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Cost Comparison for REDC Pretreatment Project

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LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL-27 (3-96)

ORNL/TM-13433

Chemical Technology Division

COST COMPARISON FOR REDC PRETREATMENT PROJECT

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Date of Issue — June 1997

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for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-96OR22464

CONTENTS

ABSTRACT

This analysis has been prepared to support the planned expenditure to provide the Radiochemical Engineering Development Center (REDC) with the capability to pretreat their liquid low-level waste (LLLW) before discharging it to the Oak Ridge National Laboratory (ORNL) LLLW system. Pretreatment will remove most of the radioactivity, particularly the transuranic isotopes and Cs-137 from the waste to be discharged. This will render the supernates that accumulate in the storage tanks low-activity Class B low-level wastes rather than high-activity Class B or Class C wastes. The sludges will be Class C rather than remote-handled transuranic (RH-TRU) wastes.

When REDC wastes are comingled with other ORNL LLLW, the present-worth treatment and transport costs are higher by a factor of 1.3 for the "no-pretreatment" cases. This result is consistent with data from similar studies conducted at other sites.

Based on the information presented in this analysis, our recommendation is to proceed with REDC treatment projects.

1. BACKGROUND

This analysis has been prepared to support the planned expenditure to provide the Radiochemical Engineering Development Center (REDC) with the capability to pretreat their liquid low-level waste (LLLW) before discharging it to the Oak Ridge National Laboratory (ORNL) LLLW system. Pretreatment will remove most of the radioactivity, particularly the transuranic isotopes and Cs-137 from the waste to be discharged. This will render the supernates that accumulate in the storage tanks low-activity Class B low-level wastes rather than high-activity Class B or Class C wastes. The sludges will be Class C rather than remote-handled transuranic (RH-TRU) wastes.

In addition to the financial advantages afforded by pretreatment, as outlined in this study, there are also regulatory advantages. ORNL has committed to the Tennessee Department of Environment and Conservation (TDEC) that no TRU sludges will be accumulated in the new storage tanks. Implementation of the pretreatment project is the most cost-effective way to honor this commitment.

2. ASSUMPTIONS

- REDC pretreatment project costs will total approximately $6.5 million.

- REDC's annual expenditure for waste management activities, about $2 million, will not be influenced by the pretreatment project. It will cost about the same to pretreat or to discharge directly to the LLLW system. This assumption is preliminary and may require additional review; however, it has been validated by the REDC staff.

- The waste volume data shown in Table 1 will be valid for the period of study. This is a conservative assumption because some one-time generations occurred during 1995 at buildings other than REDC.
  - REDC generates 15,000 gal per year of dilute LLLW containing 10,102 Ci of activity. Evaporation reduces this volume to 1700 gal of 95% supernate and 5% sludge.
  - REDC pretreatment will result in (1) a dry salt cake containing 9,926 Ci in 11 gal and (2) 15,000 gal of dilute LLLW containing 175 Ci. This volume of LLLW will be reduced to 1,690 gal of 100% supernate by evaporation. The resins used in the REDC pretreatment system will be regenerated each time the column is loaded with cesium. Each column can be regenerated approximately six times before the resin becomes exhausted and must be replaced. It is estimated that 1 gal of exhausted resin will require disposal each year. Approximately twice per year the regenerated resin will be transferred to a disposal container, dewatered, and disposed of as solid LLLW on site.

