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SECTION 7 OF

United States Government Department of Energ

memorandum

DATE: JUL 01 1996

REPLY TO ATTN OF: RW-30

SUBJECT: Repository Disposal Fee Estimates for the Hanford Tank Waste Remediation System (TWRS) Environmental Impact Statement (EIS)

TO: Jackson Kinzer, Assistant Manager
Office of Tank Waste Remediation System

The Office of Civilian Radioactive Waste Management is pleased to transmit the information to address your request for disposal fee estimates to support the development of the Hanford TWRS EIS. This responds to your June 7, 1996, request for more rigorous cost estimates based on application of our Total System Life Cycle Cost (TSLCC) methodology. We have completed an analysis for the following four alternative scenarios and compared them against the 1995 TSLCC baseline:

1. Use of 23,000 "standard" canisters for the most probable quantity (14,260 m^3) of immobilized HLW for the reference "enhanced sludge wash" process.

2. Use of 12,200 "long" 0.61m D x 4.5m L canisters for the most probable quantity of Hanford HLW.

3. Use of 530 "long" canisters for 620 m^3 of HLW resulting from the "extensive separations" pretreatment process.

4. Use of 36,400 "very large" 1.68m D x 5.03m L canisters for 364,000 m^3 of HLW produced without any pretreatment.

Results of the analysis, including key assumptions, significant cost drivers, and limitations on the cost calculations, are provided in the attachment entitled "Cost Estimate Report on Disposal Costs for Tank Waste Remediation System Alternatives". It must be pointed out that the results presented are consistent with the assumptions documented in the 1995 TSLCC. In this regard, scenario 4 is so significantly outside the range of these assumptions that there may be other implications, beyond the large cost increase projected for disposal, which could affect our ability to license a repository or implement emplacement within the currently envisioned disposal system.

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196-TWR-497

We appreciate the opportunity to assist you in the completion of the Hanford TWRS Final EIS. Please feel free to contact James Carlson of my staff at (202) 586-5321, if you have any questions regarding the report.

Ronald A. Milner

Ronald A. Milner, Director
Office of Program Management
and Integration
Office of Civilian Radioactive
Waste Management

Attachment

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WBS: 8.2.1
QA: N/A

Civilian Radioactive Waste Management System
Management & Operating Contractor

Cost Estimate Report on Disposal Costs for Tank Waste Remediation System Alternatives

June 28, 1996

WBS: 8.2.1
QA: N/A

Civilian Radioactive Waste Management System
Management & Operating Contractor

Cost Estimate Report on Disposal Costs for Tank Waste Remediation System Alternatives

June 28, 1996

Prepared for:

U.S. Department of Energy
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TABLE OF CONTENTS

1. SUMMARY 1

2. SCOPE 4

3. APPROACH 5
- 3.1 TSLCC BASELINE 5
- 3.2 TWRS ALTERNATIVE SCENARIOS 5
- 3.3 METHODOLOGY 7
  - 3.3.1 Defense Share Methodology 7
  - 3.3.2 Mined Geologic Disposal System (MGDS) Cost Estimates 7
  - 3.3.3 Transportation Cost Estimates 8
  - 3.3.4 Development and Evaluation and Other Program Costs 8

4. ANALYSIS 9
- 4.1 DEFENSE SHARE OF TOTAL SYSTEM COSTS 9
  - 4.1.1 Results Summary 9
  - 4.1.2 Limits of Analysis 9
  - 4.1.3 Direct Costs 9
- 4.2 COST ESTIMATE SENSITIVITIES 15
  - 4.2.1 Repository 15
  - 4.2.2 Transportation 15
  - 4.2.3 Development and Evaluation and Other Program Costs 18
- 4.3 EVALUATION OF ALTERNATIVES 18
  - 4.3.1 Scenario 1 18
  - 4.3.2 Scenario 2 19
  - 4.3.3 Scenario 3 19
  - 4.3.4 Scenario 4 19
- 4.4 QUALITATIVE IMPACTS OF USE OF HANFORD MULTI-PURPOSE CANISTER 20
  - 4.4.1 Repository 20
  - 4.4.2 Transportation 20

REFERENCES 21

APPENDIX A 22
- Request for Repository Disposal Fee Estimates 22

LIST OF TABLES

Table 1-1 Repository Disposal Cost Evaluation Matrix 2

Table 3-1 Waste Package Emplacement Schedule Assumptions for TWRS Alternative Scenarios 6

Table 4-1 Summary of Civilian, Defense, and West Valley Allocation, Scenario 1 10

Table 4-2 Summary of Civilian, Defense, and West Valley Allocation, Scenario 1 11

Table 4-3 Summary of Civilian, Defense, and West Valley Allocation, Scenario 1 12

Table 4-4 Summary of Civilian, Defense, and West Valley Allocation, Scenario 1 13

Table 4-5 Summary of Direct Disposal Costs for TWRS Alternatives 14

Table 4-6 Repository Cost Summary 16

Table 4-7 Repository Cost Drivers 17

1: SUMMARY

This analysis was performed at the request of the Department of Energy Richland Operations Office to support analysis of alternatives for the TWRS as part of the development of the TWRS Environmental Impact Statement (reference 1, see Appendix A). Estimates of disposal costs were developed for four alternatives for the Hanford Tank Waste Remediation System (TWRS). Estimates of the total defense share of disposal costs were generated using a consistent methodology, as used by the Civilian Radioactive Waste Management Program in development of the Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program of September 1995 (95 TSLCC) (reference 2). Technical feasibility and the environmental effects of disposal are not within the scope of this study and are not addressed. Costs are presented in constant 1994 dollars to maintain consistency with the 95 TSLCC.

The 95 TSLCC base case and TWRS alternatives analyzed in this study are summarized in Table 1-1. The TSLCC assumed 9,860 standard canisters from Hanford would be disposed of in the repository. Scenario 1 would require disposal of 23,000 standard canisters from Hanford. Scenario 2 is based on the same volume of glass as Scenario 1, disposed of as 12,200 "long canisters" (4.5 meters in length versus 3.0 meters for the standard canisters). Scenario 3 assumes extensive separations resulting in less glass volume, to be disposed of as only 530 long canisters. Scenario 4 assumes 36,400 very large 10 cubic meter canisters are used to dispose of the very large volumes of vitrified waste which could result from a "no pretreatment" TWRS alternative.

Summary results are presented in Table 1-1. Each of four Hanford TWRS alternative scenarios are compared against the baseline assumed for the 95 TSLCC. Total Disposal Cost for the 95 TSLCC base case is $33.1 billion in constant 1994 dollars (94$s). The first three alternatives would result in a small variation in Total Disposal System Costs. Scenario 3 would save $0.5 billion (94$s) or 1.4 percent. Scenario 2 would increase Total Disposal System Costs by $1.4 billion (94$s) or 4.2 percent, and Scenario 1 would increase costs by $2.0 billion (94$s) or 6.0 percent. Scenario 4 would double the Total System Disposal Cost to over $66 billion (94$s) or 100 percent.

Scenario 1 has been identified by the TWRS program as the most likely current estimate of borosilicate glass canisters to be produced. Scenario 1 poses the disadvantage, from a disposal standpoint, of utilizing most available space between Spent Nuclear Fuel (SNF) waste packages. This could limit growth capacity to accept other wastes being considered for disposal, such as DOE SNF.

Scenario 4 is not a preferred alternative from a disposal standpoint. Scenario 4 would not only double the Total System Disposal Cost to over $66 billion (94$s), it would require approximately 35 additional years of geologic emplacement and extension of the planned disposal program

Table 1-1 Repository Disposal Cost Evaluation Matrix

	Canister Size (OD x L)	Pretreatment Process	Volume of Glass, m^3	Number of Hanford Canister	Total No. of DHLW Canisters	Total Disposal Cost (94$s)	Allocated Defense Share (94$s)
Base Case (RW-0479)	0.61m x 3.0m	Enhanced Sludge Wash	6,100	9,860	18,046	$33.1B	$6.43B
Scenario #1 (most probable volume)	0.61m x 3.0m	Enhanced Sludge Wash	14,260	23,000	31,186	$35.1B	$10.3B
Scenario #2 (long canister)	0.61m x 4.50m	Enhanced Sludge Wash	14,260	12,200	20,386	$34.5B	$8.6B
Scenario #3 (minimum volume)	0.61m x 4.50m	Extensive Separations	620	530	8,716	$32.6B	$4.0B[1]
Scenario #4 (very large canister)	1.68m x 5.03m	No Pretreatment	364,000	36,400	44,586	$66.2B[2]	$49.4B[1]

1 Share methodology understates defense share of unassigned costs due to extremely low piece counts. Actual share will be higher.
2 Scenario significantly in excess of repository planning basis. Requires assumptions which increase uncertainty of estimate. Scenario outside methodology validity for piece counts and disproportional waste package size.

completion from an assumed decommissioning in 2071 to 2102. Further, it would require characterization of additional area, suitability determination of the area, and associated licensing of a Hanford only section of the repository. A substantial portion of the Hanford wastes would require emplacement in the additional areas in a low thermal setting, following emplacement of some Hanford and all other HLW with all the available SNF in a high thermal setting in the primary area of the repository. This is in contrast to the 95 TSLCC assumption of emplacement of all HLW with SNF in the primary area in a high thermal loading setting. Excess quantities of Hanford HLW may exceed available areas in the repository. Disposition of remaining HLW would not be decided until DOE makes a recommendation on the need for a second repository.

The last column in Table 1-1 shows an estimate of the total defense share of each alternative. Estimates range from a reduction of $2.5 billion for Scenario 3 to an increase of $43 billion for Scenario 4. Estimates of defense share in Table 1-1 do not represent firm estimates of the full cost recovery for disposal of defense high level waste. The cost sharing allocation methodology was developed for a point estimate and design. Extreme case variations such as Scenario 3 and 4 fall outside the validity of the computational method. Differences between the cases appear to be exaggerated by the defense share allocation methodology bias.

2. SCOPE

This analysis was performed at the request of the Department of Energy Richland Operations Office to support analysis of alternatives for the TWRS as part of the development of the TWRS Environmental Impact Statement. The analysis was developed under an accelerated schedule, and of necessity provides scoping level detail, scaled from the detailed point estimate reported in the 95 TSLCC. It provides life cycle cost estimates for four alternative scenarios for disposal of vitrified high level waste (HLW) from Hanford. Scenarios vary HLW quantities and package sizes from the 95 TSLCC estimate basis. The scenarios and approach are described in Section 3. The analysis includes estimates for two new HLW waste packages, two new transportation casks, and estimates of changes to repository surface facilities, subsurface impacts, transportation, and other program costs.

Estimates of the total defense share, based on application of the 1987 Federal Register methodology, are provided in Section 4. Two cases, Scenarios 3 and 4, depart significantly from the base case. For these scenarios, quantitative estimates are provided, with qualitative discussion of impacts and limits of the analysis. Analyses are based on and consistent with the 1995 TSLCC.

A Hanford Multi-Purpose Canister (HMPC) is being considered by DOE for on-site storage at Hanford, followed by transportation to and disposal in a repository. An HMPC would be an overpack canister 4.65 meters in length by 1.61 meters outside diameter, sized to contain four of the long Hanford canisters of vitrified HLW such as those assumed for Scenarios 2 and 3 in this analysis. For transportation, each HMPC would be placed in a transportation overpack for shipment. At the repository, the unopened HMPC would be transferred to a disposal overpack, which, combined with the HMPC and its contents would comprise a four canister waste package. It is assumed that the HMPC would be licensed for storage, transportation, and disposal. The 95 TSLCC was not based on use of the HMPC. A qualitative discussion of the impacts of possible use of an HMPC is included.

3. APPROACH

3.1 TSLCC BASELINE

The 95 TSLCC forms the baseline for comparison of disposal costs for alternatives, and for estimation of the defense share for each alternative. The TSLCC assumes 9,860 standard canisters of HLW from Hanford are disposed of with 8,186 canisters of HLW from other DOE sites and the West Valley Demonstration Project, comingled with waste packages containing approximately 84,000 metric tons of Uranium (MTU) of commercial spent nuclear fuel (SNF). The 95 TSLCC does not include other wastes being considered for inclusion in the Civilian Radioactive Waste Management System (CRWMS), such as DOE SNF. The 95 TSLCC assumes disposal in a single repository, with the Yucca Mountain site in Nevada serving as a surrogate to allow estimation of total system life cycle costs. The Nuclear Waste Policy Act as Amended (NWPAA) (reference 3) establishes a 70,000 Metric Tons of Heavy Metal (MTHM) limit on a first repository, tied to opening of a second repository, and also specifies that the need for a second repository will be assessed between 2007 and 2010. This analysis assumes disposal in a single repository, consistent with the 95 TSLCC assumptions. Design concepts in the 95 TSLCC assume emplacement of waste packages, containing four HLW canisters each, in the spaces between SNF waste packages, in a spacial arrangement with a high thermal load. The 95 TSLCC assumptions were held constant, except as required for the scenarios. Costs reported in this analysis are reported in constant 1994 dollars to maintain consistency with the 95 TSLCC.

The 95 TSLCC baseline assumed use of Multi-Purpose Canisters (MPCs) for disposal of commercial SNF. HLW is assumed to be disposed of in waste packages containing four standard canisters each. Current Civilian Radioactive Waste Management System (CRWMS) planning does not assume MPCs for SNF and the TWRS program is planning use of HMPCs for HLW. This analysis maintains MPCs for SNF disposal, and shipment and disposal of individual HLW canisters in waste packages to maintain consistency with the 95 TSLCC. Future TSLCC reports will update the CRWMS baseline. A qualitative discussion of the impacts of an HMPC is provided in Section 4.

3.2 TWRS ALTERNATIVE SCENARIOS

Waste streams that minimized impact on repository capital costs were established for each alternative scenario. Delivery schedules were generated in discussion with the TWRS program to develop reasonable cases for evaluation of disposal costs without inordinate or unnecessary impact to the repository. Additional opportunity for optimization of total defense high level waste flows can result in capital cost reduction. Further improvement of waste stream flows was not possible within task schedule constraints. The schedules for emplacement of waste packages containing Hanford HLW are shown in Table 3-1.

Table 3-1 Waste Package Emplacement Schedule Assumptions for TWRS Alternative Scenarios

Year	All Scenarios	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	[illegible] WP's	Hanford WP's	[illegible] WP's	Hanford WP's	[illegible] WP's	Hanford WP's	[illegible] WP's	Hanford WP's	[illegible] WP's
2010	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
2011	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
2012	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
2013	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
2014	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
2015	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
2016	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
2017	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
2018	[illegible]	249	[illegible]	249	[illegible]	95	[illegible]	249	[illegible]
2019	[illegible]	50	[illegible]	49	[illegible]	19	[illegible]	49	[illegible]
2020	[illegible]	295	[illegible]	295	[illegible]	19	[illegible]	368	[illegible]
2021	[illegible]	309	[illegible]	309	[illegible]		[illegible]	369	[illegible]
2022	[illegible]	302	[illegible]	302	[illegible]		[illegible]	373	[illegible]
2023	[illegible]	291	[illegible]	291	[illegible]		[illegible]	369	[illegible]
2024	[illegible]	292	[illegible]	292	[illegible]		[illegible]	372	[illegible]
2025	[illegible]	300	[illegible]	300	[illegible]		[illegible]	363	[illegible]
2026	[illegible]	306	[illegible]	306	[illegible]		[illegible]	371	[illegible]
2027	[illegible]	320	[illegible]	320	[illegible]		[illegible]	387	[illegible]
2028	[illegible]	317	[illegible]	317	[illegible]		[illegible]	373	[illegible]
2029	[illegible]	323	[illegible]	20	[illegible]		[illegible]	388	[illegible]
2030	[illegible]	355	[illegible]		[illegible]		[illegible]	390	[illegible]
2031	[illegible]	342	[illegible]		[illegible]		[illegible]	409	[illegible]
2032	[illegible]	392	[illegible]		[illegible]		[illegible]	425	[illegible]
2033	[illegible]	351	[illegible]		[illegible]		[illegible]	419	[illegible]
2034	[illegible]	360	[illegible]		[illegible]		[illegible]	424	[illegible]
2035	[illegible]	380	[illegible]		[illegible]		[illegible]	415	[illegible]
2036	[illegible]	211	[illegible]		[illegible]		[illegible]	426	[illegible]
2037	[illegible]		[illegible]		[illegible]		[illegible]	394	[illegible]
2038	[illegible]		[illegible]		[illegible]		[illegible]	412	[illegible]
2039	[illegible]		[illegible]		[illegible]		[illegible]	412	[illegible]
2040	[illegible]		[illegible]		[illegible]		[illegible]	528	[illegible]
2041								814	
2042								814	
2043								814	
2044								814	
2045								814	
2046								814	
2047								814	
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2073								814	
2074								814	
2075								[illegible]	
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

3.3 METHODOLOGY

3.3.1 Defense Share Methodology

The Nuclear Waste Policy Act as Amended requires full cost recovery from both defense and commercial users of the repository, with no cross-subsidization of program costs. Commercial SNF disposal costs are paid from receipts from a ratepayer fee charged on electricity generated and sold from nuclear power plants. Defense costs are paid from Defense Nuclear Waste Disposal appropriations. Costs are allocated among program participants according to a methodology published in the Federal Register (reference 4). This methodology has been applied to each case to estimate a total defense share for each scenario.

The methodology collects direct costs, allocates certain indirect costs based on piece count and areal dispersion factors, and then assigns remaining costs based on factors derived from relative direct and allocated costs. *Assignable direct costs* are incurred solely for the disposal of either HLW or SNF and are allocated in total to either the civilian program, defense program, or to West Valley. *Assignable common variable costs* are allocated among the civilian, defense, and West Valley programs by appropriately applying cost sharing factors, piece count, and areal dispersion to the specific individual cost accounts. *Common unassigned costs* are the remaining costs that cannot be either directly allocated or allocated on the basis of the cost sharing factors described above. Unassigned costs comprise a significant portion of the total system cost due to high development and evaluation costs compared to construction and operation.

The methodology was not developed to evaluate extreme variations from the base case such as the very low piece counts in Scenario 3 or the disproportionately large waste package sizes in Scenario 4. For these reasons, share allocation methodology may require modification if such alternatives are pursued, and respective cost shares may change as a result. This bias in methodology due to application of a method for a point estimate to a significant case variation tends to understate costs for Scenario 3, and may misrepresent costs for Scenario 4. A lesser degree of change also may be required for Scenario 2 to account for change in relative size of waste packages.

3.3.2 Mined Geologic Disposal System (MGDS) Cost Estimates

Analyses of Scenarios 1, 2, and 3 were able to maintain 95 TSLCC design assumptions for the repository thermal loading approach and emplacement of HLW waste packages in the space between hot SNF waste packages. Scenario 4 requires assumption of development of additional area(s) at the repository with a low thermal load setting which is dedicated to excess Hanford HLW. The HLW quantity exceeds the number of available openings in the high thermal load repository. Detailed engineering evaluations were not performed for this study. Waste package design verified sufficient corrosion allowances for the defense high level waste packages for

emplacement in a low thermal setting.

MGDS estimates were developed for each case using TSLCC models adjusted for changes in throughput capacity and additional underground excavation where required. Waste package dimensions and cost were developed consistent with the 95 TSLCC and 96 Advanced Conceptual Design bases. Repository estimates are based on the waste stream shown previously in Table 3-1, and are consistent with 95 TSLCC assumptions.

