, reactors, and fuel reprocessing, and consists of cloth, paper, glass, rubber, plastic, and metal. TRU sludge is processing and research waste contained in storage tanks.

Shipment of ORNL transuranic waste to WIPP is scheduled to begin in 2002, and that waste must meet established WIPP waste acceptance criteria (WIPP WAC). It must also meet the Resource Conservation and Recovery Act Land Disposal Restrictions (RCRA LDR), whether or not WIPP disposal is an available option. In its present state, the retrievable TRU waste at ORNL meets neither the WIPP criteria nor the LDR and thus must be converted to a form that does (Fig. 1.1).

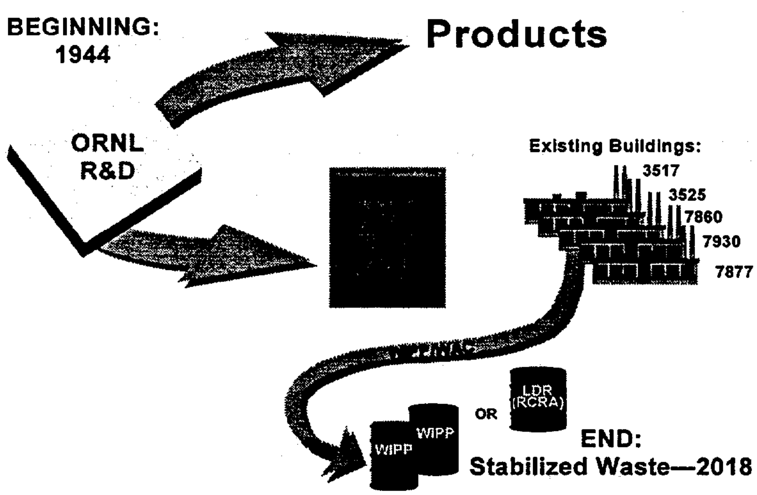

Fig. 1.1 ORNL TRU waste production and processing overview

Originally, DOE planned to construct a new plant for the on-site processing and final disposal of TRU waste. Given projected life cycle costs exceeding $1 billion, however, the DOE turned its attention to the evaluation of less expensive alternatives. The feasibility

*Transuranic waste is defined as radioactive waste that, at the time of assay has concentrations higher than 100 nCi/g of alpha-emitting radionuclides—i.e., radionuclides with atomic numbers greater than 92 and half-lives greater than 20 years. Such waste is further classified in terms of the dose rate at the surface of the container: "contact-handled" if the rate is less than or equal to 200 mrem/h, and "remotely handled" if it is higher.

study that is the subject of this report involved an extensive investigation of alternatives to the new facility, including over 20 waste processing technologies (Table 1.1) and five existing ORNL facilities. One requirement of the technologies evaluated was a capability for processing TRU waste for shipment to WIPP within the 16-year period from 2002 through 2018. Facilities selected for life cycle cost evaluations in connection with the selected TRU waste-processing options included Buildings 3517, 3525, 7860, and 7930. A less-detailed evaluation was performed of TRU sludge solidification using the existing waste tank supernate processing equipment and techniques at Building 7877 to solidify TRU sludge.

The impact of management strategies was an essential part of the feasibility study. Business strategies evaluated include (1) a modified line item approach (implementing building modifications deemed "necessary and sufficient") that was used as the baseline for the life cycle cost estimates, (2) a "best business practices" approach within the line item method, and (3) innovative strategies such as partnering with the Management and Operating (M&O) contractor and privatizing the waste management activity. Risks and uncertainties identified during the study were also evaluated for their likely impact on mission cost, safety, schedule, and overall success.

Table 1.1 Technology Candidates

RH Sludge Solidification Technology Candidates
Non-thermal Processes
Cementation (Grouting)
Aquaset
Thermal Processes
Bitumen Solidification
Joule-Heated Vitrification
Microwave Vitrification
Plasma Arc Vitrification
Ceramic Vitrification
Glass-Ceramic Vitrification
In-can Glass Melting
Catalytic Extraction Process
Cermet
Supercalcine Hot Isostatic Pressing
Synroc Hot Isostatic Pressing
Titanate

The "most feasible" TRU waste-processing alternative emerging from the study entails the processing of remotely handled sludge by cementation in Building 7860, for which a new wing is required, and processing remotely handled and contact-handled solids by sorting and compaction in Building 7930. Assuming DOE pursues its traditional line item approach to large capital projects, the estimated total life cycle cost for that combination of facilities and technologies is $226 million net present value ($693 million escalated). Partnering, privatization, or other innovative business practices yield additional cost savings estimated to exceed 50%. The selected technologies meet the goal of economically processing the ORNL transuranic waste into a final waste form that meets both the WIPP WAC and the RCRA LDR. Their application also creates no unreasonable risks to human health and safety or to the environment.

2 PURPOSE AND SCOPE

The purpose of the study was to determine the most feasible and cost-effective combinations of existing buildings and technologies for preparing TRU wastes stored at ORNL for shipment to, and long-term storage at, WIPP. Specific objectives were as follows:

- Establish the feasibility of using existing ORNL facilities for processing TRU waste and determine the modifications and additions necessary to accommodate the processes selected, taking into account environmental, safety and health, and regulatory compliance issues.

- Assess alternative-process flowsheets and recommend the process flowsheets and equipment that have the highest potential for meeting the schedule for shipment of TRU waste to WIPP.

- Provide a cost estimate for alternative-process flowsheets, facilities, and modifications, as well as data and information on the business strategies, uncertainties and risks associated with the costs, and the probability for success of the processes and equipment.

- Provide a basis for proceeding with the conceptual design of any of the alternatives addressed that can meet the required schedule. Include information on the basic layouts of facilities, a specification of modifications, basic process flowsheets, and functional specifications for process equipment.

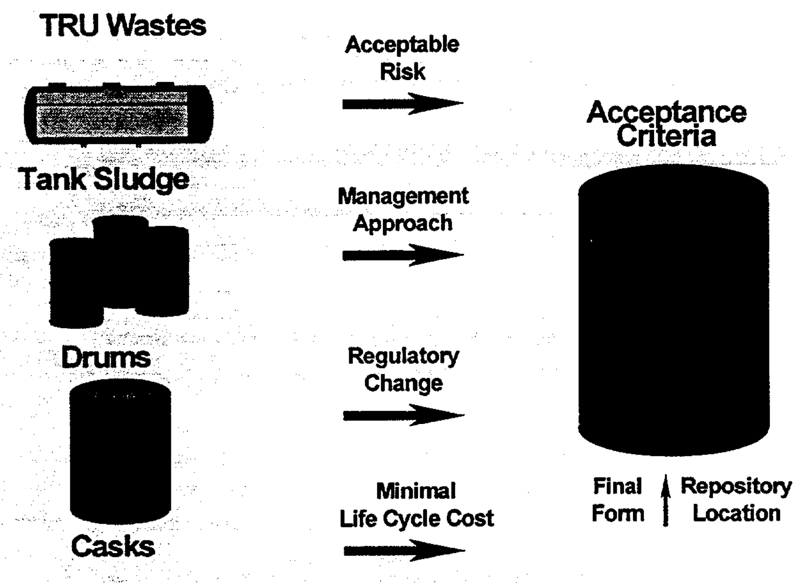

Fig. 2.1 ORNL TRU waste project challenges

Three types of TRU waste stored at ORNL were included in the study: (1) remotely handled TRU waste sludge, approximately 225,000 gal of which are stored in eight 50,000-gal Melton Valley Storage Tanks (MVSTs) and five 50,000-gal Bethel Valley Evaporator Storage Tanks (BVESTs); (2) remotely handled solid TRU waste, which is stored or buried in approximately 300 concrete casks, two 55-gal drums, and 13 wooden boxes in Solid Waste Storage Area 5 (SWSA 5); and (3) contact-handled TRU waste solids, which are stored in approximately 2,600 55-gal drums and 60 boxes (Fig. 2.1).