Table 1. Summary of LLLW generation during 1995

Tank(s)	Activities that generate LLLW	Generator/facility	Dilute generation (gal/year)	Concentrate generation (gal/year)	Isotope present: Isotope	Isotope present: Ci/year
WC-10	Decontamination and maintenance of hot cells	Bldgs. 3028, 2029, 3030-32, 3038, 3039, 3047, 3093	1,800	< 100	Various	Trace
WC-19	Regeneration of ion-exchange column	Bldgs. 3001(OGR), 3042(ORR), 3119(BSR)	2,400 [a]	< 50	Various	Trace
2026	Analytical sampling and research	Bldg. 2026	2,300	< 50	Various	Trace
WC-20	Cf-252 separation and purification for use in nuclear medicine, defense-related applications; transplutonium radionuclides for worldwide research	Bldg. 7920, 7930 (REDC)	15,000	1,700	Am-241,-243 Mixed Pu Cm-244,-245,-246 Cf-250,-252 MFP	1.2 19.6 81 0.6 10,000
HFIR	Irradiation of specimens to produce elements that are purified at REDC	Bldg. 7900 (HFIR)	100,000	4,500	H-3 Na-24 Mg-27 Cr-51 Co-60 W-181 W-187	4 396 22 84 8 968 4
WC-3	Metal polishing	Bldg. 3025	750	< 50	Various	Trace
W-22	Flush water; treatment of off-gas; treatment of process waste	PWTP 3039 Stack	10,600 [b] 44,000	10,600 100	Various Various	Trace Trace
N-71	Research	Bldg. 3019	420	< 100	Pu-239	0.6
Trucked	Repair and maintenance of manipulators. Metal polishing and extended decontamination during 1995 NOTE: In 1 out of 12 sample analyses, 0.0007 Ci of Am-243 was detected in a batch. This facility does not currently handle TRU isotopes, and this is considered a result of historical work at this facility.	Bldg. 3074 Bldg. 3525	1,500 15,000 [c]	< 50 100	Various Fe-59 Cr-51 Co-60 Nb-95 Zr-95 Cs-134 Cs-137 Ce-144 Eu-152,-153,-154 Ir-192	Trace 20 1,300 4 1 2 20 900 9 31 200
Bottled	Research	Bldg. 1505, 3047,3592, 4500N,4500S,4501, 4508, 5505	200	< 50	Various	Trace
WC-2,-3,-5,-6,-8,-9,-10,-11,-12,-13, 14,-19;W-1A,-12,-16,-17; HFIR; S-523,-324,-223	Nonprogrammatic inleakage; sumps; filter pits, etc.		227,900	800	Various	Trace
TH-4, W-3, W-6, W-8	Inactive tank waste		167,000	4,500	Co-60 Sr-90 Cs-137 Eu-152, -154, -155	3 22 530 2
Totals			589,070	22,600		14,633

a Within the group of reactors listed in the previous column, only the OGR currently generates LLLW.
b This is only the amount of dilute PWTP waste sent to the evaporator. Concentrate number also includes waste sent directly to W-21.
c Tank W-12 was used by Bldg. 3525 for disposal of LLLW during 1995.

- The entire ORNL complex generates 589,070 gal of dilute LLLW containing 14,633 Ci of activity (10,102 Ci from REDC). Evaporation reduces this volume to 22,600 gal of 95% supernate and 5% sludge.

- Waste treatment flow sheets are shown in Figs. 1 and 2.
  - Figure 1 shows the annual REDC waste generation rates if the REDC waste could be segregated from the remainder of ORNL's LLLW. It should be noted that REDC waste cannot be physically segregated from the existing LLLW system without significant upgrades, which are not included in this cost estimate. Figure 1 is shown only to compare the relative impact that REDC waste has on the overall LLLW system (Fig. 2).
  - Figure 2 shows the annual ORNL LLLW system waste generation rates with and without REDC pretreatment.
  - The curie removal efficiencies by pretreatment operations are estimates. More accurate information will not be available until operational experience has been obtained.

- Final waste forms without pretreatment are
  - high-activity Class B cement from a liquid waste solidification project (LWSP)-type treatment of supernates for disposal at the Nevada Test Site (NTS), and
  - RH-TRU cement or glass from a sludge treatment operation for disposal at the Waste Isolation Pilot Plant (WIPP).

- Final waste forms after REDC pretreatment are
  - low-activity Class B cement from LWSP-type supernate treatment operations for disposal at NTS,
  - Class C cement or glass from sludge treatment operations for disposal at NTS,
  - Class A cement or glass from solidification of regenerated REDC resins for on-site disposal, and
  - RH-TRU cement or glass from fixation of the small volume of salt cake from the REDC pot dryer or evaporator for disposal at a high-level waste repository.

- Volume changes due to solidification will vary, depending on waste formulation and waste loading. Actual values will not be available until waste formulation studies have been completed. Midrange values were chosen for these estimates. Ratios of treated volumes to original volumes can be summarized as follows: 1:1 for glass solidification of sludge, 1.7:1 for grout solidification of supernate, and 3:1 for grout solidification of sludge.