3.3.3 Transportation Cost Estimates

New HLW transportation cask designs would be required to support Scenarios 2, 3 and 4. An estimate has been made of changes required to the HLW cask design used in the 95 TSLCC to accommodate different size canisters compatible with the Hanford TWRS scenarios. No new thermal, mechanical, or radiological analyses were performed. The 95 TSLCC assumes a HLW rail cask with a capacity of five standard HLW canisters. The required cask types were scaled from the notional cask design used in the 95 TSLCC. Capacity of the transportation casks for the long canisters in Scenarios 2 and 3 was determined as four long canisters each, to meet national rail transportation system limits, assuming similar shielding as the TSLCC cask design basis (reference 5). This may be conservative. Design studies to optimize shielding for the low radiologic activities of HLW may permit a reduction in shielding which could increase the capacity for long canisters to five canisters. Scenario 4 was based on one very large canister per transportation cask. Capital costs for alternative casks were estimated based on data for the BR-100 rail cask. Shipping and related costs were estimated using the same methods as the 95 TSLCC.

3.3.4 Development and Evaluation and Other Program Costs

Development and evaluation (D&E) costs and other program costs were evaluated and are assumed to be essentially constant for Scenarios 1, 2 and 3. An addition for alternative cask development was identified for Scenarios 2 and 3.

Significant increases in development and evaluation, and other program costs would occur for Scenario 4 due to additional repository area characterization and licensing, and significant extension of waste acceptance and transportation operations. Costs were estimated based on notional schedules and throughput rates consistent with the capacity required for the high thermal loading repository. Estimates are based on 95 TSLCC costs for similar activities associated with a repository in the primary area, with a high thermal loading setting. Estimates for the new scope related to the Hanford only repository areas assume cost efficiencies gained from experience during the first phase of development and operations.

4. ANALYSIS

4.1 DEFENSE SHARE OF TOTAL SYSTEM COSTS

4.1.1 Results Summary

A summary of defense disposal costs for the TWRS alternatives is shown in Tables 4-1, 4-2, 4-3, and 4-4. From lowest to highest total system and defense share costs, the alternatives are ranked Scenario 3, 95 TSLCC Base Case, Scenario 2, Scenario 1, and Scenario 4. Scenario 3 reduces overall program costs by approximately $0.5B in 1994 dollars. Variation from the total system life cycle cost ranges from -1 percent to +6 percent for the first three alternatives. Scenario 4 doubles the total system disposal costs, and shifts the program from a civilian repository that is less than approximately 25 percent defense to a repository that is almost 75 percent defense on a total emplaced waste package count basis.

4.1.2 Limits of Analysis

Results should support evaluation of alternatives for TWRS but should not be taken as final estimates of the defense share. The estimates are consistent with the 95 TSLCC. Estimates are at a scoping level of detail, scaled from TSLCC data and estimated through use of TSLCC models. Results are not based on engineering studies of the specific alternatives and do not represent detailed point estimates. As noted in Section 3, the cost sharing methodology is limited in its application to cases which differ significantly from the base case. In particular, defense share is understated by the methodology for Scenario 3, and to lesser degrees for Scenarios 4 and 2, respectively. In addition, future TSLCC updates are required to incorporate developing changes to the CRWMS. Disposal of DOE SNF, accommodation of a variety of utility cask/canister systems for commercial SNF, and changes in funding profiles are current changes which will have system impact and will affect costs and cost shares.

4.1.3 Direct Costs

Tables 4-1 through 4-4 provided estimates of total disposal system costs and total defense share allocations of disposal costs for each scenario, based on a consistent methodology. Defense share estimates include disposal of all planned HLW from Hanford, Savannah River, and Idaho National Engineering Laboratory. Estimates of direct costs for Hanford HLW compared to total defense HLW are provided in Table 4-5 for use in further allocation of program indirect costs among the various defense programs. The Federal Register cost allocation methodology estimates total defense share compared to civilian to ensure no cross-subsidization of defense and civilian programs but does not address allocations among defense programs.

Table 4-1 Summary of Civilian, Defense, and West Valley Allocation (In Millions of 1994 Dollars) Scenario 1

Category	COST ALLOCATIONS											
	TSLCC95				Scenario 1				Delta			
	Defense	WV	Civilian	Total	Defense	WV	Civilian	Total	Defense	WV	Civilian	Total
Development & Evaluation	2,756	46	9,717	12,520	4,120	40	8,353	12,521	1,372	(6	(1,364	1
Repository 1	2,817	47	7,932	10,796	4,880	47	7,652	12,566	2,050	0	(280)	1,770
Transportation	434	10	1,846	2,290	687	9	1,838	2,515	233	(1	(8	225
MPCs	0	3	5,516	5,519	0	3	5,516	5,519	0	0	0	0
Waste Acceptance	236	5	1,005	1,246	331	5	912	1,247	95	(1	(93	1
MRS	N/A				N/A				N/A			
Benefits	109	2	306	417	162	2	254	417	53	(0	(52	(0
PETT	80	1	226	308	110	1	188	308	39	(0	(39	(0
Total	$6,432	$114	$26,550	$33,096	$10,274	$106	$24,712	$35,093	$3,842	($8	($1,838	$1,997
Percentage %	19.43%	0.34%	80.22%	100.00%	29.28%	0.30%	70.42%	100.00%	0.84%	-0.04%	-0.80%	0.00%

Note: Totals may not add due to independent rounding

Table 4-2 Summary of Civilian, Defense, and West Valley Allocation (In Millions of 1994 Dollars) Scenario 2

Category	COST ALLOCATIONS											
	TSLCC95				Scenario 2				Delta			
	Defense	WV	Civilian	Total	Defense	WV	Civilian	Total	Defense	WV	Civilian	Total
Development & Evaluation	2,750	46	9,717	12,520	3,482	52	9,010	12,543	726	5	(708)	23
Repository 1	2,817	47	7,932	10,796	3,816	56	7,986	11,858	998	9	54	1,061
Transportation	434	10	1,846	2,290	754	13	1,832	2,598	320	3	(15)	308
MPCs	0	3	5,516	5,519	0	3	5,516	5,519	0	0	0	0
Waste Acceptance	238	5	1,005	1,246	362	6	879	1,247	126	1	(126)	1
MRS	N/A				N/A				N/A			
Benefits	109	2	306	417	134	2	281	417	25	0	(26)	(0)
PETT	80	1	226	308	99	1	207	308	19	0	(19)	(0)
Total	$6,432	$114	$26,550	$33,096	$8,640	$133	$25,711	$34,490	$2,214	$19	($839)	$1,394
Percentage %	19.43%	0.34%	80.22%	100.00%	25.07%	0.39%	74.55%	100.00%	5.63%	0.04%	-5.67%	0.00%

Note: Totals may not add due to independent rounding

Table 4-3 Summary of Civilian, Defense, and West Valley Allocation (In Millions of 1994 Dollars) Scenario 3

Category	COST ALLOCATIONS											
	TSLCC95				Scenario 3				Delta			
	Defense	WV	Civilian	Total	Defense	WV	Civilian	Total	Defense	WV	Civilian	Total
Development & Evaluation	2,756	46	9,717	12,520	1,646	57	10,838	12,543	(1,100	11	1,121	23
Repository 1	2,817	47	7,932	10,796	1,554	53	8,719	10,326	(1,263	7	787	(470
Transportation	434	10	1,846	2,290	416	16	1,852	2,283	(18	6	5	(7
MPCs	0	3	5,516	5,519	0	3	5,516	5,519	0	0	0	0
Waste Acceptance	236	5	1,005	1,246	227	9	1,011	1,247	(9	3	6	1
MRS	N/A				N/A				N/A			
Benefits	109	2	306	417	63	2	352	417	(46	0	46	(0
PETT	80	1	226	306	46	2	260	306	(34	0	34	(0
Total	$6,432	$114	$26,550	$33,096	$3,954	$141	$28,549	$32,643	($2,478	$27	$1,999	($453
Percentage %	19.43%	0.34%	80.22%	100.00%	12.11%	0.43%	87.46%	100.00%	-7.32%	0.09%	7.23%	0.00%

Notes: Share methodology understates defense share of unassigned costs due to extremely low piece counts. Actual share will be higher.
Totals may not add due to independent rounding

Table 4-4 Summary of Civilian, Defense, and West Valley Allocation Scenario 4
(In Millions of 1994 Dollars)

Category	COST ALLOCATIONS											
	TSLCC95				Scenario 4				Delta			
	Defense	WV	Civilian	Total	Defense	WV	Civilian	Total	Defense	WV	Civilian	Total
Development & Evaluation	2,756	46	9,717	12,520	12,866	26	3,497	16,389	10,110	(21	(6,220	3,869
Repository 1	2,817	47	7,032	10,196	31,221	61	5,317	36,599	28,404	14	(2,016	26,402
Transportation	434	10	1,846	2,290	3,577	14	1,838	5,379	3,094	4	(9	3,089
MPCs	0	3	5,516	5,519	0	3	5,510	5,510	0	0	0	0
Waste Acceptance	238	5	1,005	1,248	957	4	498	1,459	721	(7	(507	213
MRS	N/A				N/A				N/A			
Benefits	109	2	306	417	375	1	64	440	267	(1	(243	23
PETT	80	1	226	308	316	1	54	370	235	(1	(173	62
Total	$6,432	$114	$26,550	$33,096	$49,262	$108	$16,784	$66,154	$42,830	($6	($9,766	$33,058
Percentage %	19.43%	0.34%	80.22%	100.00%	74.47%	0.16%	25.37%	100.00%	55.03%	-0.18%	-54.85%	0.00%

Notes: Scenario significantly in excess of repository planning basis. Requires assumptions which increase uncertainty of estimate.
Scenario outside methodology validity for place counts and disproportional waste package size.
Totals may not add due to independent rounding

Table 4-5 Summary of Direct Disposal Costs for TWRS Alternatives (Millions of 1994$)

Category	1995 TSLCC		Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Hanford	Total Direct Defense	Hanford	Total Direct Defense	Hanford	Total Direct Defense	Hanford	Total Direct Defense	Hanford	Total Direct Defense
Repository										
Waste Packages	734	1,344	1,708	2,317	1,270	1,880	55	664	18,053	18,662
Emplacement	117	217	267	367	143	244	10	111	1,737	1,838
Transportation										
Shipping & Security (1)	123	264	294	435	204	345	15	156	2,241	2,382
Cask Purchases/Decon.	46	136	92	181	268	357	142	231	705	874
Total Direct	1,021	1,961	2,360	3,301	1,885	2,825	222	1,162	22,816	23,756

(1) Includes 180(c) costs

(2) Totals may not add due to independent rounding

4.2 COST ESTIMATE SENSITIVITIES

4.2.1 Repository

A summary of total repository costs is provided in Table 4-6 for the 95 TSLCC base case and the 4 TWRS scenarios, with a cost breakout by major cost element. The estimates are a subset of the total system costs shown in Tables 4-1 through 4-4. The values represent total repository costs for each scenario, without regard to allocation of costs to defense or civilian cost accounts. This data provides insight into the effect of each scenario on total system costs. For example, repository development and evaluation is constant for Scenarios 1, 2, and 3, but increases by $2.3 billion (94$s) for Scenario 4. The increase is a result of the cost of characterization of additional area, and associated licensing and development. This contrasts with defense shares of total D&E shown previously in Tables 4-1 through 4-4, which vary by scenario, dependent on sharing factors based on direct and assignable costs discussed in Section 3.3.1.

Major components of the repository estimate include waste package costs, the quantity of canisters, surface facility capital and operating costs, subsurface capital and operating costs, Nevada transportation capital and operating costs, and performance confirmation operations. Operating costs are driven primarily by years of emplacement. Capital costs are driven by either requirements for additional area or throughput capacity. Table 4-7 summarizes repository cost drivers. It identifies cost changes as a ratio relative to the 95 TSLCC for each of the Hanford TWRS scenarios.

4.2.2 Transportation

Transportation operations costs are primarily direct costs accrued by specific shipments. The defense share of transportation operations for the alternatives is most affected by the number of canisters per transportation cask, quantities of shipments, and cask fleets required to support the shipping schedule. Mileages are addressed in the modeling of costs but are constant for all Hanford alternatives.

The defense shares of transportation operations increased by 54 percent for Scenario 1, 74 percent for Scenario 2, and 713 percent for Scenario 4. Scenario 1 had a high number of shipments but these costs were offset in part by reduced cask fleet costs due to the commonality of casks for all DHLW. Cask costs increased only 34 percent to support the increased operational tempo. Scenario 2 had fewer shipments than Scenario 1, but defense cask fleet costs increased 163 percent due to multiple cask types and high system throughputs. Scenario 4 increases are due to the extremely large number of shipments over a long period of time, and dedicated transportation fleets. Scenario 4 cask costs increased 549 percent. Scenario 3 costs decreased by 4 percent overall. Savings that resulted from fewer trips were offset by a 67 percent increase in cask fleet costs due to use of different types for DHLW. There may be approaches to reduce this impact by adjusting the assumed delivery schedules.

Table 4-6 Repository Cost Summary (millions of 94$s)

Cost Category	1995 TSLCC	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Rail Spur & Performance Confirmation	926	926	926	926	1,159
Surface Facilities	3,312	3,918	3,774	3,607	7,681
Subsurface Facilities	2,748	2,897	2,775	2,642	6,491
Waste Package	3,876	4,786	4,354	3,133	21,145
Development and Evaluation (Yucca Mountain only)	6,532	6,532	6,532	6,532	8,819
Totals (1)	17,394	19,059	18,361	16,840	45,295

(1) Totals may not add due to independent rounding

Table 4-7 Repository Cost Drivers

Source of Change	Ratio
Waste Package	(scenario/95 TSLCC)
Unit cost due to glass pour canister sizes	
Scenario 1	1.00
Scenarios 2, 3	1.41
Scenario 4	1.67
Waste Package quantity variation	
Scenario 1	1.71
Scenario 2	1.40
Scenario 3	0.50
Scenario 4	13.69
Surface Facilities	
Capital costs	
Scenarios 1, 2, 3	1.19
Scenario 4	1.28
Operating labor	
Scenario 1	1.2
Scenario 2	1.15
Scenario 3	1.08
Scenario 4	2.59
Subsurface Facilities	--
Capital and operating affected by excavation lengths and waste package quantities	
Scenario 1	1.05
Scenario 2	1.01
Scenario 3	0.96
Scenario 4	2.36

4.2.3 Development and Evaluation and Other Program Costs

4.2.3.1 Scenarios 1, 2, and 3

Development and evaluation (D&E) costs and other program costs were evaluated and are assumed to be essentially constant for Scenarios 1, 2 and 3. The only change identified for Scenarios 2 and 3 is an addition for alternative cask development.

4.2.3.2 Scenario 4

In Scenario 4, repository D&E would increase to characterize additional repository areas required to accommodate excess Hanford HLW which can not be emplaced within the primary area. Characterization is assumed to start in 2026, followed by license application in 2032 and construction authorization in 2035. Costs are assumed to be approximately 50 percent of 95 TSLCC costs for characterization and licensing of the repository primary area. Repository surface operations and emplacement, along with supporting transportation and waste acceptance operations, would continue 35 years after completion of emplacement of all commercial SNF and other HLW. Allowing for a caretaker period ending 50 years after start of emplacement in the additional area, program duration would be extended from the 95 TSLCC case completion in 2071 to closure and decommissioning in 2102.

Other D&E, waste acceptance operations, and other program costs were adjusted to the increased scope. These activities also assume efficiencies over similar activities in development of the initial repository primary area, and make adjustments for system simplification since there is only one source of wastes to be disposed of in the Hanford HLW only period of operations.

4.3 EVALUATION OF ALTERNATIVES

The following identifies quantitative and qualitative discriminators for the scenarios determined in the course of this cost analysis for each alternative. This analysis does not take in to account other additional wastes such as DOE SNF which may be required to be emplaced in a repository, or potential variation in HLW canister quantities from other sites. Technical feasibility and environmental effects of disposal are not within the scope of this study and are not addressed.

4.3.1 Scenario 1

Scenario 1 significantly increases the quantity of HLW waste packages over the 95 TSLCC base case. The 95 TSLCC design approach of emplacing HLW waste packages in spaces between the higher thermal output SNF packages requires matching the incoming HLW and SNF waste stream. A disadvantage of this alternative is that it requires an efficient use of most available spaces between SNF packages. Defense HLW waste packages fill approximately 74 percent of the available spaces between SNF waste packages in the period from 2015 through 2040. This

could limit growth capacity in the primary area of the repository. This analysis also does not take in to account other additional wastes such as DOE SNF which may be required to be emplaced in a repository, or potential variation in HLW canister quantities from other sites. For these reasons, this alternative could compete with other wastes being considered for disposal. A more efficient (lower quantity of HLW packages) utilization of repository space would be preferred. This alternative is ranked third in terms of overall cost.

4.3.2 Scenario 2

Scenario 2 is closest to the base case in terms of the number of canisters and repository utilization, given Hanford expectations of higher glass production identified in reference 1 (14,260 m^3 vs. 6,100 m^3 assumed for TSLCC). It is a cost effective alternative and is compatible with the design concepts utilized in the 95 TSLCC. Some modification to cost share methodology may be required to account for disproportionate changes in waste package size, however the methodology bias is much less than for Scenario 3.

4.3.3 Scenario 3

Scenario 3 is a favorable alternative from standpoint of maximizing the efficient use of repository capacity. This alternative has the lowest overall defense waste disposal cost, and reduces total disposal program costs slightly. The cost sharing methodology requires modification to achieve legal requirements for full cost recovery as noted in the discussions in Section 3.3.1 above. The low piece counts of this scenario fall outside the validity of the computational method. Following such adjustment, costs for this alternative would increase, however this would still be the lowest cost alternative from the standpoint of disposal.

4.3.4 Scenario 4

Scenario 4, a no separations alternative, is not preferred from a disposal standpoint. Scenario 4 far exceeds other alternatives in total costs for disposal. This alternative requires substantial disposal area beyond what is being characterized by the Civilian Radioactive Waste Management Program. Scenario 4 would require characterization of secondary areas in addition to the primary area being characterized, suitability determination of the area, and associated licensing of a Hanford only section of the repository. It would require an alternate thermal strategy from that being planned for the repository. Seventy six percent of the Hanford wastes would require emplacement in the additional areas in a low thermal setting, following emplacement of the first twenty four percent of the Hanford HLW and all other HLW with all the available SNF in a high thermal setting in the primary area of the repository. This would require a license update for additional area in an alternate thermal setting. The requirement for both high and low thermal loading areas in Scenario 4 would complicate the licensing process. This is in contrast to the 95 TSLCC assumption of emplacement of all HLW with SNF in the primary area in a high thermal loading setting. Excess quantities of Hanford HLW may exceed available areas in the repository.

Disposition of remaining HLW would not be decided until DOE makes a recommendation on the need for a second repository, required by the NWPAA to be in the period from 2007 to 2010.

The cost sharing methodology may require modification to achieve legal requirements for full cost recovery as noted in the discussions in Section 3.3.1 above. The very high piece counts and large relative size of waste packages in this scenario fall outside the validity of the computational method. Further, uncertainties due to Scenario 4 assumptions may result in delays which could require prolonged on-site storage of excess canisters at Hanford. Uncertainties in assumptions also may increase disposal costs for this scenario.