Four existing ORNL buildings were originally considered: (1) Building 3517, the Fission Product Development Laboratory; (2) Building 3525, the Irradiated-Fuel Evaluation Laboratory; (3) Building 7860, the New Hydrofracture Facility; and (4) Building 7930, the Thorium-Uranium Recycle Facility. Building 7877, the Low-Level Waste Solidification Facility, was added after the study was begun specifically to allow for evaluation of the feasibility of an in-liner cementation process for TRU sludge.

Over 20 potential TRU waste–processing technologies were evaluated. While many of these processes yield final waste forms that meet the WIPP WAC, only those resulting in final waste forms that also meet the more restrictive RCRA LDR were deemed viable for this project. Such waste forms would be acceptable for disposal in other locations should WIPP become unavailable.

With the application of weighted selection criteria, the list of potential technologies was ultimately reduced to four for detailed evaluation: (1) Joule-heated and plasma arc vitrification of solids (advanced thermal), (2) Joule-heated and plasma arc vitrification of sludge (advanced thermal), (3) cementation of sludge (non-thermal), and (4) sorting and compaction of solids (non-thermal). The feasibility of these technologies was evaluated in detail for each existing building selected.

Several major changes in scope occurred during the study. Included were (1) addition of the requirement that the final waste package meet the RCRA LDR, (2) the addition of Building 7877 and its existing waste treatment process, and (3) the added requirement of a life cycle benefit-cost-risk analysis of each TRU waste–processing option.

The scope was bounded by several constraints and assumptions imposed during the study by LMES, DOE, and the Project Team. Major constraints and assumptions are shown in Table 2.1.

Table 2.1 Project Constraints and Assumptions

Constraints	Assumptions
DOE Orders and LMES standards were used as guidance, or the need for sensible application was identified	The DOE philosophy of "necessary and sufficient" was assumed to apply to the interpretation of DOE Orders and applicable regulations.
WIPP is the ultimate repository for all TRU waste generated at ORNL.	The isotopic and physical characterization of stored TRU waste was assumed to be accurate for the basis of design and estimating.
Final TRU waste composition and packaging must meet the WIPP WAC.	Appropriate shipping casks and containers will be available for the shipment of remotely handled TRU waste.
TRU waste-processing options must allow for processing and shipment to WIPP during a 16-year period 2002 to 2018.	The processing sequence will be (1) remotely handled TRU sludge, (2) contact-handled TRU solids, and (3) remotely handled TRU solids.
Final TRU waste composition and packaging must meet RCRA LDR.	The inventory of existing TRU waste will be processed within the scope of this project; newly generated TRU waste will be processed by the generator.
The TRUPACT–II shipping containers will be used to transport contact-handled solid TRU waste.	Existing facility design information is correct although not all of the facilities had complete facility design information, Safety Analysis Reports, and drawings.

3 METHOD

Achieving the primary objective of this study—determination of the most feasible and cost-effective methods for preparing TRU waste for shipment to the WIPP—involved analytical activities along three separate paths, as shown in Fig. 3.1. These paths included (1) an evaluation of TRU waste–processing technologies; (2) an assessment of selected existing facilities and necessary modifications; and (3) an evaluation of associated risks, hazards, and regulatory compliance. The results of these analytical elements were used as inputs to the cost estimates and final feasibility determinations.

Analytical activities began with process selection, with initial efforts focused on evaluating the merits of approximately 20 candidate technologies for treating TRU waste. Overall, more than 250 vendors of these technologies were contacted, technical documentation was extensively reviewed, other DOE facilities were contacted, and DOE studies were reviewed for information on the operating performance of each technology. These technologies were evaluated against comprehensive screening and selection criteria to determine which warranted detailed evaluation.

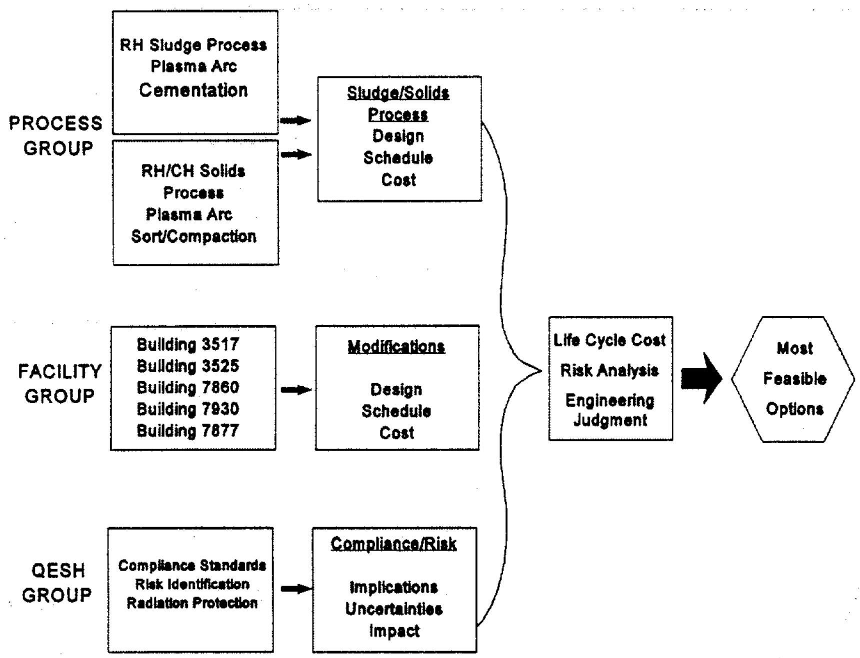

Fig. 3.1 Analytical Process

This was followed by a review and analysis of Buildings 3517, 3525, 7860, and 7930. The piping, instrumentation, utilities, and existing infrastructure of each building were evaluated to determine the modifications necessary to support TRU waste processing. Overall, the facility analysis provided a snapshot of each building with regard to its condition, structure, assets, and liabilities.

A thorough evaluation of the risks and hazards associated with TRU waste processing was the third part of the analyses. This task involved documentation of the philosophy according to which DOE Orders pertaining to human health and safety and environmental issues are addressed.

As the leading technologies for waste processing were identified, general design concepts including sketches, estimates, and process flow diagrams were prepared. Each building under consideration was evaluated to determine how it would accommodate each of the selected technologies. Attention was directed not only to the prospects for building additions and other modifications, but also the possibilities for modifying the process itself to meet the constraints imposed by the building.

Once process and building designs were completed, detailed estimates were prepared based on bills of materials using LMES's Automated Estimating System software. These estimates were developed according to a project-specific work breakdown structure which provided a framework for the documentation of project activities. To allow for the development of usable and defensible cost estimates, technical and cost assumptions were documented. The assumptions were based on vendor quotes, recent and similar job histories, nationally recognized publications, and LMES and DOE guidance documents. It was necessary to identify all major equipment and materials necessary for building modifications (i.e., structural, electrical, and mechanical), radiation protection, confinement, environmental compliance, decontamination and decommissioning, operations and maintenance, solid waste retrieval, sludge mobilization, on- and off-site transportation, and interim storage. Also supplied and factored in were wage rates, labor categories, material and labor pricing, personnel training and safety requirement costs, safety inspections, allowances for Occupational Safety and Health Administration (OSHA) compliance, indirect markups, escalation, and LMES site overhead and contingency costs.