- Waste will be accumulated for 16 years before treatment to be consistent with TRU waste treatment planning.[1] This may not be a valid assumption since more frequent treatment will probably be required. However, the cost trends would be the same even if more frequent treatment of wastes was scheduled.

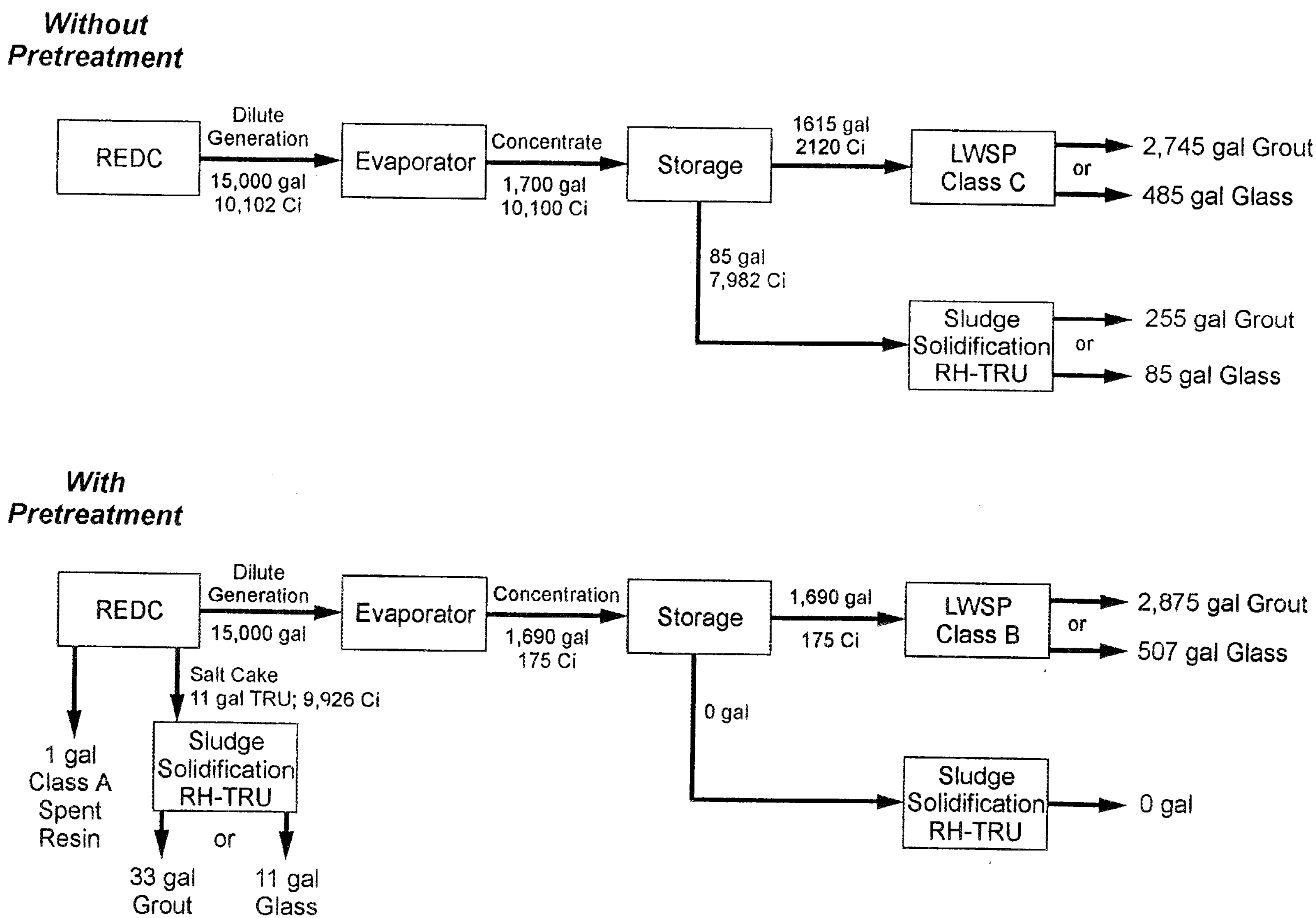

Fig. 1. Annual REDC waste generation rates.

