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DEFENSE REMOTE HANDLED TRANSURANIC WASTE

COST/SCHEDULE OPTIMIZATION STUDY

DEPARTMENT OF ENERGY

ROCKWELL INTERNATIONAL

WESTINGHOUSE

JOINT INTEGRATION OFFICE

ALBUQUERQUE, N.M.

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TRANSURANIC WASTE PROGRAM

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

1.0 EXECUTIVE SUMMARY

Purpose: The purpose of this study is to provide the Department of Energy (DOE) information with which it can establish the most efficient program for the long term management and disposal, in the Waste Isolation Pilot Plant (WIPP), of remote handled (RH) transuranic (TRU) waste. To fulfill this purpose, a comprehensive review of waste characteristics, existing and projected waste inventories, processing and transportation options, and WIPP requirements was made. Cost differences between waste management alternatives were analyzed and compared to an established baseline. The result of this study is an information package that DOE can use as the basis for policy decisions.

Background: Approximately 2% by volume (1330 cubic meters) of DOE's transuranic waste is remote handled, that is, having surface dose rates greater than 200 mRem/hr. The baseline waste management plan (Ref. 7, Ref. 8) for the RH TRU waste included: design and construct a facility at each waste generating and storage site for processing and certifying RH TRU waste; packaging the waste in canisters at the generator sites; transportation, by truck, of the canisters in shielded casks; and disposal in WIPP.

As part of this study, a comprehensive list of alternatives for each element of the baseline was developed and reviewed with the sites. Two workshops, with the participation of each generating site and WIPP, were integral parts of the alternatives development. From this list of alternatives, a group of scenarios covering all combinations of alternatives was defined. Each scenario was then considered for each waste stream at each site. A complete round of visits to generator sites and WIPP was made to review the final list of alternative/scenario/waste stream combinations for applicability and to ensure that no combinations had been omitted. Site specific cost and inventory data were also collected during this round of site visits. Detailed cost analyses were made for most scenario/waste stream combinations; some combinations were clearly not applicable or possible and were not analyzed further.

A baseline system for management of RH TRU waste was defined, based on the Defense Waste Management Plan (Ref. 7) and the latest revision of the Long Range Master Plan (Ref. 8). This baseline provides the reference point for evaluating potential cost savings and schedule improvements.

Principal Conclusions: The principal conclusions of the study follow; supporting analyses and data are given in the full report or in the appendices.

1. A single processing facility for RH TRU waste is both necessary and sufficient.

2. The RH TRU processing facility should be located at Oak Ridge National Laboratory (ORNL).

3. Shielding of RH TRU to contact handled levels is not an economic alternative in general, but is an acceptable alternative for specific waste streams.

4. Compaction is only cost effective at the ORNL processing facility, with a possible exception at Hanford for small scale compaction of paint cans of newly generated glovebox waste.

5. It is more cost effective to ship certified waste to WIPP in 55-gal drums than in canisters, assuming a suitable drum cask becomes available. Some waste forms cannot be packaged in drums, a canister/shielded cask capability is also required.

6. Generators must begin certifying newly generated waste by the end of FY 87 to support the 300 canister emplacement goal of the 1989-1993 demonstration period, to support the full scale operating rate at WIPP in 1994, and to minimize additional interim storage costs at the generator sites. (Some exceptions exist, see sections 4.1 and 4.4.)

7. Three hundred canisters of certified waste should be emplaced in WIPP during the 1989-1993 demonstration period.

8. Beginning in 1994, a disposal rate of 250 canisters per year is required to complete inventory workoff by the year 2013. To achieve this rate, the ORNL processing facility must be operational by 1996.

9. Implementing the conclusions of this study can save approximately $110 million, compared to the baseline, in facility, transportation, and interim storage costs through the year 2013.

2.0 INTRODUCTION

2.1 Purpose

The goal of the Remote Handled Cost/Schedule Optimization (RH C/SO) report is to provide an information package to DOE/HQ from which it can establish, within institutional constraints, the most cost-effective and efficient Defense RH Transuranic Waste Management Program. To accomplish this purpose, waste inventories and WIPP requirements were reviewed, a baseline was established, processing and transportation alternatives were identified, and cost and schedule differences were evaluated.

2.2 Goals

The Defense Waste Management Plan (DWMP) (Ref. 7) establishes that the goals for management of transuranic wastes, including RH TRU, are to end interim storage and to achieve permanent disposal. To accomplish these goals, the DWMP states that waste will be retreived, if necessary, then processed, if necessary, to comply with the Waste Isolation Pilot Plant (WIPP) Waste Acceptance Criteria (WIPP-WAC) (Ref. 10), and transported to WIPP for emplacement.

2.3 Baseline

The DWMP, in Section 5, "Plan for Permanent Disposal of Transuranic Waste", establishes a plan and schedule for RH TRU processing facilities at the Idaho National Engineering Laboratory (INEL), Hanford, and the Oak Ridge National Laboratory (ORNL). The plan for the Los Alamos National Laboratory (LANL) does not differentiate between contact handled and RH processing facilities, but does establish a schedule for a TRU processing facility. The DWMP does not specifically mention newly generated RH TRU wastes arising from activities at the Argonne National Laboratory-East (ANL-E), which has no waste interim storage facility.

The plans required to implement the goals set forth in the DWMP are found in Ref. 8, The Long Range Master Plan for Defense Transuranic Waste Management (LRMP). The schedule and milestones in the LRMP also identify RH processing facilities at the sites listed above. The LRMP milestone schedule is also reproduced in Appendix F.

For purposes of comparing alternatives in this study, and based on the DWMP and LRMP elements discussed above, the baseline RH TRU waste management system is defined as follows:

1. INEL, Hanford, ORNL, and LANL will each construct a facility to retrieve, process, examine, assay, package, and certify stored RH TRU waste retreived from interim storage at that site; each of these sites will certify its own newly generated RH TRU waste.

2. ANL-E will certify and package newly generated RH TRU for direct shipment to WIPP.

3. All RH will be shipped from the generating/certifying site to WIPP in RH canisters. The canisters will be transported in shielded canister transportation casks; each cask will carry one canister.

4. WIPP will receive and emplace all RH TRU wastes in canisters.

2.4 Scope

This study examines the economics and technical aspects of the system for processing, certifying, and packaging RH TRU waste, followed by transportation to and emplacement in the Waste Isolation Pilot Plant (WIPP), located near Carlsbad, New Mexico. This study focused on system alternatives, not site-specific alternatives. For example, two of the issues examined include the transportation alternative of shipping RH TRU to WIPP in 55-gal drums rather than canisters (see Section 4.9 and Appendix B), and the processing alternative of shielding to contact handled (CH) levels (see Section 4.7 and Appendix H). These alternatives have potential impacts on WIPP receiving and aboveground transfer operations, as well as on-site and transportation system requirements.

Management alternatives for Special Case (SC) TRU waste were not included in this study. Finally, management options that do not include disposal in WIPP, such as various greater confinement disposal technologies, were not within the study scope.

Institutional concerns were not allowed to eliminate an option from consideration, although they were identified.

The RH program is, in general, not as far advanced as the CH program. No facilities for processing stored RH TRU waste have been constructed or designed. No transportation cask presently exists that is licensed to transport all forms of RH-TRU waste. (As of August 1, 1986, seven vendors have submitted proposals to manufacture and provide an RH transportation cask by October, 1988.) However, because no large capital expenditures have yet taken place, the opportunity exists to achieve significant savings through careful long-range planning, trade-off studies and the resultant implementation of recommendations.

2.5 RH Program Objectives

The goals and objectives of the program are given here to define the framework of the study.

As defined in the LRMP (Ref. 8), the goal of the TRU Waste Management Program is to end interim storage and to achieve permanent isolation for TRU waste. The current alternative of choice is to isolate TRU wastes in a deep mined geological repository: the Waste Isolation Pilot Plant (WIPP). Some TRU waste is impractical to certify. This waste is classified as special case (SC) waste and will be evaluated for alternative disposal methods. This study is limited to non-special case RH waste.

In order to achieve the goal of permanent geological isolation, several objectives for the management of TRU wastes have been established in the LRMP. For RH waste, these objectives are listed below.

Objectives for Newly Generated RH Waste

- o Reduced generation of both waste volume and radioactivity by administrative and technical controls where such controls are cost effecive and practical.
- o Direct shipment from a generation site to a disposal site.
- o Permanent isolation from the biosphere of quantities that would otherwise pose a significant threat to public health and safety.

Objectives for Stored RH-TRU Waste

- o Phase out of all retrievable storage activities, except surge capacity as needed for wastes awaiting processing or shipment.
- o Transfer to a disposal site.
- o Permanent isolation.
- o For as long as needed, continued safe operation and monitoring of interim storage.

In order to accomplish the goals and objectives listed above, the WIPP will begin a demonstration period for emplacement of RH waste in January, 1989. During the demonstration period of up to 5 years, WIPP will emplace RH waste in a retrievable manner. Upon successful completion of the demonstration, a decision will be made to convert WIPP into a permanent repository.

2.6 Report Organization

This report is organized into five sections, plus references and appendices. The executive summary was presented above. This introductory section is followed by a description of the study methodology, the development of scenarios for analysis, and a review of alternatives that were not analyzed. Section 4 presents the study findings. This section describes major findings for each site, as well as discussions of several system alternatives and schedule considerations. Finally, in Section 5, institutional, regulatory and technical uncertainties are presented. Also in this section, a discussion of sensitivities is included. In particular, inputs that have a reasonable potential for changing conclusions are identified. Detailed analyses and raw data have been placed in the appendices.

3.0 METHODOLOGY

The following sections describe the methods used to determine what subject areas were examined in this report. Justification is presented for the elimination of subjects from consideration.

3.1 Development of Scenarios

In order to maximize the potential for developing realistic and useful recommendations, a formal process was employed. This process was initiated by soliciting a wide range of ideas from waste management personnel from each of the participating sites. Two workshops were held with WIPP and all of the RH generator and storage sites represented. During these workshops, the participants were encouraged to present any alternatives to the baseline plans for RH TRU waste management. These brainstorming sessions led to the consideration of many alternatives. The goal of this scenario development process was to provide a list of study subjects that would satisfy two criteria. The first criterion demanded that the list be comprehensive. No scenario should be eliminated because of preconceived notions of the authors or because they did not conform to current program methods and plans. Secondly, the list of scenarios had to be small enough so that each could be examined in the time and resource constraints given. In order to satisfy this second constraint, some scenarios were grouped into a more general form. Necessarily, some of the detail was lost. However, the intent of this study is to show system alternatives with large potential savings, not to provide detailed implementation plans. In the process of developing these implementation plans, trade-offs between the more specific alternatives may be examined. From this large list, certain alternatives were eliminated based on previous studies, or based on technical impracticality.

The next step was to create a flowchart of possible alternatives for management of this waste. The flowchart that was used is shown as Figure 1. From this flowchart, we see that there are four basic pathways that RH waste can follow from retrieval to certification. They are:

1. Direct Certification
2. Volume Reduction Followed by Certification
3. Processing Followed by Certification
4. Processing Followed by Volume Reduction and Certification

If we now consider the possibility of transportation, as shown in Figure 2, these four pathways become 10 scenarios. Six of the scenarios apply to not directly certifiable waste and four apply to directly certifiable waste.

The following pages describe all possible pathways through the flowchart. Note that the first decision point on the flowchart determines if the waste is directly certifiable, or if the waste requires processing for certification. There is a strong correlation between certifiable waste and newly generated waste; and a strong correlation between not directly certifiable waste and stored waste. Thus certain

RH TRU CERTIFICATION PATHWAYS

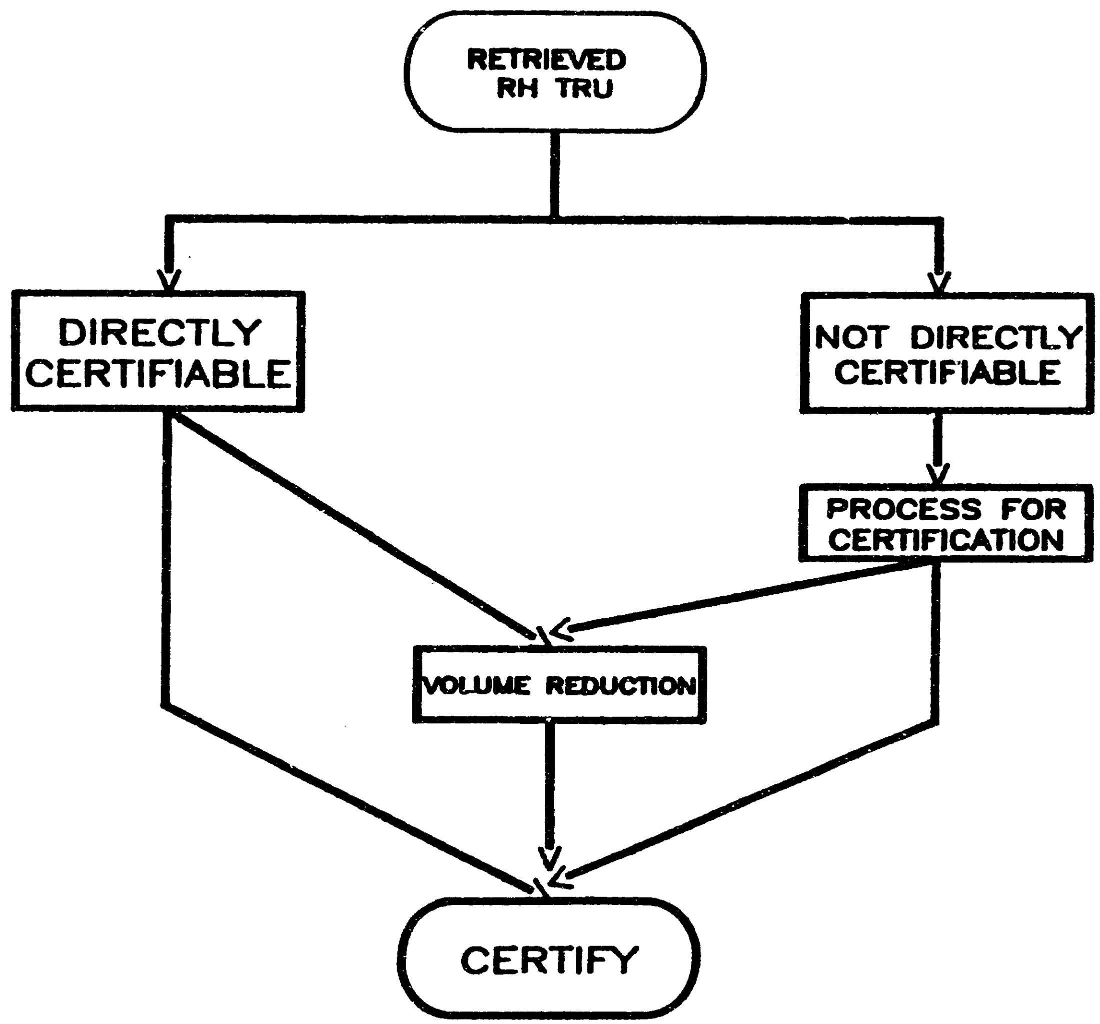


FIGURE 1

RH TRU CERTIFICATION PATHWAYS

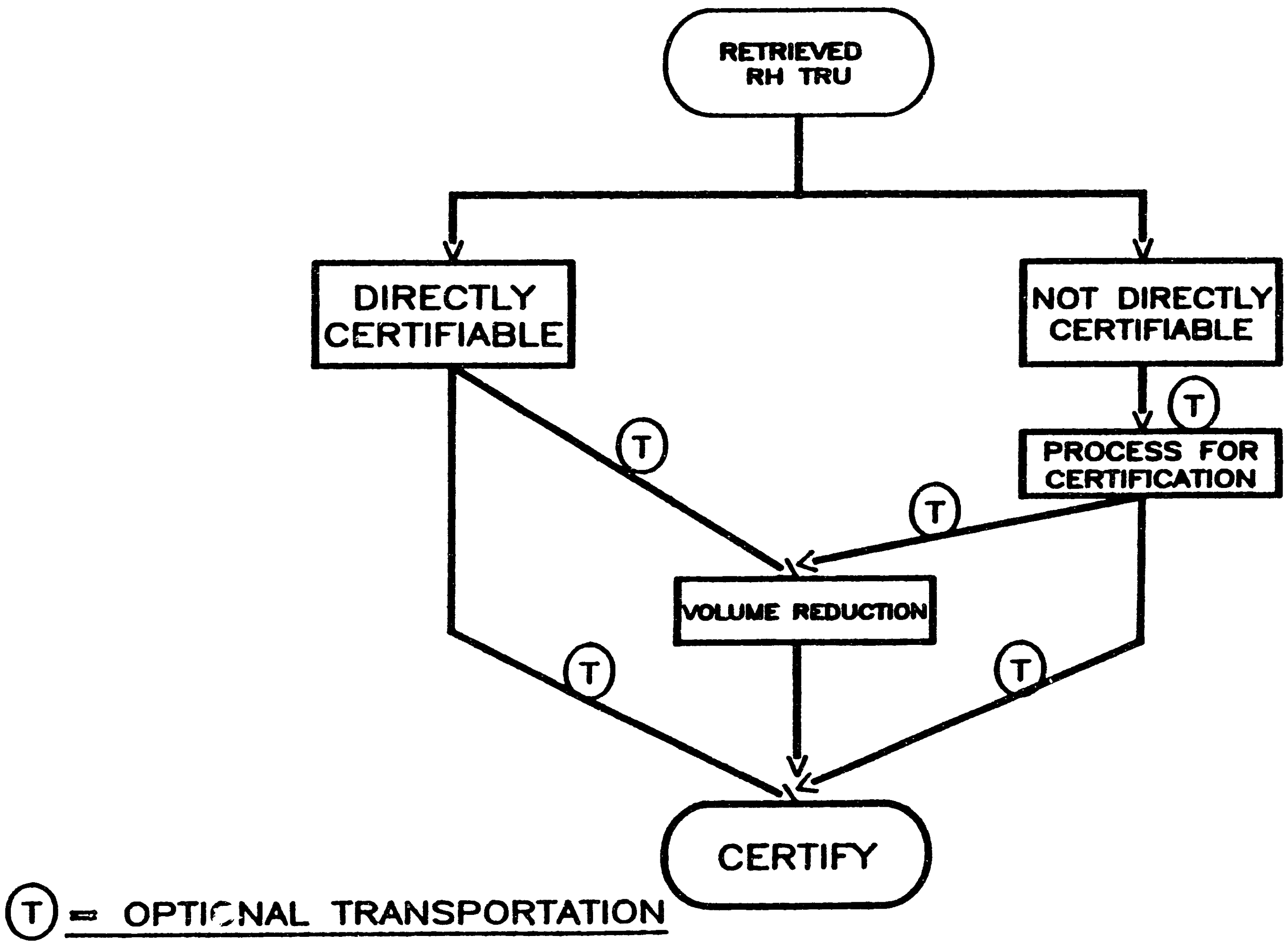


FIGURE 2

scenarios for stored waste that does not require processing for certification have corresponding alternatives for newly generated waste. These correlations are noted in the scenario descriptions.

This format presents a series of decision points and resultant pathways that emcompass every alternative that merit consideration. While this flowchart included every scenario that was to be considered, it also included many pathways (or scenarios) that were nonsensical. The flowchart was used to help determine, in a formal manner, that every resonable scenario was considered.