Cost estimates were integrated with schedules to form detailed life cycle cost estimates for each processing alternative within each building and for selected combinations of processes thought to represent the most economical and viable options. The baseline scenario used to estimate life cycle costs follows the traditional DOE line item approach to large capital projects, with the exception of costs associated with DOE 6430.1A natural phenomena upgrades. The costs associated with modifying the process buildings to meet natural phenomena event qualification under DOE 6430.1A are not included because structural reinforcements to the buildings were deemed to be unnecessary in keeping with the "necessary and sufficient" philosophy of risk response.

4 TECHNICAL EVALUATION

The technical evaluation involved an extensive investigation of TRU waste–processing technologies, retrieval, mobilization, interim storage and transportation options, and the assessment of existing ORNL facilities. Waste-processing technologies were evaluated and the feasibility of their incorporation in selected buildings assessed. The technical evaluation encompassed the basic process flows shown in Fig. 4.1.

4.1 Most Feasible TRU Waste- Processing Technologies

The feasibility study entailed technical evaluation of a number of technologies for processing TRU waste: Aquaset, bitumen solidification, grouting, polymer encapsulation, fluetap concrete, molten salts, cermet, marbles in lead, the catalytic extraction process, hot pressing (Synroc and supercalcine), titanate, and various methods of vitrification. Final selection of candidate processes involved the application of specific screening criteria (Fig. 4.2). Although many of the technologies reviewed yield a final waste form that meets the WIPP WAC, only those whose

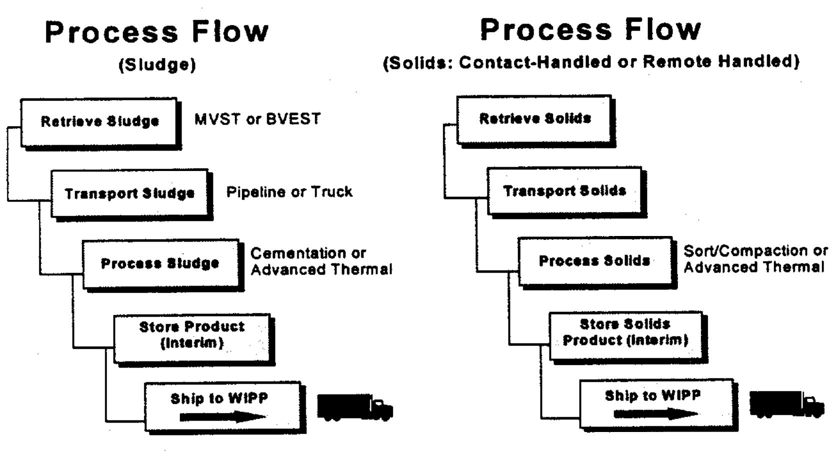

Fig. 4.1 ORNL TRU waste process flow

final waste form also meets the more restrictive RCRA LDR were deemed viable.

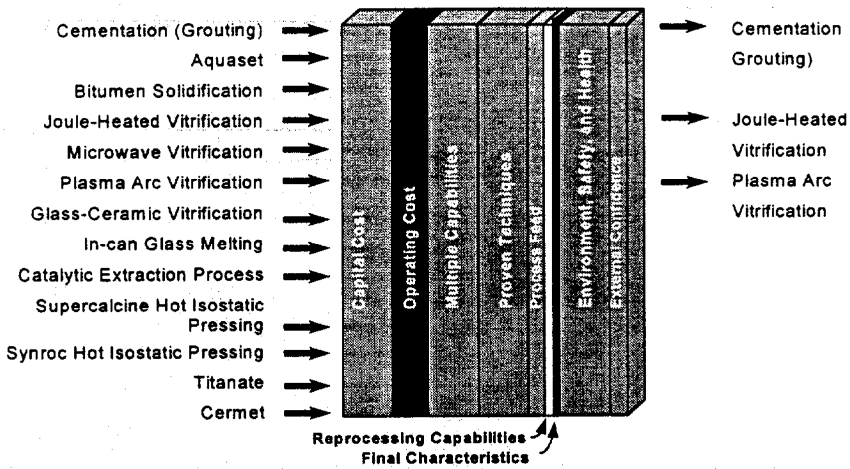

Fig. 4.2 Remote handled sludge technology screening process

Such waste will also be acceptable for disposal in other locations if the WIPP is unavailable. Selective weighting criteria included capital, operating, transportation, and storage costs; health and safety requirements; the ability to process various waste forms; the extent of development; and reprocessing capabilities. Use of these criteria allowed the team to narrow an extensive list of candidate technologies down to a manageable number, which could then be evaluated in greater detail.

Ultimately, four TRU waste–processing technologies were selected for detailed evaluation: (1) Joule-heated or plasma arc vitrification of sludge (advanced thermal), (2) Joule-heated or plasma arc vitrification of solids (advanced thermal), (3) cementation of sludge (non-thermal), and (4) sorting and compaction of solids (non-thermal). The feasibility of the potential TRU waste–processing technologies was evaluated in detail for each existing building selected.

Solidification of Remotely Handled Sludge by Cementation

Given its simple design, low operating cost, and reliability, solidification of remotely handled sludge by cementation is feasible and attractive. In addition to advantages in terms of materials involved, energy requirements, and overall cost, the cementation process is performed under ambient atmospheric conditions,and eliminating the need for an extensive off-gas systems. Moreover, that process has been proven in numerous other facilities around the world.

In the cementation process, feed tanks are filled with sludge and analyzed in a batch process manner. The analyzed sludge is treated, mixed with a prepared dry blend, and transferred to drum liners for solidification. Implementing cementation, however, requires a thorough determination of the TRU sludge chemistry at the tanks and testing of the final waste form to verify that it meets WIPP WAC and RCRA LDR.

Solidification of Remotely Handled Sludge by Advanced Thermal Processing

Solidification of waste through the use of the advanced thermal process is currently practiced overseas. Several advanced thermal facilities are also under construction within this country.

The advanced thermal processes addressed in this study are Joule-heated glass vitrification and plasma arc vitrification. For purposes of sludge processing the two are similar, except for the type of furnace and the temperature used to melt the waste and additives. Advanced thermal processing includes a molten bath consisting of the waste and glass-forming additives. It incorporates additive tanks, a furnace, and an extensive off-gas system.

Advanced thermal processing will require process formulation testing. Further development of the off-gas system contingent on the quantities of volatile metals, organics, and nitrates will also be necessary.

Processing of Solids by Sorting/Compaction

For non-thermal solids processing, a sorting and compaction process for the repackaging of remotely and contact handled solid wastes was selected. The non-thermal process for repackaging remotely handled solids consists of remote sorting to eliminate RCRA materials and size reduction by compaction. Remotely handled solids are unloaded from casks, radiographed for RCRA materials, sampled, sorted, placed in drums, and compacted. Unlike sludge processing, waste compaction does not provide a homogeneous form; consequently, waste characterization to ensure compliance with TRU requirements is vital.

The non-thermal process for repackaging contact-handled TRU solids is performed in gloveboxes and involves sorting, size reduction, and compaction to produce WIPP-acceptable waste packages.

Processing of Solids by Advanced Thermal

The high temperature of the advanced thermal process provides the melting necessary for treating remotely handled and contact-handled solids, and grinding is employed to make the incoming waste stream more homogeneous. While melting may alter the off-gas stream by introducing different elements in the exhaust gasses, the off-gasses can be effectively treated through secondary combustion, scrubbing, particle collection, and filtering.

4.2 Mobilization, Interim Storage, and Transportation Options

Processing of TRU waste at ORNL involves several operations. Remotely handled sludges, currently stored in tanks, must first be mobilized and transferred to the processing facility. Remotely handled solids must be retrieved from their burial sites and bunker storage locations and transported to the processing facility. Contact-handled TRU waste must only be trucked from its aboveground storage locations to the processing facility. After the waste is converted into a form acceptable for WIPP, it will be transferred to an on-site interim storage area pending shipment to WIPP (Fig. 4.3).