4.4 QUALITATIVE IMPACTS OF USE OF HANFORD MULTI-PURPOSE CANISTER

4.4.1 Repository

Use of an HMPC which satisfies disposal requirements would result in a small cost saving at the repository for Scenarios 1, 2, and 3. In each case, HLW canisters are already planned to be disposed of in waste packages containing 4 canisters each, as is planned for the MPC. An HMPC would simplify surface facility handling operations. Repository cost savings would be small if any.

4.4.2 Transportation

The HMPC being considered in current TWRS planning is most analogous to Scenario 2 in this analysis. Use of an HMPC would have negligible effect on transportation for Scenario 2, which assumes a HLW transportation cask with a capacity of four long canisters each. Shipping costs would be reduced slightly due to a lower empty weight for return shipments because any basket structure to hold the canisters is part of the HMPC. Cask capital costs would be lower due to absence of the basket structure and reduction in shielding thickness to account for shielding provided by the HMPC canister wall.

The efficiency of an HMPC for Scenario 3 would depend upon the availability of suitable casks required for other purposes. Acquisition of dedicated casks would not be cost effective.

Use of an HMPC for Scenario 1 would require development of alternative transportation casks if not developed for other requirements, and would increase the number of shipments by 25 percent due to the capacity change of five canisters per cask to four.

An HMPC would have no effect on transportation for Scenario 4 since these very large canisters would be transported one per cask and there is no basket in either case.

REFERENCES

1. U.S. Department of Energy, *Request for Repository Disposal Fee Estimates for the Hanford Tank Waste Remediation System (TWRS) Environmental Impact Statement*, letter Ser WDD:PL 96-WDD-069 of Jun 7, 1996.

2. U.S. Department of Energy, *Analysis of the Total System Life Cycle Cost for the Civilian Radioactive Waste Management Program* (DOE/RW-0479), September, 1995.

3. Nuclear Waste Policy Amendments Act of 1987, Pub. L. No. 100-203, December, 1987

4. U.S. Department of Energy, "Civilian Radioactive Waste Management; Calculating Nuclear Waste Fund Disposal Fees for Department of Energy Defense Program Waste", pp. 31508-31524, *Federal Register*, Vol. 52 No. 161, August 20, 1987.

5. Jones, Robert H. and Nickell, Robert E., *Final Report, MRS-to-Repository Transportation System Design Characterization and Capacity Study*, Los Gatos, CA, December, 1989

APPENDIX A

Request for Repository Disposal Fee Estimates for the Hanford Tank Waste Remediation System (TWRS) Environmental Impact Statement, dated Jun 7, 1996.

RL-F-1325.5# DEF012
(04/93)

United States Government | Department of Energy

memorandum

Richland Operations Office

DATE: JUN 07 1996

REPLY TO ATTN OF: WDD:PL 96-WDD-069

SUBJECT: REQUEST FOR REPOSITORY DISPOSAL FEE ESTIMATES FOR THE HANFORD TANK WASTE REMEDIATION SYSTEM (TWRS) ENVIRONMENTAL IMPACT STATEMENT (EIS)

TO: Ronald A. Milner, Director
Office of Program Management
and Integration, RW-30, HQ

References:

1. Office of Civilian Radioactive Waste Management Report, "Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program," DOE-RW-0479, dated September 1995.

2. Memorandum from R. A. Milner, HQ, to J. Kinzer, RL, "Evaluation of Hanford Longer High-Level Waste Product Canister Option for Acceptance by the Civilian Radioactive Waste Management System," dated April 5, 1996.

TWRS urgently requests support from RW concerning the estimated costs for disposal of defense High-Level Waste (HLW) from Hanford in order to complete the final TWRS EIS. Disposal costs in the draft TWRS EIS were initially estimated by extrapolating data from Reference 1.

In order to address recent comments on the draft EIS, more rigorous cost estimates based on application of RW's disposal cost methodology are needed for four TWRS alternative scenarios, which are defined in Attachment 1. These scenarios include use of a fifteen-foot long canister (Reference 2), as well as incorporation of the results of a recently completed probabilistic estimate of the quantity of borosilicate glass expected from the reference HLW pretreatment and vitrification processes. Attachment 2 provides additional technical data, requested by your staff, to assist them in evaluating these scenarios.

The scheduled date for release of the TWRS EIS is July 31, 1996. To achieve this date, the revision must be completed by June 28, 1996. Based on recent discussions with members of your staff, it is our understanding that RW could provide informal input for the four scenarios by June 18, 1996. A formal, referenceable memorandum summarizing the estimates should be transmitted by June 21, 1996. These dates are the latest that will allow the TWRS Program to meet the schedule for issuing the TWRS EIS by the end of July.

Choon Quan of your staff has advised us that RW contractor staff are available to respond to this request. It is understood that RW is willing to proceed with this study pending satisfactory resolution of funding considerations.

Thank you very much for your prompt consideration of this very important request. If you have any questions, please contact me on (509) 376-7591 or Phil E. LaMont of my staff on (509) 376-6117.

ORIGINAL SIGNED BY

Jackson Kinzer, Assistant Manager
Office of Tank Waste Remediation System

Attachments (2)

cc w/attachs:
S. Cowan, EM-30
T. Harms, EM-38
M. Hunemuller, EM-38
C. Myler, EM-38
C. Conner, RW-35
J. Carlson, RW-37
S. Gomberg, RW-37
C. Quan, RW-37
S. Rousso, RW-40

bcc w/attachs:
WDD OFF File
WDD Rdg File
RMIC File
P. LaMont, WDD
C. Henderson, Jacobs
B. Gibson, TRW
L. Meyer, TRW
S. Schaus, WHC

DEFENSE WASTE DISPOSAL FEE ESTIMATES NEEDED BY HANFORD FOR THE TANK WASTE REMEDIATION SYSTEM ENVIRONMENTAL IMPACT STATEMENT

The Hanford Tank Waste Remediation System (TWRS) program is on an aggressive schedule for completion of its Environmental Impact Statement (EIS) for the disposal of Hanford's tank wastes. In order to complete the required definition and evaluation of major alternatives, preliminary estimates of the repository fees for defense HLW disposal for the four (4) scenarios described below are needed by 6/14/96. An approved referenceable memorandum transmitting these disposal fee estimates is needed no later than June 21, 1996.

RW has provided a baseline allocated cost estimate for disposal of 18,046 defense HLW "standard" 0.61m x 3.0m (0.62 m^3) canisters in a single repository as reported in DOE/RW-0479, "Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program". Starting with the TSLCC as a baseline, TWRS is requesting allocated defense HLW disposal fee estimates for the following scenarios as summarized in Table 1:

Scenario 1: Increase the estimated number of "standard" canisters for Hanford from 9,850 in the TSLCC to 23,000, which reflects current judgment of the most probable quantity of immobilized HLW (14,000 m^3) for the reference "enhanced sludge wash" process.

Scenario 2: Assume 12,200 "long" 0.61m x 4.5m canisters (1.17 m^3) for the most probable quantity of Hanford's HLW as described in Scenario 1.

Scenario 3: Assume 530 "long" canisters for 620 m^3 of HLW resulting from "extensive separations" pretreatment process.

Scenario 4: Assume 36,400 "very large" 1.68m x 5.03m canisters (10 m^3) for 364,000 m^3 HLW produced without any pretreatment.

Since the TSLCC included Multi-Purpose Canisters for commercial Spent Nuclear Fuel and for West Valley's HLW, but not for defense HLW, this cost component should be retained for the above calculations in order to ensure comparability with the TSLCC report. If the MPC cost component is not retained for the requested calculations, Table 7-1 in the TSLCC should be updated to delete the MPC.

The draft TWRS-EIS is based on placing the HLW canisters in a "Hanford Multi-Purpose Canister" (HMPC) for interim onsite storage and transfer to RW for disposal. Recognizing that defense HLW canisters were not placed in MPCs in the 1995 TSLCC, RW is requested to comment qualitatively on the disposal fee impact, if the HMPC concept were to be used. (NOTE: Cost of the HMPC is currently included in the cost of waste treatment at Hanford.)

It is requested that the disposal fee estimates be reported similarly to the TSLCC base case shown in Table 7-1 of the TSLCC report and summarized as shown in Table 1.

TABLE 1 - REPOSITORY DISPOSAL FEE EVALUATION MATRIX

	Canister Size	Pretreat Process	Volume of Glass, m^3	Number of Hanford Canisters	Total No. of DHLW Canisters	Total Reposi-tory Cost	Allocated DHLW Share
Base Case (RW-0479)	0.61m D X 3.0 m	ESW[1]	6,100	9,860	18,046	$33.1 B	$6.43B
Scenario #1 (most probable volume)	0.61m D X 3.0m	ESW	14,260	23,000[2]	31,186	TBD by RW	TBD by RW
Scenario #2 (long canister)	0.61m D X 4.50m	ESW	14,260	12,200	20,386	TBD by RW	TBD by RW
Scenario #3 (minimum volume)	0.61m D X 4.50m	Extensive Separa-tions[3]	620	530	8,716	TBD by RW	TBD by RW
Scenario #4 (very large canister)	1.68m D X 5.03m	No Pretreat-ment[4]	364,000	36,400	44,586	TBD by RW	TBD by RW

[1] Enhanced Sludge Wash (Caustic Leaching)--TWRS Technical Baseline for pretreatment of HLW sludges

[2] This value was judged to be the most probable volume of glass produced using the current TWRS flowsheet (memo, Taylor/Lang to Distribution, 4/29/96)

[3] Extensive Separations--Alternative pretreatment processes for HLW waste sludges

TECHNICAL DATA TO SUPPORT DISPOSAL FEE CALCULATIONS FOR TWRS-EIS

	Outer Diam., m	Length, m	Wall thickness, cm	Nominal Glass Volume, m^3	Total Nominal Weight, kg	Annual Production Rate, # of canisters
DWPF standard canister	0.61	3.00	1.0	0.62	2,200	15000[1]
TWRS standard canister	0.61	4.50	1.0	1.17	3,700	800[1] 75[2]
TWRS "very large" canister	1.68	5.03	2.5	10.0	29,700	2,200[3]

The total thermal output from all Hanford waste is 930 kW, indexed to December 2021 and assuming that the Cs and Sr capsule inventories are included in the glass. For purposes of evaluating the four (4) scenarios, it should be assumed that the thermal output is uniformly distributed among the number of canisters associated with each scenario, e.g. 1.8 kW per canister for Scenario 3.

The total equivalent Metric Tons Heavy Metal (eMTHM) for all Hanford tank waste is estimated to be 2,600, using the proposed methodology for calculating equivalency that is described in DOE-RL/HT-04. Again it should be assumed for purposes of this exercise, that the EMTHM are uniformly distributed among the number of canisters associated with each scenario, e.g. 4.9 eMTHM per canister for Scenario 3.

[1] For Scenarios 1 and 2, the full-scale (Phase II) production rates are based on an instantaneous melter capacity of 12 MT/day at 60% total operating efficiency.

[2] For Scenario 3, the production rate is based on an instantaneous melter rate of 1 MT/day and a 60% TOE.

[3] For Scenario 4, the full-scale (Phase II) production rate is based on an instantaneous melter rate of 260 MT/day and a 60% TOE.

Full-scale production (Phase II) of HLW glass at Hanford is scheduled to start in 2013 and is to be completed no later than 2028 (Tri-Party Agreement milestone). For earlier information from RW (Brandt, July 1993), Hanford's HLW canisters could be shipped starting in 2022 at a maximum rate of 800 canisters per year. However, the current planning base for the TWRS program is to provide interim on-site storage for all of the HLW canisters.

Attachment 2
page 2 of 5

HLW Conc Data TWRS EIS

Intermediate Separations Base Case (6/3/96)		
	Scenario 2 based on 12,200 Long Canisters (1.17 m^3)	
		Scenario 2
		Curies/1.17 m^3
Radionuclide		canister
Inventory	glass	
	Ci/m^3	
Am-241	1.38E+02	7.71E+00
Am-243	4.41E-02	2.47E-03
C-14		
Cm-244	1.52E-01	4.55E-03
Cs-135	1.92E-01	1.16E-02
Cs-137	4.63E+04	2.85E+03
I-129		
Ni-63	5.58E+00	2.16E+01
Np-237	9.23E-02	5.09E-03
Pu-238	1.42E+00	8.48E-02
Pu-239	3.46E+01	2.01E+00
Pu-240	8.77E+00	5.17E-01
Pu-241	9.82E+01	6.02E+00
Ra-226	3.56E-10	
Ru-106	5.00E-05	2.93E-06
Sm-151		5.09E+01
Sn-126	8.24E-01	3.86E-02
Sr-90	7.05E+04	4.32E+03
Tc-99	4.24E+01	4.86E-01
Th-230	5.14E-08	3.16E-09
U-233	2.43E-08	9.25E-07
U-234	4.46E-07	1.62E-05
U-235	6.32E-02	1.62E-03
Zr-93		3.16E-01
Total (m3)	1.43E+04	

Note: Curies from decay daughter products not included

Radionuclides reflect decay to 12/31/99

Attachment 2
page 3 of 5

HLW Conc Data TWRS EIS

Extensive Separations alternative (6/3/96)						
	volume based on 530 long canisters at 1.17 m^3 (620 m^3 of HLW)					
						Scenario 3
		Extensive Separations Data Package values				
		Radionuclide Inventor		HLW Glass		Curies/1.17m^3
				Base Case (A-1)		canister
				Ci/m3		
		Am-241		1.67E+02		1.96E+02
		Am-243		5.35E-02		6.26E-02
		C-14				
		Cm-244		1.84E-01		2.15E-01
		Cs-135		2.33E-01		2.72E-01
		Cs-137		5.62E+04		6.57E+04
		I-129				
		Ni-63		6.78E+00		7.93E+00
		Np-237		1.12E-01		1.31E-01
		Pu-238		1.72E+00		2.01E+00
		Pu-239		4.20E+01		4.91E+01
		Pu-240		1.06E+01		1.24E+01
		Pu-241		1.19E+02		1.39E+02
		Ra-226		4.32E-10		5.05E-10
		Ru-106		6.06E-05		7.09E-05
		Sm-151				
		Sn-126		1.00E+00		1.17E+00
		Sr-90		8.56E+04		1.00E+05
		Tc-99		5.14E+01		6.02E+01
		Th-230		6.24E-08		7.30E-08
		U-233		2.94E-08		3.44E-08
		U-235		5.26E-05		6.15E-05
		U-238		1.22E-03		1.43E-03
		Zr-93		7.67E-02		8.98E-02
		total m3		6.20E+02		
Radionuclides reflect decay to 12/31/99						
Note: Curies from decay prod. not included						

HLW Conc Data TWRS EIS

Intermediate Separations Base Case (6/3/96)		
Scenario 1 based on 23,000 std size canisters of HLW		
		Scenario 1
		Curies/0.62 m^3
Radionuclide Inventory	HLW glass Ci/m^3	canister
Am-241	6.59E+00	4.09E+00
Am-243	2.11E-03	1.31E-03
C-14		
Cm-244	3.89E-03	2.41E-03
Cs-135	9.89E-03	6.13E-03
Cs-137	2.44E+03	1.51E+03
I-129		
Ni-63	1.85E+01	1.14E+01
Np-237	4.35E-03	2.70E-03
Pu-238	7.25E-02	4.50E-02
Pu-239	1.71E+00	1.06E+00
Pu-240	4.42E-01	2.74E-01
Pu-241	5.14E+00	3.19E+00
Ra-226		
Ru-106	2.50E-06	1.55E-06
Sm-151	4.35E+01	2.70E+01
Sn-126	3.30E-02	2.04E-02
Sr-90	3.69E+03	2.29E+03
Tc-99	4.15E-01	2.57E-01
Th-230	2.70E-09	1.68E-09
U-233	7.91E-07	4.90E-07
U-234	1.38E-05	8.58E-06
U-235	1.38E-03	8.58E-04
Zr-93	2.70E-01	1.68E-01
Total (m3)	1.43E+04	
Note: Curies from decay daughter products not included		
Radionuclides reflect decay to 12/31/99		

HLW Conc Data TWRS EIS

No Separations Alternative (6/3/96)			
	20 wt % sodium oxide loading, 1.5 blending factor		
		Vitrification	Scenario 4
		Radionuclide Concentration Curies /m^3	Curies/10 m^3 canister
Am-241		2.86E-01	2.86E+00
Am-243		9.12E-05	9.12E-04
Cm-244		3.24E-04	3.24E-03
Cs-137		9.58E+01	9.58E+02
Ni-63		7.39E-01	7.39E+00
Np-237		1.91E-04	1.91E-03
Pu-238		2.97E-03	2.97E-02
Pu-239		7.25E-02	7.25E-01
Pu-240		1.84E-02	1.84E-01
Pu-241		2.06E-01	2.06E+00
Ru-106		1.04E-07	1.04E-06
Sm-151		1.73E+00	1.73E+01
Sn-126		1.72E-03	1.72E-02
Sr-90		1.20E+02	1.20E+03
Tc-99		8.81E-02	8.81E-01
U-233		3.32E-08	3.32E-07
U-234		5.82E-07	5.82E-06
U-235		5.66E-05	5.66E-04
U-238		1.32E-03	1.32E-02
Zr-93		1.08E-02	1.08E-01
Total (m3)		3.64E+05	
Radionuclides reflect decay to 12/31/99			
Note: Curies from decay daughter products not included			

TWRS FEIS HLW DISPOSAL COST METHODOLOGY

This paper outlines the proposed methodology for calculating the disposal cost for each of the ex situ alternatives addressed in the TWRS EIS. The disposal cost for placement of HLW in the potential geologic repository will be calculated using the scenarios outlined in the Draft Cost Estimate Report on Disposal Costs for Tank Waste Remediation System Alternatives developed by OCRWM. Based on four scenarios developed by DOE-RL, this report identifies the total repository cost and the allocated defense share using the same methodology as the 1995 Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program.

In order to show the disposal cost by alternative in the TWRS EIS, Hanfords' share of the allocated defense share must be estimated. The proposed approach for estimating the Hanford share would be to multiply the allocated defense share by the ratio of the number of waste packages generated at Hanford to the total number of defense waste packages. A waste package would contain four of the standard or long canisters and one of the large 10 m^3 canisters.

Disposal fees for scenarios not specifically modeled by OCRWM (e.g., Ex Situ/In Situ Combination 1, Ex Situ/In Situ Combination 2, and No Separations alternatives) and for scenarios with a revised canister count (Ex Situ No Separations Vitrification) will be extrapolated from the modeled data. This would be accomplished by plotting the number of waste packages versus the TWRS repository costs. The disposal fees for the TWRS EIS alternatives using this approach are shown in Table 1.