Scenarios for Not Directly Certifiable Waste

Scenario 1: On-Site Processing and Certification, No VR

On-site (not centralized) processing for certification. No volume reduction processes are allowed. Processing, NDA/NDE, and canister welding occur on-site. The waste is transported to WIPP in an RH shipping cask.

Scenario 2: On-Site Processing, No VR, Centralized Certification

On-Site (not centralized) processing. No volume reduction processes are allowed. Processing occurs on-site, however, NDA/NDE (followed by certification) and canister welding occur at a central facility.

Scenario 3: On-Site Processing and Certification with VR

On-site processing to include volume reduction. Volume reduction techniques examined include compaction, repackaging, and shielding to CH levels. (Shielding is considered a volume reduction technique in scenario development because it decreases the volume of RH waste, not the volume of total waste.) Following processing, NDA/NDE for certification and canisterization occur on-site. Transportation mode depends on the volume reduction method. If shielding is employed, then the TRUPACT is used.

Scenario 4: On-Site Processing, Centralized Vr and Certification

On-site processing for certification, followed by centralized volume reduction. Also, because of the justification presented (in Section 3.2, Alternatives Not Considered) for preventing redundant shipping, NDA/NDE for certification, as well as canister welding occur at the central facility. Again, the method of volume reduction dictates the packaging used for shipment.

Scenario 5: Centralized Processing and Certification, No VR

Centralized processing for certification, followed by NDA/NDE, canister welding and certification, all at the centralized facility.

Scenario 6: Centralized Processing and Certification with VR

Centralized processing for certification, followed by volume reduction, NDA/NDE, canister welding and certification, all at the centralized facility.

Scenarios for Directly Certifiable and Newly Generated Waste

Scenario 7: On-Site Direct Certification with On-Site VR

On-site volume reduction, NDA/NDE, canister welding and certification.

Scenario 8: On-Site Direct Certification

On-site NDA/NDE, canister welding and certification without volume reduction.

Scenario 9: Centralized Certification and VR

Centralized NDA/NDE, canister welding, volume reduction and certification.

Scenario 10: Centralized Certification, No VR

Centralized NDA/NDE, canister welding and certification, no volume reduction.

These scenarios have been used as a tool to develop a list of alternatives to be studied (Section 4.6 presents the possibility of modifying each scenario to include shipment of certified waste to WIPP in drums rather than canisters, with canisterization to be accomplished at WIPP. This possibility is not considered a unique scenario, but a modification to the above ten.) The next step in the process was to eliminate some of these possiblities based on technical impracticality, on previous work, or on scoping analysis.

3.2 Alternatives Not Considered

This section of the report details the scenarios that were not considered. Bear in mind that this study does not examine site-specific alternatives to site-specific waste management challenges. Rather, only system-wide impacts are examined.

Rail Shipment of RH TRU Waste: Based on previous work (Ref. 2, Ref. 4) it appears that rail shipment of TRU waste is not cost effective. However, the conditions that may exist over the 25 year life of WIPP may change to the extent that rail shipment may become an attractive alternative. The responsible traffic managers will establish the most cost effective means for transport of waste to WIPP through competitive bidding and through negotiation of published freight rates with carriers. The present plan is that JIO will be the traffic manager.

Current published rates for rail transport of TRU waste are higher than those for truck transport. Although the published tariff rates are highly negotiable, it is not considered probable that rail rates will be reduced enough to overcome the cost of extra casks required for rail transportation (Ref. 2, Ref. 4). (More casks are required for rail transportation because it is much slower than truck transportation.)

Decontamination: Decontamination was not considered as a viable alternative for several reasons. First, if a site were to consider implementation of this process, it would be a site-specific and waste stream specific trade-off, and would therefore be outside the scope of this study. As a central processing option, it was not considered practical for several reasons. First, most decontamination methods employ a stripper solution that would become a mixed waste stream. This mixed waste stream would require solidification, and thus the processing complexity (and expense) increases dramatically. Secondly, because of the diverse physical nature of the waste, decontamination will not work well in many cases.

Sequential Transportation: If waste was to be transported from one site to another, it is assumed that it would be subsequently transported to WIPP. This assumption eliminated possibilities that resulted in multiple site to site shipments for various certification operations. For example, under this assumption, it would not be permissible to ship to one site for processing, then to another for canister welding, and another for NDA/NDE and final certification. In short, if waste is to be transported for certification processes, all necessary steps would occur at one site. The justification for this assumption lies in the design of a central processing facility. Any processing facility would be constructed at an existing storage site, and that site will need NDA/NDE and canister welding capabilities. Therefore, it does not make sense to construct a central processing facility that lacks any necessary equipment for certification.

Summary

The final list of options to be considered is given below:

compaction

shielding

transportation alternatives

schedule

central processing

The results are presented for each site, as appropriate, and by major topic, in Section 4.

ILLUSTRATIVE WORKOFF PLAN
(RH TRU)

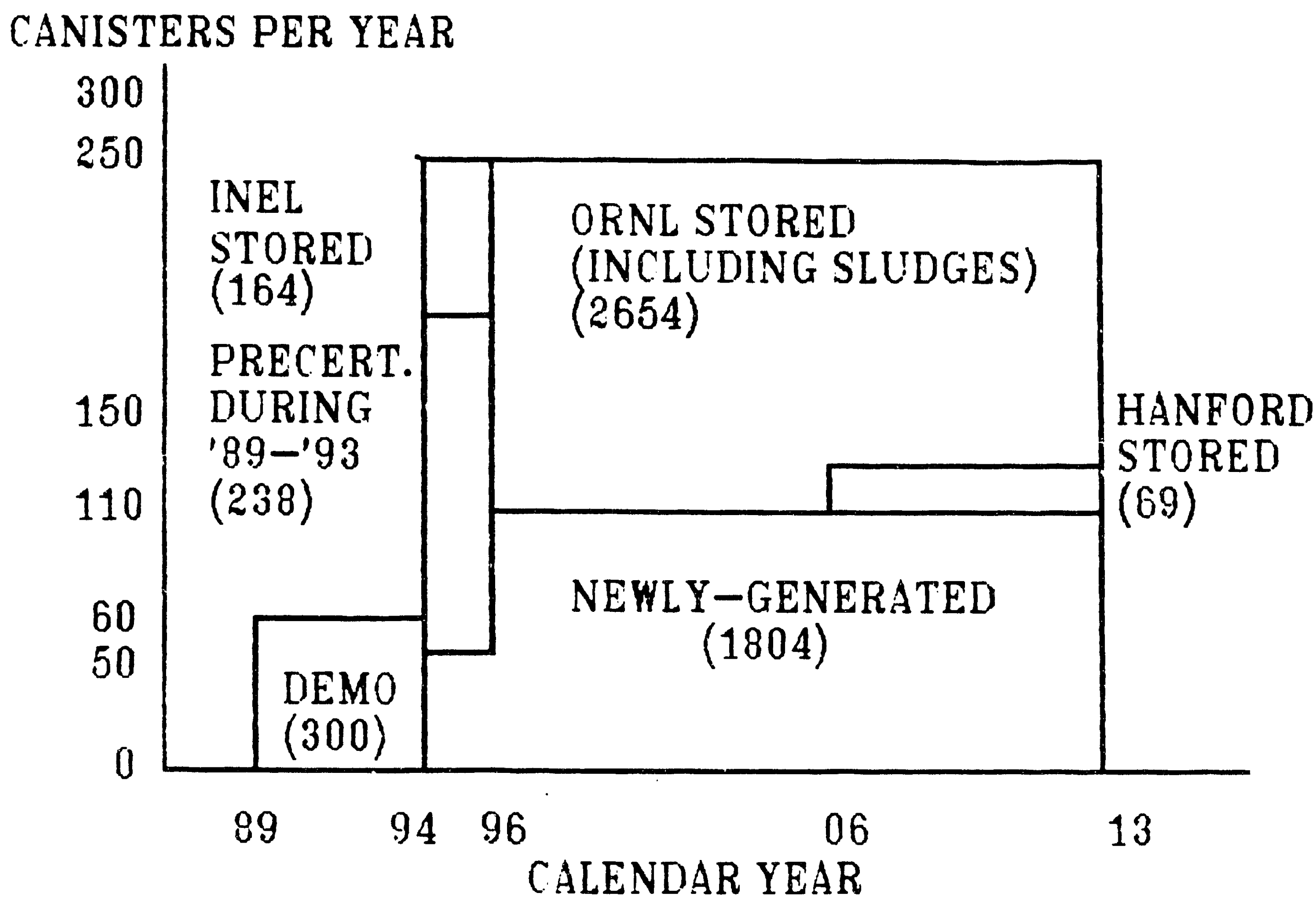


FIGURE 3

4.1 ORNL

4.1.1 Site Findings. About 95% (by volume) of the existing RH TRU waste inventory is in interim storage at ORNL. This waste is stored in several forms and locations. The first form consists of large concrete casks. This waste is stored both above ground, in Building 7855, and below ground (retrievably buried) in Solid Waste Storage Area 5. It is projected that this waste will result in about 1,100 canisters. Also at ORNL, about 116,000 gallons of RH TRU sludge are in storage in the Melton Valley Storage Tanks and in the Gunite Tanks. It is projected that, after a volume increase from solidification, this waste will fill 1500 to 1600 canisters. DOE-OR is considering classifying cans of uranium oxide, from the Consolidated Edison Solidification Project (CEUSEP) Campaign as RH TRU. This would add about 2 cubic meters, or a minimum of 33 canisters, to the inventory. Finally, several other miscellaneous storage methods are used, such as stainless steel wells and other small packages.

Upon review of records, it is thought that none of the retrievably stored RH waste at ORNL will be certifiable without some form of processing. This processing may be as simple as repackaging, or it may be more complex, depending on the form of the retrieved waste. This determination can be made only upon retrieval. The judgement of ORNL personnel is that the plastic buckets used for contamination control within the concrete casks have degraded over time due to the radiation fields present. The paint cans within the plastic buckets may also have rusted away due to the humid environment.

In FY 1986, ORNL determined that the Melton Valley Storage Tanks, which had previously been used for hydrofracture injection, and other inactive liquid waste tanks (such as the Gunnite tanks) still contained significant amounts of RH TRU waste and would require processing and disposal as such. Processing options for solidification of the sludge are still under investigation. Some of the options being considered include an asphalt process, concreting, vitrification, and the TRUEX process. In most alternative processes, a volume increase of up to 2:1 appears likely. The addition of this waste to the existing inventory has nearly doubled the projected amount of RH waste destined for WIPP. Clearly, this sludge will require significant processing for certification.

The TRUEX process has been proposed as a sludge treatment alternative, on the basis that a decrease in TRU waste volume is possible. Therefore, the ORNL contractor is currently investigating the TRUEX technology as an alternative process for management of the RH-TRU sludges in storage in the Melton Valley and Gunnite tanks. A visit to ORNL by several experts in the TRUEX process from Argonne National Laboratory took place in October 1986. A summary of the meeting discussions of this alternative follows (Ref. 20).

ORNL waste management personnel are pessimistic that TRUEX can be a technically feasible, operationally acceptable, or cost effective process for management of RH-TRU sludges. The concerns regarding technical feasibility include: (a) TRUEX is an acid process, and the storage tanks and ancillary piping were not designed for an acid process. Since ORNL plans future use of these tanks, the tanks must remain intact through any sludge removal operation. If the sludges were removed from the tanks mechanically rather than through acid dissolution, then construction of a shielded, remotely operable reaction vessel would be required. (b) The sludges contain significant radioactive iodine species which will off-gas in acid conditions. No capability for managing this iodine currently exists at the storage tanks.

The concerns regarding operational acceptability derive from the characteristics of the low-level waste remaining after the TRUEX process has segregated the transuranim nuclides into a small volume. Since essentially all of the total radioactivity, due to fission and activation products, remains in the non-TRU phase, the resultant low-level waste has a verv high direct radiation does rate, possibly as high as tens of rem/hr. ORNL does not presently have any other high dose rate low-level waste stream (except for occasional very small volumes), nor does ORNL have any on-site disposal option for such waste. The high dose rate low-level waste would require construction of interim storage facilities, and eventual retrieval and transport to a disposal site. The TRUEX process is not a volume reduction process, since the total volume of waste is not reduced. While it is indeed true that the volume of transuranic waste could be reduced by this process, the volume of high dose rate low-level waste is actually increased.

An accurate evaluation of the cost effectiveness of TRUEX is not possible yet. Great uncertainty remains regarding the process cost as well as the costs of additional low-level waste mangement. As cost data become available, ORNL can compare the economics of TRUEX to other sludge processing alternatives.

None of the waste in storage at ORNL is considered to be transportable (under DOT rules) without significant processing.

Because ORNL has such a large volume of waste that is not certifiable or transportable without processing, it is clear that processing capabilities will be required on site. Because ORNL is the only site that clearly requires processing facilities for RH waste, ORNL has indicated that it will attempt to support any off-site processing requirements for stored RH waste and applicable SC waste (e.g., lead lined waste drums in storage at INEL).

The nature of the ORNL waste dictates that both solidification and repackaging capabilities will be required. The ORNL strategy is for processing capabilities to occur sequentially, with solid waste being processed before sludges. ORNL personnel have evaluated processing requirements and have begun work on some very preliminary designs for the Waste Handling Pilot Plant (WHPP). Initial indications are that such processing capabilities will cost between $25 and $50 million to design and construct. The actual cost will depend on several factors, including the selected sludge solidification process, on the availability of existing facilities for modification, and on the extent to which volume reduction will be employed. The sludge solidification process is planned as a Phase II WHPP.

4.1.2 Cost and Schedule. The cost of constructing an RH TRU processing facility at ORNL is estimated in the DWMP at $53 million and in the LRMP at $48 million. These estimates assume a new facility. ORNL is reviewing existing site facilities for possible applicability and potential cost savings. Since the stored ORNL wastes require processing for WIPP certification, the alternatives are processing at ORNL or processing elsewhere. Processing the ORNL waste at another generator site would require an additional $15 million transportation expense above the baseline, and would not result in facility savings at ORNL (See Appendix G). No facility savings would accrue at ORNL since the processing necessary to convert the wastes in storage to forms transportable under Department of Transportation (DOT) regulations requires a facility that is not significantly different from (nor cheaper than) the facility necessary to produce WIPP certified waste forms. This eliminates the possibility of modifying the existing Engine Maintenance and Disassembly (EMAD) facility (at NTS) for RH-TRU waste processing.

The transportation cost for shipping waste (from Hanford and ANL-E)to ORNL for processing and certification (and subsequently to WIPP) versus shipping directly to WIPP is less than $2 million (see Appendix G). In order for the total RH inventory to be emplaced in WIPP by the year 2013, the emplacement rate at WIPP between 1994 and 2013 must be approximately 250 canisters per year. During the first two years of WIPP full scale operations, 1994 and 1995, the 250 canisters per year rate can be achieved by a combination of newly generated waste, waste generated and precertified between 1987 and 1993 in excess of the amount emplaced during the demonstration period, and stored waste not requiring processing for certification. Beginning in 1996, all precertified and directly certifiable stored wastes will have been worked off and the WIPP rate of 250 canisters per year will be supplied by 100-110 canisters per year of newly certified waste and 140-150 canisters per year of processed stored waste from WHPP. To meet the milestone of WHPP start-up in 1996, the project schedule shown in Figures 4 and 5 is required. It is important to note that in order to achieve the desired 25 year workoff, development work must begin in FY 87, and the WHPP must be a FY 91 budget line item.

As noted in Appendix A, ORNL newly-generated waste does not meet the WIPP-WAC due to high neutron dose rates, and must be allowed to decay for approximately 5-10 years before certification and shipment to WIPP.

4.1.3 Recommendation. The TRU Waste Management Program recommends that the ORNL WHPP be designed and constructed, on the schedule shown in Figures 4 and 5, to process stored RH TRU wastes beginning in 1996. This requires a budget year line item of FY 91.