Sludge Mobilization And Removal Options

More than 20 sludge mobilization and removal options were examined in the study. The recommended mobilization process is similar to "hydraulic mining"; the sludge is impacted by a high-kinetic-energy liquid jet to transport it through piping to its processing location. That process incorporates a 2,000-gal/min mixer pump with a high-kinetic-energy sluicing nozzle. Located above the liquid level, the nozzle has the ability to provide a forceful liquid impact to mobilize the sludge. A closed-circuit television with an infrared lighting system permits supervision of the sluicing operations. This recommended sludge mobilization method is based on the process that was used successfully to mobilize the same type of sludge in the gunite tanks at ORNL in 1984.

Sludge Transportation Options

The study focused on three options for the transfer of sludges from the tanks to the treatment facility and the return of supernate to the tank: the use of existing pipelines, the installation of new pipelines, and trucking. New pipelines are recommended because of the regulatory concerns associated with trucking.

Solids Retrieval and Transportation

Contact-handled drums and boxes are stored in various buildings in SWSAs 5, 6, and 7 and near the Radiochemical Engineering Development Center. All are readily accessible and can be removed with minimal effort using a small forklift or other drum-handling equipment. Existing transportation procedures and equipment will be used to deliver the approximately 2,600 drums to the facility selected for contact-handled TRU waste processing.

Solids Waste Storage Area 5 contains approximately 315 containers of remotely handled solid waste. Approximately 100 of these are casks in Storage Bunker 7855 that can be removed using a fork truck. The remaining containers, the majority of which are also casks, are buried in earthen trenches. Radiological sampling prior to excavation will determine whether shielded, manually operated equipment or remotely operated excavation equipment will be required. The area will be enclosed within a portable, temporary structure in order to protect the environment and allow for continued operation during inclement weather. The exteriors of the casks will be cleaned and the casks transported in an overpack to the processing facility. B–25 boxes and shielded overpacks will be used for any containers with questionable integrity.

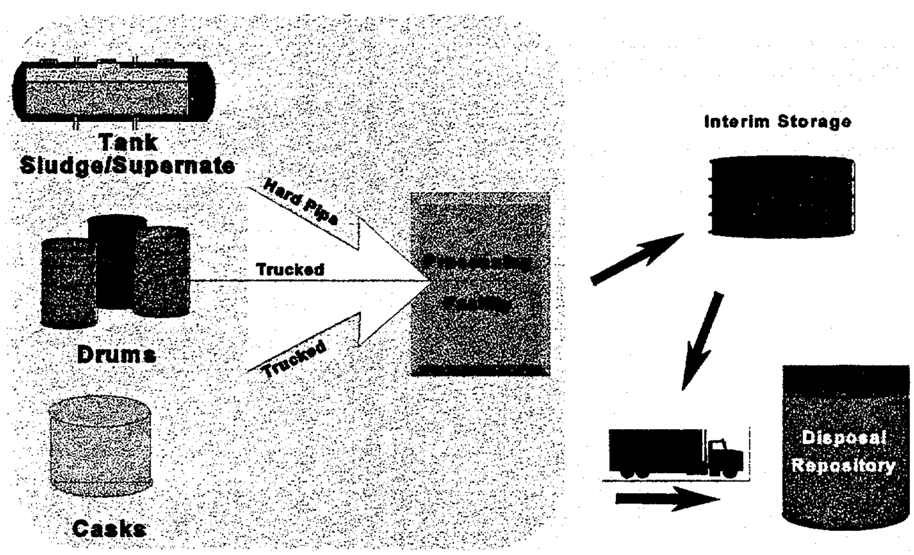

Fig. 4.3 Transport and storage

Interim Storage

Interim storage of the solidified waste is required because the processing rate for the selected technologies exceeds WIPP's ability to receive shipments. Since volume reduction of contact-handled TRU waste is accomplished through compaction, such waste can be returned to its original storage location. Existing bunker storage of remotely handled TRU solids is adequate and will be used for its interim storage. A cost estimate for a new bunker-type interim storage facility for remotely handled TRU sludge drums was developed as part of the feasibility study.

4.3 Facilities Assessment

The facilities included in the initial scope of this study are Building 3517, the Fission Product Development Laboratory; Building 3525, the Irradiated-Fuel Evaluation Laboratory; Building 7860, the New Hydrofracture Facility; and Building 7930, the Thorium-Uranium Recycle Facility. Building 7877, the Low Level Solidification Facility, was added late in the study to allow for the consideration of another attractive processing scenario for remotely handled TRU sludge (Fig. 4.4).

During the facilities assessment, each building was evaluated to determine the extent and nature of the modifications required for processing remotely handled TRU sludges and contact-handled and remotely handled TRU solids. These evaluations were based on a review of building design documents, drawings, previous technical evaluations, and interviews with engineers and operations personnel familiar with these facilities. Also reviewed was the support infrastructure—e.g., roads, utilities, facilities—for each building.

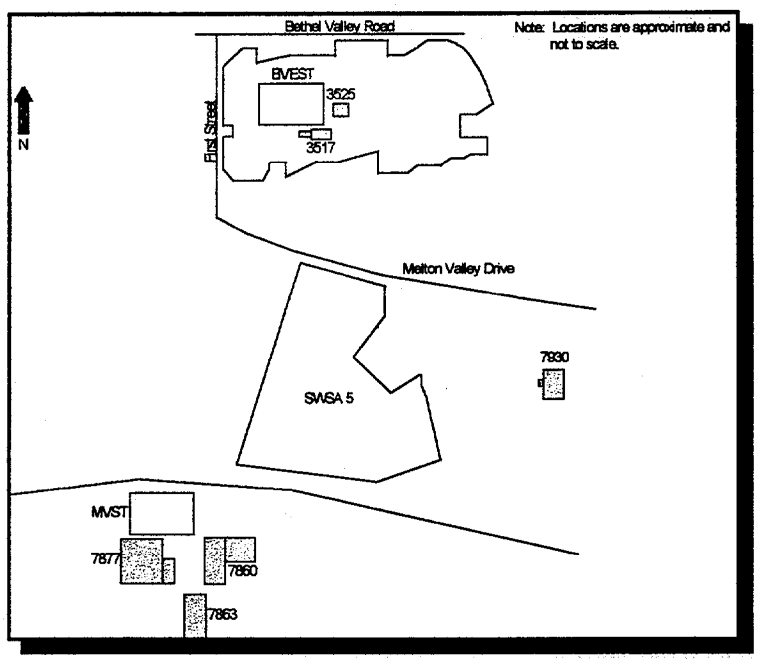

Figure 4.4 Building locations at ORNL

Table 4.1 provides comparative data on specific activities required to support TRU waste processing in each building. Review of the cost estimates reveals that for each building the costs for construction and modification are of the same order of magnitude and that such costs do not dominate total project costs. This indicates that total life cycle cost may not be the sole determinant of the selection of either process or building. Other considerations include confidence in the ability to effectively operate and maintain the process equipment, the degree of regulatory and safety risk deemed acceptable, the risk of discovery of additional faults and adverse conditions, proximity to the waste, and the impact on other ORNL missions.

Table 4.1 Building Comparisons

Building Specific Activities	3517	3525	7860	7930	7877
Decon Cells	YES	YES	NO	NO	Minor
Remove Existing Equipment	YES	YES	Minor	NO	Minor
New Pipeline	YES	YES	Short	YES	Short
Structural Mods	NO	YES	New Wing	NO	NO
HVAC Mods	YES	YES	YES	YES	Minimal
Process Equipment	YES	YES	YES	YES	Minimal

Results of the specific building assessments are as follows. A comparison of factors impacting the feasibility of the waste processes in each building is provided as Table 4.2.