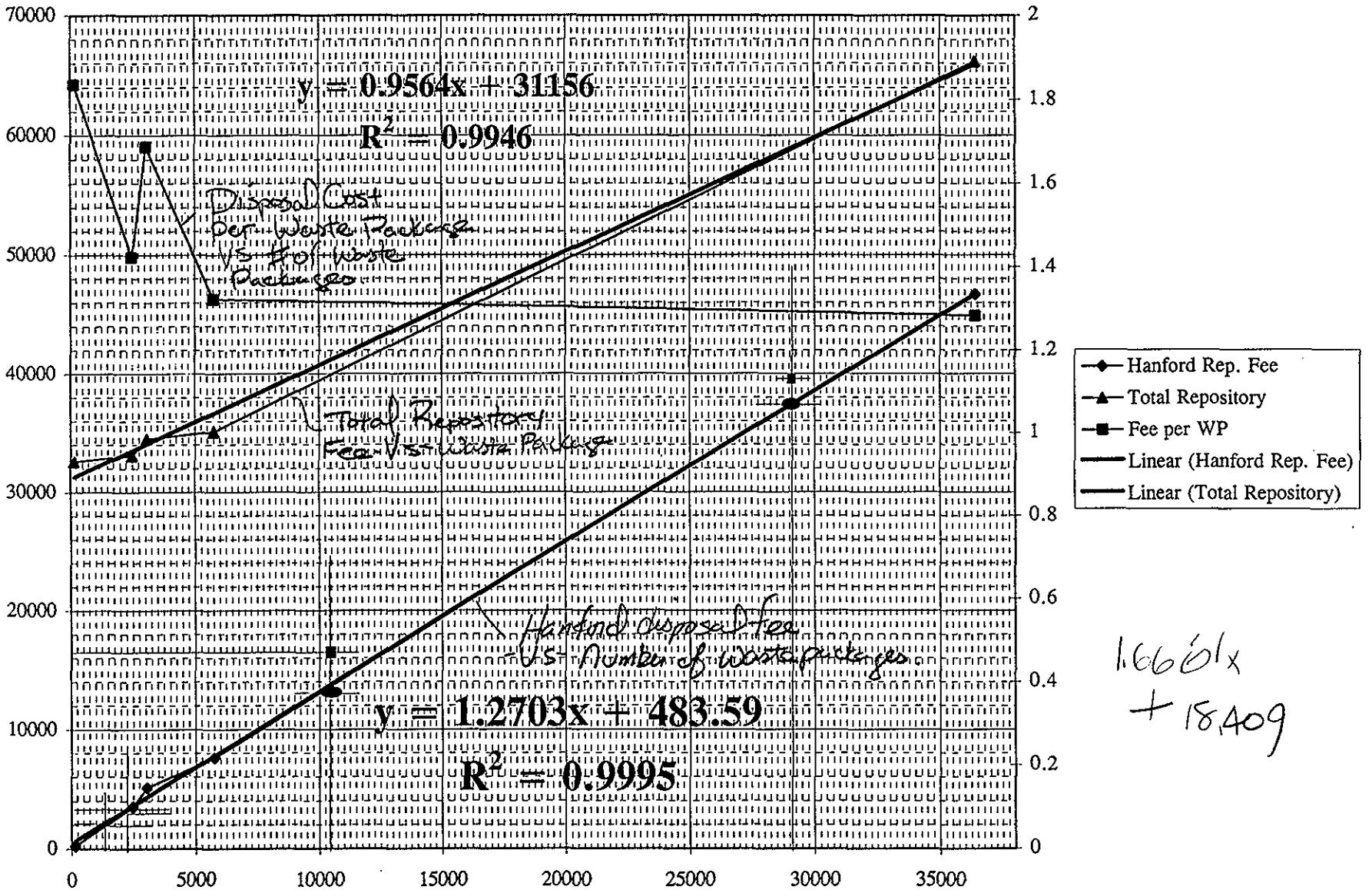
Comments on the proposed TWRS EIS disposal cost methodology are needed by 7/15 to incorporate into the 7/31 Preliminary Final EIS. Please forward comments via cc mail to Jacobs Engineering Group and Carolyn Haass.

Table 1. TWRS EIS Repository Fee Estimates

Alternative	Canister Size	Number of Hanford Canisters	Number of Hanford Waste Packages	Allocated Defense Share (94$s) [1]	Hanford Share (94$s)	Cost per Waste Package (94$s)
Ex Situ Intermediate Separations	1.17 m^3	12,200	3,050	$8.6B	$5.1B	$1.688M
Ex Situ No Separations - Vitrification	10 m^3	29,100	29,100		$37.6B	$1.291M
Ex Situ No Separations - Calcination	10 m^3	10,300	10,300		$14.12B	$1.373M
Ex Situ Extensive Separations	1.17 m^3	570	143	$4.0B	$0.26B	$1.818M
Ex Situ/In Situ Combination 1	1.17 m^3	8,540	2,135		$3.6B	$1.677M
Ex Situ/In Situ Combination 2	1.17 m^3	4,940	1,235		$2.1B	$1.684M
Phased Implementation	1.17 m^3	12,200	3,050	$8.6B	$5.1B	$1.688M
Scenarios evaluated but not used in the TWRS EIS						
Minimum Volume	1.17 m^3	530	133	$4.0B	$0.24B	$1.836M
Base Case	0.62m^3	9,860	2,465	$6.43B	$3.51B	$1.424M
Scenario 1	0.62m^3	23,000	5,750	$10.3B	$7.6B	$1.322M
Scenario 4	10 m^3	36,400	36,400	$49.3B	$46.7B	$1.283M

Notes:
1. For alternatives that were modeled by OCRWM
Table modified 7/16/96 based on refined extrapolation for EIS alternatives not modeled.

chart 3



1.6601x
+ 18,409

Henderson, Colin

From: Stein, David
To: Henderson, Colin
Subject: TWRS Repository Costs
Date: Monday, July 08, 1996 12:56PM

I have reviewed Steve Schaus's (Westinghouse) comments on TRW's "Draft Cost Estimate Report on Disposal Costs for TWRS Alternatives" dated June 25, 1996, and agree with his analysis to use waste package count rather than canister count as the basis for allocating Defense Share Costs. His analysis and calculations of the TWRS Hanford share are in fact the same approach that we discussed last week. The proposed formula for calculating repository costs for the Hanford TWRS will be as follows:

Defense Share Cost x Hanford Share = Alternative Repository Cost

where Hanford Share = ratio of Hanford waste pkgs/ total Defense waste pkgs

Waste packages for the 0.61m x 3.0m and 0.61m x 4.5m canisters will be calculated by dividing canister count by four, while waste package count for the very large canisters (1.68m x5.03m) will be the same as the canister count.

Repository fees for scenarios not specifically modeled by TRW (Combos 1 & 2 , No Separations Calcination) and for scenarios with a revised canister count (No Separations Vitrification) will be extrapolated from the existing data (plot of # waste pkgs vs Hanford TWRS Repository Costs). The Repository Costs for Hanford for the alternatives using this approach are as follows:

Alternative	# Canisters	# Waste Pkgs	Hanford Repository Fees Total	Per Waste Pkg
No Separations				
Vitrification	29,100	29,100	$37.4 billion	$1285 thou
Calcination	10,300	10,300	$13.2 billion	$1285 thou
Intermediate Sep.	12,200	3,050	$5.1 billion	$1688 thou
Extensive Sep.	570	143	$0.24 billion	$1836 thou
Combo 1	8,540	2,135	$3.6 billion	$1688 thou
Combo 2	3,550	888	$1.5 billion	$1688 thou
Phased Imple	12,200	3,050	$5.1 billion	$1688 thou

Call me if you have any questions.

[1] From: Paul S (Steve) Schaus at ~WHC300 7/3/96 2:55PM (7533 bytes: 18 ln, 1 f
l)
Priority: Urgent
To: ^Jacobs Engineering Group at ~DOE_HANFORD_1
Receipt Requested
cc: Philip E LaMont at ~DOE4, Carolyn C Haass at ~DOE4, Robert W Lober at ~DOE4,
Daniel D Button at ~DOE4, Roger W (Rod) Powell, Russell J Murkowski,
Dennis J Washenfelder at ~WHC156, Thomas W Crawford at ~WHC347,
E J (Gene) Kosiancic at ~WHC156, Paul S (Steve) Schaus
Subject: Preliminary Analysis of RW's Disposal Fee Calculations
---------- Message Contents ----------

Text item 1:

Colin--Based on our telephone conversation earlier today, I have summarized my preliminary analysis of the disposal fee calculations that RW has recently completed at our request. While the results are first order estimates and based on a rather simplistic approach, they have the potential to impact the conclusions that have been reached in the TWRS-EIS.

Since it sounded as if you might be working on resolving EIS comments addressing the disposal fee issue over the weekend, I wanted to share my early conclusions with you even in a preliminary fashion. We can discuss in more detail next week. While I will not be back in the office until next Monday (Friday is a holiday for WHC), I will be in the Tri-Cities most of the weekend and can be reached at 627-1500 (home phone).

Steve Schaus

File item 2: DISP_FEE.SUM 7/3/96 2:28PM

TWRS'S PRORATED SHARE OF DISPOSAL FEE

I would propose to use a canister (piece part) count approach as a basis for estimating TWRS's prorated share of the repository disposal fee (p. 2, Table 1-1) for the following reasons:

1) the common unit for repository disposal is RW's waste package, not the canister; the same waste package will be used for 10' canisters, 15' canisters and bundles of spent nuclear fuel rods.

2) glass volume isn't an appropriate basis; otherwise, the disposal costs for Scenarios #1 and #2 would be the same (both are based on 14,260 m^3 of TWRS-produced glass).

3) it's easy to understand and explain as the TWRS Program attempts to respond to comments from the EIS review.

However, for Scenario #4 the very large canister is already the approximate size of RW's waste package. Therefore, in order to determine TWRS's share of the disposal fee, the number of canisters produced by DWPF and Idaho (8,186) needs to be divided by 4 in order to establish an equivalency. The total number of defense "waste packages" is 38,467, of which 36,400, or 94.6%, would be produced at Hanford.

A comparison of Scenarios #1 and #2 (volume of HLW glass is constant) provides an estimate of the potential disposal fee savings realized by using the 15' (4.5m) canister. The cost of the repository is reduced by $0.6B, while the DOE's share of the disposal fee is reduced by $1.7B and TWRS's prorated share is reduced by $2.5B.

Similarly, a comparison of Scenarios #2 and #3 provides insight into the potential disposal fee savings realized by substantially reducing the volume of HLW glass produced at Hanford from 14,260 m^3 to 620 m^3. The benefit of extensive separations (provided that the target volume could be achieved) can be expressed as a repository cost savings of $1.9B, a disposal fee savings to DOE of $4.6B, and a prorated disposal fee savings to TWRS of $4.9B.

For both of the comparisons shown above, the fact that the allocated defense share savings is larger than the total repository cost savings can be easily explained. As the number of TWRS canisters is reduced, not only is the cost of the repository reduced, but more of the repository's fixed costs are reallocated from the defense HLW canisters (and the taxpayers) to the commercial SNF (and the ratepayers). Similarly some of the fixed costs

included in the defense share is shifted away from TWRS and to DWPF and Idaho as fewer canisters are produced.

DISPOSAL FEE ALLOCATION TO TWRS

	Repository Cost	DOE's Share	Comm. SNF Share	TWRS's Share	Disp. Fee/Can
Base Case (RW-0479)	$33.1B	$6.43B	$26.67B	$3.51B	$356K
Scenario #1 (10' canisters)	35.1	10.3	24.8	7.6	330
Scenario #2 (15' canisters)	34.5	8.6	25.9	5.15	422
Scenario #3 (ext. sep.)	32.6	4.0	28.6	0.24	459
Scenario #4 (no separation)	66.2	49.3	16.9	46.7	321[a]

[a] The disposal fee for each very large canister is actually 4X this value, since a very large canister is dimensionally the same as a waste package which contains four (4) canisters. For purposes of comparison with the other scenarios an "equivalent" value is shown.

[1] From: ^Jacobs Engineering Group at ~DOE_HANFORD_1 7/9/96 2:20PM (11103 bytes : 3 ln, 1 fl)
To: Carolyn C Haass at ~DOE4, Kevin J Kjarmo at ~WHC117, Robert W Lober at ~DOE4, craig myler, Philip E LaMont at ~DOE4, Paul S (Steve) Schaus at ~WHC300, Daniel D (Dan) Button at ~DOE16, ^Jacobs Engineering Group at ~DOE_HANFORD_1
Subject: TWRS FEIS HLW Disposal Cost Methodology
---------- Message Contents ----------

Text item 1:

Please see attached file.

Thank you.

File item 2: REPOS.709 7/9/96 2:23PM

TWRS FEIS HLW DISPOSAL COST METHODOLOGY

This paper outlines the proposed methodology for calculating the disposal cost for each of the ex situ alternatives addressed in the TWRS EIS. The disposal cost for placement of HLW in the potential geologic repository will be calculated using the scenarios outlined in the Draft Cost Estimate Report on Disposal Costs for Tank Waste Remediation System Alternatives developed by OCRWM. Based on four scenarios developed by DOE-RL, this report identifies the total repository cost and the allocated defense share using the same methodology as the 1995 Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program.

In order to show the disposal cost by alternative in the TWRS EIS, Hanfords' share of the allocated defense share must be estimated. The proposed approach for estimating the Hanford share would be to multiply the allocated defense share by the ratio of the number of waste packages generated at Hanford to the total number of defense waste packages. A waste package would contain four of the standard or long canisters and one of the large 10 m^3 canisters.

Disposal fees for scenarios not specifically modeled by OCRWM (e.g., Ex Situ/In Situ Combination 1, Ex Situ/In Situ Combination 2, and No Separations alternatives) and for scenarios with a revised canister count (Ex Situ No Separations Vitrification) will be extrapolated from the modeled data. This would be accomplished by plotting the number of waste packages versus the TWRS repository costs. The disposal fees for the TWRS EIS alternatives using this approach are shown in Table 1.

Comments on the proposed TWRS EIS disposal cost methodology are needed by 7/15 to incorporate into the 7/31 Preliminary Final EIS. Please forward comments via cc mail to Jacobs Engineering Group and Carolyn Haass?

Table 1. TWRS EIS Repository Fee Estimates

Alternative	Canister Size	Number of Hanford Canisters	Number of Hanford Waste Packages	Allocated Defense Share (94$s) [1]	Hanford Share (94$s)	Cost per Waste Package (94$s)
Ex Situ Intermediate Separations	1.17 m^3	12,200	3,050	$8.6B	$5.1B	$1.688M
Ex Situ No Separations - Vitrification	10 m^3	29,100	29,100		$37.4B	$1.285M
Ex Situ No Separations - Calcination	10 m^3	10,300	10,300		$13.2B	$1.285M
Ex Situ Extensive Separations	1.17 m^3	570	143	$4.0B	$0.24B	$1.836M
Ex Situ/In Situ Combination 1	1.17 m^3	8,540	2,135		$3.6B	$1.688M
Ex Situ/In Situ Combination 2	1.17 m^3	4,940	1,235		$2.1B	$1.688M
Phased Implementation	1.17 m^3	12,200	3,050	$8.6B	$5.1B	$1.688M
Scenarios evaluated but not used in the TWRS EIS						
Base Case	0.62m^3	9,860	2,465	$6.43B	$3.51B	$1.424M
Scenario 1	0.62m^3	23,000	5,750	$10.3B	$7.6B	$1.322M
Scenario 4	10 m^3	36,400	36,400	$49.3B	$46.7B	$1.283M

Notes:
1. For alternatives that were modeled by OCRWM

MN/RF/CH

[1] From: Paul S (Steve) Schaus at ~WHC300 7/10/96 11:48AM (15315 bytes: 15 ln, 1 fl)
To: ^Jacobs Engineering Group at ~DOE_HANFORD_1
Receipt Requested
cc: Philip E LaMont at ~DOE4, Daniel D Button at ~DOE4, Carolyn C Haass at ~DOE4, Robert W Lober at ~DOE4, Roger W (Rod) Powell, Paul S (Steve) Schaus
Subject: Comments on Proposed Repository Fee Estimates
---------- Message Contents ----------

Text item 1:

Colin--Phil LaMont, Dan Button and I met this morning to review your proposed TWRS-EIS Repository Fee Estimates. The attached file is a revision of what you had sent out for our review. The revised values are based on linear interpolations of the computed estimates of the allocated defense share provided by RW/TRW using their Total System Life Cycle Cost model. From those interpolated values we computed both the Hanford share and cost per waste package values.

If you have any questions regarding the information provided, please call me at 372-1149. Thank you for the opportunity to provide comments.

Steve Schaus

6.18.2

File item 2: REPOSFEE.710 7/10/96 11:47AM

TWRS FEIS HLW DISPOSAL COST METHODOLOGY

This paper outlines the proposed methodology for calculating the disposal cost for each of the ex situ alternatives addressed in the TWRS EIS. The disposal cost for placement of HLW in the potential geologic repository will be calculated using the scenarios outlined in the Draft Cost Estimate Report on Disposal Costs for Tank Waste Remediation System Alternatives developed by OCRWM. Based on four scenarios developed by DOE-RL, this report identifies the total repository cost and the allocated defense share using the same methodology as the 1995 Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program.

In order to show the disposal cost by alternative in the TWRS EIS, Hanfords' share of the allocated defense share must be estimated. The proposed approach for estimating the Hanford share would be to multiply the allocated defense share by the ratio of the number of waste packages generated at Hanford to the total number of defense waste packages. A waste package would contain four of the standard or long canisters and one of the large 10 m^3 canisters.

Disposal fees for scenarios not specifically modeled by OCRWM (e.g., Ex Situ/In Situ Combination 1, Ex Situ/In Situ Combination 2, and No Separations alternatives) and for scenarios with a revised canister count (Ex Situ No Separations Vitrification) were linear interpolations from the modeled data. The interpolated disposal fees for the TWRS EIS alternatives using this approach are shown in Table 1 (see Footnote 1).

Table 1. TWRS EIS Repository Fee Estimates

Alternative	Canister Size	Number of Hanford Canisters	Number of Hanford Waste Packages	Allocated Defense Share (94$s)	Hanford Share (94$s)	Cost per Waste Package (94$s)
Ex Situ Intermediate Separations	1.17 m^3	12,200	3,050	$8.6B	$5.1B	$1.688M
Ex Situ No Separations - Vitrification	10 m^3	29,100	29,100	$42.6B[1]	$39.8B[1]	$1.368M[1]
Ex Situ No Separations - Calcination	10 m^3	10,300	10,300	$19.8B[1]	$16.5B[1]	$1.598M[1]
Ex Situ Extensive Separations	1.17 m^3	570	143	$4.0B	$0.24B	$1.836M
Ex Situ/In Situ Combination 1	1.17 m^3	8,540	2,135	$7.25B[1]	$3.7B[1]	$1.734M[1]
Ex Situ/In Situ Combination 2	1.17 m^3	4,940	1,235	$5.85B[1]	$2.2B[1]	$1.782M[1]
Phased Implementation	1.17 m^3	12,200	3,050	$8.6B	$5.1B	$1.688M
Scenarios evaluated but not used in the TWRS-EIS						
Base Case	0.62m^3	9,860	2,465	$6.43B	$3.51B	$1.424M
Scenario 1	0.62m^3	23,000	5,750	$10.3B	$7.6B	$1.322M
Scenario 4	10 m^3	36,400	36,400	$49.3B	$46.7B	$1.283M

[1] Interpolated values derived from TSLCC model results

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering - LAW VAULT Inventory Revisions for FEIS

ORIGINATOR Colin Henderson DATE 7/5/96

REVISION NO. 0

OBJECTIVE Establish LAW VAULT Inventory

METHODOLOGY See attached

ASSUMPTIONS See attached

(Continue on another sheet if necessary)

J.C. Hale 8/1/96
SIGNATURE/DATE

8-1-96
CHECKED/DATE

CALCULATION & RESULTS
ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

Change in LAW VAULT Inventory for FEIS.