Fig 4

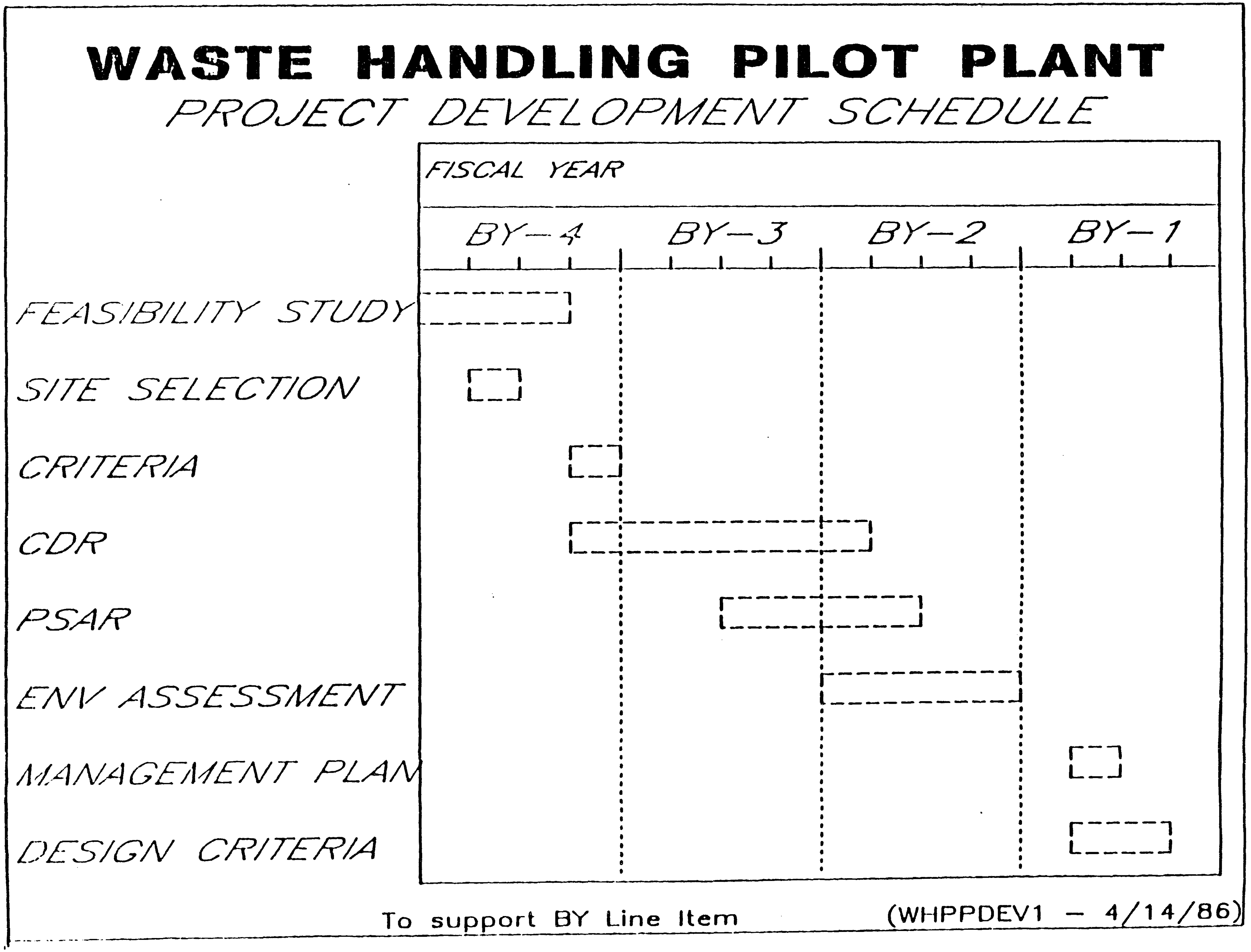
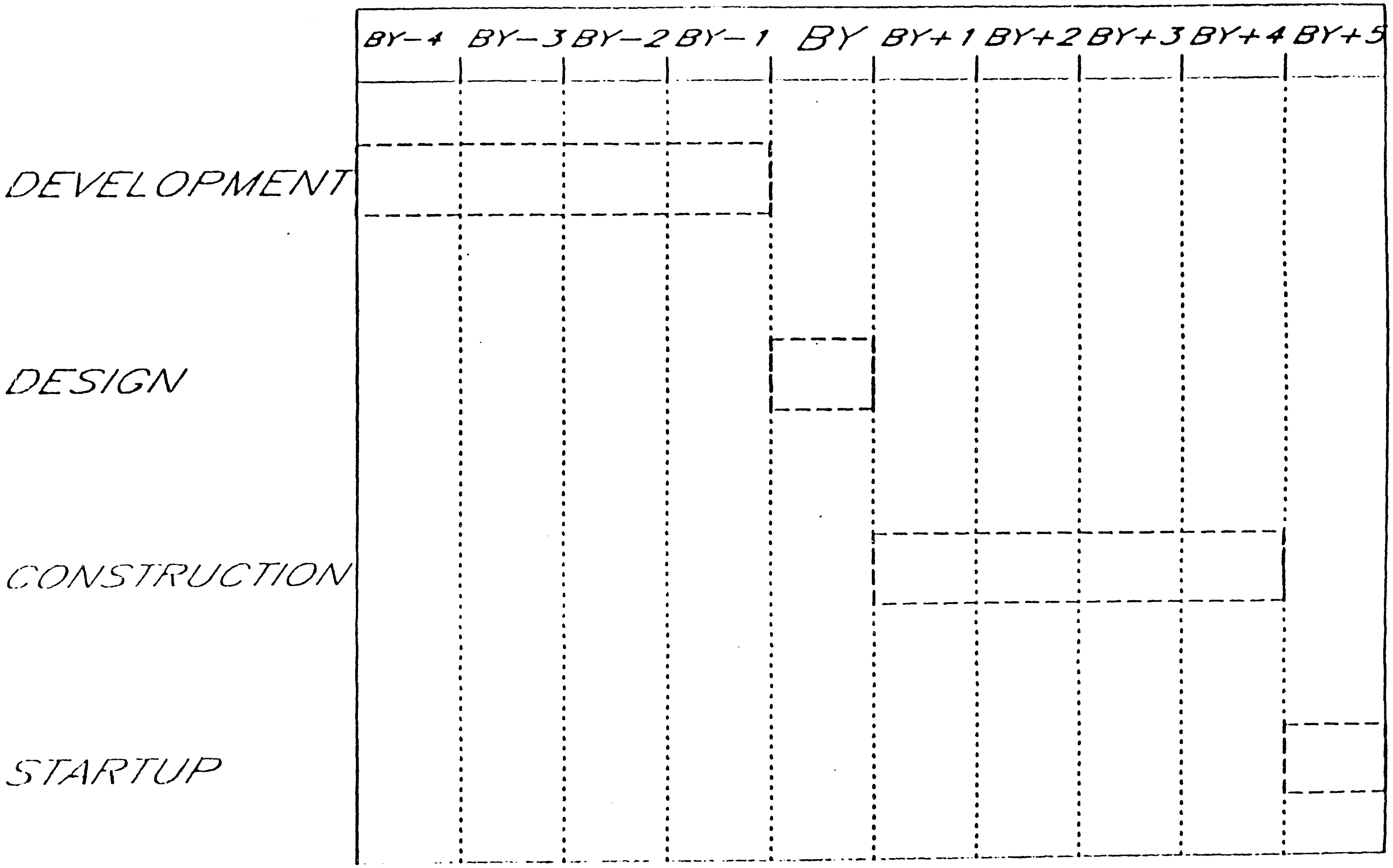

WASTE HANDLING PILOT PLANT
PROJECT DEVELOPMENT SCHEDULE
FISCAL YEAR
BY-4
BY-3
BY-2
BY-1
FEASIBILITY STUDY
SITE SELECTION
CRITERIA
CDR
PSAR
ENV ASSESSMENT
MANAGEMENT PLAN
DESIGN CRITERIA
To support BY Line Item
(WHPPDEV1 - 4/14/86)

Fig 5

WASTE HANDLING PILOT PLANT

OVERALL PROJECT SCHEDULE



FOR BY LINE ITEM

(WHPPOP1 – 4/14/86)

4.2 ANL-E

4.2.1 Site Findings. Argonne National Laboratory-East (ANL-E) generates about ten to twelve cubic meters of RH TRU waste per year. ANL-E has no storage facilities for this waste, except for a small amount of staging capability. ANL-E has hot-cell size limitations that preclude economical on-site canisterization. For these reasons, the most logical alternative for disposition of newly-generated waste from ANL-E is to ship off-site for canisterization. This alternative is in conflict with the objective for newly generated RH TRU waste presented in the baseline that specifies direct shipment of newly generated waste to WIPP. However, analyses presented in the evaluation of WIPP canisterization capability clearly show that on-site canisterization for ANL-E is not cost effective.

Historically, ANL-E has shipped waste to INEL for interim storage. Depending on where canisterization facilities will exist and when these facilities will come on line, this waste could be canisterized in a number of locations. The practice of shipping waste to INEL could be continued, and canisterization could occur there; or the waste could be shipped to ORNL for compaction and canisterization; or, if WIPP develops canisterization capabilities, the operation could be performed there (see Appendices B and G). This decision will depend on the outcome of facility development at the sites mentioned. It will be the responsibility of ANL-E to certify, as to form, waste generated at ANL-E, regardless of where the waste is finally canisterized. The cost differentials involved in shipping the waste to ORNL or to INEL for canisterization and final certification will not be large, due to the small volume of ANL-E waste.

4.2.2 Cost and Schedule. Since ANL-E is not an RH TRU storage site, no processing facility for stored wastes will be required. Newly generated RH TRU is expected to be certifiable without processing. Therefore, the waste management alternatives for this site are to canisterize the RH TRU at ANL-E or at another site. A rigorous engineering estimate of the cost of constructing a canisterization facility for RH TRU at ANL-E has not been done. However, since the laboratory does not have an existing facility with sufficient overhead room to handle the 10-ft long RH canister in a vertical position, nor does the laboratory have lifting equipment of the necessary capacity in any shielded facility, the expense of providing canisterization capability for ANL-E is estimated to be at least $2 million. (The actual cost would probably be much higher; WIPP has estimated the cost to modify the WIPP hot cell to canisterize RH TRU at $2.2 million, for a facility with no headroom or crane constraints.) To transport the ANL-E waste to another site for canisterization would increase the total transportation cost between ANL-E and WIPP.

The ANL-E RH TRU waste is central to the 60-300 canisters committed for emplacement in WIPP during the 1989-1993 demonstration period. The prototype RH canister welder developed at Hanford in 1985 should be available, at ORNL or INEL, to canisterize this waste beginning in late 1988. During the demonstration period, waste generation at ANL-E should be canisterized at INEL until the capability exists at ORNL. At that point, ORNL should assume responsibility for the canisterization of ANL-E waste.

4.2.3 Recommendation. The ANL-E newly generated waste should be certified as to form by ANL-E and transported to an off-site canisterization facility for final packaging.

4.3 INEL

4.3.1 Site Findings INEL has 164 canisters worth of waste in storage (see Appendix A). NDA/NDE is expected to show that 8 canisters have dose rates greater than 100 rem/hr, and 2 canisters are not certifiable due to unidentifiable contents. The 8 high-dose canisters could be shipped to WIPP under the Agreement for Consultation and Cooperation (Ref. 13). This agreement states (in Article VI - WIPP Mission) that, "The DOE agrees that no defense RH-TRU with a surface dose rate in excess of 1,000 rem per hour will be shipped to WIPP and that no more than 5% of the total volume of 250,000 cubic feet (or 12,500 cubic feet maximum) of defense RH-TRU shipped to WIPP will exceed 100 rem per hour surface dose rate.

The stored RH at INEL could be certified by the proposed SWEPP II/PREPP II. However, ignoring the SC waste at INEL, we would be constructing a facility (or modifying an existing facility) to process waste that would fill one RH canister. We therefore conclude that a prccessing facility to be sited at INEL to process only INEL RH waste is not practical.

INEL is currently examining alternatives for certification of SC and RH waste. This study will be complete at the end of FY 86 and may provide some alternatives for RH waste. INEL has over 5,000 packages of SC waste, and only 2 packages of not directly certifiable RH waste that will require processing for certification. Thus we see that the processing requirements at INEL that are not satisfied by the existing PREPP facility will be dictated by characteristics of SC waste. Some of the SC waste contains shielded waste that could become RH if the package is ever opened. Although construction of PREPP II is not justified by the characteristics and ammounts of RH TRU in interim storage at INEL, the facility may be justified in the future by the characteristics and amounts of special case wastes at INEL. If this is the case, then it is possible that processing required for certification of RH waste may occur in this facility. Analysis of SC processing requirements is outside the scope of this study.

It is important to remember that even though practically all INEL stored RH TRU waste is presumed to be directly certifiable without additional processing, the waste must still be retreived from storage, subjected to NDA and NDE for certification, and packaged for transportation. The facility and operations requirements to acheive the retreival, certification, and packaging are not clearly established. Historically, the RH TRU wastes were placed into interim storage in open air transfers using a combination of ordinary lifting equipment (cranes and forklifts) and generator specific shield/transportation casks. Operations were conducted on a year-round basis, with occasional interruptions for springtime flooding and mud. However, the storage operations did not include steps comparable to NDA/NDE or canisterization. Furthermore, the on-site transportation casks are not licensed for travel on public roads. Occasional retrieval operations on RH TRU have been conducted at INEL; for example, to carry out storage vault closure modifications or to return an HFEF canister to Argonne-West. These retrievals did not disclose failed or leaking containers or contamination control problems. (Nor did these retrievals include assay, examination, or repackaging.) The implications of this uncertainty about INEL requirements on system costs are discussed in Section 4.3.2. The INEL site alternatives study is scheduled for completion at the end of FY 86; that study should clearly establish requirements for retrieving, certifying, and canisterizing stored INEL RH TRU wastes.

4.3.2 Cost and Schedule. The estimate for construction of SWEPP II and PREPP II is approximately $28 million. No breakdown has been given between the examination (SWEPP) and processing (PREPP) functions. Since the TRU program is funding development of a mobile NDA/NDE system and has developed a prototype canister welder that could be provided to INEL for use on INEL and ANL-E wastes (see Section 4.2.2), and since INEL has the equipment used to originally place the RH TRU into interim storage, this study concludes that the entire $28 million facility cost can be saved. (This conclusion can be modified based on the results of the INEL site alternatives study results, when published.)

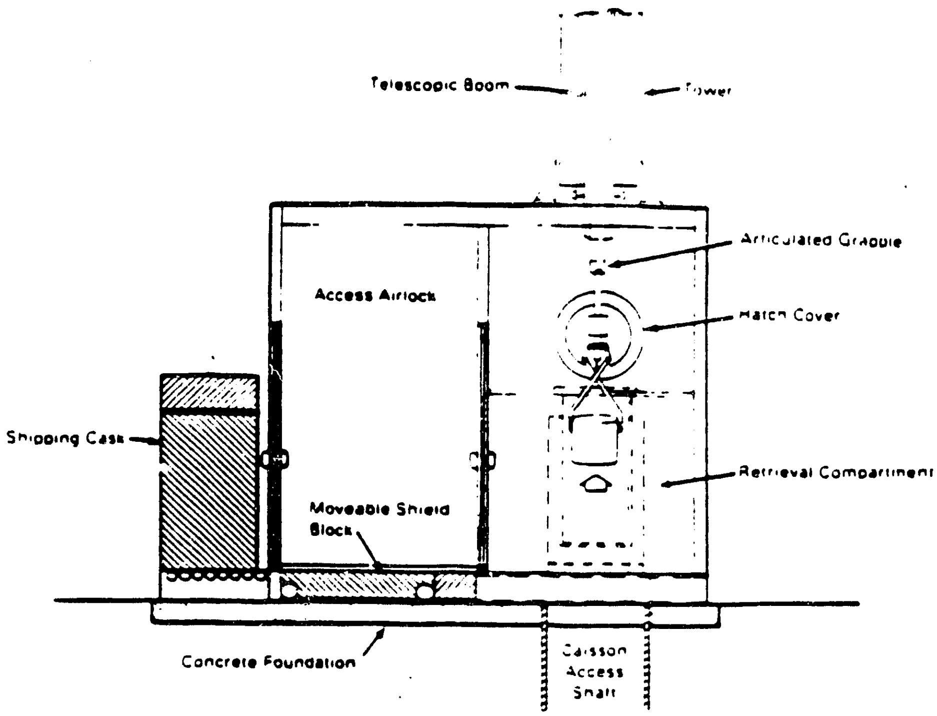
The INEL stored RH inventory can be worked off early in the period of routine WIPP operations, specifically during 1994 and 1995. This schedule requires use of the mobile NDA/NDE system, scheduled for trial operations in FY 87. Meeting this schedule is necessary to allow the schedule proposed for the ORNL WHPP above.

4.3.3 Recommendation. The TRU Waste Management Program recommends that SWEPP II/PREPP II is not required for the processing of INEL stored RH TRU waste. The RH TRU stored at INEL should be certified and canisterized at INEL, making full use of the mobile NDA/NDE system. The stored RH TRU inventory at INEL should be worked off by the end of 1995.

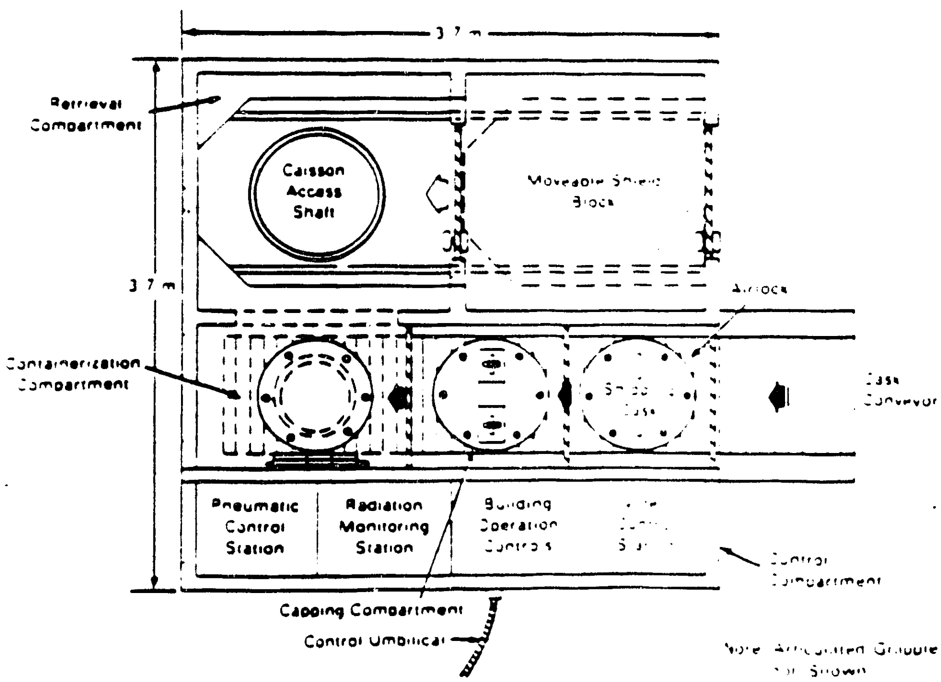
4.4 Hanford

4.4.1 Site Findings. The RH TRU waste in storage at Hanford is not well characterized. Thus the findings presented for Hanford contain more uncertainty than for other sites. The reason for the uncertainty may be traced to the fact that the fraction of directly certifiable waste from the alpha caissons at Hanford is not known. However, the volume of this waste is relatively small (about 22 cubic meters), so it is difficult to justify a dedicated processing facility.

These caissons contain about 5,000 one-gallon and five-gallon paint cans and other miscelleanous materials. The Hanford Defense Waste Draft Environmental Impact Statement (Ref. 3) provides some detail on the most likely method to be used for retrieval of the cassion waste. Figure 6 (Figure B.7 from the EIS) shows a caisson recovery buiding. This building would retrieve individual paint cans and place them into a shipping cask. It should be noted that this building would only be used if waste from TRU-Contaminated Soil sites were to be retrieved. If the



Caisson Recovery Building, Side View



Caisson Recovery Building, Top View

Figure 6

waste from the TRU-Contaminated Soil sites were left in place, a smaller but similar building would be used. In any case, the current plan calls for the retrieved RH TRU waste to be transported to a waste processing facility for conversion to a WIPP acceptable form. The EIS states that, "The waste would be processed in a new facility, (or in a temporary facility, since such a small volume is involved) of suitable size, possibly as an addition to the Waste Receiving and Processing Facility ..."

It is important that the chosen method allows for individual paint can retrieval. Such a method will permit some important, and possibly cost-effective, alternatives.

Once a paint can is retrieved, one of three things may happen. First, if a retrieved paint can is directly certifiable, no processing will be necessary, and the can may go directly to WIPP. If the can is not directly certifiable but still legally transportable, the can may be shipped to an off-site processing facility for certifiaction. Finally, if the can is not directly certifiable and not transportable, it must be processed on site.

It is clear that the capability of segregating waste into these three categories is very important. Further, it is important to segregate the waste as early in the retrieval operation as possible. The best implementation of this concept would allow for a determination as to which category the waste belongs in before placing it into a shipping cask.

To illustrate the significance of this segregation capability, we will arbitrarily assume that a certain cassion contains 1,000 one-gallon paint cans. Further, we assume that 50% of the paint cans are directly certifiable, that 40% are not directly certifiable but transportable, and that 10% are neither directly certifiable or transportable. Next we assume a shipping cask that will hold 10 one-gallon paint cans.

If no segregation of cans is possible before placing them into the shipping cask, we will randomly retrieve 10 cans and place them into a cask. Elementary probability tells us that each of the 100 resultant casks-loads will have only a 1 in 1024 chance of containing only direcly certifiable waste. In this case, we obtain a likelihood of better than 90% that each of the 100 cask-loads would have to undergo some processing step.

If, on the other hand, we assume perfect segregation capability, we would obtain 50 directly certifiable cask-loads, 40 cask-loads that could be shipped off-site, and only 10 cask loads that require processing on site. If only one in ten paint cans require on-site processing, then the facility requirements would be much more modest. In fact it may be possible to use an existing hot-cell for certification operations if the amount requiring processing is small enough.

We again emphasize that the above values for percent directly certifiable are assumed only for demonstrative purposes. Because of the nature of the cassion waste and historical waste management practices, it is not known how much of the waste will be directly certifiable. When this fraction is determined, it will play an important role in designing the retrieval, segregation and on-site processing facilties.

Other options for segregation may exist. If segregation is not practical as the waste is being retrieved, an attractive option may be to design a facility that will receive the shipping casks, and individually NDA/NDE and sort the paint cans. This facilty could accommodate both NGW and stored waste, and have canister welding capabilities.