ORNL DWG 97C-162

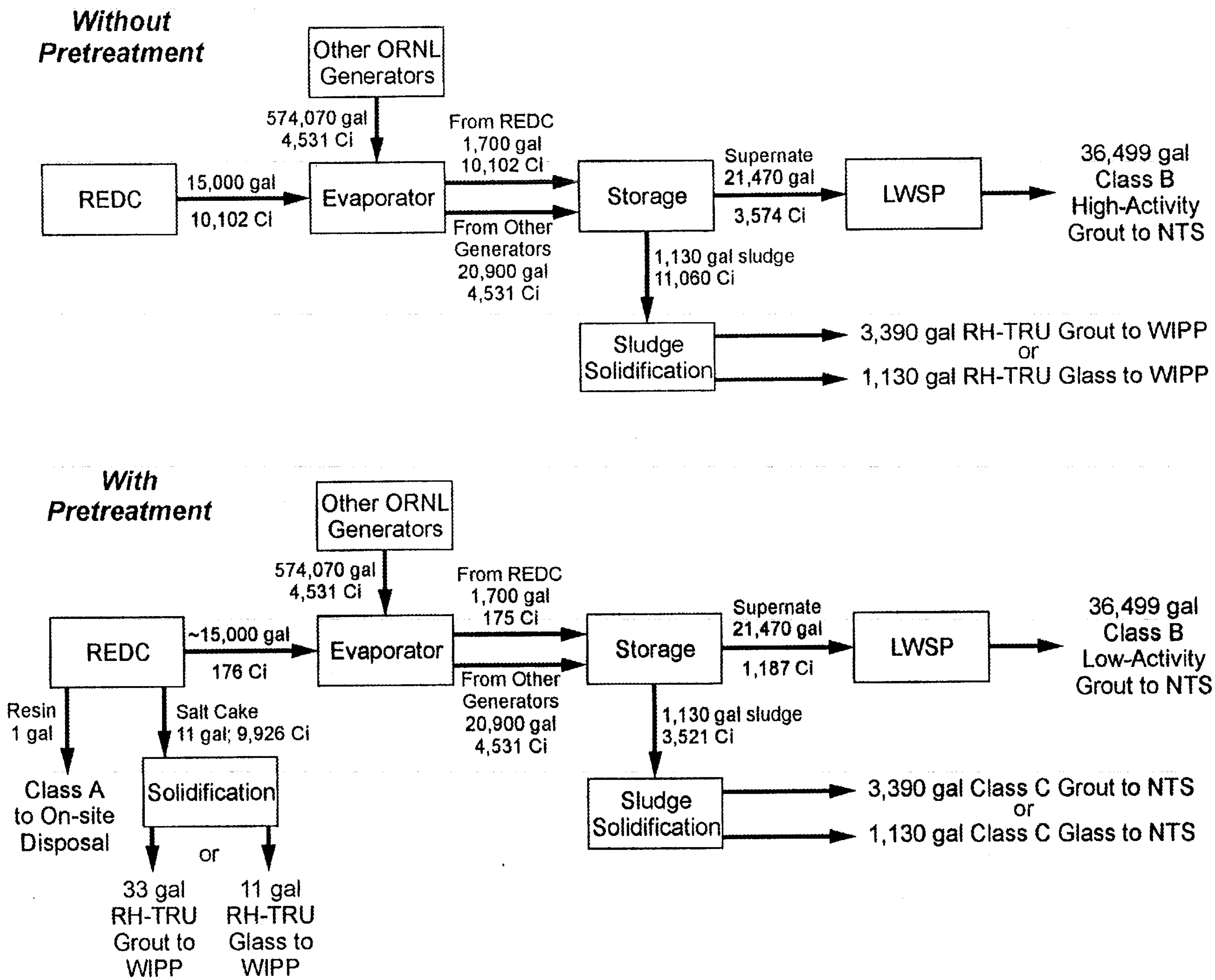

Fig. 2. Annual ORNL LLLW generation rates—with and without pretreatment at REDC.