Building 3517. With some modifications, all processes can be fitted into Building 3517. However, space limitations leave little room for operations and maintenance activities. To overcome this condition, several options for the placement of process equipment were investigated: (1) the north cell bank, (2) the second floor mezzanine area, and (3) because of shielding and space considerations, a combination of these areas involving a hybrid equipment layout. The hybrid arrangement involves locating equipment containing radioactive material within the shielded hot cells and equipment containing nonradioactive material on the second floor. This building is not recommended because of the numerous modifications required, its congested location, and risks of discovery of additional faults and conditions which could increase costs.

Building 3525. Even with extensive modifications, the resulting configuration in Building 3525 entails the least amount of space for waste processing. With the exception of the glovebox processing and compaction of contact-handled solids on the second floor, all other processes studied are limited in space. The space limitations jeopardize the capability to maintain the equipment for processing TRU wastes. Because of the numerous modifications required, its congested location, and risks of discovery of additional faults and conditions which could increase costs, the use of Building 3525 is not recommended.

Building 7860. The main advantage of Building 7860 is its immediate proximity to the MVSTs. One difficulty, however, is that unlike Buildings 3517, 3525, and 7930, it does not have an enclosed upper level for locating process equipment. This condition in addition to low cell height, limited cell area, and other space limitations, make processing in the existing cells of Building 7860 impractical. As indicated in the study, adaptation and modification of the building for this purpose requires as much if not more effort as the addition of a new wing. Under the new wing option, most of the existing building is devoted to the electrical equipment room, control room, air compressors, diesel generator area, and change rooms. The new wing option for Building 7860 is recommended for any of the selected TRU waste processes.

Building 7930. Building 7930 is an excellent candidate facility for any of the baseline processes evaluated because of its current condition, space availability, and other attributes. The major disadvantage is a need for lengthy pipelines to transport slurried, remotely handled sludge from the MVSTs to the building and returning decanted supernate to the MVSTs. Of the buildings studied, Building 7930 is closest in its as-built configuration to complying with DOE 6430.1A. As indicated by the study, Building 7930 requires only minimal modification and thus is a practical choice for TRU waste processing.

Table 4.2 Process and Building Analysis

Building	Advanced Thermal RH Sludge/Solids	Non-thermal (Grout) RH Sludge	Non-thermal Compaction RH/CH Solids
3517	Long pipeline Process barely fits Significant mods required Extensive decon, Congested area High risk of discovery Exceptions to DOE 6430.1A required.	Long pipeline, fits in-cell (with extensive mods and decon), can fit on second level with extensive shielding, congested area, high risk of discovery. Exceptions to DOE 6430.1A required	Fits in-cell (with extensive mods and decon) or on second floor with extensive shielding. CH Solids (only) can be processed on second floor within glovebox. Exceptions to DOE 6430.1A required.
3525	Uncertain if space is sufficient for effective Ops & Maint, congested area, not well suited, high risk of discovery, exception to DOE 6430.1A required. Significant mods needed, long pipeline, extensive decon	Uncertain if space is sufficient for effective operations and maintenance, congested area, high risk of discovery, not well suited. Long pipeline, fits in-cell (with extensive mods and decon), structural mods and excavation within building.	CH Solids (only) can be processed on second floor within glovebox. RH Solids extensive mods required, not well suited.
7860	Requires major addition. Adjacent to tanks, good location. Addition complies with DOE 6430.1A. No decon required. Short pipeline needed	Adjacent to tanks, good location. 1)In-cell with extensive mods and decon, very tight Ops & Maint; or 2) Major addition. Addition complies with DOE 6430.1A. No decon required. Short pipeline needed.	Requires major addition. Not acceptable in existing building. Addition complies with DOE 6430.1A.
7930	Long pipeline required. Excellent facility, no decon, closest to meeting DOE 6430.1A. Sufficient space for Ops & Maint.	Long pipeline required. Excellent facility, no decon, closest to meeting DOE 6430.1A . Sufficient space for Ops & Maint.	Excellent facility, start with clean cells, sufficient space for Ops & Maint., closest to meeting DOE 6430.1A .

Building	Advanced Thermal RH Sludge/Solids	Non-thermal (Grout) RH Sludge	Non-thermal Compaction RH/CH Solids
7877	Not considered.	Promising facility, process similar to existing, adjacent to tanks, short pipeline and shielding needed. Cannot meet DOE 6430.1A.	Not considered.

Building 7877. After initiation of the study, its scope was increased to include consideration of the use of Building 7877 in conjunction with Building 7863 for the processing of remotely handled sludges. A major advantage of Building 7877 is its proximity to the MVSTs. It is also currently used to process decanted supernate from the MVSTs that contain remotely handled sludges. Should Building 7877 be used, modifications will include a short pipeline sized to transport the sludge in a slurry; additional shielding; additional heating, ventilation, and air conditioning; and confinement. The use of this building has promise of significant cost savings and privatization. The study recommends that further development of this option be included in later project phases.

5 SCHEDULES, COST ESTIMATES, AND BUSINESS APPROACHES

The study produced detailed schedules and cost estimates for the alternatives using a baseline case that reflects the traditional DOE line-item approach to managing large capital projects. However, the baseline cost estimates include only building modifications deemed "necessary and sufficient." Accordingly, the baseline case entails saving funds through the avoidance of modifications that might have been adopted under a more rigid application of orders and standards. Also considered in the study was a range of business approaches from the best business practices to privatization with private financing. The cost savings that can be obtained through alternative business strategies range from about 25% for best business practices to more than 50% for partnering or privatization.

5.1 Project Schedules

As part of the study, schedules were developed for each of the building process configurations. All the schedules are based on the traditional line item approach to funding and assume a FY 1996 start for technology demonstration and conceptual design activities. They further assume a beginning of capital expenditures in FY 1998 and an end to waste processing by 2018. After processing ends, the facility or facilities will be decontaminated. Non-thermal sludge processing involves three shifts and a 5-day work week; non-thermal solids processing involves one shift and a 5-day work week; advanced thermal processing requires four shifts and a 7-day work week.

Each schedule was developed using project management software, and each was electronically interfaced with the appropriate cost estimate as it was being developed in the LMES cost-estimating system to ensure consistency between the two documents. A work breakdown structure was created and used to link the schedules and cost estimates. Each estimate and schedule conforms to the WIPP shipping window of 2002 through 2018.

The schedules are for a well-managed line item project that receives adequate and timely support from the operations budget. Delays in approvals throughout the project will extend the project period. Other business approaches might accelerate the project, especially if the number of bid and proposal cycles can be reduced. Greater privatization of the business strategy could increase the complexity of qualifying vendors and developing proper procurement documents and thereby lengthen the project; however, it could also be expected to shorten its design, construction, and operational phases, and thus to reduce the schedule and costs.

5.2 Cost Estimate and Analysis

Line item cost estimates were prepared for all selected processing and building alternatives. Table 5.1 at the end of this volume presents the estimates for the five processes and four buildings. This table of estimates reflects the costs according to the work breakdown structure, which is based on phases of the proposed project and the principal functions of a line item project and segregates overhead and contingency.