Bearing in mind the limited data available, it appears that Hanford will require a hot cell for use in RH waste certification and segregation. The use of an existing hot-cell for certification operations is currently being studied by Westinghouse Hanford Company (WHC). The mission of the process should be to ship the waste off site (to WIPP if certifiable, to ORNL if not certifiable) with as little effort as possible. No volume reduction is justified in view of the small volume of waste.

Clearly, trade-offs will exist in certain situations. For example, if a paint can is retrieved that is both not directly certifiable and not tranportable, it is probable that it will be more cost effective to take measures to solve both problems at once.

In 1995, a new waste stream will come on line, namely the hulls from the Process Facility Modification Project (PFMP). These hulls will add about 46 cubic meters per year of RH-TRU waste to the system (or about 73 canisters per year). This waste stream is expected to be generated through 2001. This waste will have very high surface dose rates and some aging will be required. Also, the limit of 23 Ci/liter maximum acitivity (Ref. 13) averaging over the canister, could present packaging problems for this waste.

Beginning in 1995 and continuing through 1999, Hanford will be generating 4.3 cubic meters of Fast Flux Test Facility hulls per year. This will result in about seven RH canisters of waste per year.

Hanford has proposed to begin storing newly generated RH TRU wastes, of the type now put into the alpha caissons, into lead-lined 55-gal drums, beginning in late 1988. The external dose rates of the shielded drums is expected to be less than 200 mrem/hr, in other words, contact handled. The costs of shielding this waste form and other RH TRU waste forms to CH levels are analyzed in Section 4.7. The conclusion of the analysis is that shielding to CH is not, in general, cost effective. However, for the very small waste stream of newly generated Hanford alpha hot cell RH TRU (2 cubic meters per year) the additional cost is justified because no additional alpha caissons will be required. The PFMP hulls waste stream, generated at 20 cubic meters per year, beginning in 1996, will have dose rates too great to allow shielding to CH levels.

4.4.2 Cost and Schedule. Two facilities for management and processing of stored RH TRU are identified for Hanford in the DWMP: the RH Waste Receipt and Packaging Plant (RH-WRAP) and a caisson recovery building.

The estimated costs for these facilities are $46 million and $17 million, respectively. There is no apparent alternative to a caisson recovery building provided that the stored RH waste is going to be retrieved. (GCD alternatives are not within the scope of this study.) There is no apparent requirement for RH-WRAP. Non-certifiable RH TRU retrieved from alpha caisson storage can either be returned to a Hanford hot cell for correction of deficiencies and packaging as newly generated waste, or prepared in a caisson recovery building for shipment to the ORNL WHPP for processing. The projected cost savings are $46 million less the additional transportation costs that result for waste shipped to ORNL rather than directly to WIPP. If all stored alpha caisson waste at Hanford through 1988 is shipped to ORNL, the total transportation cost increase is about $600,000. Hence, cost savings of at least $45 million are possible.

The alpha caissons at Hanford are adequate and low cost (provided no additional caissons are constructed) interim storage units for RH TRU. Workoff of the stored inventory at Hanford is not critical to WIPP operations, nor to WHPP operations if the waste is processed at ORNL. Consequently, the caisson recovery building can be deferred until 2000 or later.

4.5 LANL

In examining the various scenarios, Los Alamos National Laboratory (LANL) was not included in the analyses. Although LANL currently is both a generator and storage site for RH TRU waste, current plans call for all hot cells that are capable of handling RH TRU to be decommissioned by FY 1991. LANL will not produce any RH TRU after this date; nor will they be able to process any of their stored waste for certification. For this reason, all RH TRU activities (except for storage) will cease at LANL in the next three years, and no waste management alternatives will apply. LANL is in the process of accelerating certification efforts for RH in the next three years. In particular, any certification steps which will require the use of a hot cell must be complete in this time frame. These decommissioning efforts will generate a new stream of RH waste. All LANL waste will be considered a primary candidate for the demonstration of RH disposal at WIPP. The use of LANL waste for the demonstration has the advantage of close physical proximity to WIPP.

4.6 WIPP

4.6.1 Site Findings. WIPP is not impacted by many of the options discussed in this study. Processing alternatives do not affect WIPP, so long as they result in a certified waste form. The areas that could affect WIPP are transportation cask selection, and the canisterization and shielding alternatives.

The base case transportation system uses an RH canister inside a modified Defense High Level Waste (DHLW) cask. WIPP has designed (and to a large extent, procured and constructed) RH waste handling equipment and facilities based on this concept. To select an alternative cask (or casks) will have an impact at WIPP, in particular if the selected alternative is not top loading. However, because this and other studies have recommended use of the modified DHLW cask for RH shipments, and because the program to procure a suitable transportation cask is on schedule toward an October, 1988, milestone, no impacts on WIPP are expected.

The alternatives of whether or not to receive RH TRU wastes at WIPP in 55-gal drums as well as in the RH canister have been proposed. The detailed analysis of these alternatives is presented in Appendix B. The summary of the Appendix B analysis is that considerable system savings are possible if RH TRU can be shipped to WIPP in 55-gal drums, transported in a suitable shield cask, and canisterized in the WIPP hot cell before underground emplacement. To accomplish canisterization at WIPP, modifications to the WIPP hot cell and procurement of a drum transportation cask are necessary. Detailed cost impacts are discussed in Section 4.6.2.

The alternative of shielding RH TRU to CH levels is analyzed in Section 4.7. The conclusion is that shielding is not a cost effective method for management of RH TRU, in general. If shielding were to be implemented for a specific waste stream, what would be the impacts on WIPP? Consider newly generated hot cell wastes from Hanford, typically removed from the hot cells in one-gallon metal "paint cans". Geometrically, 84 of these cans could fit into an RH canister (presuming overpackaging of the cans into intermediate drums is required for contamination control). The same 84 cans could be packaged into six shielded drums under the Hanford plan. Given that the capacity of a double-containment value analysis TRUPACT is 36 drums (per WPO communication of July 28, 1986), six RH canisters could be saved and one additional TRUPACT shipment would result instead. The direct labor receipt-through-emplacement timeline at WIPP for a TRUPACT is essentially equal to the same timeline for one RH canister, that is 40 man hours. Therefore, each canister-full of RH shielded to CH saves WIPP about 33 man hours for other activities. This is not a cash savings, since the crew remains on the payroll, but it is a desireable result for WIPP. Unfortunately, Section 4.7 shows that extra package costs more than offset both the labor savings at WIPP and transportation savings that result from shielding. Nevertheless, if future waste form specific analyses show a system savings from shielding, no adverse impacts are expected at WIPP.

It is essential to recognize that 55-gal drums shipped in a shielded drum cask cannot accommodate some existing or planned RH TRU waste forms. As examples, the HFEF canisters from INEL, most of the stored RH at LANL, and some equipment racks in storage at ORNL are too large to fit in drums. By the time a drum cask has a large enough capacity, in volume, to be more transportation cost effective than a canister cask, it becomes weight limited. This is because the greater surface area requires more mass for equal shielding thickness. As a result, a volume efficient shielded drum cask will probably be limited to waste forms of less than 20 rem per hour in order to be within weight limits for transportation. While much of the RH TRU inventory is below this dose rate, many waste forms (PFMP hulls, HFEF canisters, essentially all LANL RH) are known to be higher. Inventory data to determine precisely how much RH TRU is below a given level are not recorded for stored wastes (INEL is an exception). In conclusion, it is cost effective to ship RH TRU to WIPP in drums to the extent possible, but the transportation and WIPP capability to ship and receive RH in canisters is essential.

4.6.2 Cost and Schedule. The alternative of canisterizing RH TRU at WIPP has the following cost impacts: modifying the WIPP hot cell costs an additional $2 million; transportation savings are $10 million, based on a nine-drum transportation cask; and cask fleet acquisition savings of $1 million result because a fleet of two canister casks and two drum casks will suffice, as opposed to a fleet of six canister casks required for canister-only shipments. The net possible system savings is $12 million.

Canisterization at WIPP can begin three years after a commitment is made. This lead time is necessary to modify the hot cell (approximately $500,000 in year minus two and $1.5 million in year minus one) and to procure a transportation cask ($300,000 development cost in year minus three, $3 million obligation for procurement in year minus two).

4.6.3 Recommendation. The TRU Waste Management Program recommends that RH TRU be shipped to WIPP in 55-gal drums and canisterized at WIPP for emplacement, to the maximum extent possible for various waste forms. It is also recommended that the capability to transport and receive RH TRU in canisters be maintained. The canisterization capability at WIPP should be implemented by the beginning of full scale operations in 1994.

4.7 Shielding

Introduction

The use of shielded 55-gallon (or 30-gallon) drums has been proposed for storage (and perhaps shipment and emplacement) of RH TRU waste. This section reviews this concept for transportation systems, for WIPP, and for interim storage at the sites. An analysis of the concept for several waste forms is presented in Appendix H. The results of the analysis are clearly dependent on assumptions regarding fabrication costs of the shielded drums. The assumed costs used in Appendix H are either engineering estimates (the Rockwell-Hanford drum of larger waste capacity) or actual procurement costs (the ANL-E drum of smaller waste capacity). In a review of an earlier draft of this report, one site challenged the cost estimates as being too high; however, that site was unable to provide alternate estimates with any basis other than intuition.

Discussion

The concept of shielding RH TRU waste to CH levels has been explored both at ANL-E and at the Hanford site. ANL-E is currently shipping a small amount of waste to Hanford in a shielded 55-gallon drum. RHO is exploring the possibilities of using the shielded drum in order to avoid some of the difficulty associated with retrieval of RH waste from the alpha cassions. Hanford personnel stated in a May, 1986, workshop that use of the shielded drum will be reexamined based on the system costs presented in this study and based on schedule. Initially it was believed that the fourth (and last to be used) alpha cassion at Hanford would be filled before WIPP opens. It now appears that it may be possible to extend the life of the fourth cassion until October, 1988 which is nearly the date on which WIPP will begin to recieve RH waste. If this is possible, the use of the shielded drum may not be necessary, and Hanford can ship newly generated waste directly to WIPP.

The Rockwell shielded drum would hold about 15 one-gallon paint cans compressed into an eight-gallon inner container surrounded by lead and overpacked in a 55-gal drum. The dose rate at the outer surface of the drum would be less than 200 mrem/hr, and would therefore be contact handled. Such a system will be initiated at RHO for newly-generated hot cell waste in FY 1989. Clearly, interim storage requirements are simplified with this method. Waste stored in this manner can be stored with other CH waste in above ground facilities with little or no shielding or occupational hazard. Retrieval of RH waste from these drums, if required, will be simpler than from the alpha cassions.

The ANL-E shielded drum holds three one-gallon waste cans in a shielded cavity constructed of concentric steel pipes with a lead filled annulus. This shielded inner container is held in the center of a 55-gal drum by metal supports.

In this report it is assumed that RH waste that has been shielded to CH levels may be shipped in the TRUPACT. Further, it is assumed that no weight penalty will result from the shipment of the heavy shielded drums. In other words, enough light CH waste will be available to mix with the heavy shielded waste to allow full shipments. This assumption is employed so that no penalty is assigned to shielded RH shipments. The calculated weights of proposed shielded drums range from 1400 pounds for the ANL-E design (which holds three one-gallon waste cans) up to 5000 pounds for the heaviest RHO design (which holds about 15 one-gallon waste cans of high dose rate). With the TRUPACT payload weight limited to 12,500 pounds, only two to eight shielded drums can be transported per TRUPACT. The Appendix H analysis shows that even with this assumption, shielded RH drums are not a cost effective alternative to the RH canister. By adding a weight penalty, the cost penalty for shielded drums increases. It has been established that WIPP can accept this waste and emplace it as CH, with no operational penalties (see Section 4.6).

Conclusions

This study concludes, based on the data available, that shielding RH TRU to CH levels is not cost effective as a generic processing method. This study did not discover any system impediment to the shielding concept other than higher cost. If a site determines that shielding can be accomplished for lower costs than those estimated here, or if a site determines that site-specific considerations offset the higher system costs for a particular waste form, shielded wastes can be accommodated by WIPP.

As mentioned in section 4.4, this generic conclusion should not imply that shielding the small volume of Hanford, newly-generated, hot-cell waste is not an attractive option. Implementation of shielding at Hanford may be cost effective due to facility cost savings. (The matter is currently under study at Hanford.)

4.8 Compaction

Analysis shows that installation of a compactor in the ORNL WHPP facility would be cost effective. No other site has enough volume of waste to justify the cost of the compactor, let alone the cost of the hot cell. At ORNL, since a processing facility appears to be necessary, little additional expenditure would be required to facilitate the installation of a compactor.

Because of transportation costs, it does not appear cost effective to ship from any storage site to ORNL for volume reduction.

The analyses of compaction involves a trade-off between the cost of the compactor and associated equipment, compared to the savings associated with reduced volume. These savings include decreases transportation requirements and reduced WIPP operation costs. In addition, extra transportation steps need to be analyzed for the case of shipping waste to the compactor from off-site.

Commercially available compactors have been used extensively for compacting dry low level waste at commercial power plants, and have an impressive operating history. These compactors can be installed permanently at a plant or they can be mounted on a tractor trailer and brought to the plant for a batch campaign. For RH TRU waste, however, health and safety requirements dictate that a compactor be used only in a hot cell facility.

The analysis shown in Appendix J shows a minimum savings of $16 million if compaction is employed at ORNL. In addition, further savings up to $5 million are possible, for a total potential savings of up to $21 million.

4.9 Transportation

Previous studies (Ref. 6) have concluded that modified Defense High Level Waste (DHLW) casks should be used for routine RH TRU waste shipments. This conclusion was based on interface capabilities, radiation exposure (ALARA), cost, package certification ease, and minimization of the need for special permits. In each of these categories, including cost, the modified DHLW cask ranked high. In the period since the above reference was published, no new casks have become commercially available that would cause this conclusion to change.

It should be remembered that the current base case shipping cask is not commercially available. DOE is funding the development effort to obtain a cask that will fill the RH transportation needs. If we assue that this process could be repeated if economically justifiable, then we may examine other cask designs. Particularly if WIPP develops canisterization capabilities, a more efficient cask becomes very attractive. For example, if a shielded cask could be developed that could carry 10 drums, and WIPP could canisterize, then the total number of trips of RH waste to WIPP could be reduced to approximately one third of the currently planned system. (The RH canister can carry three 55-gallon drums.) The savings could amount to approximately $15 million. (For detailed analyses, see Appendix B.)

If the drum cask can be successfully procured, this will not eliminate the need for the modified DHLW cask. Several waste forms will be too large for the drum cask or will have dose rates that will be too high.

4.10 Optimum System

Based on the findings and analyses of this study, we conclude that the system baseline defined in Section 2.3 is not the optimum system. In this section, the optimum system is defined, with the intent that the defined system become the new baseline system for management of RH TRU wastes. Section 4.11 presents a schedule of key milestones that are required to implement the new baseline, and Section 4.12 summarizes the cost savings expected as a result of implementing the new baseline.

The essential elements of the optimum system, recommended as the new system baseline, are:

1. Newly generated RH TRU wastes should be certifiable without processing, certified by the waste generator, and shipped directly from the generator to WIPP. Generators should begin certification of newly generated RH TRU as soon as possible and not later than the end of FY 87.

2. To the maximum extent allowed by waste form characteristics, certified RH TRU should be shipped to WIPP in drums, either 55-gal or 30-gal, and canisterized at WIPP. Canisterization at WIPP should begin by early FY 1994.

3. Canisterization capability will be required at the INEL and Hanford sites for waste forms that cannot be shipped in drums. INEL requires that capability by January, 1989, and Hanford requires the capability in 1996, coincidental with the start of the PFMP hulls waste stream. ANL-E should utilize the canisterization capability of INEL through 1993, and ship drums to WIPP for canisterization beginning in 1994.

4. Transportation capability for both canisters and drums will be required. The TRU program should procure a fleet of two canister casks and two drum casks of six drum or greater capacity for transportation of certified RH TRU to WIPP.

5. A facility for processing RH TRU wastes that are not directly certifiable should be constructed at ORNL. This facility, WHPP, should be used for processing wastes from all RH TRU generators, as necessary. The WHPP should be operational by January, 1996.

6. The proposed facilities at INEL (SWEPP II/PREPP II) and at Hanford (RH-WRAP) are not required for processing RH TRU waste.

7. LANL, which will not generate new RH TRU waste after the end of FY 88, should retrieve, certify, and canisterize the stored RH TRU waste at that site, and transport the waste to WIPP beginning in January, 1989.

4.11 Optimum System Milestone Schedule

The milestone schedule required to implement the optimum system described in Section 4.10 is shown in Figure 7, below.

4.12 Summary of Cost Savings

Projected life cycle cost savings possible from implementation of the system described in Section 4.10 are approximately $110 million, as shown in Figure 8, below.

SCHEDULE

- o WIPP
  - – COLD OPS 10/87
  - – FIRST CH 10/88
  - – FIRST RH (BEGIN DEMO) 1/89
  - – COMPLETE RH DEMO 1/94
- o TRANSPORTATION
  - – SHIPPING CASK AVAILABLE 10/88
  - – FULL FLEET AVAILABLE 1/94
- o PROCESSING
  - – WHPP DEVELOPMENT FY 87–90
  - – WHPP DESIGN FY 91
  - – WHPP CONSTRUCTION FY 92–95
  - – WHPP START–UP FY 96
  - – HANFORD WRF START–UP FY 06

Figure 7

SAVINGS: TOTAL LIFE CYCLE SAVINGS UP TO $110 MILLION

- o CAPITAL: $70 MILLION

- o DRUM SHIPMENT: $10 MILLION

- o VOLUME REDUCTION: $30 MILLION

Figure 8

5.0 ISSUES AND UNCERTAINTIES

This section of the report explores uncertainties in the analyses (data and assumptions), in technical areas, and in institutional areas.

5.1 Uncertainties in Analyses

The analyses were not very sensitive to variations in much of the data, due to the fact that such a large fraction of the waste is in storage at ORNL; and due to the fact that this waste is not transportable without processing.

5.2 RH Demonstration

An analysis of the number of canisters that should be emplaced in WIPP during the demonstration concluded that there were insignificant cost differentials. Other factors that may influence the number of canisters emplaced in the demonstration include the following:

Availability of RH shipping casks

Budget levelization

WIPP Considerations (Technical Demonstration of Full Scale Operations)

One factor not considered was retrieval of waste from WIPP in the unlikely event that the demonstration was not successful. In that case, it is clear that very little waste should be emplaced in WIPP. However, the CH program is proceeding as if the demonstration will be successful, and it is assumed that the RH program will be successful as well.

5.3 Hanford Retrieval

The retrieval of Hanford alpha cassion waste will determine the extent to which processing will be required and the extent to which the waste is transportable. However, even in the worst case, (100% requires processing for certification and 100% requires processing for transportation) it is still difficult to justify a facility at Hanford. Hanford has only 22.5 cubic meters of RH waste in the alpha cassions. If the facility costs only $15 million and operations cost only $5 million, the cost of certification of this waste would approach one million dollars per cubic meter. These figures would suggest that this waste might be considered for alternate disposal practices. It should be noted that this worst case is considered unlikely.

As waste is retrieved from alpha caissons, judgement is required to determine if certification processing at WHPP is required. Therefore, assay and examination capabilities, as well as DOT acceptable packaging will be required. If existing Hanford hot cells cannot be used to fulfill this requirement, the capabilities of the caisson recovery building will have to be enhanced, at additional cost.