- Unit cost estimates are estimated as follows:
  - Treating RH-TRU sludge is based on a cost of $150M to treat 200,000 gal, or $525 per gal based on TRU Program estimates for private sector treatment.
  - Treating Class A resins or low-activity Class B supernates is based on LWSP costs of $2.5M per 50,000 gal of waste treated, or $50 per gal.
  - Treating high-activity Class B or Class C waste is estimated at three times LWSP costs.
  - On-site storage costs are estimated at $203/ft^3$, or $1100 per drum filled with 40 gal of Class B solidified waste (disposal costs for the Interim Waste Management Facility).
  - On-site storage costs are estimated to be $9200 per drum containing 40 gal of Class C or RH-TRU solidified waste ($1.1M for 24 below-grade storage wells that will hold a maximum of 120 drums).
  - Shipping container costs are estimated as
    - $700 per drum for 55-gal DOT-certified stainless steel drums;
    - $150K per LWSP for low-activity Class B waste and $450K per LWSP for high-activity Class B waste (an LWSP generates 60 liners containing 1400 gal solidified waste each);
    - $10K per canister for RH-TRU waste (a canister holds three 55-gal drums containing 40 gal of solidified waste each);[2]
    - $1.6M per cask for RH-TRU waste; two casks are required for a significant number of shipments.[2]
  - Transportation costs are estimated to be $600K per LWSP for low-activity Class B waste and three times that for high-activity Class B or Class C waste for disposal at the Nevada Test Site.
  - Transportation costs are estimated to be $11K per canister for RH-TRU waste for disposal at the WIPP.[2]
  - Disposal costs in this analysis are limited to emplacement costs only for off-site disposal. It is assumed that disposal costs will be paid for by other programs. In a true life-cycle cost analysis, these costs would have to be considered. If total disposal costs were considered, the results would be more favorably inclined toward pretreatment because of the high cost of repository disposal for relatively large volumes of RH-TRU wastes generated by the "no-pretreatment" cases.
  - Disposal costs for the Nevada Test Site are estimated to be $250K per LWSP for low-activity Class B waste and three times that for high-activity and Class C waste.
  - Disposal costs for WIPP are estimated to be $3450 per canister for RH-TRU waste.[2]
  - On-site storage costs are estimated at $203/ft^3$ or $1100 per drum filled with 40 gal of Class A solidified waste, assuming disposal costs for the Interim Waste Management Facility.
  - On-site storage, transportation, and disposal costs for RH-TRU salt cake at a high-level waste repository are assumed to be the same as those for RH-TRU sludges at WIPP.

3. RESULTS

The results of this analysis can be summarized as follows:

- See the "boxes" on the right margin of Table 2. See also the present-worth calculations shown in Table 3.

- The life-cycle costs for ORNL LLLW with and without REDC pretreatment can be summarized as follows:
  - — Total cost of treating 16-year ORNL waste accumulation *without* REDC pretreatment
    - $157.7 million using grout treatment
    - $141.3 million using glass treatment
    - Present-worth expenditures (discount rate of 7%) are $72.3 million and $66.8 million, respectively
  - — Total cost of treating 16-year ORNL waste accumulation *with* REDC pretreatment
    - $97.8 million using grout treatment
    - $88.0 million using glass treatment
    - Present-worth expenditures (discount rate of 7%) are $56.3 million and $53.0 million, respectively

- The big discriminators must also be considered:
  - — Large relative costs for treating large volumes of high-activity Class B supernate for "no-pretreatment" case as compared with low-activity Class B supernate for "pretreatment" case.
  - — Large shipping containers and transportation costs for large volumes of RH-TRU waste that must be transported for "no-pretreatment" cases as compared with large volumes of Class C waste and small volumes of RH-TRU for "pretreatment" case.

4. DISCUSSION OF RESULTS

- When REDC wastes are comingled with other ORNL LLLW, the present-worth treatment and transport costs are higher by a factor of 1.3 for the "no-pretreatment" cases. This result is consistent with data from similar studies conducted at other sites.[3,4]

- The smaller volume of waste generated by vitrification as compared with grout lowers the overall costs. The incentive to solidify newly generated waste in glass is greater if REDC pretreatment is not implemented since smaller volumes of RH-TRU would be generated for disposal at WIPP or a high-level repository.