Reference: CC Mail message from Neil Brown (DOE-RL Disposal Group) dated ~~4~~ 5/30/96

These changes would apply to the Ex Situ Intermediate Separations, and Phased Implementation alternatives. This would also apply to a lesser degree to the Combination alternatives.

The original INTERMEDIATE Separations Data Package had:

Cs & Ba = 0.493 MCi
Sr & Y = 1.93 MCi

The inventory developed for the Phased Implementation alternative had:

Cs & Ba = 0.493 MCi
Sr & Y = 1.07 MCi

The LAW VAULT Inventory for Both Intermediate Separations and Phased Implementation should be:

Cs & Ba = 10 MCi
Sr & Y = 6.8 MCi
Tc-99 = 0.0259 MCi (Same as Intermediate Sep)

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

This translates into the following Masses:

Cs + Ba = 10 MCi ⇒ Cs = 5 MCi

Sp Act = 86.4 Ci/gram

Mass Cs = 5×10^6 Ci ÷ 86.4 Ci/gram = 57,900 gram

Cs = 57900 gram

as an Oxide Cs_2O

Cs_2O = 57900 gram $\left(\frac{137 \times 2 + 16}{137 \times 2}\right)$ = 61,300 grams Cs_2O

Cs_2O = 61,300 grams.

Sr + Y = 6.8 MCi ⇒ Sr = 3.4 MCi

Sp Act = 139 Ci/gram

Mass Sr = 3.4E6 Ci / 139 Ci/gram = 24460 ~ 24,500 gram

as SrO = 24500 gram $\left(\frac{90 + 16}{90}\right)$ = 28,900 gram

SrO = 28900 gram.

Law Vault Inventory for Int. Sep. & Phased Imp.

Cs_2O = 61,300 grams (~ 10 MCi Cs+Ba)
SrO = 28,900 grams (~ 6.8 MCi Sr+Y)

FORM 91-005-1 (4/81)

[2] From: Neil R Brown at ~DOE4 5/30/96 9:56AM (4071 bytes: 46 ln)
To: ^Jacobs Engineering Group at ~DOE_HANFORD_1
Subject: Re: LAW Inventory Left Onsite Under TWRS EIS
---------- Message Contents ----------

Text item 1: RFC822 message headers

Mark Nelson

Please make sure this is the inventory used in the EIS. Let me know if there are any problems.

---------- Forward Header ----------
Subject: Re: LAW Inventory Left Onsite Under TWRS EIS
Author: Neil R Brown at ~DOE4
Date: 4/24/96 12:51 PM

Colin Below is my list of radionuclides to be disposed of at the Hanford site as LLW product. The basis is found in WHC-SD-WM-TI-699 rev0 (not yet released) information can be found in the grout PA etc with similar numbers. These are the numbers that should be used for both the intermediate and phased implementation plans.

Cs+Ba= 10MCi
Sr+Y = 6.8MCi
TRU = 1.22 E-02 (this is your intermediate separations case)(I do not have the breakout of the different radionuclides yours should be fine)

Tc = 0.0259 (this is your intermediate separations case)

total =17 MCi

Call if you have any questions. Simply stated, these are the numbers we are asking the NRC for, and we do not want to be constrained unnecessarily by the EIS.

---------- Reply Separator ----------
Subject: LAW Inventory Left Onsite Under TWRS EIS
Author: Colin.Henderson@jacobs.com (Henderson; Colin) at -MailLink
Date: 4/24/96 8:21 AM

Received: from fep0.rl.gov by ccmail.rl.gov with SMTP

(IMA Internet Exchange 1.04b) id 17e47840; Wed, 24 Apr 96 08:23:48 -0700
Received: by fep1.rl.gov (5.51/5.17.rl-1)
id AA06908; Wed, 24 Apr 96 08:18:29 PDT
Received: from Microsoft Mail (PU Serial #1418)
by PASNT02.jacobs.com (PostalUnion/SMTP(tm) v2.1.8 for Windows NT(tm))
id AA-1996Apr24.082100.1418.180815; Wed, 24 Apr 1996 08:21:25 -0700
From: Colin.Henderson@jacobs.com (Henderson, Colin)
To: neil_r_brown@rl.gov (Neil Brown)
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Date: Wed, 24 Apr 1996 08:21:25 -0700
Subject: LAW Inventory Left Onsite Under TWRS EIS

Text item 2: Text Item

To: Neil Brown

From: Colin Henderson , Jacobs Engineering

Subject: Radionuclide Inventory Left in the LAW Vaults

One of the issues we have identified is whether the optimistic separation efficiencies that were assumed for the engineering data packages (Intermediate Separations, Extensive Separations, and Phased Implementation) result in adequately bounding the EIS analysis for the LAW. We bound the impacts from a volume standpoint by lowering the waste loading of the LAW to 15 wt. % Na2O but at the time we did not evaluate the inventory of the LAW.

The inventory used in the EIS for the LAW under the Intermediate Separations alternative (old TPA case) was:
Cs and Ba =0.493 MCi
Sr and Y = 1.9 MCi
Tc = 0.0259 MCi
Am = 8.6 E-03 MCi
Np = 1.03E-05 MCi
Pu-239 = 1.67E-03 MCi
Pu-240 = 4.14E-04 MCi
Pu-241 = 1.48E-03 MCi
total TRU = 1.22E-02 MCi
Total MCi = 2.43 MCi

The inventory used in the EIS for the LAW under the Phased Implementation alternative was:
Cs and Ba =0.493 MCi
Sr and Y = 1.07 MCi
Tc = 3.2E-04 MCi
Am = 1.04 E-03 MCi
Np = 1.03E-06 MCi
Pu-239 = 2.64E-04 MCi
Pu-240 = 6.69E-05 MCi
Pu-241 = 7.49E-04 MCi
total TRU = 2.12E-03 MCi
Total MCi = 1.76 MCi

Please give me a call at 736-0616 when you get a chance to discuss.

Thanks Colin Henderson

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING / STAFFING ESTIMATES AND REVISIONS for FEIS

ORIGINATOR Colin Henderson DATE 8/21/96

REVISION NO. 0

OBJECTIVE Develop staffing estimates for Ex Situ/In Situ Combination 2 and revise estimates for Phased Implementation to reflect changes in alternative. Assess changes in Alternative Estimates based on Revised Schedules.

METHODOLOGY See Attached

ASSUMPTIONS See Attached.

(Continue on another sheet if necessary)

J.C. Hend 8/27/96.
SIGNATURE/DATE

David J Murray 8/27/96
CHECKED/DATE

CALCULATION & RESULTS
ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

INDEX

		Pg.
SECTION 1	Phased Implementation	1-1 thru 1-6
SECTION 2	Ex Situ/In Situ Combination 2	2-1 thru 2-4
SECTION 3	General Staffing All Alternatives	3-1 thru 3-4
Attachment	6 Pages Ex Situ/In Situ Combination 1	

Pg 1-1

June 24, 1996
Jim Goodwin
Modified Phased Implementation Alternative

Objective: Estimate the operation and construction requirements for the subject alternative for both Rad and Non Rad workers. The data is to be used in transportation (employee commute) and risk analysis.

Description of the Alternative: This alternative will include a demonstration phase and a production phase. Each phase will have duplicate, functionally equivalent facilities operated by separate contractors. The functional duplicates may use different processes or simply be different designs of the same process. The Modified Phased Alternative can be used on any of the ex situ alternatives, but this analysis will be based on the duplicate facilities using the improved Ex Situ Intermediate Separations alternative.

The Phased Implementation alternative includes additional separations processes to remove about a third more HLW from the waste stream before the LAW is vitrified.

The first phase will include two, 20 ton per day (each) LAW demonstration plants and one, 1 tpd HLW demonstration plant. The HLW plant will be operated by one of the LAW operating contractors. Feed material for this phase will come from the DSTs and selected SSTs. The product will be stabilized LAW which will be temporarily stored on site until it can be permanently stored onsite under phase 2 and vitrified HLW which will be temporarily stored on site until they can be transferred to a geologic repository. The phase 1 plants will be shut down when phase 2 starts.

The second phase will include two, 100 tpd LAW facilities and one, 10 tpd HLW facility which will be operated by one of the two LAW operating contractors. The feedstock will be from the tank farm, the LAW product will be permanently stored in buried vaults onsite and the HLW will be temporarily stored onsite until a geologic repository is ready to receive it.

In summary, the difference between this Revised Phased Implementation Alternative and the base case, the DEIS Phased Implementation Alternative, follows:

1.0 Phase 1 is unchanged except that the demonstration plants will be shut down when Phase 2 operation starts.

2.0 Although the schedule changes for Phase 2; the man-hours for Continued Operations, Retrieval, Transfer, Closure and Post Closure remain unchanged because the tanks and waste processed remains unchanged.

3.0 Two 100 tpd plants replace one 200 tpd plants. However, only one of the plants has an associated HLW process.

Approach: The manpower requirements will be scaled from the Phased Implementation Staffing Estimate, the base case for this exercise.

There are two types of scale down, one relating to the number of items of equipment and one relating to the size of the equipment required. Fewer items of equipment will have a direct effect on both construction and operation manpower. Smaller equipment will have a more subtle effect. Smaller equipment may be slightly easier to install and operate, but the number of foundations, the number of electrical connections, the piping installations etc. will not change. As a result the construction man-hours will not be significantly reduced. Similarly, smaller equipment will take as much attention from an operator as larger equipment so the number of operators will not significantly change.

Phase 1 Discussion:

Waste Retrieval and Transfer No change from base case.

Routine Operations. No change to annual staffing levels from base case, routine operations extended out to 2030 or 2 years beyond completion of HLW vitrification.

Separations and Vitrification. The man-hours from the year 2012 through 2021 were removed from the spreadsheet to represent the shutdown for both demonstration plants with the start of phase 2. The spreadsheet totaled the remaining hours.

Construction. No change from base case.

Closure and Post Closure. No change from base case.

Phase 2 Discussion:

Waste Retrieval and Transfer. No change from base case

Routine Operations. No change from base case.

Separations, Vitrification, Disposal and Storage For the reasons discussed above under the subject of scale-down, the manpower for both operations and construction are reduced to 80% of the base case. This is the only change made for the facility that includes the HLW. Operational manpower for the other facility is reduced further to 63% of the previously reduced figure. The reduction was derived from Table 9-2 in the TPA data package reflecting the ratio of non HLW workers to the total work force. Similarly, construction man-hours are reduced to 60% according to Table 9-8.

Rad vs. Non-Rad Workers. The number of Rad and Non-Rad workers was developed from the total workers using Table 9-3 in the TPA Engineering Data Package which indicates that 87% of the operational workers are Rad workers. Retrieval and transfer staff is 60% rad workers. Treatment plant construction is non rad work. Continued operations is 80% rad workers. Facility construction workers are all classed Non-Rad.

MODIFIED PHASED IMPLEMENTATION STAFFING ESTIMATE

		STAFF HOURS	STAFF HOURS RAD	STAFF HOURS NON-RAD	STAFF YEARS	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
PHASE 1																								
CONTINUED OPERATIONS					14129			981	958	960	943	1040	1038	1035	1029	1016	955	933	826	819	804	792		
SEPARATIONS +HLW/LAW																								
DESIGN AND ENG.	CONST.	1.87E+06			937			72	180	393	265	27												
CONSTRUCTION	CONST.	1.02E+07		1.02E+07	5102			340	1020	1360	1360	680												
SUPERVISORY	CONST.	1.04E+06		1.04E+06	518			34	102	136	136	68												
EXEMPT	OPS.																							
RAD	OPS.	1.01E+06	1.01E+06		507								30	30	30	30	43	43	43	43	43	43	43	
NONRAD	OPS.	8.52E+05		8.52E+05	426								30	30	30	30	34	34	34	34	34	34	34	
NONEXEMPT	OPS.																							
RAD	OPS.	1.56E+06	1.56E+06		780								60	60	60	60	60	60	60	60	60	60	60	
NONRAD	OPS.	1.66E+06		1.66E+06	832								64	64	64	64	64	64	64	64	64	64	64	
BARGAINING UNIT	OPS.																							
RAD	OPS.	1.33E+06	1.33E+06		667								43	43	43	43	55	55	55	55	55	55	55	
NONRAD	OPS.	1.33E+06		1.33E+06	667								43	43	43	43	55	55	55	55	55	55	55	
SEPARATIONS + LAW																								
DESIGN AND ENG.	CONST.	1.35E+06		1.35E+06	674			55	157	242	199	21												
CONSTRUCTION	CONST.	7.94E+06		7.94E+06	3970			259	778	1037	1037	519												
SUPERVISORY	CONST.	8.78E+05		8.78E+05	439			29	85	113	114	56												
EXEMPT	OPS.																							
RAD	OPS.	7.46E+05	7.46E+05		373								28	28	28	28	29	29	29	29	29	29	29	
NONRAD	OPS.	7.80E+05		7.80E+05	390								30	30	30	30	30	30	30	30	30	30	30	
NONEXEMPT	OPS.																							
RAD	OPS.	1.56E+06	1.56E+06		780								60	60	60	60	60	60	60	60	60	60	60	
NONRAD	OPS.	1.66E+06		1.66E+06	832								64	64	64	64	64	64	64	64	64	64	64	
BARGAINING UNIT	OPS.																							
RAD	OPS.	1.09E+06	1.09E+06		546								42	42	42	42	42	42	42	42	42	42	42	
NONRAD	OPS.	1.09E+06		1.09E+06	546								42	42	42	42	42	42	42	42	42	42	42	
SUB TOTAL PHASE 1		3.80E+07	7.31E+06	2.88E+07	33115			1770	3280	4241	4054	2411	1574	1571	1565	1552	1533	1511	1404	1397	1382	1370	578	
PHASE 2																								
Continued Operations		2.02E+07	1.62E+07	3.96E+06	10078																		762	753
Retrieval and Transfer	CONST	1.80E+07	1.56E+07	2.33E+06	8975.15										337	539	607	675	743	675	675	675	541	514
Retrieval and Transfer (60% rad)	OPR	5.41E+07	3.25E+07	2.16E+07	27055.5		SEE NOTE 2											272	544	1071	1607	1874	1874	1874
Retrieval and Transfer (60 % rad)	D&D	8.19E+06	4.92E+06	3.28E+06	4096.15																			
Treatment (similar to Ex Situ/In Situ Comb) including HLW process component																								
	CONST	2.70E+07		2.70E+07	13515.00											799	1598	2380	2380	2380	2380	1598		
	OPR	2.54E+07	2.21E+07	3.30E+06	12676.90																	272	536	811
	D&D	3.34E+06	2.90E+06	4.34E+05	1667.70																			
	M&M	1.92E+05	1.67E+05	2.50E+04	96.05																			
Treatment (similar to Ex Situ/In Situ Comb) without HLW process component																								
	CONST	1.62E+07		1.62E+07	8109.00											479	959	1428	1428	1428	1428	959		
	OPR	1.33E+07	1.15E+07	1.73E+06	6636.99																	171	337	511
	D&D	3.34E+06	2.90E+06	4.34E+05	1667.70		SEE NOTE 4																	

PD 1-4

MODIFIED PHASED IMPLEMENTATION STAFFING ESTIMATE

2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041-2140
								171	171																		
								21	21																		
								43	43																		
								34	34																		
SEE NOTE 1								60	60																		
								64	64																		
								55	55																		
								55	55																		
								170	170																		
								21	21																		
								29	29																		
								30	30																		
SEE NOTE 1																											
								60	60																		
								64	64																		
								42	42																		
								42	42																		
								961	961																		
748	712	713	661	642	600	588	563	556	541	500	450	400	350	300	162	77											
487	461	461	461	461	366	298																					
1874	1607	1607	1607	1607	1607	1607	1607	1607	1339	1071	803																
	247	332	332	332	332	332	332	332	332	332	332	288	247														
811	811	811	811	811	811	811	811	811	811	536	536	536	536	536	272												
								70	139	208	226	226	226	226	208	139											
												11	11	11	11	11	10	10	10	10							
511	511	511	511	511	511	511	511	511	511	337	171																
								70	139	208	226	226	226	226	208	139											

MODIFIED PHASED IMPLEMENTATION STAFFING ESTIMATE

	M&M	1.92E+05	1.67E+05	2.50E+04	96.05																			
Closure		1.15E+06	1.15E+06		576		SEE NOTE 5																	
Post Closure M&M		1.00E+06	1.00E+06		500																			
SUB TOTAL PHASE 2		1.91E+08	1.11E+08	8.04E+07	95746										337	1817	3164	4755	5095	5554	6089	5549	4050	4463
		STAFF HOURS			STAFF YEARS		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
TOTAL PHASE 1 + PHASE 2		2.58E+08	1.18E+08	1.09E+08	128861			1770	3280	4241	4054	2411	1574	1571	1902	3369	4697	6266	6499	6951	7471	6919	4628	4463
Changes Above Baseline																								
Phase 1 Construction								789	2322	3281	3111	1371												
Phase 1 Operation													536	536	536	536	578	578	578	578	578	578	578	
Phase 1 Closure																								
FOR APPENDIX H TABLES																								
Total Construction								789	2322	3281	3111	1371			337	1817	3164	4483	4551	4483	4483	3232	541	514
Total Operation													536	536	536	536	578	850	1122	1649	2185	2896	3325	3196
Total Closure																								
routine ops (difference from baseline)																								
total (const + ops + post rem + diff from baseline)								789	2322	3281	3111	1371	536	536	873	2353	3742	5333	5673	6132	6667	6127	3866	3710
The following staffing estimate numbers are unfactored from the Int. Separations																								
WR&T	CONST	2.11E+07			10559										397	634	714	794	874	794	794	794	636	605
WR&T	OPR	6.37E+07			31830													320	640	1260	1890	2205	2205	2205
WR&T	D&D	9.64E+06			4819																			
Ex Situ/In Situ Combination 1 (vitrification only)																								
80% of Int Separations	CONST	3.18E+07			15900.00											940	1880	2800	2800	2800	2800	1880		
80% of Int Separations	OPR	2.48E+07			12394.00																	320	630	954
40%	D&D	4.09E+06			2044.00																			
100%	M&M	2.26E+05			113.00																			
Closure		1.15E+06			576																			
Post Closure M&M		1.00E+06			500																			

NOTE 1: The Demo plants will be shut down when phase 2 operations start

NOTE 2: The overall hours for Retreival and Transfer will not change under this modification.

NOTE 3: This production facility includes the HLW process and is modified as follows:

The total hrs scale = .85 (lessons learned), combo I hrs @ 80% of Int Sep used as basis — 0.85

The Rad workers are 87% of the total — 0.87

NOTE 4: This production facility excludes the HLW process and is modified as follows:

The total hrs scale = .85(lessons learned), combo I hrs @ 80% of Int Sep used as basis — 0.85

The factor for operations is 63% to correct for no HLW facility — 0.63

The factor for construction is 60% to correct for no HLW facility — 0.6

The Rad workers are 87% of the total — 0.87

Spare, factor should be "1" until used — 1

NOTE 5: Closure and Post Closure hours are unchanged from the base case.

NOTE 6: Added 3 years of ops to end of HLW plant schedule to reach scheduled completion date of 2028.

Note 7: Added additional staff to continued operations to reach 2030 (= completion of HLW vit + 2 yrs)

Note 8: Staffing spreads used to estimate total staffing requirements and not annual staffing levels. The annual levels shown may not agree with the latest Phased Implementation Schedule.