5.4 INEL Special Case Waste

INEL does not need a facility for RH waste processing. However, if it is determined that they do need one for SC waste processing, it is possible that some benefit could accrue to the RH program.

5.5 ORNL Facility Cost

The cost of the proposed WHPP facility at ORNL is not yet well defined. Options for WHPP construction (or existing facility modification) are still being explored, as well as options for sludge solidification. However, the cost of this facility will not change the need. The stored waste at ORNL cannot be shipped to another site for processing without extensive preparation. This preparation would cost very nearly as much as certification.

5.6 Cost of the Shielded Drum

One actual and one estimated cost for the shielded drum have been obtained, and these costs vary by a factor of seven. This difference is due to the variations in design used. The cost of the shielded drum influences the desirability of the concept. Uncertainties in the use of the shielded drum have been discussed earlier.

5.7 Transportation

The cost of production casks is not well defined. The feasibility of obtaining a cask to ship eight to ten 55-gallon (or 30-gallon) drums is a big unknown as applied to the concept of canisterization at WIPP. As mentioned earlier, if such a cask could be certified for shipment of RH-TRU waste, the cost effectiveness of shipping drums to WIPP (rather than canisters) is very favorable.

5.8 Canisterization at WIPP

As mentioned above, transportation is the hurdle for implementation of canisterization at WIPP. The concept of abandoning the RH canister after the demonstration and directly emplacing RH drums in WIPP is very attractive.

5.9 Technical Uncertainties

Compaction

Although compaction appears to be cost effective at ORNL, the technical feasibility of the concept is unproven on TRU waste. If the volume reduction is diminished by dose rate considerations or by Pu limits, the attractiveness will be limited.

Processing

The sludge solidification processing facilities required at ORNL will represent the first application of large scale solidification of RH TRU waste. It should be anticipated that some schedule and cost projections may be soft.

NDA/NDE

The applicability of non-destructive techniques for examination and assay of RH waste may present problems for certification of stored waste. Although confidence is growing, this technology is unproven. If certain waste forms are not amenable to these techniques, additional processing may be necessary for certification.

Retrieval

The retrieval of waste from the alpha cassions at Hanford will challenge the available technology of robotics and of transportable containment structures. If the costs for retrieval of this waste becomes excessive, consideration of on-site disposal may be appropriate.

5.10 Institutional Issues

Double Containment

The issue of double containment has apparently been solved by DOE's recent commitment to double contain the RH shipping cask.

Central Processing at ORNL

The concept of shipping uncertifed waste to ORNL from other sites may not appeal to the corridor states. However, in view of the potential savings and the small amount of waste to be shipped, institutional considerations should not be extreme. Precedents exist for transportation of radioactive wastes between DOE sites in compliance with DOT regulations.

Canisterization at WIPP

The concept of performing the canisterization operation at WIPP may not fall into WIPP's historically defined role; however, this does not appear to be an obstacle. The concept of discarding the RH canister following the demonstration may prove problematic.

Schedule

Delaying facility schedules could necessitate an extension to the life of WIPP, but the life of WIPP is defined in the WIPP FEIS, and may be challenged on this basis.

6.0 REFERENCES

1. Feasibility Study RH-TRU Waste Handling Facility, ORNL X-OE-25, Sept. 28, 1984

2. Letter Report, PNL Systems Tradeoff Study for Remote Handled and Special Case TRU Waste, R.W. McKee, B.W. Howes, S.A. Weakley, September, 1984.

3. DOE, 1996, Disposal of Hanford Defense High-Level, Transuranic, and Tank Waste - Draft Environment Impact Statement, U. S. Department of Energy-Headquarters, Washington, D.C., DOE/EIS-0113.

4. Contact Handled TRU Waste Cost/Schedule Optimization Study, Detamore, Raudenbush, Wolaver, Hastings, September, 1985.

5. Tri-State Motor Transit Company Tariff Document for Transport of Radioactive Materials, Effective January 1, 1986.

6. Evaluation of Alternatives for a Second-Generation Transportation System for Department of Energy Transuranic Waste, EGG-2268, January, 1984.

7. The Defense Waste Management Plan, DOE/DP-0015, June, 1983.

8. The Long-Range Master Plan for Defense Transuranic Waste Management, Nov., 1984.

9. Remote Handled TRU Waste Strategy Document (in Draft).

10. TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, Sept., 1985, WIPP-DOE-069.

11. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, Dec., 1985, DOE/RW 0006, Rev. 1.

12. Idaho National Engineering Laboratory Transuranic Waste Inventory Workoff Plan, M. G. Bullock, September, 1986, EGG-WM-7142.

13. Agreement for consultation and cooperation (between the State of New Mexico and the United States Department of Energy), July 1, 1981.

14. Letter to Robert W. Wolaver from William T. McManus, Vice President of Marketing and Sales, A. J. Metler Hauling and Rigging, Inc., April 25, 1986.

15. Savannah River TRU Waste Inventory Workoff Plan, K. S. Wierzbicki, S. J. Mentrup, V. B. Wheeler, July 15, 1986, DPSP-86-116.

16. Inventory Workoff Plan for Transuranic Waste at Oak Ridge National Laboratory.

17. Hanford Site Transuranic Waste Inventory Workoff Plan, September 1986, RHO-WM-PL-14P.

18. Final TRU Waste Inventory Workoff Plan, J. L. Warren, A. E. Dress, August, 1986, LA-UR-862932.

19. Final Inventory Workoff Plan for Nevada Test Site Transuranic Waste, August, 1986, RWM-6.

20. Letter to Mr. Doyle R. Brown, Program Manager, Radioactive Waste Management Program, DOE Oak Ridge Operations, from L. D. Bates, Mangager, TRU Waste Program, ORNL, October 6, 1986.

APPENDICES

APPENDIX A

SUMMARY OF TOTAL RH CANISTERS TO BE EMPLACED AT WIPP

Source data for existing and projected waste amounts was provided by the generating and storage sites through their Inventory Workoff Plan (IWOP) submissions. Workoff rates submitted by the sites reflect the baseline described in Section 2.3 (i.e., each site processes its own waste). Therefore, the IWOP shipment rates differ from the uniform rate recommended by this study.

This Appendix gives projections for the number of RH canisters to be emplaced at WIPP. These numbers are given by site for both stored and newly generated waste. Assumptions regarding volume changes due to processing are explained. The availability of waste as a function of time is presented. The supporting data for this section includes Refs. 11, 12 and 15 through 19, and conversations with site waste management personnel.

Table A-1 shows both the volumes in storage as of 12/31/85 and the resulting number of canisters. The reader is reminded that the number of canisters in storage is not a linear conversion from the volume in storage. Rather, to convert volume to canisters, the storage container geometry must be accounted for. The date 12/31/85 was used to ensure consistancy with Ref. 11. Table A-2 shows the projected number of canisters generated for the period 1986 through 1993. This time period was chosen to support Table A-4, which projects the amount of waste available for the WIPP demonstration.

Following presentation of the data tables, details on the basis for the tables are given. The assumptions regarding canister packing and volume changes due to processing are presented. For each site, the waste generation is given in the time frame 1986 - 1993 in order to show the amount of waste available for the WIPP demonstration.

Table A-1

Stored RH Waste
(As of 12/31/85)

Site	Total Number of Canisters	Volume (Cubic Meters)*
Hanford	69	20
INEL	164	35
LANL	28	5
ANL-E	0	0
ORNL	2654 (including sludges)	1,270
TOTAL	2915	1,330

* Volume numbers were taken from site IWOP submission (Refs. 12 and 15-19).

Table A-2

Newly Generated RH Waste
(For the eight year period 1986-1993)

Site	Total number of Canisters
Hanford	12
INEL	82
LANL	0
ANL-E	136 (Identified in the INEL IWOP)
ORNL	280*
TOTAL	510

* Not shippable for 5-10 years from date of generation due to neutron dose rates.
(See Table A-4 for Waste Available for WIPP Demonstration.)

Table A-3

Newly Generated RH Waste
(For the 20 year period 1994-2013)

Site	Canisters
Hanford	546
INEL	220
LANL	0
ANL-E	338 (Identified in the INEL IWOP)
ORNL	700
TOTAL	1804

NOTE: For stored and newly generated waste the grand total is 5229 canisters.

Table A-4

Waste Available for the WIPP Demonstration
(1989-1993)

Site	Canisters
LANL	28
ORNL	33
Newly Generated* (All Sites)	196
TOTAL	257

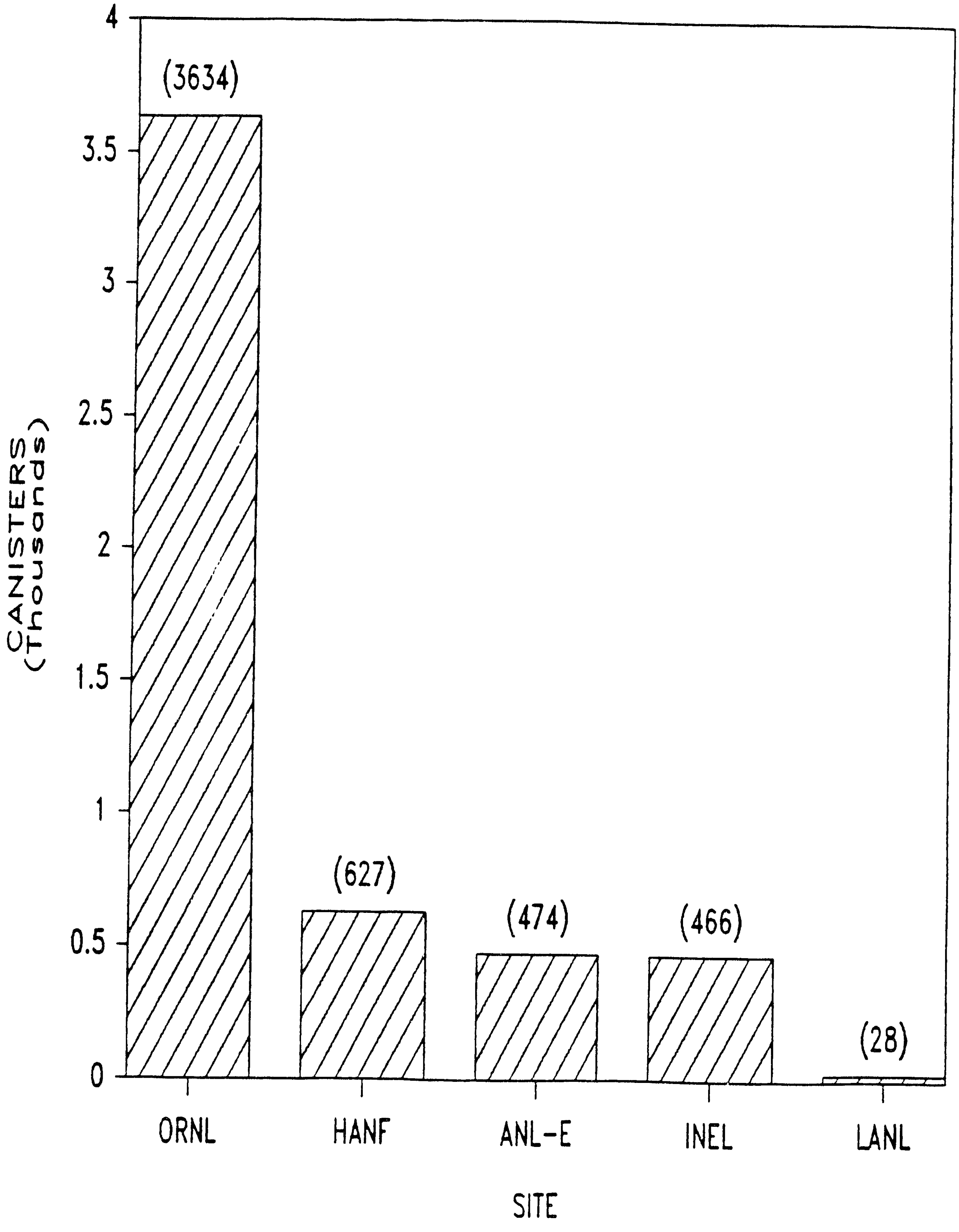
* Assumes certification beginning in CY 87, including the waste available from ANL-E staging storage. Also, the Hanford newly-generated waste is not included because it will be stored in the alpha caissons and will not be retrieved until that work off begins in 1997.

Table A-5

Waste Available for WIPP Emplacement by Site

Site	Canisters
ORNL	3634
Hanford	627
INEL	466
ANL-E	474
LANL	28
TOTAL	5229

WASTE AVAILABLE BY SITE



Hanford

Stored:

Alpha Cassions:

5283 one-gallon paint cans currently in storage
93 five-gallon paint cans currently in storage
14 other containers (Approximately three gallons each)

Packaging: 28 one-gallon paint cans per 55-gallon drum
3 55-gallon drums per RH canister

Total of 63 canisters from one-gallon paint cans

6 five-gallon paint cans per 55-gallon drum
3 55-gallon drums per RH canister

Total of 5 canisters from five-gallon paint cans

Assume one canister for 14 other containers

Total of 69 canisters from alpha cassions

Newly Generated (1986 through 1988)(3 years):

1.1 M^3 per year of hot-cell waste or approximately:

300 one-gallon paint cans per year

Same packaging as above for 4 canisters per year, 12 canisters total

NOTE: Beginning in 1989, this waste will be shielded and handled as CH waste.

Beginning in 1995 through 2001 (7 years):

46 M^3 per year of N reactor hulls

Packaging: .21 M^3 per 55-gallon drum
3 55-gallon drums per RH canister

Total of 73 Canisters per year of N reactor hulls, total of 511 canisters

Hanford (Continued)

Beginning in 1995 through 1999 (5 years):

4.3 M^3 per year of FFTF hulls

Packaging: As N reactor hulls

Total of 7 canisters per year, total of 35 canisters

The Hanford IWOP lists two other sources of RH waste. The first in 70.8 M^3 every three years from the Hanford Waste Vitrification Plant (HWVP). This waste consists of melters which are replaced every three years. Their huge size* prevents them from being handled as normal RH waste and classifies them as Special-Case (SC) waste. Since SC waste is beyond the scope of this report, this waste is not reflected in RH inventory for the report.

The second source is waste retrieved from the 618-11 burial sites. This waste is considered buried waste (i.e., not retrievable) and also not reflected in the RH inventories for this report.

*(A vessel 70.8 M^3 can be considered as a sphere over 5 meters in diameter)

INEL

Stored:

369 30-gallon drums currently in storage
90 30-gallon drums staged at ANL-E awaiting shipment to INEL

Total: 459 drums

Packaging: Three 30-gallon drums per canister for a total of 153 canisters

21 inserts (from Hot Fuel Examination Facility) currently in storage

(An "insert" is INEL terminology for a 65 inch long by 12 inch diameter, stainless steel canister, generated at ANL-W in the Hot Fuels Examination Facility (HFEF)).

Packaging: 2 inserts per canister
Total of 11 canisters

Total Stored: 164 canisters

Newly Generated (1986 through 1993) (8 years):

10 inserts per year

Packaging: 2 inserts per canister
Total of 5 canisters per year, for a total of 40 canisters

Newly Generated (1986 through 1993) (8 years):

50 drums per year originating at ANL-E

Packaging: 3 drums per canister for a total of 17 canisters per year, or 136 canisters total

INEL (Continued)

Newly Generated (1994 through 2013)(20 years):

1012 drums total (IWOP inventory is 1412 drums, less 400 from 1986-1993) originating at ANL-E

Packaging: 3 drums per canister for a total of 338 canisters at the approximate rate of 17 canisters per year

Newly Generated (1994 through 2013) (20 years):

10 inserts per year

Packaging: 2 inserts per canister
Total of 5 canisters per year or 100 canisters

Newly Generated (1987 through 1993) (7 years):

18 55-gallon drums per year originating at ICPP

NOTE: The INEL IWOP shows 32 30-gallon drums per year; based on discussions with INEL personnel, packaging in 55-gallon drums is operationally acceptable at ICPP and the RWMC. Therefore, this analysis assumes packaging in 55-gallon drums.

Packaging: 3 drums per canister for a total of 6 canisters per year, or 42 canisters total.

Newly Generated (1994 through 2013) (20 years):

18 55-gallon drums per year originating at ICPP (see above)

Packaging: Same as above for 6 canisters per year, or 120 canisters total

NOTE: The ICPP portion of the INEL IWOP indicates that this waste stream will total 960 30-gallon drums. The timeframe for this generation is the 30 years from 1986 through 2015. The totals shown above for this document reflect waste generation through 2013 only, at an equivalent annual rate of 32 30-gallon drums per year.

ORNL

Stored:

CEUSP (Consolidated Edison Uranium Solidification Project) Waste and MUO (Mixed Uranium Oxide) cans in storage: 33 canisters (ORNL Provided Data)

Building 7920 waste in storage through 1986:

19,706 plastic buckets

Packaging: 6 buckets per 55-gallon drum, 3 55-gallon drums per canister

Total of 1095 canisters

Sludges:

1,526 canisters resulting from solidification of 115,000 gallons of sludge.

Grand Total of Stored Waste:

CEUSP and MOU:	33 Canisters
Building 7920:	1,095 Canisters
Sludges:	1,526 Canisters
Total:	2,654 Canisters

Newly-Generated (1986-1993):

440 buckets per year

Same packaging as above for 25 canisters per year (but subject to 5-10 year delay in shipping due to neutron decay for WIPP-WAC)

Newly-Generated (1994-2013):

Same as above for 25 canisters per year

LANL

Stored As of 1988:

28 Canisters (LANL provided number)

Los Alamos has stored hot-cell waste in a variety of long steel pipes, shielded with concrete, that are placed in underground retrievable vaults. Where their size permits, these can only be packaged one pipe per canister. Other hot-cell wastes are packaged in small welded steel containers (cans) which may be stored either in underground retrievable vaults or unused hot-cells.

Newly-Generated:

None

APPENDIX B

SAVINGS DUE TO USE OF A SHIELDED DRUM CASK AND CANISTERIZATION AT WIPP

This section will explore the consequences of use of a shielded, double contained cask that can carry individual 55-gallon drums. If such a cask were available, WIPP would receive individual drums of RH TRU waste, place the drums in canisters in the Waste Handling Building and weld the canisters shut prior to emplacement. The analyses is expanded to determine the minimum drum capacity such a cask would have in order to be cost effective.

As shown in Appendix A, a total of 5229 canisters will be shipped to WIPP using the modified DHLW cask. These canisters originate from the sites in quantities shown in Table A-5. The freight cost projections used for this report are given in Appendix C. Table B-1 shows freight costs, number of canisters and total freight costs for the transportation of RH TRU to WIPP.

Table B-1

Total Freight Cost for Shipping RH TRU Waste to WIPP

Site	Canisters	Freight Cost to WIPP per Trip	Total Freight Cost (In Millions
ORNL	3634	$4743	$17.24
Hanford	627	$6014	$ 3.77
INEL	466	$4600	$ 2.14
ANL-E	474	$4901	$ 2.32
LANL	28	$1770	$ 0.05
Total	5229		$25.52

Again using data presented in Appendices A and C, we calculate the number of casks required, and the cost of these casks, based on the number of canisters shipped and the miles to WIPP from each site.