Table 2. Cost comparison for ORNL LLLW management

Activity or parameter	Entry units	Cost units $	Cost units per	Annual w/o pretreatment	Annual w/pretreatment	16-year cumulative w/o pretreatment	16-year cumulative w/pretreatment
Dilute LLLW generation	gal			589,070	589,070	9,425,120	9,425,120
LLLW concentrate	gal			22,600	22,600	361,600	361,600
Ci content (primarily MFP)	Ci			14,633	14,633	234,128	234,128
Volumes to be treated for disposal							
High-activity Class B LLLW supernate	gal			21,470		343,520	
Low-activity Class B LLLW supernate	gal				21,470		343,520
Class A LLW solids	gal				1		16
RH-TRU dry salt cake	gal				11		176
RH-TRU sludge	gal			1,130		18,080	
Class C LLW sludge	gal				1,130		18,080
Ci content of waste							
High-activity Class B LLLW supernate	Ci/gal			0.17		0.17	
Low-activity Class B LLLW supernate	Ci/gal				0.06		0.06
Class A LLW solids	Ci/gal				0		0
RH-TRU dry salt cake	Ci/gal				902		902
RH-TRU sludge	Ci/gal			10		10	
Class C LLW sludge	Ci/gal				3		3
Costs - grout flow sheet							
Treated waste volumes							
High-activity supernate cement block	gal			36,499		583,984	
Low-activity supernate cement block	gal				36,499		583,984
Class A solids cement block	gal				3		48
RH-TRU salt cake cement block	gal				33		528
RH-TRU sludge cement block	gal			3,390		54,240	
Class C sludge cement block	gal				3,390		54,240
Treatment costs							
Pretreatment GPP	$ million				2.000		2.000
Pretreatment expense funding	$ million				4.500		4.500
REDC internal costs	$ million			2.000	2.000	32.000	32.000
Solidification high-activity supernate	$ million	150	gal			51.528	
Solidification low-activity supernate	$ million	50	gal				17.176
Solidification Class A solids	$ million	50	gal				0.001
Solidification RH-TRU salt cake	$ million	525	gal				0.092
Solidification RH-TRU sludge	$ million	525	gal			9.492	
Solidification Class C sludge	$ million	150	gal				2.712
On-site storage costs							
LLW storage (Class B)	$ million	1,100	drum			16.060	16.060
RH TRU and Class C storage	$ million	9,200	drum			12.475	12.597
Shipping container costs							
Drums (TRU and Class A solids)	$ million	700	drum			0.949	0.010
Casks (high-activity Class B and C)	$ million	7,500	liner			3.128	0.291
Casks (low-activity Class B)	$ million	2,500	liner				1.043
Canisters (TRU)	$ million	10,000	canister			4.520	0.044
Casks (TRU)	$ million	1,600,000	cask			3.200	1.600
Transportation costs							
High-activity Class B and C to NTS	$ million	30,000	liner			12.514	1.162
Low-activity Class B to NTS	$ million	10,000	liner				4.171
RH-TRU to WIPP	$ million	11,000	canister			4.972	
RH-TRU to HLW respository							0.048
Disposal costs							
Nevada Test Site (high activity)	$ million	12,600	liner			5.256	0.488
Nevada Test Site (low activity)	$ million	4,200	liner				1.752
WIPP (RH-TRU)	$ million	3,450	canister			1.559	
HLW respository (RH-TRU)							0.015
On-Site LLW (Class A)	$ million	1,100	drum				0.001
Totals ($ million)						157.654	97.763