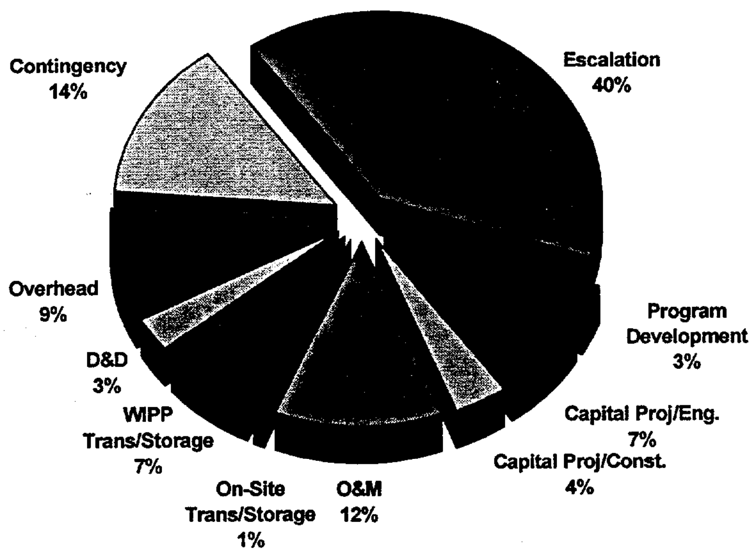

Figure 5.1 TRU waste processing LCC components by percent

Table 5.2 represents a summary of the life cycle costs for sludge processing only (LCC-A-1 through 8) and combinations of sludge and solids processing (LCC-B-1 through 20). Included in this table are figures of merit for net present value (ORO only and DOE total), initial costs, and peak year funding. Using these figures of merit it was determined that LCC-B-16, non-thermal sludge processing (cementation) in Building 7860 and solids processing by sorting/compaction in Building 7930, had the lowest life cycle costs based on net present value for ORO and DOE as well as a favorable initial cost figure of merit. A summary of the distribution of costs for processing RH sludge by cementation in Building 7860 and CH/RH solids by sorting/compaction in Building 7930 is presented as Fig. 5.1.

The life cycle cost estimates reflect large overhead, escalation, and contingency costs. In fact, these three categories account for more than 60% of the project's total cost. Building modification costs, by comparison, account for less than 10% of the total. Costs for building modification are sizeable—e.g., between $25 and $75 million for cementation—and should affect any decision about which building is used as a TRU waste–processing facility. The significance of such costs, however, can only be judged against the overall cost estimate of $700 million (escalated).

Following is an explanation of the significant figures in Table 5.2, Summary Table of Life Cycle Cost:

- "Present value" is the value of future costs discounted to 1995.
- Cost/benefit is expressed as $1,000 per cubic meter of processed waste or as shipped waste product.
- "Initial cost" is for the cost of those scenario activities that will occur in the immediate future.
- The difference between "ORO only" and "Total DOE" in the last two columns is the cost of shipping the wastes to WIPP and WIPP disposal costs.

5.3 Business Strategies

Three business strategies for processing the TRU waste stored at ORNL were considered. Included are the traditional DOE approach to large capital projects, a best business practices approach using the same participants as the traditional approach, and innovative strategies that involve partnering and privatization. The first two assume that Congress will fund the project through line item appropriations; the third is broad enough to include private financing.

The traditional DOE approach to large projects is to operate a line item project in which the DOE delegates responsibilities to its prime contractors and integrates the project activities itself. For its facilities on the Oak Ridge Site, the DOE has used the M&O contractor, an architect-engineering firm, and the construction management contractor. Any of these firms can contract as appropriate to accomplish necessary work, a condition that can result in costly overlap. This approach is the baseline for the estimates and schedules presented in the feasibility study. The exception to the traditional approach is that the "necessary and sufficient" philosophy is applied with respect to compliance with the natural phenomena and safety requirements of DOE Orders and standards.

In the best business practices model, systematic improvements are incorporated in the use of the line item as the funding mechanism for the project. The DOE designates one of the prime contractors, usually the M&O for the site, as the contractor responsible for the project, and other contractors—e.g., the architect-engineer, the construction manager—serve as subcontractors to the M&O contractor. The M&O contractor can contract out various phases of the work subject to the approval of DOE. DOE holds the M&O contractor accountable for performance of the entire project and has oversight responsibilities for the project. The cost savings are realized from the elimination of redundancies in personnel, unnecessary practices, and duplication of effort. The study indicated a potential cost savings of 15–20% over the conventional line item approach with improved business practices.

In their search for methods of reducing cost and yet meeting their program objectives, DOE and its contractors are considering the cost-minimizing strategies and streamlined business methods employed by the private sector. Contracting budgets and demands for increased productivity have created an atmosphere conducive to more innovative approaches to privatization. The study revealed that privatization of some facility construction projects has led to savings of 10–50% in construction costs and 10–30% in operational costs, and has accelerated facility construction schedules by as much as 30–50%. It also indicated that DOE could save more than 50% by privatizing the TRU waste retrieval and processing activities. All of these savings could be realized while maintaining sufficient attention to protection of the environment and the health and safety of workers and the public. It would require, however, a major redesign of the business approach by DOE and its contractors. To that end, certain business methods considered in the feasibility study deserve more thorough consideration.

The M&O contractor can also form a partnership with one or more speciality firms to process TRU waste. In such an arrangement, project work is accomplished with the resources of DOE, the M&O contractor, and at least one other firm under a (per-unit or full-scope) fixed-price contract with DOE. A partner or partners are typically selected through competitive bidding, which encourages a sense of shared risk and enhances the prospects for private financing.

Another innovative approach is for the DOE or M&O contractor to obtain a Design/Build/Operate (D/B/O) contractor through a new procurement. The D/B/O contractor performs all work related to process design and to the modification, construction and equipment installation, operation, and decontamination of the facility. The selected contractor is responsible to the M&O contractor for all phases of the project. This method differs from the partnership arrangement in that the D/B/O contractor is also responsible for project integration.

The third innovative strategy also entails privatization and private financing for on-site processing. By this method, the M&O contractor qualifies vendors for TRU waste processing and prepares and isolates a processing site. Through a bidding process, a company is selected to perform all aspects of the defined project. (It may be possible to divide the TRU waste–processing program into several projects providing opportunities to utilize the expertise of more than one company.)

5.4 Improved Business Methods

Substantial savings can be realized through any approach to contracting for TRU waste processing, given certain fundamental changes in the way DOE and the M&O contractor conduct business. The following are practical guidelines for achieving cost savings conducive to the goal of greater efficiency in DOE's environmental management program:

- Recognize and implement the DOE philosophy of "necessary and sufficient" with respect to DOE Orders. The project approach should be to develop a compliance plan that meets the applicable portions of DOE Orders and standards and is graded according to the hazards to be confronted.

- Reduce the number and shorten the time for all review processes (NEPA, QA, ES&H, ORR).

- Centralize decision-making authority and responsibility; for example, give the project manager contracting and procurement authority up to a minimum of $1 million.

- Define, and perhaps restrict, the authority of support groups not directly under the organization responsible for the project.

- Streamline procurement practices.

- Limit design requirements to what is necessary within the margins of safety codified by private industry.

- Limit construction inspection and review to the levels typical of private industry.

- Limit reporting requirements to those absolutely necessary to control the project.

6 UNCERTAINTIES THAT AFFECT THE PROJECT

The main uncertainties deriving from the study relate to characterization data on TRU waste streams, changing regulatory constraints, the acceptability of new business methods, and the level of risk acceptance.

Uncertainties in the characterization—isotopic, physical, and chemical—of TRU waste affect operations and maintenance costs, the retrieval method, processing options, and disposal locations. TRU waste streams at ORNL are not as yet fully characterized. Moreover, there are uncertainties in the characterization data available for TRU waste sludge. Isotopic data are based on best available samples obtained in single-point sampling of only 8 of the 13 BVESTs and MVSTs. Detailed physical data such as particle size, hardness, viscosity, and particle distribution are unknown. Chemical data on tank contents are not completely known. To a lesser extent, uncertainties also exist in available characterization data on TRU waste solids. Generally, data are available on the physical and radiological content of remotely and contact-handled TRU waste solids, but there are numerical disparities within this documentation.