Calculation of required number of casks:

We will first reduce the inventory by the number of canisters to be shipped during the demonstration, and then calculate the number of casks required during the work off period, which is the most demanding period in terms of fleet size. Based on carrier supplied information, we assume 840 miles per day (Ref. B.1). We also assume a total of 3 days of cask turnaround time per round trip.

Table B-2

Number of Canisters, Cost and Cask Requirements for RH Waste Emplaced During WIPP Demonstration by Site

Site	Canisters	Cask Days to WIPP (Round Trip)	Total Days	Freight Cost Per Trip	Total Cost (Millions)
Stored					
LANL	28	3.7	104	$1770	$ .05
ORNL	33	6.1	201	$4743	$ 0.20
Newly Generated*					
ANL-E	119	6.2	738	$4901	$ 0.60
INEL	77	5.7	439	$4600	$ 0.40
TOTAL	257		1482		$ 1.30

*This assumes that all waste generated in 1987 and after will be certifiable and that waste generated in 1986 is not certifiable. However, if some waste generated in 1986 is certifiable, then it will also be eligible. Also, some of the aged ORNL waste may prove to be usable for the demonstration period. Hanford newly-generated waste is not included because it will be placed in the alpha caisson storage and not retrieved until 1997.

These numbers were based on the current plan of emplacing 300 canisters during the demonstration. Assuming an availability of 300 (Ref. B.2) cask-days per year (allowing for holidays and some breakdowns), we see that we need 4.9 cask years for the 5 year demonstration. In other words, one cask could probably suffice for the demonstration. Another cask, however, will be required to support the radioactive experiments at WIPP. After these experiments are completed, the second cask may be used for routine RH-TRU shipments. Using the data presented in Table A-5, we now present the total number of remaining canisters to be shipped, by site, as Table B-3.

Table B-3

Total Canisters to be Emplaced Following the Demo by Site

Site	Canisters
INEL	389
Hanford	627
ORNL	3601
ANL-E	355
TOTAL	4972

Using these numbers for the number of shipments following the demonstration, we can calculated the number of required casks. Again we assume 840 miles per day and a total of 3 days of cask turnaround time per round trip.

Table B-4

Total Cask Days Following The Demo
(Using a fleet of canister casks)

Site	Canisters	Miles to WIPP	Days Per Trip*	Total Days
INEL	389	1150	5.7	2217
Hanford	627	1550	6.7	4201
ORNL	3601	1303	6.1	21966
ANL-E	355	1350	6.2	2201
TOTAL	4972			30585

* Includes turnaround time

With a total of 30,585 cask-days required, and a workoff period of 20 years (following the demonstration), we require 1529 cask-days per year.

With 300 days per year (Ref. B.2), allowing for holidays and some breakdowns, we find that the number of required casks is 5.1, which we round to 6.

The cost of these casks is $3.2 million for development and procurement of the first two, with each additional cask costing $1 million. Thus the total cask cost is $7.2 million.

Thus the total transportation cost for RH TRU waste to WIPP using the canister cask is $7.2 million for the casks and $25.5 for freight, for a total of $32.7 million.

The same methods used above will be employed to estimate the savings due to use of a postulated shielded, double contained cask. As has been mentioned several times, some canister casks will be necessary to transport large items and items with high dose rates. This analysis assumes that two canister casks will be constructed (one of the casks will be primarily used for the radioactive experiments during 1989-93). It is further assumed that all of the LANL waste will be transported using the canister cask, and that the cask will then be used for waste from other sites. To begin, we will assume that the drum cask has a capacity of 10 55-gallon drums. We will later vary this assumption to examine the sensitivity.

To begin, we first calculate the number of shipments the canister casks could make.

First of all, the canister cask would support the demonstration. They would ship the number of canisters shown in Table B-2. Next, if the canister casks moved waste "full-time" from January, 1994 through October, 2013, they would accrue a total of 19.75 cask-years each, or at 300 cask-days per year, 11850 cask-days.

The canister casks would be primarily used to ship waste that cannot be shipped in drum casks. Due to the fact that dose rates for the RH inventories are not precisely characterized, some engineering judgement was exercised when deciding which waste will be shipped in the canister casks. It is assumed that all of Hanford's waste will be shipped in the canister casks due to the high dose rates and waste configurations not suitable to 55-gallon drums. All of the HFEF hulls generated at INEL will also be shipped in this manner. The remainder of the casks' shipping capacity will be utilized to ship ORNL waste. Table B-5 shows the RH canisters shipped via the canister casks.

Table B-5

Waste Shipped Using the Canister Casks

Site	Canisters	Miles to WIPP	Days Per Trip	TOTAL
Hanford	627	1550	6.7	4201
INEL	100	1150	5.7	570
ORNL	1160	1303	6.1	7076
TOTAL	1887			11847

This shipping strategy is intended to a conservative case. If some of the waste identified in Table B-5 proves to be shippable in the drum casks, then it would be shipped in that manner. This would increase the savings associated with the use of the drum casks.

The drum casks would only have to transport the quantities shown below in Table B-6. This table also show the equivalent number of drums.

Table B-6

Canisters Remaining After Use of Canister Casks

Site	Canisters	Drums
ORNL	2441	7323
ANL-E	355	1065
INEL	289	867
TOTAL	3085	9255

We now assume 10 drums per cask, and find the number of casks required. We will assume that use of the drum cask begins following the demonstration, in 1994. Table B-7 show the number of cask days required.

Table B-7

Cask Days Required for the Ten Drum Cask

Site	Drums (10 per Cask)	Cask Days (Round Trip to WIPP)	Total Days
ORNL	7323	6.1	4467
ANL-E	1065	6.2	660
INEL	867	5.7	494
TOTAL	9255		5621

We now find that if we use 300 cask days per year and a 20 year post-demonstration work off, we only need .94 casks, which we round to 1.

For cask cost we will assume a cost of $4.2 million for the three casks (two canister casks and one drum cask.)

Freight costs are given below in Table B-8. For comparison, this table gives freight costs for both the demonstration period and for routine operations.

Table B-8

Freight Costs for a Three Cask Fleet
(Two Canister Casks, One Modified Drum Cask)

Site	Canisters	Drum Equiv.	Shipments DHLW Cask	Shipments Drum Cask	Freight (per Trip)	Total Million
ORNL	3634	10902	1193	733	$4743	$ 9.10
Hanford	627	x	627	x	$6014	$ 3.80
INEL	466	1348	177	87	$4600	$ 1.20
LANL	28	x	28	x	$1770	$ .05
ANL-E	1422	1422	119	107	$4901	$ 1.10
Total	5229		2144	927		$ 15.30

In summary, the total cost for this three-cask system is $15.3 million for freight, and $ 4.2 million for casks for a total of $19.5 million. This compares to $ 32.7 million for the system that uses only the modified DHLW cask. The total savings for this system is $ 13.2 million dollars.

Several factors were not considered in the above analyses. First, WIPP modifications to accept the drum cask and to perform routine canisterization operations have been estimated at $ 2.1 million. The expense of the modifications can be partially offset by some of the generator sites not having to purchase canister welding equipment and facilities. The cost of the canisterization operation was not addressed because it will have to occur at the sites or at WIPP, and these costs were assumed to be the same regardless of the location. Also, cost differentials associated with loading and unloading were not considered. Although the two cask system described resulted in fewer trips, loading of individual drums could be more difficult to the sites. These two effects were assumed to cancel.

Also, the assumption of which sites would be served by the drum cask and which sites would be served by the canister cask were somewhat arbitrary, and variations on this selection could slightly change the magnitude of the savings.

Since loading equipment at the sites has not yet been purchased, it is assumed that this cost will not result in a differential. At INEL, both casks were used in this example, and the use of two loading techniques and two sets of equipment would result in a slight reduction in the savings.

We now examine the cost implications if the postulated drum cask could carry fewer than 10 drums. Because of the methods used in this analysis, we need only repeat Tables B-7 and B-8 for the new conditions.

We now assume 8 drums per cask, and find the number of casks required. Table B-8 show the number of cask days required.

Table B-9

Cask Days Required for the Eight Drum Cask

Site	Drums (8 per Cask)	Cask Days (Round Trip to WIPP)	Total Days
ORNL	7323	6.1	5584
ANL-E	1065	6.2	825
INEL	867	5.7	618
TOTAL	9255		7027

We now find that if we use 300 cask days per year and a 20 year post-demonstration work off, we only need 1.2 casks, which we round to 2.

For cask cost we will assume a cost of $5.2 million for the four casks (two canister casks and two modified drum casks).

Freight costs are given in Table B-10.

Table B-10

Freight Costs for a Four Cask Fleet
(Two Canister Casks, Two Drum Casks)
(8 Drums per Drum Cask)

Site	Canisters	Drum Equiv.	Shipments DHLW Cask	Shipments Drum Cask	Freight (per Trip)	Total Million
ORNL	3634	10902	1193	915	$4743	$10.00
Hanford	627	x	627	x	$6014	$ 3.80
INEL	466	1398	177	108	$4600	$ 1.30
LANL	28	x	28	x	$1770	$ .05
ANL-E	474	1422	119	133	$4901	$ 1.20
TOTAL	5229		2144	1156		$ 16.40

In summary, for a drum cask that holds only 8 drums, the freight cost increases by $1.1 million, the cask cost increases by $ 1.0 million for an additional cask, so the system savings are reduced from $13.2 million to $ 11.1 million.

We now assume 6 drums per cask, and find the number of casks required. We will assume that use of the drum cask begins following the demonstration, in 1994. Table B-11 shows the number of cask days required.

Table B-11

Cask Days Required for the Six Drum Cask

Site	Drums (6 per Cask)	Cask Days (Round Trip to WIPP)	Total Days
ORNL	7323	6.1	7445
ANL-E	1065	6.2	1101
INEL	867	5.7	824
TOTAL	9255		9370

We again find that if we use 300 cask days per year and a 20 year post-demonstration work off, we need two additional casks.

For cask cost we will assume a cost of $5.2 million for the four casks (two canister casks and two drum casks).

Freight costs are given below in Table B-12.

Table B-12

Freight Costs for a Four Cask Fleet
(Two Canister Casks, Two Drum Cask)
(6 Drums per Drum Cask)

Site	Canisters	Drum Equiv.	Shipments DHLW Cask	Shipments Drum Cask	Freight (per Trip)	Total Million
ORNL	3634	10902	1193	1221	$4743	$11.40
Hanford	627	x	627	x	$6014	$ 3.80
INEL	466	1398	177	145	$4600	$ 1.50
LANL	28	x	24	x	$1770	$ .05
ANL-E	474	1422	119	178	$4901	$ 1.50
TOTAL	5229		2144	1544		$ 18.30

In summary, for a drum cask that holds only 6 drums, the freight cost increases to $18.3 million, the cask cost remains at $5.2 million, so the system savings are reduced from $13.2 million to $9.2 million (compared to the 10 drum cask).

We now assume four drums per cask, and find the number of casks required. Table B-13 show the number of cask days required.

Table B-13

Cask Days Required for the Four Drum Cask

Site	Drums (4 Per Cask)	Cask Days (Round Trip to WIPP)	Total Days
ORNL	7323	6.1	11168
ANL-E	1065	6.2	1651
INEL	867	5.7	1235
TOTAL	9255		14054

We find that if we use 300 cask days per year and a 20 year post-demonstration work off, we need three additional casks.

For cask cost we will assume a cost of $6.2 million for the five casks (two canister casks and three drum casks).

REFERENCES

B.1 Telecon with Earl Rutenkroger, Tri-State Motor Transit Company, October 28, 1986.

B.2 Transportation Impacts of the Commercial Radioactive Waste Management Program, April 1986, SAN 85-2715 TTC-0633.

APPENDIX C

TRANSPORTATION DATA

This appendix presents the freight cost data used to calculate the cost of shipping waste from one site to another, or from the sites to WIPP. These data were developed using Tri-State Motor Transit Company tarrif rates (Ref. 5). It should be understood that these rates are negotiable, and the rates presented here are not actual. However, in order to quantify alternatives, use of these published rates is considered the best method. In order to verify the reasonableness of these rates, a second trucking company, A.J. Metler Hauling and Rigging, Inc. was contacted (Ref. 14). The rates given by Metler were found to be in generally good agreement with those presented here.

Table C-1 gives mileage and costs for shipping RH waste under the assumptions that DOE will provide a trailer, and that a second driver will be used.

Table C-1

TRUCK COSTS FOR SHIPPING RH TRU WASTE

ORIGIN	DESTI-NATION	MILEAGE	TRIP COST (PER MILE)	RETURN COST (PER MILE)	BASIC COST	2ND DRIVER COST (.15/MI)	TRAILER ALLOWANCE (.05/MI)	TOTAL
ANL-E	ORNL	600	1.85	1.85	2220	180	60	2340
ANL-E	WIPP	1350	1.87	1.56	4631	405	135	4901
HANF	ORNL	2442	1.56	1.74	8059	733	244	8547
HANF	WIPP	1550	1.84	1.84	5704	465	155	6014
INEL	ORNL	2131	1.56	1.77	7096	639	213	7522
INEL	WIPP	1150	1.90	1.90	4370	345	115	4600
LANL	ORNL	1419	1.56	1.86	4853	426	142	5137
LANL	WIPP	300	2.85	2.85	1710	90	30	1770
ORNL	WIPP	1303	1.88	1.56	4482	391	130	4743
INEL	HANF	594	2.22	2.22	2637	178	59	2756
WIPP	NTS	967	1.93	1.93	3733	290	97	3926
HANF	NTS	960	1.93	1.93	3706	288	96	3898
INEL	NTS	715	2.09	2.09	2989	215	72	3132
ORNL	NTS	1993	1.80	1.56	6696	598	199	7095

Turnaround Costs

When a cask is delivered to a site for loading or delivered to WIPP for unloading, some time is required to perform the required tasks. The time from when the shipment arrives to when it departs is called turnaround. There are certain transportation costs associated with turnaround. These charges compensate the carrier for time lost due to having to wait for another shipment or for having to return with no load. Costs vary according to the length of turnaround time, the proximity to the nearest carrier transit center, and the strategy employed. Two options for turnaround strategy are shown below.

1. Vehicle Detention

This strategy assumes that the driver and rig are held over until another load is available. The advantage is that the driver is available whenever the cask is ready to go. The associated cost is $17.50 per hour (Ref. 5) with the following exceptions:

a) The first three hours are free.

b) The maximum charge for the first day is the charge for 10 hours ($175).

2. Trailer Set Out

This strategy assumes that the cask is delivered, dropped-off, and that the driver is released to return to the carrier's nearest transit center. The charge is $1.98 per mile (Ref. 5) for this trip during which no load is hauled. This option could also present additional dispatching problems due to uncertainties in driver availability.

The dispatching system for the cask fleet has not yet been established. It is therefore impossible to determine which of the above strategies will be used at each site. Once the dispatching decisions are made, then estimates for turnaround costs will be included in the transportation costs.

APPENDIX D

BASIC COST PER CERTIFIED RH CANISTER

This analysis presents the costs associated with packaging certifiable RH TRU waste into an RH canister, certifying the canister, transporting the canister to WIPP, and emplacing the canister at WIPP. Costs are included for canister procurement; for canister welding equipment and operations; for NDA/NDE equipment and operations; for WIPP emplacement operations; for RH cask use; and finally, for freight cost to WIPP. The costs of any processing facilities or operations necessary to get the waste into a certifiable form have not been included in this base cost analysis. The numbers presented here are used later in the report to evaluate alternatives, such as volume reduction or shielding, which involve a trade-off between capital expenditure and change in RH volume.

Canisters

The estimated cost of one RH canister is $10,000.

NDA/NDE

The cost of an NDA/NDE system for RH TRU waste has been estimated to be about $650,000. The life of the system will probably be limited only by the amount of waste available, not by system wear out. In order to amortize the cost of this equipment, it is assumed that each NDA/NDE system will have an effective life of 1,000 operations. We assume that one NDA/NDE operation can be completed in one man-day at $50 per hour. Thus the total cost per canister for NDA/NDE is as follows:

NDA/NDE Capital Cost = $.65 million / 1,000 canisters

= $650 per canister

NDA/NDE Operations Cost = 8 hours * $50 per hour

= $400 per canister

Total NDA/NDE Cost = $1050 per canister

Canister Welding

The cost of a RH canister welder has been estimated at $1 million, including installation. We assume that the life of the welder is 1,000 canisters. We assume that one weld takes one man-day at $50 per hour.

Thus the cost per canister for welding is as follows:

Capital Cost per Canister = \$1 million / 1000 canisters

= \$1,000 per canister

Operations Cost per Canister = 8 hours * \$50 /hour

= \$400 per canister

Total Welding Cost per Canister = \$1,400

WIPP Emplacement

The direct cost for emplacement of one RH canister at WIPP is assumed to be \$1,000. This represents only direct labor costs, and does not include equipment or facility. These costs are assumed to be sunk because most of the facility will be used for CH waste.

RH Cask Usage

The production cost of the RH cask has been estimated at \$1 million per copy. (Developmental costs are considered sunk at the time the first casks are procured. Similar logic is used for estimating per use costs for TRUPACT. If the developmental costs of the casks is amortized over the entire cask fleet, the totals in Table D-2 change by less than 3%.) We assume a life of 1000 shipments (one round trip per week for each cask, 50 trips per year, 20 year routine operation). The usage cost of the cask is therefore \$1000 per shipment. We use this approximation regardless of the length of trip. It should be noted that the 1000 shipment life is an estimate and could possibly be extended.

Freight Cost

Freight cost has been estimated using published tarriffs. The freight cost from each site to WIPP is listed below, in Table D-1.

Table D-1.

FREIGHT COSTS

ORIGIN	DESTINATION	COST
INEL	WIPP	\$4600
HANFORD	WIPP	\$6014
ORNL	WIPP	\$5284
ANL-E	WIPP	\$4901

From the above we find the total cost for three drums of directly certifiable waste, presented below, in Table D-2.

Table D-2

TOTAL FREIGHT COSTS

SITE	BASIC COST	CONTINGENCY (20%)	TOTAL COST
INEL	$ 19,000	$ 3,800	$ 22,800
Hanford	$ 20,414	$ 4,082	$ 24,497
ORNL	$ 19,684	$ 3,937	$ 23,621
ANL-E	$ 19,301	$ 3,860	$ 23,161

Because of the large uncertainty in many of these costs, we will ignore the small site-to-site variability in freight cost, and assume that the cost from each site is equivalent and use the value $23,000 per three drums. Of course, caution must be used in employing these values. These costs assume that enough waste exists at a site to fully amortize the costs of welding equipment and NDA/NDE equipment (and installation), or that the mobile system will be fully functional.

From these numbers we can address volume reduction options. For example, if ORNL proposes a $3 million dollar (capital and operations) volume reduction capability, to pay for itself it would have to eliminate the equivalent of 127 canisters (or 381 55-gallon drums) of volume. (For example, 2:1 volume reduction on 762 55-gallon drums.) For shielding options, the cost of CH drums, NDA/NDE, transportation, and WIPP operations must be accounted for.

APPENDIX E

FACILITY DESCRIPTIONS AND SCHEDULES

This appendix presents as much data as is currently available on RH TRU processing facilities. Facility capabilities, descripions, cost estimates, and schedules are given by site.

INEL

INEL has proposed SWEPP II/PREPP II for retrieval, processing, and certification of contact-handled (CH) special-case (SC) and remote-handled (RH) stored TRU waste. In FY 1985, a characterization of INEL stored CH SC and RH was conducted to determine the amount of RH waste that could be certified through non-destructive testing and records examination. This study concluded that 95% of all stored waste at INEL is expected to meet the WIPP-WAC without processing. However, 5436 packages (7% of total inventory) are expected to be SC.