SPECIAL NOTE

CHANGE THESE NUMBERS TO MODIFY SPREADSHEET

PS1-6

MODIFIED PHASED IMPLEMENTATION STAFFING ESTIMATE

												11	11	11	11	11	10	10	10	10							
		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24		
																										5	495
4431	4347	4457	4405	4386	4250	4170	3847	3979	3834	3216	2768	1722	1630	1334	897	400	44	44	44	44	24	24	24	24	24	5	495
2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041-2140
4431	4347	4457	4405	4386	4250	4170	3847	4940	4795	3216	2768	1722	1630	1334	897	400	44	44	44	44	24	24	24	24	24	5	495
								961	961																		
487	461	461	461	461	366	298																					
3196	2928	2928	2928	2928	2928	2928	2928	2928	2661	1944	1510	536	536	536	272												
	247	356	356	356	356	356	356	1456	1594	772	808	786	745	498	463	323	44	44	44	44	24	24	24	24	24	5	495
												-79	-81	-81	-50	-10											
3683	3635	3744	3744	3744	3650	3582	3284	4384	4254	2716	2318	1243	1199	953	685	313	44	44	44	44	24	24	24	24	24	5	495
573	542	542	542	542	431	351																					
2205	1890	1890	1890	1890	1890	1890	1890	1890	1575	1260	945																
	290	390	390	390	390	390	390	390	390	390	390	339	290														
954	954	954	954	954	954	954	954	954	954	630	320																
								82	163	245	266	266	266	266	245	163	82										
												13	13	13	13	13	12	12	12	12							
		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24		
																										5	495

Rev 2, June 25
MANPOWER CALCS

June 12, 1996
Jim Goodwin
Task 1.4h
Ex Situ/In Situ Combination 2

Objective: Estimate the operation and construction manpower requirements for the Ex Situ/In Situ Combination 2 alternative The data is to be used in transportation (employee commute) and risk analysis.

Description of Alternative: The contents from 25 tanks containing the greatest amount of HLW will be pumped to a scaled down Intermediate Separations facility (ISA). As in the ISA facility the LLW cullet will be permanently disposed of on site in vaults and the HLW will be temporarily stored on site until it can be shipped to the repository for permanent disposal. The remaining tanks will have the liquids removed by evaporation as described in the Fill and Cap Alternative. The empty tanks will be filled with gravel, then the tanks and the LLW vaults will be capped as described in the Closure Engineering Data Package. The processing facility will be entombed in place.

Approach: The manpower requirements will be scaled from the Intermediate Separations Alternative , the Waste Recovery and Transfer Engineering Data Package, the In Situ Treatment and Disposal Engineering Data Package and the Closure Engineering Data Package.

There are two types of scale down, one relating to the number of items of equipment and one relating to the size of the equipment required. Fewer items of equipment will have a direct effect on both construction and operation manpower. Smaller equipment will have a more subtle effect. Smaller equipment may be slightly easier to install and operate, but the number of foundations, the number of electrical connections, the piping installations etc. will not change. As a result the construction man-hours will not be significantly reduced. Similarly, smaller equipment will take as much attention from an operator as larger equipment so the number of operators will not significantly change.

The Bargaining Unit employees is included with the Non-exempt employees.

The data is presented in overall hours for the life of the project. Peak hours and the peak year are estimated for the waste treatment using the TPA staffing chart, page 10-2 and 10-3, in the TPA Engineering Data Package

Manpower for the 14 year construction period peaks in the year 2001 at 5.6E+06 man-hours. The average is 4.0E+06 man-hours per year and the peak is 1.4 times the average.

Manpower for the 35 year operating period has a broad peak from the year 2008 to the year 2019. The average is 8.3E+05 man-hours per year.

Discussion:

Waste Retrieval. Since fewer tanks are being evacuated under the Combo-Low Alternative, fewer sluicers, pumps and arms are needed. The physical dimensions of the equipment will not change because their size generally relates to the tank size, but hydraulically they will be smaller. The pumping rate from the tanks will be lower in order to recover the smaller amount of waste on a schedule approximating the ISA time frames.

The appropriate scale down for construction manpower is the ratio of tanks to be evacuation in the Combo-Low Alternative to the ISA.. The construction man-hours for waste recovery will be 177 tanks/25 tanks or 14% of the hours required to evacuate 177 tanks

The appropriate scale down for operation manpower is the ratio of the waste volume to be removed in the Combo-Low Alternative to the ISA. The operating man-hours for waste recovery will be 30% of the hours required to evacuate 177 tanks

Waste Transfer. The transfer operation will scaled down from the ISA. All of the equipment and facilities used in the ISA will be present but will be smaller. Pipe diameters will be smaller in order to maintain the velocities needed to keep the slurries in suspension. While waste transfer will continue for the entire operational period.

The appropriate scale down for both construction and operation manpower is the ratio of the volume to be removed in the Combo-Low Alternative to the ISA. The construction and operating man-hours for waste transfer will be 30% of the hours required to evacuate 177 tanks

Tank Stabilization. The tanks which are not pumped to the processing facility will have as much of the liquids as possible evaporated and the tank freeboard filled with basalt gravel. Tanks which have been pumped will also be back filled with basalt gravel. We have assumed that the mobilization and demobilization operations to gravel fill each tank will tend to equalize the time required to fill each tank regardless of whether it is empty or partly empty. Since the Combo-Low Alternative needs a Hanford Barrier for 177 tanks and the LLW vaults as does the ISA the man-hour factor for scaling is 1.0.

The first stage of tank stabilization for the 152 unprocessed tanks is to evaporate the liquids with the 242A Evaporator. The procedure is described in the Drying and Gravel Fill section of the In Situ Treatment and Disposal Engineering Data Package. Only the hours for start-up, operation and D&D for the 242A Evaporator are used. The scale down factor is 177 tanks/152 tanks or 86%.

Continuing Operations:

Continuing Operations is the Maintenance and Monitoring (M&M) effort in the tank farms prior to closure. Initially, all of the tank farms will be maintained and monitored as they are now. As the tanks are stabilized the M&M responsibility, and probably the staff, will pass to the post closure M&M budget.

Under the TPA alternative tank closures were scheduled from the year 2010 through 2027. Under the Ex Situ/In Situ Alternative 2 closing the tanks can start in 2005 (tank fill operations 2000-2009; evaporation 2000-2005; tank fill 2005-2009) instead of 2010. Under this schedule the tanks to be stabilized In Situ can be complete in the year 2009. The last 25 tanks will be stabilized in the years 2024 and 2025. Assuming a steady hand-off of closed tanks to the post closure M&M group the continuing operation staff will be reduced to a steady staffing level of 200 in 9 years. Another 2 years will be required for transition of the last tanks that would be treated in situ. Continuing operations staffing would start out in 1997 at a level equal to the Intermediate Separations alternative, between the years 2005 -2009 staffing levels would undergo a linear reduction from current levels to a flat staffing level of 200. The 200 staff/yr level would be maintained through the stabilization of the 25 tanks that were emptied (2025). Continuing operations would then be equal to 8,000 staff yrs (ISA levels for 1997-2005) +3,600 staff yrs (=200 staff x 6 yrs + 800 staff x 6 yrs x 1/2) + 200 staff x 14 yrs = 14,400 staff yrs (28.8E6 staff-hours)

Processing. A number of manpower groups are included under this heading in addition to the manpower to run the processes. Included are Start-up, Maintenance, LLW vault construction, Administration and all other support, D&D, and M&M.

The processes will be a scaled down ISA process. All of the process operations will be performed in similar, but smaller, equipment. Processing includes pretreatment, LLW processing, HLW processing, LLW vaults and HLW temporary storage. LLW vitrification will be revised from two process trains to a

single train and fewer, slightly smaller, equipment items will be required. Waste storage and disposal will use full sized vaults, canisters, overpacks, etc., but fewer will be required as well.

While staff reductions can be made in some areas such as LLW vitrification operations or LLW vault construction, most of the staff is only slightly affected by the smaller waste throughput. Our subjective opinion is that construction manpower and operational manpower will be reduced to 80 percent of the ISA.

Closure. The operating man-hours include the man-hours required for closure of the process plants, which will be entombed in place. These man-hours are included in the Fill and Cap and the processing man-hours.

Transportation. Man-hours to transport the casks to the final HLW disposal site and to transport fluxes and heavy chemicals used in the process are not included in these estimates.

Peak employment level. Combination 2 Peak labor year would be during construction ~ 2001. Construction breakdown: WR&T 1,440 staff years (schedule 1998-2016), Separations +LAW vitrification = 2.4e7 x 0.8 (scaling) = 1.92E+07. HLW vitrification = 1.6E+07 (Int Sep) x 0.80 (scaling) = 1.28E+07. Since hours were scaled from Intermediate Separations use same construction schedule to maintain comparability.

WR&T =1,440 staff-year/18 yr =80 staff/yr
Separations +LAW Immobilization = 1.92E+07/2000/10 yrs = 960 staff/year
HLW vitrification = 1.28E+07/2000/10 = 640

Peak year = 2 x WR&T + 1.4 x Separations+LAW+HLW
=2x80+1.4x(960+640) = 2144 or ~2200 staff/yr

Assumptions:

1.0 Only 25 of the 177 tanks will be recovered for ex-situ processing.

2.0 The transfer operation will be scaled down to reflect that only 30 percent of the total wastes will be transferred to the treatment facility. While 14 percent of the tanks will have the wastes removed, these tanks generally contain more wastes than the average.

3.0 The HLW facility will be scaled down from 20 tpd product, the ISA, to 5 tpd.

4.0 The LLW facility will be scaled down from 200 tpd product, the ISA to 70 tpd

5.0 The construction and production schedules will not change from the ISA.

6.0 The construction outside of the tank farm areas is assumed to be non-rad.

MANHOUR REQUIRMENTS FOR COMBO-LOW ALTERNATIVE						
	MANHOURS		COMBO-IOW MANHOURS			
	(See Ref.)	Factor				REFERENCES
WASTE RETRIEVAL						
Construction, Rad Worker	2.20E+06	0.14	3.08E+05			Transition Table
Construction, Non Rad Worker	1.84E+07	0.14	2.58E+06			Transition Table
Operation, Rad Worker	2.33E+07	0.30	7.00E+06			Transition Table
Operation, Non Rad Worker	1.16E+07	0.30	3.49E+06			Transition Table
WASTE TRANSFER						
Construction, Rad Worker	0.00E+00	0.30	0.00E+00			Transition Table
Construction, Non Rad Worker	0.00E+00	3.00	0.00E+00			Transition Table
Operation, Rad Worker	1.43E+07	0.30	4.30E+06			Transition Table
Operation, Non Rad Worker	1.17E+07	0.30	3.52E+06			Transition Table
TANK STABILIZATION						
Construction, Rad Worker	6.75E+05	1.00	6.75E+05			Transition Table
Construction, Non Rad Worker	4.72E+05	1.00	4.72E+05			Transition Table
Operation, Rad Worker	9.73E+05	0.86	8.37E+05			Transition Table
Operation, Non Rad Worker	2.77E+05	0.86	2.38E+05			Transition Table
ROUTINE OPERATIONS						
Construction, Rad Worker						
Construction, Non Rad Worker						
Operation, Rad Worker			2.30E+07			See discussion
Operation, Non Rad Worker	5.76E+06					
INTERMEDIATE SEPARATIONS						
Construction, Rad Worker		0.80	0.00E+00			
Construction, Non Rad Worker	4.00E+07	0.80	3.20E+07			Table 9-8, TPA Data Package
Operation, Rad Worker	2.68E+07	0.80	2.15E+07			Table F-8, TPa Data Package
Operation, Non Rad Worker	2.27E+06	0.80	1.82E+06			Table F-8, TPa Data Package

2-5

TRANSITION TABLES FOR COMBO-LOW ALTERNATIVE

	MAN-HOURS							
	EXEMPT		NON-EXEMPT		BARGAINING UNIT		TOTAL	
UNIT OPERATION	RAD W'KE	NON-RAD	RAD W'KE	NON-RAD	RAD W'KE	NON-RAD	RAD W'KE	NON-RAD
OPERATIONS								
STABALIZE TANKS								
	(Note 4)		(Note 4)					
Evaporation, Start-up	430,000		820,000					
Evaporator, Operation	530,000		540,000					
Evaporator, D&D	430,000		820,000					
Evaporator, Total								
See Note 3								
Rad/Non Rad factor	49%	51%	93%	7%				
Revised Evap Total	210,700	219,300	762,600	57,400			973,300	276,700
CONSTRUCTION								
STABALIZE TANKS								
GRAVEL FILL (Note 1)	36,000	177,000	65,000	29,000			101,000	206,000
HANFORD BARRIER								
CAP (Note 2)	86,000	266,000	488,000	0			574,000	266,000
TOTAL FILL AND CAP	1,722,700	662,301	3,495,601	86,400	0	0	1,648,300	748,700

Note 1: Table 5-2A, Closure Technical Data Package.
Note 2: Table 5-2D, Closure Technical Data Package
Note 3: Ratio of Rad workers to Non Rad workers maintained per table 7-3 in In Situ Engineering Data Package.
Note 4: Hours from table 7-2 in In Situ Disposal Technical Data Package

2-6

TRANSITION TABLES FOR COMBO-LOW ALTERNATIVE

	MAN-HOURS							
	EXEMPT		NON-EXEMPT		BARGAINING UNIT		TOTAL	
UNIT OPERATION	RAD W'KE	NON-RAD	RAD W'KE	NON-RAD	RAD W'KE	NON-RAD	RAD W'KE	NON-RAD
Reference: Note 1	A-16	A-20	A-14	A-18				
OPERATIONS								
WASTE RETRIEVAL								
SST								
Retrieval, Arm-base	867,479	1,518,089	10,754,770	374,593				
Retrieval, sluicing	889,166	1,713,271	2,559,064	1,062,662				
Confinement, Arm-base	552,032	1,734,958	4,928,859	3,864,226				
DST								
Retrieval, Arm-base	572,832	660,960	1,674,432	264,384				
Retrieval, sluicing	77,427	149,188	222,838	92,534				
MUST								
Retrieval, sluicing	60,221	116,035	173,318	71,971				
Sub-Total Retrieval	3,019,157	5,892,501	20,313,281	5,730,370			23,332,438	11,622,871
WASTE TRANSFER								
SST								
Pipeline Transfer	1,821,312	5,346,432	8,783,424	3,378,240				
DST								
Pipeline Transfer	546,394	1,603,930	2,635,027	1,013,472				
MUST								
Container Transfer	177,504	207,101	371,606	174,787				
Sub-Total Transfer	2,545,210	7,157,463	11,790,057	4,566,499			14,335,267	11,723,962
CONSTRUCTION								
WASTE RETRIEVAL								
WASTE TRANSFER								
Reference: Note 2	Table 8	Table 8	Table 8	Table 8				
Sub-Total Construction	1,700,000	5,200,000	500,000	13,200,000			2,200,000	18,400,000

Note 1: Reference to page number in Waste Recovery and Transfer Engineering Data Package.
Does not include subsurface barriers.

Note 2: Reference to table in JEG Nov. 1994 report revising WR&T report to remove the subsurface barrier.

2-7

Table 9-2. Unit Process: Operating Personnel Requirements (Staff-Hours)[1].

Unit Process	Tri-Party Agreement Preferred Alternative
Sludge wash	2.3E+6
Cesium removal	5.0E+6
Other radionuclide removal	n/a
Low-level waste vitrification	1.1E+7
Low-level waste disposal	2.8E+5
High-level waste vitrification	1.1E+7
High-level waste transportation/disposal	6.2E+5
Total	3.1E+7

7.8E+06

Notes:

[1]Includes staffing for start-up, decontamination and decommissioning, and monitoring and maintenance.

1.1E+7
.062E+7
1.162E+7

$$\frac{3.1E+7 - (1.162E+7)}{3.1E+7} =$$

63%

TPA

2-8

Table 9-3. Operating Personnel Requirements (Staff-Hours)[1].

Operating Personnel[2]	Tri-Party Agreement Preferred Alternative
Nonexempt	
Radiation worker	0
Nonradiation worker	3.8E+6
Exempt	
Radiation worker	2.7E+7
Nonradiation worker	0
Total Staff Hours	3.1E+7

Notes:

[1]All exempt and bargaining unit employees are assumed to be radiation workers. All nonexempt employees are nonradiation workers.

[2]Includes staffing for start-up, decontamination and decommissioning, and monitoring and maintenance.

2-9

Table 9-8. Unit Process: Construction Personnel Requirements. (Staff-Hours)[1]

Unit process	Tri-Party Agreement Preferred Alternative
Sludge wash[1,2]	4.4E+5
Cesium removal[1,3]	4.0E+6
Centralized facilities	6.0E+6
Low-level waste vitrification[1]	1.3E+7
Low-level waste disposal	0
High-level waste vitrification	1.6E+7
High-level waste transportation	0
High-level waste disposal	0
Total	4.0E+7

Notes:

[1]Backup in Appendix F contains staff hours for pretreatment/low-level waste (LLW) combined. To separate sludge wash and cesium removal from LLW vitrification other cost estimates were employed. Cost estimates were found for a detached pretreatment facility and a detached LLW facility (these are contained in Appendix F). The staff hours for each were taken and added together. This total was then divided into each staff hour value separately. The calculation was as follows:

Detached Separations - Total staff hours = 1,463,389
Detached LLW - Total staff hours = 4,704,549
Total = 6,167,938

% separations = 1,463,389/6,167,938 = 0.237 => Value used is 25 %
Therefore % LLW = 75%

[2]Engineering judgement set the sludge wash staff hours equal to 10% of the total staff hours for separations (see number 2 above).

[3]Engineering judgement set the cesium removal staff hours equal to 90% of the total staff hours for separations (see number 2 above).

$\frac{4.0E7 - 1.6E7}{4.0E7} = 60\%$

2-10

Table 9-9. Construction Personnel Requirements. (Staff-Hours)

Construction Personnel	Tri-Party Agreement Preferred Alternative
Design and engineering	1.0E+7
Construction[1]	
Radiation worker	0
Nonradiation worker	2.4E+7
Supervisory[2]	5.6E+6
Total	4.0E+7

Notes:

[1]Staff hours equal to summation of staff hours calculated for equipment/facility installation and subcontract in backup. All construction staff hours are assumed to be for nonradiation work.

[2]Staff hours equal to summation of staff hours calculated for construction and project management.

2-11

10.0 RATE DATE

The calculation of the peak and average for the data given in the data tables (Section 9.0) is outlined in this section.

10.1 YEAR-BY-YEAR DATA

Figures 10-1 through 10-3 give year-by-year data for construction, staffing, and total processing cost respectively. Table 10-1 lists the figures to which the data in the data tables correspond.

Table 10-1. Table/Figure Key.

Figure	Title	Data Tables
10-1	Tri-Party Agreement Chart for Construction	9-2 9-3 9-19[staff only]
10-2	Tri-Party Agreement Chart for Staffing	9-8 9-9 9-10 9-11 9-12 9-13 9-18
10-3	Tri-Party Agreement Processing Cost	9-16 9-17

For the construction and staffing figures, the totals from the appropriate data tables can be multiplied by the percentage that corresponds to the year in question. Percentages were given so that the figures could be used for more than one data table (the use of absolute numbers would require each table to have its own figure). For the total processing cost figure, the absolute value can be read directly from the chart.