Uncertainties in the actual isotopic concentrations of final waste forms affect interim storage, transportation, and final disposal costs. For cost-estimating purposes, the study assumes that all TRU waste will meet the WIPP WAC of greater than 100 nCi/g isotopic concentration. However, if the final waste is not greater than 100 nCi/g, it will have to be stored on-site until other disposal options are found. Based on existing information, only a few of the 13 tanks contain high enough isotopic concentrations to meet the WIPP WAC. Additionally, methods studied for sludge processing dilute isotope concentrations. Although sorting and compaction processes concentrate the isotopes by volume, they do not concentrate them by mass.

Another source of uncertainty is the evolutionary status of WIPP WAC, in particular the fact that the recommended requirements for remotely handled waste have not received final approval. There is also uncertainty associated with the possibility that WIPP may not open as scheduled.

Finally, uncertainty exists regarding the ultimate acceptability of the higher levels of risk associated with "necessary and sufficient" and "commercial approach" assumptions in the study. These risks fall into three broad categories: economic and financial risk, the risk to worker health of exposure to radionuclide or chemical contaminants, and human health and ecological risk posed by a release of the TRU material. DOE is in a process of transition to the use of "necessary and sufficient" concepts and more "commercial approaches" in its waste management activities. In the study, therefore, costs for structural reinforcements and modifications of the buildings required to meet general design criteria for natural phenomena are included only to the extent they are "necessary and sufficient." Commercial approaches such as privatization and partnering are only recently gaining acceptance in DOE.

7 CONCLUSIONS

Each of the buildings examined in this study are good candidates for TRU waste processing. Total cost estimates for use of the different buildings differ minimally. Given the extensive modifications required to fit waste-processing equipment into Buildings 3517 and 3525, however, and the location of these buildings in a congested area, the study concludes that Buildings 7860 and 7930 are the "most feasible" facilities for TRU waste processing at ORNL.

For simultaneous processing of sludge and solids within multiple buildings, the study concludes that a combination of cementation in Building 7860 and sorting and compaction in Building 7930 is the "most feasible" option as well as the most cost effective based on figures of merit from life cycle cost analysis. Cementation in Building 7860 is the best option for sludge, because of the building's proximity to the MVSTs, flexibility in layout for new additions, minimal risk of discovery, and proximity to RH storage areas. Sorting and compaction in Building 7930 is the best option for CH and RH solids processing because of the buildings existing physical and radiological condition, ease of access, existing infrastructure, and minimal modifications.

If DOE desires to accelerate its TRU waste sludge-processing schedule, then, according to the study, the use of Building 7877 pending modification of its existing processes is an option that merits investigation. Its application might result in dramatically reduced schedules for, and costs of, sludge processing.

The study describes a wide range of feasible options for TRU waste processing at ORNL. It also provides an independent basis for proceeding with the conceptual design of the "most feasible" options described in this report. Maximizing privatization and private financing, as described in the study, will result in substantial cost savings for any TRU waste-processing option considered. Nevertheless, substantial uncertainties with respect to the characterization of TRU waste streams could affect the results of the study. These uncertainties must be addressed during development, design, and procurement activity.

8 RECOMMENDATIONS

Results of the feasibility study suggest some immediate actions which could help expedite the resolution of the TRU waste problem at ORNL. Near-term activities should include the following:

1. Identify in detail the nuclear, chemical, and physical characteristics of the sludge in the 13 tanks of remotely handled TRU waste. Consider mixing all tank contents to establish a homogeneous waste stream that can be processed into TRU waste. Implement a mobilization test for remotely handled sludge. During this testing, cement (grout) formulation and chemistry can be validated.

2. Evaluate disposal options for non-TRU wastes that might be generated by the processes. Some of these wastes might be more hazardous than Class C waste.

3. Conduct a more detailed feasibility study for the in-liner cementation of remotely handled sludge in Building 7877. This option appears to have a potential for significant cost and schedule reduction.

4. Further characterize contact-handled TRU to separate suspect drums, potentially remotely handled, and characterize the burial ground for remotely handled solids in SWSA 5. Prepare privatization plan and specifications for CH TRU solids.

5. Consider with DOE regulators the interpretation of "necessary and sufficient" criteria with regard to natural phenomena and safety requirements of DOE Orders and standards.

6. Focus on "how" the work can best be accomplished, evaluate business methods with qualified vendors, concentrate on proven technology, and examine the use of on-site facilities in a partnering or privatization scenario.

Finally, DOE should expedite discussions with the State of Tennessee concerning the processing of TRU waste and the disposal of secondary wastes that will not be TRU per WIPP WAC. It should also reexamine the criteria to determine if the legislation or regulations should be changed to clarify the acceptance criteria and to reduce the analytical requirements associated with waste characterization.

Table 5.1
Transuranic Waste Feasibility Study, ORNL
Summary Of Cost Estimates ($1=$1000)
Escalated Totals

Building - Process	1.1.1 Program Mgmt.	1.1.2 Project Mgmt.	1.1.3 Pre-Title I Activities	1.2.1 Proj. Mgmt. Integration	1.2.2 Engr. Design	1.2.3 Const	1.3.1 Pre-Op Activities	1.3.2 Operations	1.3.3 Maint.	1.3.4 Transport & Storage	1.4.1 Transport To WIPP	1.4.2 WIPP Storage	1.4.3 Shipping Cask	1.5.* D&D	Overhead	Contingency	Totals
3517 Non Thermal RH Sludge's	9,261	4,157	9,057	31,390	17,869	31,621	9,892	28,301	15,021	7,995	0	0	0	16,121	52,725	87,086	320,496
3517 Non Thermal RH Solids	9,113	3,935	4,477	15,638	9,323	13,910	7,237	32,331	6,540	4,010	0	0	0	14,485	39,776	60,318	221,093
3517 Non Thermal CH Solids	4,755	2,043	1,227	4,513	3,468	1,325	6,246	23,056	3,682	3,626	0	0	0	3,913	23,125	29,829	110,808
3517 Advanced Thermal RH Sludge's	9,106	4,085	10,043	33,233	19,123	37,392	12,294	34,932	14,171	5,373	0	0	0	41,471	64,209	106,209	391,641
3517 Advanced Thermal RH/CH Solids	9,395	4,222	7,982	29,459	16,458	25,149	16,465	57,860	12,519	3,941	0	0	0	33,602	70,015	106,473	393,540
3525 Non Thermal RH Sludge's	9,261	4,156	9,102	31,447	17,920	31,869	9,914	31,052	15,251	9,410	0	0	0	15,976	54,728	89,787	329,873
3525 Non Thermal RH Solids	9,113	3,933	4,513	15,703	9,373	14,097	7,219	32,074	6,657	4,009	0	0	0	14,481	39,745	60,921	221,838
3525 Non Thermal CH Solids	4,769	2,043	1,247	4,556	3,493	1,433	6,457	16,796	3,429	3,072	0	0	0	3,919	20,131	25,966	97,311
3525 Advanced Thermal RH Sludge's	9,106	4,085	9,867	33,039	18,872	36,243	12,452	36,916	13,840	5,634	0	0	0	41,479	64,958	106,727	393,218
3525 Advanced Thermal RH/CH Solids	9,395	4,222	7,819	29,051	16,245	24,270	12,159	57,863	12,213	3,941	0	0	0	33,596	67,771	103,818	382,363
7930 Non Thermal RH Sludge's	9,261	4,157	9,032	31,210	17,839	31,472	9,914	31,052	14,519	8,381	0	0	0	16,131	53,844	87,107	323,919
7930 Non Thermal RH Solids	9,267	3,934	3,880	14,698	8,523	10,327	7,186	32,074	4,495	2,320	0	0	0	14,483	37,313	54,191	202,691
7930 Non Thermal CH Solids	4,769	2,043	1,147	4,187	3,369	882	6,266	14,532	3,429	3,618	0	0	0	3,919	19,148	24,403	91,712
7930 Advanced Thermal RH Sludge's	9,106	4,085	10,288	33,757	19,428	38,668	12,418	36,920	14,017	5,634	0	0	0	41,481	65,525	107,500	398,827
7930 Advanced Thermal RH/CH Solids	9,395	4,223	7,178	28,536	15,293	20,054	12,317	57,848	10,879	3,941	0	0	0	33,599	66,469	98,869	368,601
7860 Non Thermal RH Sludge's	9,261	4,156	8,426	30,374	17,026	28,058	9,897	30,875	13,747	8,426	0	0	0	16,121	52,745	83,350	312,462
7860 Non Thermal RH Solids	9,113	3,934	4,319	15,678	8,987	12,384	7,333	32,074	6,109	4,025	0	0	0	14,481	39,435	57,596	215,468
7860 Non Thermal CH Solids	4,769	2,043	1,754	5,578	4,068	3,961	6,281	15,147	4,688	3,603	0	0	0	3,919	20,847	27,817	104 475
7860 Advanced Thermal RH Sludge's	9,262	4,085	9,850	33,278	18,791	36,126	12,418	34,623	13,643	5,634	0	0	0	41,485	64,049	103,533	386,777
7860 Advanced Thermal RH/CH Solids	9,540	4,222	8,285	30,381	16,797	26,616	12,217	57,941	11,081	3,941	0	0	0	33,874	68,240	104,241	387,376
7860 In Cell Non-Thermal RH Sludge	14,078	6,515	8,005	29,224	16,083	23,857	7,425	72,316	36,944	11,504	0	0	0	24,332	86,035	125,553	461,871