SWEPP II/PREPP II is still in the early stages of conceptual development. Alternatives being examined include: modification of existing SWEPP and PREPP, modification of other facilities (e.g. hot cell), and construction of a new facility. Of course, the alternative for shipping to another (off-site) facility is still under consideration.

If a new facility is constructed, the cost estimate is as follows:

Table E-1

SWEPP II/PREPP II COST ESTIMATE

Description	Cost (In $ Thousand)	
Waste Characterization	$ 50	(complete)
Alternative Selection	$ 300	(underway)
Conceptual Design	$ 400	(sched. FY 1988)
Title 1 and II Design	$ 1,600	
Construction		
Buildings and Structures	$ 3,600	
Remote Handling Equipment	$ 1,800	
Instrumentation	$ 900	
Remote Retrieval Equipment	$ 2,800	
Transportation Equipment	$ 1,500	
Construction Total	$10,600	
Technology Development	$ 4,000	
Staffing and Training	$ 3,380	
EG&G TRU Program Mgmt.	$ 2,000	
TOTAL	$22,330	
Less FY 1985,1986 Amounts	$ 350	
Total to Complete	$21,980	

The operating cost for SWEPP II/ PREPP II is estimated to be $5 million per year.

Error bands for these estimates are significant (up to 60% for some items). The uncertainty of the operations cost is given as plus or minus 50%.

October, 1994 is the start date for SWEPP II/PREPP II, and the operating campaign (of 13 years) would last until October, 2007. Again, this time period estimate is based on a new facility. If SWEPP and PREPP are modified, operations could not commence until a later date.

HANFORD

Hanford is proposing the Remote-Handled Waste Handling and Packaging Facility (RH WRAP). This facility is also in the very early stages of conceptual design.

ORNL

ORNL has proposed the Waste Handling Pilot Plant (WHPP) for processing stored RH waste. While this facility has been examined more closely than those at INEL and Hanford, again, it is still in the early stages of conceptual design. Current plans call for this facility to have three cells, as described in Ref. 1. However, due to the large amount of recently discovered RH TRU sludge at ORNL, the addition of some form of solidificaion capability is now contemplated. Ref. 1 estimated a baseline WHPP cost of $35 million. Due to the addition of a glass melter and ancillary equipment, this estimate has been revised upward to $47.6 million. Details of this estimate appear on the following page.

The WHPP, as currently envisioned, would have the capability of opening, repackaging, and processing for certification. The addition of a super-compactor could be expected to cost about $1 million. Operating costs have not yet been established.

The WHPP schedule calls for start-up to occur in FY 1996, and for operations to continue through the life of WIPP, or the year 2013. This schedule assumed that development work would begin in FY 1987.

APPENDIX F

MILESTONE SUMMARY

SITE	MILESTONE	DATE
PROGRAMMATIC		
*	Complete plans for retrieval, preparation, and transportation of RH wastes to WIPP	12/86
	Complete greater confinement disposal field test	09/87
*	SC Management Decisions	09/87
	SC assay system operational	09/87
	Mobile NDA/NDE system operational	09/87
	Complete NEPA documentation for small sites	09/87
	Begin shipping certified waste to WIPP	10/88
*	Decisions complete on long-term management of buried waste, all sites	12/94
PACKAGING AND TRANSPORTATION		
*	Decision on Follow-on Type B packaging	12/86
	Initiate DOE certification of TRUPACT I	05/87
	Packages of simulated CH and RH waste available for non-radioactive demonstration at WIPP	07/87
	RH canister performance final report	07/87
	Final design complete, Follow-on Type B packaging	09/87
	TRUPACT II certificate of compliance	02/88
	Delivery of Follow-on Type B packaging prototype for testing	05/88
	Qualification testing of Follow-on Type B packaging complete	07/88
*	RH Cask Available	09/88
	TRUPACT fleet available for shipment to WIPP	10/88
	TRUPACT II fleet fabrication complete	08/89
	Complete construction of RH shipping fleet	01/94
WASTE ISOLATION PILOT PLANT (WIPP)		
	Packages of simulated waste available for demonstration	07/87
*	Begin WIPP demonstration operations with radioactive waste	10/88
	Receive first shipment of RH TRU at WIPP	01/89
*	Decision on whether to convert WIPP to a permanent repository	10/93
*	Decision whether follow-on repository needed in 2008	04/02
	WIPP decommissioning complete	12/16

* Key Decision

** Includes Contingency Operations

SITE	MILESTONE	DATE
IDAHO NATIONAL ENGINEERING LABORATORY		
	Begin treating uncertified stored/retrieved CH waste at INEL (PREPP experiments)	03/88
	Complete waste sorting studies in PREPP	09/88
	Stop receiving off-site CH waste at INEL	10/88
	Begin shipping stored/retrieved CH waste to WIPP from INEL	10/88
	Begin retrieval of stored not precertified RH waste at INEL	10/93
	Begin treating uncertified stored/retrieved RH waste at INEL	10/93
	Stop receiving offsite RH waste at INEL	01/94
	Begin shipping new RH waste directly to WIPP from INEL	01/94
	Begin shipping precertified RH waste to WIPP from INEL	01/94
*	Begin full operation of SWEPP-II	09/94
	Complete shipping stored/retrieved RH waste to WIPP from INEL	10/95
*	Complete retrieval and processing of stored/not precertified RH waste at INEL	10/95
	INEL goal for completion of SWEPP and PREPP experiments	10/96
	Complete retrieval and processing of stored/not precertified CH waste at INEL	10/00
	Complete processing of SC and CH waste at INEL	10/06
	Complete shipping stored/retrieved CH waste to WIPP from INEL	10/13
HANFORD		
	Final Hanford Defense Waste EIS to public	04/87
	Complete certification plans for stored waste at Hanford	09/87
	Begin shipping new CH waste directly to WIPP from Hanford	10/88
	Begin retrieval of stored/not precertified CH waste at Hanford	04/94
	Begin treating uncertified stored CH waste at Hanford (WRAP)	04/94
	Begin shipping stored/retrieved CH waste to WIPP from Hanford	04/94
	Begin shipping new RH waste directly to WIPP from Hanford	10/97
	Begin shipping precertified RH waste to WIPP from Hanford	10/97
	Begin retrieval of stored RH waste at Hanford	10/97

* Key Decision

** Includes Contingency Operations

SITE	MILESTONE	DATE
	Complete retrieval and processing of stored/ not precertified CH waste at Hanford	10/13
**	Complete shipping stored/retrieved RH waste to WIPP from Hanford	10/13
*	Complete shipping stored/retrieved CH waste to WIPP from Hanford	10/13
LOS ALAMOS NATIONAL LABORATORY		
	Complete certification plans for stored waste at LANL	03/88
	Begin shipping new CH waste directly to WIPP from LANL	10/88
	Complete shipping stored/retrieved RH waste to WIPP from LANL	10/89
	Begin shipping new RH waste directly to WIPP from LANL	01/89
	Begin shipping precertified RH waste to WIPP from LANL	01/89
	Begin retrieval of stored not precertified RH waste at LANL	08/89
	Begin shipping stored/retrieved CH waste to WIPP from LANL	10/91
	Complete size reduction on oversize boxes of metal stored at LANL	09/97
	Complete retrieval and processing of stored/ not precertified CH waste at LANL	09/97
	Complete shipping stored/retrieved CH waste to WIPP from LANL	10/13
NEVADA TEST SITE		
	Begin shipping stored/retrieved CH waste to WIPP from NTS	10/88
	Stop receiving offsite CH waste at NTS	10/88
	Complete retrieval and processing of stored/ not precertified CH waste at NTS	09/91
	Complete shipping stored/retrieved CH waste to WIPP from NTS	09/91
OAK RIDGE NATIONAL LABORATORY		
	Begin generating certifiable RH waste, but not containers, at ORNL (it is planned to age RH waste before shipment)	01/87
	Complete certification plans for stored waste at ORNL	09/87
	Complete certification of stored/not precertified CH waste at ORNL	10/88

* Key Decision

** Includes Contingency Operations

SITE	MILESTONE	DATE
	Begin shipping new CH waste directly to WIPP from ORNL	10/88
	Begin shipping stored/retrieved CH waste to WIPP from ORNL	10/88
	Begin retrieval of stored not precertified RH waste at ORNL	10/95
	Begin shipping aged RH waste to WIPP from ORNL	01/96
	Complete retrieval and processing of stored/ not precertified RH waste at ORNL	10/13
	Complete shipping store RH waste to WIPP from ORNL	10/13
	Complete shipping stored/retrieved CH waste to WIPP from ORNL	10/13
SAVANNAH RIVER PLANT		
	Complete formal NEPA analysis	09/87
	Begin shipping new CH waste directly to WIPP from SRP	10/88
	Complete certification plans for stored waste	12/91
	Begin retrieval of stored not precertified CH waste at SRP	04/94
	Begin treating uncertified stored/retrieved CH waste at SRP	04/94
	Begin shipping stored/retrieved CH waste to WIPP from SRP	04/94
	Complete retrieval and processing of stored/ not precertified CH waste at SRP	04/09
	Complete shipping stored/retrieved CH waste to WIPP from SRP	10/13
ROCKY FLATS PLANT		
	Certify all major streams of new CH waste at at RFP	04/87
	Fluid Bed Incinerator Operational	05/87
	RFP HEPA filter compacter or coating operational	11/86
	Begin shipping new CH waste directly to WIPP from RFP	10/88
	Begin operation of second generation LOSAC	01/90
OTHER GENERATING SITES		
	Begin generating certifiable CH waste for major new streams	10/86
	Submit RH certification plan (ANL-E)	09/87
	Begin certifying new RH waste for major steams	04/87
	Begin shipping new CH waste directly to WIPP	10/88
	Begin shipping new RH waste directly to WIPP	01/94

* Key Decision
** Includes Contingency Operations

APPENDIX G

TRANSPORTATION COST ANALYSES FOR CENTRAL PROCESSING

This appendix analyzes the cost impacts for processing RH TRU waste at a central processing facility located at ORNL. Because ORNL has about 95% of the stored waste, it is clear that the transportation penalties for central processing will be smallest at ORNL. Further, the waste in storage at ORNL (both the stored hot cell waste and the sludges) cannot be transported without extensive processing. This processing would have to occur in a facility nearly as sophisticated and expensive as the proposed ORNL WHPP facility. Therefore, only the cost consequenses for shipping waste to ORNL have been evaluated.

Assumptions:

1. As presented in Appendix C, the freight costs and mileages between sites are as follows:

Site	Mileage	Freight Cost
Hanford to WIPP	1550	$6014
Hanford to ORNL	2442	$8547
ORNL to WIPP	1303	$4743
ANL-E to ORNL	600	$2340
ANL-E to WIPP	1350	$4901

2. The waste that will require processing is as follows:

   INEL: None. For this analyses, the entire amount of waste from INEL is considered certifiable without processing.

   Hanford: 69 Canisters. As shown in Appendix A, Hanford has the equivalent of 69 canisters in storage. All of this waste is assumed to require processing for certification.

   LANL: None. This waste is considered certifiable without processing.

   ANL-E: 474 Canisters. As shown in Appendix A, ANL-E will produce 474 canisters over the life of WIPP. Although this waste will be certified as to form, ANL-E does not have canisterization facilities

3. As presented in Appendix B, a truck travels 840 miles per day with three days total turnaround per round trip.

4. No volume reduction occurs. (Note that volume reduction is analyzed in Appe[illegible] J.)

The cost differential for transportation for central processing involves eliminating the cost of shipping directly from a site to WIPP, and adding the cost of shipping from the site to ORNL and then from ORNL to WIPP. These cost are quantifed both for freight costs and for cask fleet size effects.

Table G-1 shows the extra cask days required for central processing. Cask-days per trip are calculated by multiplying the mileage by two (for a round trip), and dividing the product by 840 (miles per day), and then by adding three days for turnaround, queueing, and breakdowns.

Table G-1

Extra Cask Days Required for Central Processing

Trip	Canisters	Distance	Cask Days Per Trip	Total Days
Reduced Travel				
ANL-E to WIPP	474	1350	6.2	2939
Hanf to WIPP	69	1550	6.7	462
Added Travel				
ANL-E to ORNL	475	600	4.4	2086
Hanf to ORNL	69	2442	8.8	607
ORNL to WIPP	543	1303	6.1	3312
			Net Total	2604

With 2604 extra cask days required, and 300 days per cask-year and a 20 year work off of stored waste, we require .43 extra casks. We round this to one extra cask, and assume that casks cost $1 million each, for a cask penalty of $1 million.

Table G-2 shows the freight cost differential for central processing at ORNL.

Table G-2

Freight Cost Differential for Central Processing

Site	Canisters	Site to ORNL* (Added Cost)	ORNL to WIPP* (Added Cost)	Site to WIPP* (Savings)	Net Total (Millions)
ANL-E	474	$2340	$4743	$4901	$1.0
Hanford	69	$8547	$4743	$6014	$0.5

The total freight and cask fleet size penalty for central processing is $2.5 Million ($1 Million for the extra cask and $1.5 Million for the added freight).

* These costs are on a per canister basis.

APPENDIX H

SHIELDING REMOTE-HANDLED TRANSURANIC WASTE TO CONTACT HANDLED LEVELS

SUMMARY AND CONCLUSIONS

The concept of shielding remote-handled (RH) transuranic (TRU) waste to contact-handled (CH) levels (i.e., less than 200mRem/hr) is evaluated in this appendix. The costs of packaging, transporting, and emplacing waste at WIPP were estimated for up to three options for each of several waste forms. The total costs for shielded-to-CH option(s) are higher than the RH canister option in all cases, by ratios ranging from about 2.4:1 to greater than 4:1. Total estimated costs are presented in the Table H-1. Savings in transporters, freight and emplacement costs for the shielded option(s) are more than offset by the much higher packaging cost of the shielded option(s). Also, some stored RH waste forms cannot be shipped in a CH form without extensive and expensive repackaging.

A waste generator may find site specific or waste form specific advantages for the shielded option, based on ALARA, operational constraints, or in-house costs, that offset the higher packaging costs developed in this analysis. An example is the RHO decision to use shielded drums to avoid the need to construct additional alpha caissons for RH TRU storage.

The conclusion of this analysis is that an RH transportation cask fleet is justified because: (a) it is cost-effective; and (b) some stored waste forms cannot be transported without it.

ANALYSES

COST: The example cost estimates are presented in Table H-1. The input data and assumptions are detailed below.

APPLICABILITY: Most newly generated RH waste could be packaged in a CH form, even though this option is not more cost-effective (as shown in the table). An exception may be the projected inventory of PFMP hulls from Hanford. The dose rate expected for this waste form precludes shielding to CH levels within the constraints of TRUPACT. Several waste generating facilities or processes would require changes to achieve an all-CH inventory or newly generated waste. Stored RH waste inventories include waste forms with characteristics or geometries, or both, that cannot be readily shielded. Examples include existing RH TRU containers at LANL and INEL. An RH transportation system (canister and cask) is essential to disposal of stored RH in WIPP.

TABLE H-1

ESTIMATED LIFE CYCLE COST FOR RH PACKAGING OPTIONS ($ in $ Millions)

WASTE FORM

	NEWLY GENERATED Hot Cell Waste in Paint Cans (6,000 cans)[a]	30 gal. Drums (1,400 drums)[b]	Sludges 916 M3 [c]
RH CANISTER	1.3	8.2	26.5
SHIELDED DRUM (ANL-E DESIGN)	2.6	Not suitable for this waste form	105.6
SHIELDED DRUM (RHO DESIGN)	3.2	11.2	127.7
MOST COST EFFECTIVE OPTION FOR THIS WASTE FORM	RH CANISTER	RH CANISTER	RH CANISTER

(a) Estimated inventory of newly generated hot cell waste in paint cans, Hanford, 1988-2013.

(b) Estimated total inventory of waste packaged by ANL-E in 30-gal. drums, stored plus newly generated through 2013.

(c) Estimated inventory of sludges in storage at ORNL. No new generation of this waste form is expected.

INPUT DATA AND ASSUMPTIONS

1. Packages

a.	RH Canister Contents -	Cost $10,000 Three 55-gal drums, each containing up to 28 one-gal. inner containers ("paint cans") = 84 cans/canister
b.	ANL-E Shielded Drum Contents -	Cost $1,100 (existing procurement cost) 3 paint cans
c.	Weight	Approximately 1,500 lbs.
d.	RHO Shielded Drum Contents -	Cost $7,800 (estimated production cost) 15 each paint cans (compacted)
	Weight	Approximately 5,000 lbs.

2. Transporters

a.	RH Cask -	Cost $1,600,000 each for first two Usable life - 1,000 trips Cost per use = $1,600 Capacity - 1 RH canister
b.	TRUPACT -	Cost $800,000 Useable life - 2,000 trips Cost per use = $400 Contents - 48 drums

3. Transportation Freight Cost

   1 RH Cask = 1 TRUPACT = (applicable value from Table C-1)

4. Emplacement Operation Cost

   1 RH Cask = 1 TRUPACT = $1,000

5. Assume that sufficient unshielded, light-weight CH is available to fill all TRUPACTs

COST ANALYSIS, HANFORD PAINT CANS

Waste Form: Newly generated hot well waste in 1-gallon paint cans

Inventory: 300 cans/yr for 20 years = 6,000 cans

Option 1: Ship in RH Canisters

$$6{,}000 \text{ cans} \times \frac{\text{Canister}}{84 \text{ cans}} = 72 \text{ canisters}$$

72 canisters x \$10,000/canister = \$720,000

$$72 \text{ canisters} \times \frac{\$1{,}600 \text{ (cask)} + 6{,}014 \text{ (freight)}}{\text{Canister}} = \$548{,}000$$

72 canisters x \$1,000/emplacement = \$72,000

Total = \$1,340,000

Option 2: Ship in ANL-E Drum

$$6{,}000 \text{ cans} \times \frac{\text{Drum}}{3 \text{ cans}} = 2{,}000 \text{ drums}$$

2,000 drums x \$1,100/drums = \$2,200,000

$$2{,}000 \text{ drums} \times \frac{\text{TRUPACT}}{36 \text{ drums}} = 56 \text{ TRUPACTS}$$

$$56 \text{ TRUPACTS} \times \frac{[\$400 \text{ (TRUPACT)} + \$6{,}014 \text{(freight)}]}{\text{TRUPACT}} = \$359{,}000$$

56 TRUPACTS x \$1,000/emplacement = \$56,000

Total = \$2,615,000

Option 3: Ship in RHO Drums

$$6{,}000 \text{ cans} \times \frac{\text{Drum}}{15 \text{ cans}} = 400 \text{ drums}$$

400 drums x \$7800/drum = \$3,120,000

$$400 \text{ drums} \times \frac{\text{TRUPACT}}{36 \text{ drums}} = 12 \text{ TRUPACTS}$$

12 TRUPACTS x \$6,414/TRUPACT = \$77,000

12 TRUPACTS x \$1,000/emplacement = \$12,000

Total = \$3,209,000

COST ANALYSIS, ANL-E 30-GALLON DRUMS

Waste Form: Hot cell waste from ANL-E, stored and newly generated, packaged by generator in 30-gal. drums.