10.2 YEARLY AVERAGE/PEAK

As shown in the previous section, the data in many of the charts could easily be shown on a year-by-year basis. Unfortunately not all of the information in all of the data tables could be displayed this way. Therefore, to estimate the yearly average and peak, the following method should be followed.

Yearly Average

Divide the value from the table by 19 (the total processing time). This gives the average value over the entire processing lifetime. If it is known that a data table value corresponds to only one of the processing facilities (Pretreatment/LLW or HLW) then the value should be divided by 14 (the processing time for each plant separately). Care should be taken to ensure that this value is used only during the operational lifetime of the appropriate facility.

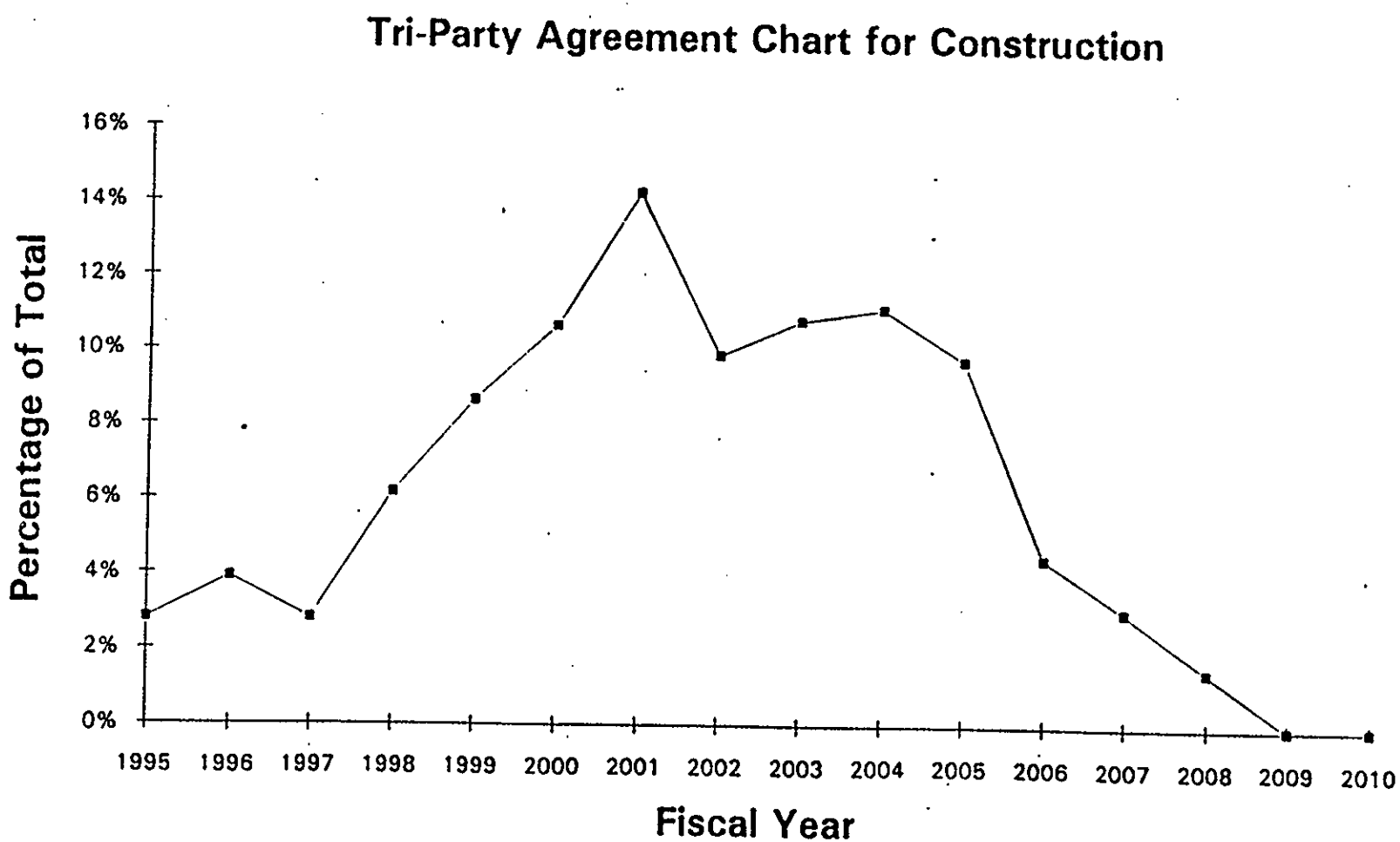

Figure 10-1. Tri-Party Agreement Chart for Construction

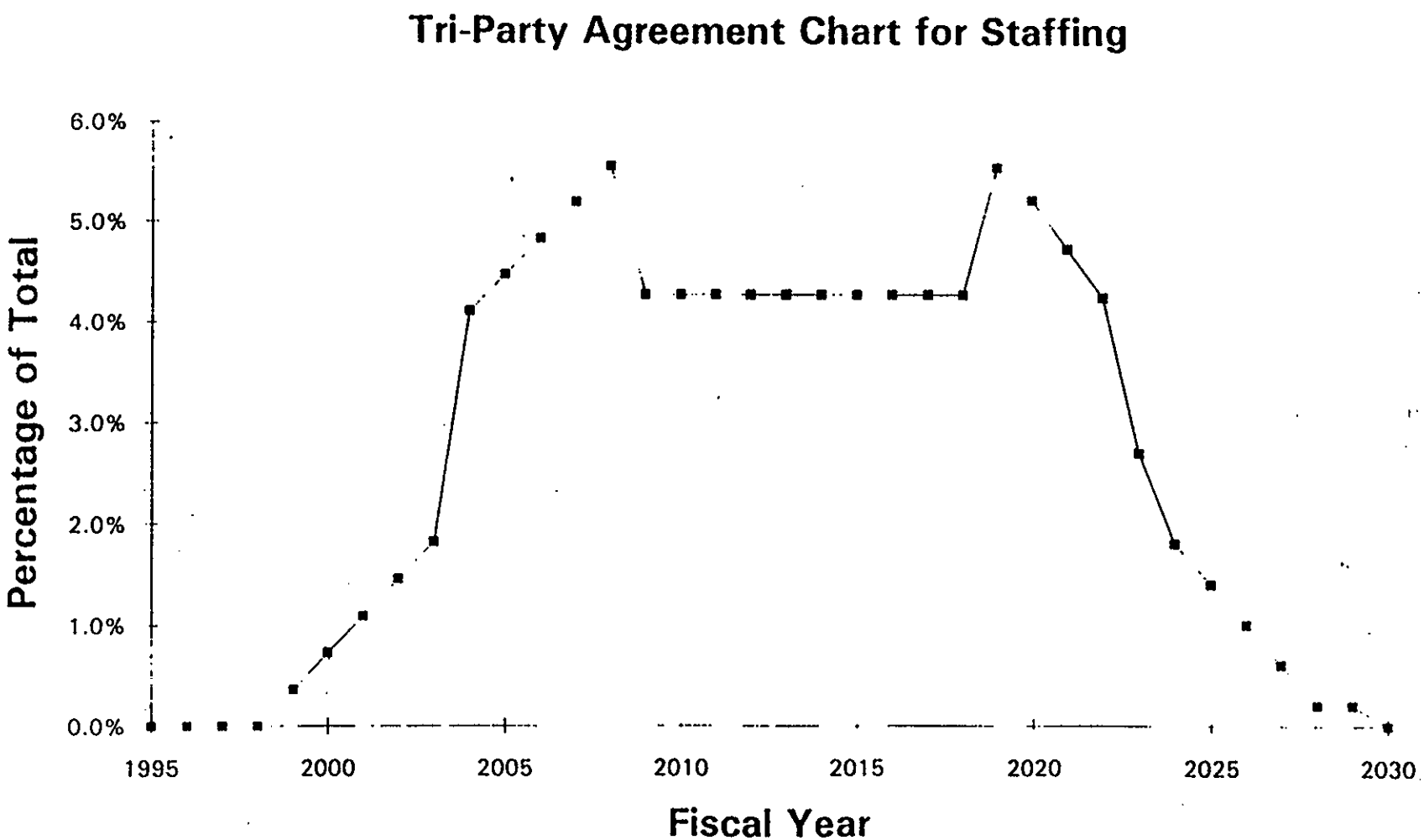

Figure 10-2. Tri-Party Agreement Chart for Staffing

2-13

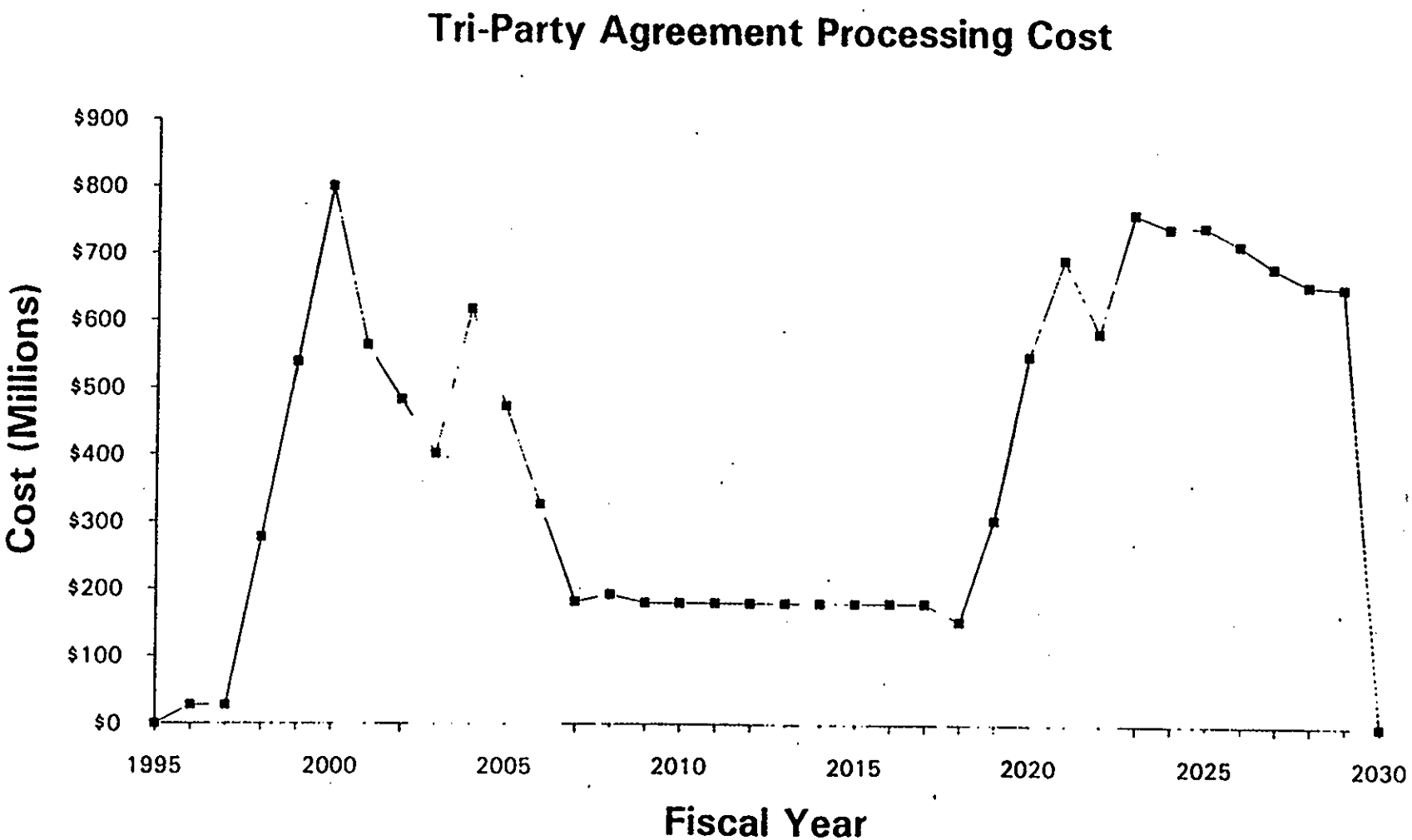

Figure 10-3. Tri-Party Agreement Processing Cost

7-14

TWRS EIS Staffing Level Changes

General- Between the Draft and Final EIS the construction and operating schedules for the alternatives have been revised to account for more realistic start dates and for operating schedule changes driven by waste loading and blending changes. The HLW transportation schedules were revised based on the revised number of HMPCs that would be produced under each of the ex situ alternatives. These changes resulted in revising the construction and operating durations by one or two years. Shorter construction durations would result in increased peaks and approximately the same number of staff years. Shorter operating durations tend to result in approximately the same staffing levels during operations and fewer cumulative staff-years. This would have a small impact on the annual and total staffing estimates. However, revised staffing data was not developed for the FEIS because the changes that would result are small (10% or less). For example using the Ex Situ Intermediate Separations alternative: Construction durations did not change and were shifted two years to the right. A two year shift to the right for construction would result in a peak of ~4600 if the operating schedule were held fixed. This is somewhat unrealistic because the operating staff ramp-up would have to also shift to the right. The shorter operating durations could potentially reduce the cumulative operating staff requirements by 6400 staff-yrs. This translates into approximately 6% of the total staffing requirement for the Ex Situ Intermediate Separations alternative. (See Attached Graph of Employees VS time for Ex Situ Intermediate Separations)

Revised start time for all alternatives to 1997.

No Action
No change from previous numbers.

Long Term Management
No change from previous numbers.

In Situ Fill and Cap
During the PDEIS review process the radiofrequency drying of the tank liquids was removed from this alternative. The result would be fewer operating personnel and a shorter duration of operation. The duration of operations is now 2000 to 2009. The original schedule went out to 2018. Removal of the radiofrequency drying would reduce the operating personnel requirements by 93 staff/year for 9 years.

In Situ Vitrification
The construction start date was revised from 1997 to 1998 while the end date was held constant. The old construction duration was 1998-2016 and the new 1999-2016. The same number of hours would now be spread over 17 years instead of 18. Operating period was not changed.

Ex Situ Intermediate Separations

H:\USERS\CHENDERS\STAFFING\STAFFNOT.WPD

The construction start date for the waste treatment facilities was revised from 1997 to 1999. The construction duration was not changed. The waste retrieval and transfer operating schedule was revised from 23 years to 21 years (2001-2022). Waste retrieval staffing levels would need to increase slightly to account for the increased level of effort required for the shorter duration. The waste treatment operations were revised downward; LAW vitrification was 20 years (2004-2024) and is now 17 years (2005-2022), HLW vitrification was 13 yrs (2011-2024) and is now 11 years (2011-2022). Staffing levels at the treatment facilities would not be appreciably affected by the shorter operating duration. A shorter operating duration at the treatment plants would translate into reductions in the number of staff-years required for waste treatment.

Ex Situ No Separations (vitrification)
The changes to the No Separations alternative would be similar to those for the Intermediate Separations alternative. Construction activities now start in 1998 for waste retrieval and 1999 for treatment compared to 1996 as shown in Appendix H. Construction duration remains the same for waste retrieval and increases from 5 to 6 years for the treatment facilities. Waste retrieval and waste treatment operations are both shortened in duration by one year.

Ex Situ No Separations (calcination)
Same as vitrification.

Ex Situ Extensive Separations
Construction for waste retrieval remains the same. Construction start for waste treatment was moved from 1997 to 1999, the construction duration for waste treatment was increased from 9 years to 12 years which should reduce the peak employment level. The operating duration for waste treatment was revised from 20 years to 19 years.

Ex Situ/In Situ Combination 1
Most of the construction and operating durations were shortened by 1 to 2 years, refer to schedule for detail. Revised the start date for construction to 1998 for retrieval and 1999 for treatment facilities. The staffing estimate for this alternative was revised to be consistent with the estimate developed for the Ex Situ/In Situ Combination 2 alternative (annual breakdown attached). The following changes were made (percentages used to scale from Ex Situ Intermediate Separations): Waste retrieval =70 tanks/177 tanks = 40% ; Waste transfer = 50% (volume based); for WR&T combined used 50%; for waste treatment construction and operation required staffing level = 80% of the Ex Situ Intermediate Separations. The revised staffing estimate was essentially the same as the previous version (48,117 staff-yrs before versus 49,461 staff-yrs revised estimate for a difference of 3%).

Ex Situ/In Situ Combination 2
All new!

Phased Implementation

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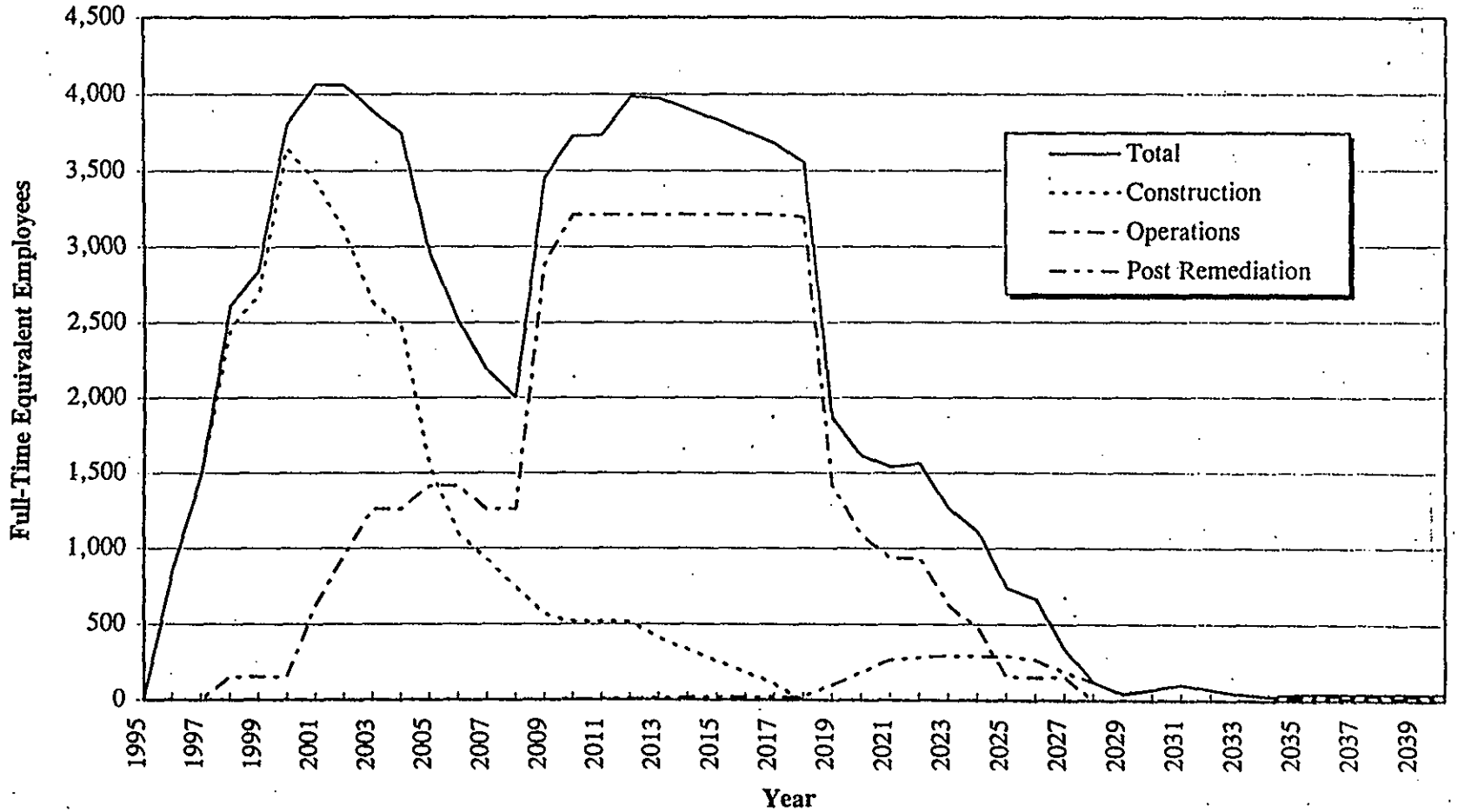
Start dates revised for construction, Phase 1 construction duration shortened from 5 years to 4 years requiring higher staffing to compensate. The operating duration for the HLW demonstration plant for Phase 1 has been revised from 10 years to 6 years. Phase 2 construction remains the same for waste retrieval and has been revised from 7 years to 6 years for the Phase 2 treatment facilities. The Phase 2 operating durations are shorter by one year for both retrieval and treatment.