* This WBS will vary according to the appropriate D&D for the processing activity.

Table 5.2
Summary Table of LCC
($x1000)

Life Cycle Cost Studies		Present Value Figures of Merit (1995)						Initial Cost Figures of Merit in Constant Dollars ($x1000)			Peak Year Funding Requirements in Escalated Dollars ($x1000)		Total LCC in Escalated Dollars ($x1000)	
		Life Cycle Cost ($x1000		Cost/Benefit $1000/m^3				WBS 1.1	WBS 1.2					
				Processed		Shipped								
		ORO Only	Total DOE	ORO Only	Total DOE	ORO Only	Total DOE	Prog Dev	Cap Proj	Total	Year	Amount	ORO Only	Total DOE
RH Sludge Only														
LCC-A-1	Advanced Thermal- Building 3517	182,327	191,238	371	389	476	499	36,301	107,491	143,792	2003	46,068	413,756	450,933
LCC-A-2	Advanced Thermal- Building 3525	182,469	191,380	371	390	476	500	36,003	105,698	141,701	2007	44,724	415,368	452,544
LCC-A-3	Advanced Thermal- Building 7860	179,447	188,358	365	383	468	492	36,196	104,204	140,400	2003	49,717	408,825	446,002
LCC-A-4	Advanced Thermal- Building 7930	185,951	194,862	378	397	485	509	36,713	109,355	146,068	2007	45,115	421,016	458,193
LCC-A-5	Non-Thermal - Building 3517	149,336	170,026	304	346	390	444	34,896	97,784	132,680	2009	35,837	327,391	413,695
LCC-A-6	Non-Thermal - Building 3525	152,526	173,216	310	353	398	452	34,972	98,274	133,246	2007	36,123	336,942	423,246
LCC-A-7	Non-Thermal - Building 7860	143,525	164,216	292	334	375	429	33,829	89,345	123,174	2003	37,922	319,279	405,583
LCC-A-8	Non-Thermal - Building 7930	150,240	170,930	306	348	392	446	34,853	96,418	131,271	2007	36,941	330,058	416,361
RH Sludge followed by CH/RH Solids														
LCC-B-1	Advanced Thermal- Building 3517	234,182	245,125	212	222	262	274	37,300	118,549	155,849	2011	63,098	646,062	691,318
LCC-B-2	Advanced Thermal- Building 3525	231,575	242,519	209	219	259	271	36,994	116,572	153,566	2011	62,995	638,588	683,844
LCC-B-3	Advanced Thermal- Building 7860	228,723	239,666	207	217	256	268	37,218	115,619	152,837	2011	68,510	628,515	673,770
LCC-B-4	Advanced Thermal- Building 7930	233,964	244,908	211	221	262	274	37,671	119,181	156,852	2011	62,791	640,539	685,795
LCC-B-5	Non-Thermal - Building 3517 - Compaction Building 3517	226,552	248,678	202	221	254	278	36,900	145,633	182,533	2007	55,588	638,365	730,492
LCC-B-6	Non-Thermal Building 3517 - Compaction Building 3525	217,999	240,125	194	214	244	269	36,906	146,471	183,377	2018	71,778	628,859	720,986
LCC-B-7	Non-Thermal Building 3517 - Compaction Building 7860	215,387	237,513	192	211	241	266	36,933	142,382	179,315	2,018	71,905	621,428	713,555
LCC-B-8	Non-Thermal Building 3517 - Compaction Building 7930	209,186	231,312	186	206	234	259	36,855	138,244	175,099	2018	105,195	608,621	700,748
LCC-B-9	Non-Thermal Building 3525 - Compaction Building 3517	226,678	248,805	202	221	254	278	36,976	146,123	183,099	2007	57,140	637,182	729,309
LCC-B-10	Non-Thermal - Building 3525 - Compaction Building 3525	223,579	245,705	199	219	250	275	36,982	146,961	183,943	2018	71,778	646,203	738,330
LCC-B-11	Non-Thermal Building 3525 - Compaction Building 7860	218,577	240,703	195	214	245	269	37,009	142,872	179,881	2018	71,905	630,979	723,106
LCC-B-12	Non-Thermal Building 3525 - Compaction Building 7930	212,421	234,547	189	209	238	262	36,931	138,734	175,665	2018	105,195	618,411	710,538
LCC-B-13	Non-Thermal Building 7860 - Compaction Building 3517	224,438	246,564	200	219	251	276	35,833	137,194	173,027	2014	83,663	652,375	744,502
LCC-B-14	Non-Thermal Building 7860 - Compaction Building 3525	211,955	234,081	189	208	237	262	35,839	137,672	173,511	2018	71,778	620,246	712,373
LCC-B-15	Non-Thermal - Building 7860 - Compaction Building 7860	209,576	231,703	187	206	235	259	35,866	133,943	169,809	2018	71,905	613,316	705,443
LCC-B-16	Non-Thermal Building 7860 - Compaction Building 7930	203,415	225,541	181	201	228	252	35,788	129,805	165,593	2018	105,195	600,730	692,857
LCC-B-17	Non-Thermal Building 7930 - Compaction Building 3517	224,801	246,927	200	220	252	276	36,857	144,267	181,124	2007	57,958	631,695	723,822
LCC-B-18	Non-Thermal - Building 7930 - Compaction Building 3525	218,904	241,030	195	215	245	270	36,863	145,105	181,968	2018	71,778	631,525	723,652
LCC-B-19	Non-Thermal Building 7930 - Compaction Building 7860	214,103	236,229	191	210	240	264	36,890	137,130	174,020	2018	71,905	618,066	710,193
LCC-B-20	Non-Thermal Building 7930 - Compaction Building 7930	212,141	234,267	189	209	237	262	36,812	136,878	173,690	2018	105,195	618,069	710,196

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