Table 2 (continued)							
		Cost units		Annual		16-year cumulative	
Activity or parameter	Entry units	$	per	w/o pretreatment	w/pretreatment	w/o pretreatment	w/pretreatment
Costs - glass flow sheet							
Treated waste volumes							
High-activity supernate cement block	gal			36,499		583,984	
Low-activity supernate cement block	gal				36,499		583,984
Class A solids glass log	gal				1		16
RH-TRU salt cake glass log	gal				11		176
RH-TRU sludge glass log	gal			1,130		18,080	
Class C sludge glass log	gal				1,130		18,080
Treatment costs							
Pretreatment GPP	$ million				2.000		2.000
Pretreatment expense funding	$ million				4.500		4.500
REDC internal costs	$ million			2.000	2.000	32.000	32.000
Solidification high-activity supernate	$ million	150	gal			51.528	
Solidification low-activity supernate	$ million	50	gal				17.176
Solidification Class A solids	$ million	50	gal				0.001
Solidification RH-TRU salt cake	$ million	525	gal				0.092
Solidification RH-TRU sludge	$ million	525	gal			9.492	
Solidification Class C sludge	$ million	150	gal				2.712
On-site storage costs							
LLW storage (Class B)	$ million	1,100	drum			16.060	16.060
RH TRU and Class C storage	$ million	9,200	drum			4.158	4.199
Shipping container costs							
Drums (TRU and Class A solids)	$ million	700	drum			0.316	0.003
Casks (high-activity Class B and C)	$ million	7,500	liner			3.128	0.097
Casks (low-activity Class B)	$ million	2,500	liner				1.043
Canisters (TRU)	$ million	10,000	canister			1.507	0.015
Casks (TRU)	$ million	1,600,000	cask			3.200	1.600
Transportation costs							
High-activity Class B and C to NTS	$ million	30,000	liner			12.514	0.387
Low-activity Class C to NTS	$ million	10,000	liner				4.171
RH-TRU to WIPP	$ million	11,000	canister			1.657	
RH-TRU to HLW repository	$ million	11,000	canister				0.016
Disposal costs							
Nevada Test Site (high activity)	$ million	12,600	liner			5.256	0.163
Nevada Test Site (low activity)	$ million	4,200	liner				1.752
WIPP (RH-TRU)	$ million	3,450	canister			0.520	
HLW repository (RH-TRU)	$ million	3,450	canister				0.005
On-site LLW (Class A)	$ million	1,100	drum				0.000
Totals ($ million)						141.336	87.992

Table 3. Present-worthed expenditures for management of ORNL LLLW, as of March 8, 1995: comparison of current operation with waste pretreatment operations at REDC[a,b]

		Without pretreatment				With pretreatment			
		Grout		Glass		Grout		Glass	
Year	PW factor	Waste mgt. operation	Waste treatment	Waste mgt. operation	Waste treatment	Waste mgt. operation	Waste treatment	Waste mgt. operation	Waste treatment
0	1.000						6.500		6.500
1	0.935	1.869		1.869		1.869		1.869	
2	0.873	1.747		1.747		1.747		1.747	
3	0.816	1.633		1.633		1.633		1.633	
4	0.763	1.526		1.526		1.526		1.526	
5	0.713	1.426		1.426		1.426		1.426	
6	0.666	1.333		1.333		1.333		1.333	
7	0.623	1.245		1.245		1.245		1.245	
8	0.582	1.164		1.164		1.164		1.164	
9	0.544	1.088		1.088		1.088		1.088	
10	0.508	1.017		1.017		1.017		1.017	
11	0.475	0.950		0.950		0.950		0.950	
12	0.444	0.888		0.888		0.888		0.888	
13	0.415	0.830		0.830		0.830		0.830	
14	0.388	0.776		0.776		0.776		0.776	
15	0.362	0.725		0.725		0.725		0.725	
16	0.339	0.677	70.857	0.677	47.875	0.677	30.913	0.677	27.604
		18.893	70.857	18.893	47.875	18.893	37.413	18.893	34.104
Totals		89.750		66.769		56.306		52.997	

[a]Assuming that REDC LLLW discharges are comingled with other ORNL LLLW.
[b]Discount factor = 0.07.

5. RECOMMENDATION

Based on the information presented in this analysis, our recommendation is to proceed with REDC treatment projects.

6. REFERENCES

1. *Feasibility Study for Processing ORNL Transuranic Waste in Existing and Modified Facilities — Management Summary*, prepared by Parallax, Inc., Oak Ridge, TN, September 1995.

2. *WHPP Feasibility Study*, prepared by Lee Wan & Associates, Inc., 1988.

3. *System Requirements Review Hanford Tank Waste Remediation System — Final Report*, prepared by Office of Hanford Waste Management Operations, U.S. Department of Energy, April 1995.

4. *Tank Remediation Plans and Activities at Idaho National Engineering Laboratory*, prepared by James Murphy, February 1995.

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