Inventory: 1400 drums total

Option 1: Ship in RH Canisters

$$1400 \text{ drums} \times \frac{\text{canister}}{3 \text{ drums}} = 467 \text{ canisters}$$

467 canisters x $10,000/canister = $4,670,000

$$467 \text{ canisters} \times \frac{\$1{,}600(\text{cask}) + \$4{,}901(\text{freight})}{\text{canister}} = \$3{,}040{,}000$$

467 canisters x $1,000/emplacement = $467,000

Total = $8,177,000

Option 2: Not suitable for this waste form, since the 30-gal. waste drum will not fit into the 9" diameter annulus of the ANL-E design shielded drum.

Option 3: Shield in RHO Drums

$$1{,}400 \text{ waste drums} \times \frac{1 \text{ shielded drum}}{1 \text{ waste drum}} = 1{,}400 \text{ drums}$$

1,400 drums x $7,800/drum = $10,920,000

$$1{,}400 \text{ drums} \times \frac{\text{TRUPACT}}{36 \text{ drums}} = 39 \text{ TRUPACTS}$$

$$39 \text{ TRUPACTS} \times \frac{(\$400 + \$4901)}{\text{TRUPACTS}} = \$207{,}000$$

39 TRUPACTS x $1,000/emplacement = $39,000

Total = $11,166,000

COST ANALYSIS, ORNL SLUDGES

Waste Form: Existing sludges.

Inventory: 961 m^3 (Assume no volume change results from the processing required to produce certified waste form. Relative cost estimates will not be changed if this assumption is changed.)

Option 1: Ship in RH Canisters

$$961 \text{ m}^3 \times \frac{\text{55-gal drum}}{0.21 \text{ m3}} \times \frac{\text{canister}}{\text{3 drums}} = 1526 \text{ canisters}$$

1526 canisters x \$10,000/canister = \$15,260,000

$$1526 \text{ canisters} \times \frac{(\$1,600 + \$4,743)}{\text{canister}} = \$9,680,000$$

1526 canisters x \$1,000/emplacement = \$1,526,000

Total = \$26,500,000

Option 2: ANL-E Design Shielded Drums

$$961 \text{ m}^3 \times \frac{\text{shielded drum}}{0.0115 \text{ m3}} = 83,600 \text{ drums}$$

83,600 drums x \$1,100/drum = \$91,960,000

$$83,600 \text{ drums} \times \frac{\text{TRUPACT}}{\text{36 drums}} = 2,323 \text{ TRUPACTS}$$

$$2,323 \text{ TRUPACTS} \times \frac{(\$400 + \$4,473)}{\text{TRUPACT}} = \$11,320,000$$

2,323 TRUPACTS x \$1,000/emplacement = \$2,323,000

Total = \$105,600,000

Option 3: Hanford Design Shielded Drum

$$961 \text{ m}^3 \times \frac{\text{shielded drum}}{0.06 \text{ m3}} = 16,000 \text{ drums}$$

16,000 drums x \$7,800/drum = \$125,000,000

$$16,000 \text{ drums} \times \frac{\text{TRUPACT}}{\text{36 drums}} = 445 \text{ TRUPACTS}$$

$$445 \text{ TRUPACTS} \times \frac{(\$400 + \$4,743)}{\text{TRUPACT}} = \$2,300,000$$

445 TRUPACTS x \$1,000/emplacement = \$445,000

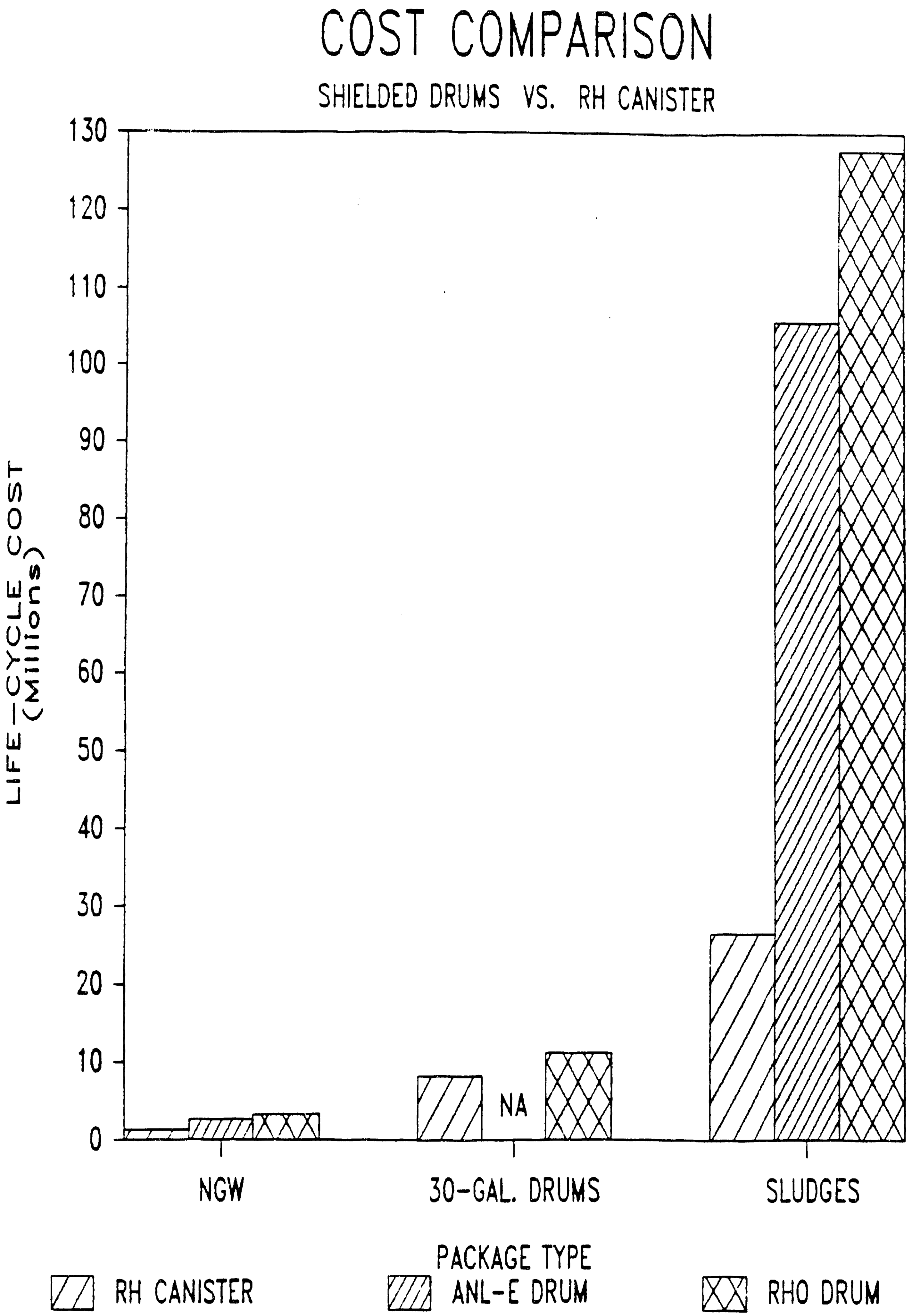
Total = \$127,700,000

ADDITIONAL DISCUSSION

1. The apparent cost disadvantages from shielding RH to CH in the above analysis results from the much higher shielded package cost. If the cost of shielded packages is lowered, other costs and institutional issues for the shielded option, not considered here, may become significant for decision making. Examples include Type A testing of shielded drums, and re-test or re-analysis of the TRUPACT for radionuclide or physical loading not covered by the existing SARP.

2. As more RH is shielded to CH, more shipments of partially full TRUPACT's could result, since only a few heavy shielded drums can be accommodated within the weight limit for TRUPACT.

3. Good waste management practices by TRU waste generators should include shielding small hot items at the point of generation so that the items can be packaged in routine CH waste drums.


COST COMPARISON
SHIELDED DRUMS VS. RH CANISTER
LIFE-CYCLE COST (Millions)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
NA
NGW
30-GAL. DRUMS
SLUDGES
PACKAGE TYPE
RH CANISTER
ANL-E DRUM
RHO DRUM

APPENDIX I

ANALYSIS OF COST IMPACTS FOR SHIPPING RH TRU WASTE FROM ANL-E TO ORNL FOR CANISTERIZATION

This appendix assumes that a facility will be constructed at ORNL and evaluates the consequenses of shipping RH TRU from ANL-E for the purpose of canisterization, volume reduction, and subsequent shipment to WIPP. The analyses varies the number of drums per shipping cask and the volume reduction factor to examine the sensitivity.

Assumptions:

1. Facility will exist at ORNL (No capital cost)

2. A canisterization facility at ANL-E will cost $2.0 million to construct

3. RH canister cost $10,000 per copy

4. WIPP emplacement cost is $1,000 per canister

5. Freight costs as presented in Appendix C are as follows:

ANL-E to WIPP	1350 Miles	$4901 per trip
ANL-E to ORNL	600 Miles	$2340 per trip
ORNL to WIPP	1303 Miles	$4743 per trip

6. Total waste to be shipped from ANL-E as presented in Appendix A, 474 canisters, each containing three 30-gallon drums

7. As presented in Appendix B, a truck moves 840 miles per day, 300 days per year, with three total days turnaround time per round trip

<u>Case One: Three Drums per Shipment, No Volume Reduction</u>

Each case examined identifies the additional transportation steps required, the transportation steps not required, and the fleet size consequences. This first case is relatively simple, in that no volume reduction occurs. The extra transportation steps are shipments from ANL-E to ORNL and from ORNL to WIPP. The transportation step that is saved is from ANL-E directly to WIPP.

<u>Extra Transportation Steps:</u>

ANL-E to ORNL

474 Shipments x $2340 per Shipment = $1.109 Million

ORNL to WIPP

474 Shipments x $4743 per Shipment = $2.248 Million

Transportation Steps Not Required:

ANL-E to WIPP

476 Shipments x $4901 per Shipment = $2.323 Million

Net Transportation Cost Penalty:

Extra Cost = $1.109 + $2.248 - $2.323 (In Millions)

Extra Cost = $1.0 Million

Thus it will cost an addition $1 Million in freight cost to ship all waste from ANL-E to ORNL and subsequently to WIPP rather than directly to WIPP.

Fleet Size Consequenses:

Extra Cask Usage

ANL-E to ORNL

474 trips x ((2 x 600 miles/840 miles per day) + 3 days turnaround)
= 2100 Cask-Days

ORNL to WIPP

474 trips x ((2 x 1303 miles/840 miles per day) + 3 days turnaround)
= 2893 Cask-Days

Reduced Cask Usage

ANL-E to WIPP

474 trips x ((2 x 1350 miles/840 miles per day) + 3 days turnaround)
= 2946 Cask-Days

Net Extra Cask-Days = 2100 + 2893 - 2946
= 2047 Cask-Days

Net Extra Cask Requirements = 2047 Cask-Days/(20 year work off x 300 days/yr)
= 0.34 Casks

Since only integer casks are possible, we will need either zero or one extra cask. To be as conservative as possible, we will assume one is necessary, at a cost of $1 million.

Finally, the cost of a canisterization facilty at ANL-E is avoided, for a savings of $2 Million. In this case, the cost of canister operations are not subject to change (the operation will have to occur the same number of times, regardless of the location), the number of canisters required and the number of emplacement operations are also unchanged because no volume reduction occurs.

In summary, for this first case, the $2 million dollar facility cost at ORNL is offset by $1 million in extra transportation and $1 million in extra cask requirements. Thus no savings or expenditure is realized. However, it must be remembered that it is not clear (or even probable) that an extra cask is truly required. An extra cask was assumed for conservatism. Also, the $2 million estimate for the ANL-E canisterization facility may be low.

Case Two: Three Drums per Shipment, 5:1 Volume Reduction

This second case has an added element in that a volume reduction of 5:1 is assumed to occur at an existing ORNL facility. This large volume reduction is reasonable because the packaging mode of this waste consists of three 30-gallon drums per canister, with a large void volume. As in case one, the extra transportation steps are shipments from ANL-E to ORNL and from ORNL to WIPP. The transportation step that is saved is from ANL-E directly to WIPP.

Extra Transportation Steps:

ANL-E to ORNL

474 Shipments x $2340 per Shipment = $1.109 Million

ORNL to WIPP

Volume Reduction of 5:1 leaves 95 shipments from ORNL

95 Shipments x $4743 per Shipment = $0.451 Million

Transportation Steps Not Required:

ANL-E to WIPP

474 Shipments x $4901 per Shipment = $2.323 Million

Net Transportation Cost Penalty:

Extra Cost = $1.109 + $0.451 - $2.323 (In Millions)

Extra Savings = $0.76 Million

Thus, due to the volume reduction at ORNL, it will save $0.76 Million in freight cost to ship all waste from ANL-E to ORNL and subsequently to WIPP rather than directly to WIPP.

Fleet Size Consequenses:

Extra Cask Usage

ANL-E to ORNL

474 trips x ((2 x 600 miles/840 miles per day) + 3 days turnaround)
= 2100 Cask-Days

ORNL to WIPP

95 trips x ((2 x 1303 miles/840 miles per day) + 3 days turnaround)
= 580 Cask-Days

Reduced Cask Usage

ANL-E to WIPP

474 trips x ((2 x 1350 miles/840 miles per day) + 3 days turnaround)
= 2946 Cask-Days

Net Cask-Days Savings = 2100 + 580 - 2946
= 266 Cask-Days

In this case, central processing actually saves cask-days due to volume reduction. This small savings will be neglected.

Again, the cost of a canisterization facilty at ANL-E is avoided, for a savings of $2 Million.

The number of canisters required is reduced from 474 to 95. At a cost of $10,000 per canister, this results in a savings of $3.8 Million.

The number of WIPP emplacement operations is reduced by a like amount. At a cost of $1,000 per operation, this results in a savings of $ .38 Million.

The cost of the volume reduction operation is assumed to be small.

In summary, this case saves $0.76 Million in transportation costs, $2.0 Million in facility costs at ANL-E, $3.8 Million in canister costs (due to compaction), and $0.38 Million in WIPP emplacement costs, for a total of $7.0 Million.

These savings would be slightly reduced by increased operations costs at the ORNL facility.

Case Three: Eight Drums per Shipment, 5:1 Volume Reduction

This case includes the volume reduction of 5:1 and also examines the consequenses of using a drum cask that will carry eight drums per shipment. In this case, ANL-E will only make 178 shipments. (474 canisters x 3 drums per canister ÷ 8 drums per cask.)

Extra Transportation Steps:

ANL-E to ORNL

178 Shipments x $2340 per Shipment = $0.416 Million

ORNL to WIPP

Volume Reduction of 5:1 leaves 35 shipments from ORNL

36 Shipments x $4743 per Shipment = $0.171 Million

Transportation Steps Not Required:

ANL-E to WIPP

178 Shipments x $4901 per Shipment = $0.872 Million

Net Transportation Cost Penalty:

Extra Cost = $0.416 + $0.171 - $0.872 (In Millions)

Extra Savings = $0.29 Million

Thus, due to the volume reduction at ORNL, it will save $0.29 Million in freight cost to ship all waste from ANL-E to ORNL and subsequently to WIPP rather than directly to WIPP.

Fleet Size Consequenses:

Extra Cask Usage

ANL-E to ORNL

178 trips x ((2 x 600 miles/840 miles per day) + 3 days turnaround)
= 778 Cask-Days

ORNL to WIPP

36 trips x ((2 x 1303 miles/840 miles per day) + 3 days turnaround)
= 220 Cask-Days

Reduced Cask Usage

ANL-E to WIPP

178 Shipments x ((2 x 1350 miles/840 miles per day) + 3 days turnaround) = 1106 Cask-Days

Net Cask-Days Savings = 778 + 220 - 1106
= 108 Cask-Days

Because the difference in cask requirements is only 108 days over 20 years, this factor will be neglected.

Again, the cost of a canisterization facilty at ANL-E is avoided, for a savings of $2.0 Million.

The number of canisters required is reduced from 474 to 96 (even though there are 36 shipments to WIPP, each will contain 8 drums, and will result in about 96 canisters). At a cost of $10,000 per canister, this results in a savings of $3.8 Million.

The number of WIPP emplacement operations is reduced by a like amount. At a cost of $1,000 per operation, this resluts in a savings of $0.38 Million.

The cost of the volume reduction operation is assumed to be small.

In summary, this case saves $0.29 Million in transportation costs, $2.0 Million in facility costs at ANL-E, $3.8 Million in canister costs (due to compaction), and $0.37 Million in WIPP emplacement costs, for a total of $6.5 Million.

Again, these savings would be slightly reduced by increased operations costs at the ORNL facility.

Summary:

These three cases represent a wide range of factors for volume reduction and freight capabilities. In the most optimistic case, nearly $7.0 million dollars was saved.

APPENDIX J

ANALYSIS OF VOLUME REDUCTION AT ORNL

The analysis shows a minimum savings of $20 million if compaction is employed. In addition, further savings up to $10.4 million are possible, for a potential savings of up to $30 million.

Assumptions:

1. A compactor will cost roughly $1 million to purchase and another $1 million to install. The operating cost for a compactor is assumed to be negligible.

2. The volume reduction (VR) from the compactor is assumed to range from 2:1 to 5:1, with 3:1 being the most likely case.

3. In the analyses, the compactor is used only for ORNL retrievable stored and newly-generated hot cell waste. The sludges are not compactable.

4. The cost to emplace one canister at WIPP is $1000 (40 man-hours at $25 per hour) (Ref. WIPP-Westinghouse).

Appendix A shows that ORNL has 1128 canisters in storage and generates 35 canisters per year (for the period 1986 through 2013), for a total of 2108 canisters. This excludes all the stored sludge, which is not appropriate for compaction. Appendix C provides the cost of transportation, from ORNL to WIPP as $4743 per trip. Table J-1 gives a cost comparison for three cases, two with and one without compaction.

Table J-1

Cost Comparison for Volume Reduction at ORNL

	Case One Without VR	Case Two With 3:1 VR	Case Three With 5:1 VR
Beginning Canister Population	2108	2108	2108
Compaction Cost	--	$2.0 Million	$2.0 Million
Resulting Canister Population	2108	703	422
Canister Cost	$21.1 Million	$7.0 Million	$4.2 Million
Transportation Cost (At $ 4743 per shipment)	$10.0 Million	$3.3 Million	$2.0 Million
WIPP Emplacement Cost (At $ 1000 per operation)	$02.1 Million	$0.7 Million	$0.4 Million
Total Cost	$33.2 Million	$13.0 Million	$8.6 Million

Under these assumptions, a savings of $20 million dollars occurs if 3:1 volume reduction occurs. Several other factors may influence this savings, and they are listed below:

* Waste shipped to ORNL for processing would be compacted, with potential added savings up to $4 million. This assumes that all stored waste from Hanford will be shipped to ORNL, and all newly-generated waste from ANL-E.

* Volume Reduction of 5:1 would increase the savings of compacting ORNL waste an additional $4.4 million, with added savings for off-site waste compaction.

* Other operations were not considered, such as the cost of loading the cask. Reducing the number of operations would increase savings. Offsetting this effect is the assumption that the operating cost of the compactor is negligible.

* By reducing the number of shipments to WIPP, the cask fleet size could be reduced from five, to four or three, depending on the amount of volume reduction assumed. This would increase the savings by $1 to $2 million.

In summary, it is easy to show a savings of $20.2 million if compaction is employed. In addition, further savings up to $10.4 million are possible, for a total potential savings of up to $30 million.