The original Phase 2 work we did was based on Phase 2 plant sizes of one 100 mt/day facility for LAW and one 10 mt/day facility for HLW. The waste loading and blending changes that took place in the Jan 96 time frame required the Phase 2 plants to increase to 185 mt/day for LAW and ~20 mt/day for HLW. Revisions to the blending factor for the FEIS result in plant sizes of one 10 mt/day HLW facility and two 100 mt/day LAW facilities.

Figure H.3.1.5 Full-Time Equivalent Employees (Change from Baseline Estimate) - Ex Situ Intermediate Separations Alternative, 1995 to 2040



JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT Sheet 1/6 SHEET NO. _____

BY _____ CHKD. _____ Attachment 1 JOB NO. _____

REVISED EX SITU / IN SITU COMBINATION 1

Staffing Estimate.

ORIGINAL = 72,286 staff year

Routine Ops = 24,169 staff-years

OR 72286
− 24169
48117 "ABOVE BASELINE

MODIFIED COMBINATION 1 (Revised to agree with Assumptions Made for Combo 2 Alt)

71,722 staff-yr
22,261 Routine Ops.

49461 staff-yr "Above baseline

Δ = 3%

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT Attach 1 2/6 SHEET NO. 3/4

BY _____ CHKD. _____ JOB NO. _____

Combo 1 staffing revisions

Waste Retrieval = 70/177 = 40%
Waste Transfer = 50% (volume based)

or for WR&T combined 50%.

For Waste Treatment construction & Operation
Required manpower = 80% of Intermediate Separations
to be consistent with other assumptions made
during development of the Combo-2 staffing estimate

Modified to be consistent with other
CSLC Assumptions.

FORM 91-005-1 (4/81)

staffing data

ALTERNATE		DATASHEET	TOTAL EQUIV MAN*YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
EX SITU/IN SITU COMBINATION																							
	FILL & CAP																						
		CLOSURE	61%						89.06	89.06	86.01	84.79	82.96	81.74	82.96	87.84	66.49	66.49	64.66	63.44	61.61	59.78	59.78
		ROUTINE OPS	60%	568.8	576	588.6	574.8	576	565.8	624	622.8	621	617.4	609.6	573	559.8	495.6	551.4	482.4	475.2	457.2	451.8	448.8
	MAX RET																						
		CONST	0.61		515	908	1501	1638	2227	2092	1896	1606	1515	943	671	562	454	345	315	315	315	250	204
		OPR	58%			0	88.74	88.74	88.74	365.4	553.9	730.8	730.8	819.54	819.54	730.8	730.8	1673.3	1861.8	1861.8	1861.8	1861.8	1861.8
		ROUTINE OPS	40%	379.2	384	392.4	383.2	384	377.2	416	415.2	414	411.6	406.4	382	373.2	330.4	327.6	321.6	316.8	304.8	301.2	299.2
		CLOSE	59%																1.77	2.36	5.9	6.49	10.03
	TOTAL		7.23E+04	948	1474.84	1888.68	2547.34	2687.2	3347.3	3586.76	3573.79	3456.11	3358	2860.34	2528.5	2314.06	2077.13	2964.05	3046.99	3034.36	3006.07	2931.17	2883.35

3/6
DEIS Estimate

staffing data

2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
																											0
64.66	64.66	61.61	56.73	58.56	59.78	46.36																					1,539
427.2	427.8	396.6	385.2	360	352.8	337.8	337.8	225	112.8																		14,403
157	111	65																									18604
1861.8	1861.8	1861.8	1850.2	819.54	631.04	542.3	542.3	365.4	277.24	88.74	88.74	88.74	0														27,610
284.8	285.2	264.4	256.8	240	235.2	225.2	222.4	216.4	64.8	30.8	31.6	32.4	32.4	20	4												9,766
11.8	11.8	11.8	11.8	11.8	11.8	11.21	11.21	10.62	9.44	9.44	9.44	8.85	15.93	20.06	37.17	54.28	37.17	20.06	11.8								364
2807.64	2762.28	2660.87	2560.73	1489.9	1290.62	1162.87	1113.71	817.42	464.28	128.98	129.78	129.99	48.33	40.06	41.17	54.28	37.17	20.06	11.8								72,286
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A 14

5/6 Revised Staffing Est. for FEIS.

			TOTAL																				
			EQUIV																				
ALTERNATE		DATASHEET	MAN*YEAR		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
EX SITU/IN SITU COMBINATION 1																							
	FILL & CAP																						
		CLOSURE	61%							89.06	89.06	86.01	84.79	82.96	81.74	82.96	87.84	66.49	66.49	64.66	63.44	61.61	59.78
		ROUTINE OPS	60%				588.6	574.8	576	565.8	624	622.8	621	617.4	609.6	573	559.8	495.6	551.4	482.4	475.2	457.2	451.8
	MAX RET		treatment	wr&t																			
		CONST	80%	40%		338	595	1817	1907	2648	2442	2154	1803	1685	934	638	507	377	246	206	206	206	164
		OPR	80%	50%			0	122.4	122.4	122.4	406.5	569	813	813	935.4	935.4	813	813	1625.5	1788	1788	1788	1788
		ROUTINE OPS	40%				392.4	383.2	384	377.2	416	415.2	414	411.6	406.4	382	373.2	330.4	327.6	321.6	316.8	304.8	301.2
		CLOSE	59%																	1.77	2.36	5.9	6.49
	TOTAL		7.17E+04		0	337.6	1576.2	2897.2	2989.6	3802.46	3977.16	3846.61	3735.99	3609.76	2967.54	2610.96	2341.04	2082.29	2817.39	2864.83	2852.2	2823.91	2771.27

6/9

2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	
																												0
59.78	64.66	64.66	61.61	56.73	58.56	59.78	46.36																					1,539
448.8	427.2	427.8	396.6	385.2	360	352.8	337.8	337.8	225	112.8																		13,258
134	103	73	42																									19226
1788	1788	1788	1788	1869.5	935.4	772.9	650.5	650.5	406.5	284.9	122.4	122.4	122.4	0														28,332
299.2	284.8	285.2	264.4	256.8	240	235.2	225.2	222.4	216.4	64.8	30.8	31.6	32.4	32.4	20	4												9,003
10.03	11.8	11.8	11.8	11.8	11.8	11.8	11.21	11.21	10.62	9.44	9.44	9.44	8.85	15.93	20.06	37.17	54.28	37.17	20.06	11.8								364
2739.41	2679.66	2650.26	2564.81	2580.03	1605.76	1432.48	1271.07	1221.91	858.52	471.94	162.64	163.44	163.65	48.33	40.06	41.17	54.28	37.17	20.06	11.8								71,722

P81
34 pages plus attachment including cover

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING / AIR EMISSIONS CHANGES FOR EMISSION RATES Reported in App. G FOR FEIS.

ORIGINATOR Colin Henderson DATE 8/27/96

REVISION NO. 0

OBJECTIVE Modify the Emission rates reported in App G to reflect - Addition of I-129 to DSTs, Correct the tank farm routine operating emissions (incorrectly reported in the Draft) and Add the Combo 2 Alternative.

METHODOLOGY Routine tank farm emissions taken from attached Routine Emissions data (taken from Hanford Site Air Permit application) data attached. Combo 2 Emissions obtained by scaling.

ASSUMPTIONS noted.

(Continue on another sheet if necessary)

JC Henderson 8/27/96.
SIGNATURE/DATE

Thomas J Murray 8/27/96
CHECKED/DATE

CALCULATION & RESULTS
ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 6/28/96 SUBJECT TWRS EIS SHEET NO. PS2 1-3

BY D Stein CHKD. JOB NO.

Attached are emission rate Tables for:

1. Intermediate Separations
2. In Situ / Ex Situ Combo 1
3. In Situ / Ex Situ Combo 2
4. Phased Implementation

Comments/Basis

1. Intermediate Separations – Correction made in Table G.3.1.24 under Sr-90 emission rates where IS6W source was incorrectly listed; changed to STH. Also added C-14 emission from STL which was included for all other ex-situ alternatives but omitted here.

2. Combo 1 – Correction in titles for combo 1 and correction in Table G.3.1.14 where chlorine emissions incorrectly shown; not present in any other Tables. Also included pollutant Table (calcium oxide, etc) omitted here. Factors from inter. sep to combo 1 used here (0.5 emission rate of inter-sep for combo 1 STL and STH). Also corrections to G.3.1.27 where some sources were incorrectly listed. Kept emission rates the same as before based on 100 T/D LAW, 10 T/D HLW and 77 out of 177 tanks recovered for ex situ.

FORM 91-005-1 (4/81)

3. Combo 2 - Construction emission rates left the same as combo 1 which is same as inter. sep. (as bounding rates). Operation phase estimates used factors from combo 1 based on plant size comparisons.

TF6W, TF5W ratioed @ $\frac{25 \text{ tanks}}{77 \text{ tanks}}$ recovered.

STH @ $\frac{5 \text{ T/D}}{20 \text{ T/D}}$

STL @ $\frac{70 \text{ T/D}}{100 \text{ T/D}}$

PM-10 TF6W (worse case) @ 1.0 (same as combo 1)

BTCH @ $\frac{177-25}{177-70} = \frac{150}{107}$ tanks in situ fill + cap

4. Phased Impl -

- Phase 1 construction + operation - no change
- Phase 2 construction - no change as same as inter. sep (bounding case) Two 100 T/D LAW plants + one 10 T/D HLW assumed to be about the same as inter. sep case of 200 T/D LAW + 20 T/D HLW.
- Phase 2 operation - factored from inter. sep. based on plant sizes
  3 stacks STH - HLW
  (no phase 1 plants operating) ST1 - LAW plant 1
  ST2 - LAW plant 2

JACOBS ENGINEERING GROUP INC.

DATE 6/28/94 SUBJECT TWRS EIS SHEET NO. 3-3 pg 4

BY D Stein CHKD. JOB NO.

Emission Rate tables for all other Alternatives should have no changes. The routine radiological emissions from the tank farms were revised to reflect the routine radiological emissions developed using the Hanford Site Air Permit Application DOE/RL-95-07.

FORM 91-005-1 (4/81)

Table G.3.1.7 Emission Rates for the Ex Situ Intermediate Separations Alternative - Construction Phase

Pollutant	Source	Emission Rate (g/sec)
Criteria Pollutants		
Sulfur Oxides	TF5W	1.77E-03
	TF6W	1.77E-03
	TA1W	7.18E-03
	TA2W	3.77E-02
	TA3W	7.18E-03
	TA1E	7.18E-03
	TA2E	7.18E-03
	PROC	2.13E-01
Carbon Monoxide	TF5W	3.72E-02
	TF6W	3.72E-02
	TA1W	9.69E-02
	TA2W	0.510
	TA3W	9.69E-02
	TA1E	9.69E-02
	TA2E	9.69E-02
	PROC	1.60E+02
Nitrogen Dioxide	TF5W	1.46E-01
	TF6W	1.46E-01
	TA1W	3.15E-01
	TA2W	1.66
	TA3W	3.15E-01
	TA1E	3.15E-01
	TA2E	3.15E-01
	PROC	1.6E+01
PM-10	TF5W	1.03E-02
	TF6W	1.03E-02
	TA1W	7.40E-02
	TA2W	3.88E-01
	TA3W	7.40E-02
	TA1E	7.40E-02
	TA2E	7.40E-02
	PROC	6.67E+00
	BTCH	3.17E+00
Hazardous Air Pollutants		
Formaldehyde	TF5W	3.61E-05
	TF6W	3.61E-05
	TA1W	9.33E-05
	TA2W	4.89E-04
	TA3W	9.33E-05
	TA1E	9.33E-05
	TA2E	9.33E-05
	PROC	3.89E-03

Notes:
g/sec = Grams per second
Routine emissions from tank farms and evaporator would occur as shown in Table G.3.1.2

P86

Table G.3.1.8 Emission Rates for the Ex Situ Intermediate Separations Alternative - Operation Phase

Pollutant	Source	Emission Rates (g/sec)
Criteria Pollutants		
Sulfur Oxides	TF5W, TF6W	1.77E-03
	ST-H	2.75E-02
	ST-L	7.56E-01
Carbon Monoxide	TF5W, TF6W	3.72E-02
	ST-H	1.21E+00
	ST-L	8.5E+00
Nitrogen Dioxide	TF5W, TF6W	1.46E-01
	ST-H	2.62E-02
	ST-L	5.14E-01
PM-10	TF5W, TF6W	1.03E-02
Hazardous Air Pollutants		
Formaldehyde	TF5W, TF6W	3.61E-05
Arsenic Compounds	ST-H	1.83E-09
	ST-L	8.8E-10
Beryllium Compounds	ST-H	4.67E-11
	ST-L	6.3E-12
Cadmium Compounds	ST-H	1.75E-08
	ST-L	7.6E-09
Cobalt Compounds	ST-H	1.96E-09
	ST-L	2.2E-10
Chromium Compounds	ST-H	9.86E-08
	ST-L	5.7E-07
Manganese Compounds	ST-H	3.50E-07
	ST-L	6.5E-08
Lead Compounds	ST-H	6.19E-08
	ST-L	9.4E-09
Antimony Compounds	ST-H	4.42E-09
	ST-L	2.3E-10
Selenium Compounds	ST-H	5.39E-09
	ST-L	2.7E-09
Nickle Compounds	ST-H	3.50E-04
	ST-L	3.2E-09
Hydrogen Chloride	ST-H	1.16E-02
	ST-L	9.6E-03
Iodine	ST-H	1.21E-05
	ST-L	1.39E-03
Ammonia	ST-H	0.000
	ST-L	1.12E-01
Silver Oxide	ST-H	8.03E-10
	ST-L	1.1E-10
Boric Oxide	ST-H	5.3E-06
	ST-L	3.0E-09

P87

Table G.3.1.8 Emission Rates for the Ex Situ Intermediate Separations Alternative - Operation Phase (cont'd)

Pollutant	Source	Emission Rate (g/sec)
Calcium Oxide	ST-H	0
	ST-L	9.6E-06
Ferric Oxide	ST-H	2.12E-06
	ST-L	4.0E-08
Magnesium Oxide	ST-H	1.58E-08
	ST-L	9.5E-06
Tellurium Trioxide	ST-H	6.19E-10
	ST-L	2.1E-11
Uranium Trioxide	ST-H	2.81E-06
	ST-L	2.9E-07
Vanadium Pentoxide	ST-H	1.26E-10
	ST-L	5.2E-11
Zinc Oxide	ST-H	3.33E-09
	ST-L	3.3E-09
Zirconium Oxide	ST-H	1.36E-06
	ST-L	5.7E-08
Fluoride	ST-H	2.71E-02
	ST-L	2.24E-02
Nitric Acid	ST-H	5.06E-03
	ST-L	4.18E-03
Barium Oxide	ST-H	4.17E-09
	ST-L	1.0E-09

Notes:
g/sec = Grams per second
In addition, routine and retrieval emissions from tank farms and evaporator would occur as shown in Table G.3.1.3.

Table G.3.1.19 Radionuclide Emission Rates for the No Action Alternative (Tank Waste)

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF6W	~~8E-09~~ 0.00	--	--	--	--
Cs-137	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.33 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	2.7E-05	TF7E	2.7E-05	TF8E	~~2.4E-05~~ 2.40 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 9.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	8.2E-08	WESF	2.6E-06
I-129	TF6E	2.3E-05	TF7E	2.3E-05	--	--
Pu-239	TF6E(1)	~~2.9E-09~~	TF7E(1)	~~2.9E-09~~ 2.85 E-09	TF10E(1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	TF4W	~~1.0E-03~~ 0.00	TF5W(1)	~~8.1E-09~~	TF6W	~~2.4E-07~~ 0.00
1.4E-04	EVAP(1)	~~1.4E-04~~	WESF	2.4E-07	--	--
Sr-90	TF1E	~~2.4E-03~~ 2.60 E-05	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-03~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 1.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.44 E-06	TF5W 2	~~3.1E-06~~ 3.1E-6
	TF6W 2	~~9.1E-08~~ 2.4E-07	EVAP 2	~~8.0E-05~~ ~~1.2E-05~~ 8.0E-05	WESF	5.1E-06

Notes:
Ci/yr = Curie per year
-- indicates no additional sources or emission rates.

(1) ALPHA assumed as Pu 239

2 Beta assumed as SR 90

Table G.3.1.20 Radionuclide Emission Rates for the Long-Term Management Alternative Phase 1

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF6W	~~3.2E-03~~ 0.00	--	--	--	--
Cs-137	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.33 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	2.7E-05	TF7E	2.7E-05	TF8E	~~2.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 8.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	8.2E-08	TF6W	~~3.1E-03~~ 8.0E-05
	WESF	2.6E-06	--	--	--	--
I-129	TF6E	2.3E-05	TF7E	2.3E-05	TF6W	6.9E-05
Pu-239	TF6E(1)	2.9E-09	TF7E(1)	2.9E-09	TF10E(1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	TF4W	~~1.0E-03~~ 0.00	TF5W(1)	8.1E-09	TF6W(1)	~~3.0E-03~~ 4.5E-08
	EVAP(1)	~~1.4E-04~~ 4E-04 ~~1.4E-08~~	WESF	2.4E-07	--	--
Sr-90	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-05~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 1.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.44 E-06	TF5W(2)	3.1E-06
	TF6W	~~2.1E-01~~ 1.2E-05	EVAP(2)	~~8.0E-05~~ 8.0E-05	WESF	5.1E-06

Notes:
Ci/yr = Curie per year
-- indicates no additional sources or emission rates.

(1) alpha assumed as Pu 239
(2) Beta assumed as SR 90

Table G.3.1.21 Radionuclide Emission Rates for the Long-Term Management Alternative Phase 2

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
~~Am-241~~	~~PROC~~	~~1.6E-03~~	--	--	--	--
Cs-137	PROC	~~2.0E-03~~ 5.3E-5	WESF	2.6E-06	--	--
I-129	PROC	4.6 ~~5.0~~E-05	--	--	--	--
Pu-239	PROC	~~1.4E-03~~ 2.9E-8	EVAP *	1.4E-04	WESF	2.4E-07
Sr-90	PROC	~~8.1E-02~~ 9.2E-06	EVAP *	8.0E-05	WESF	5.1E-06

Notes:
Ci/yr = Curie per year
-- indicates no additional sources or emission rates.

~~(1.61E-08)~~

~~(2.15E-09)~~

~~* these are continuous potential values (actual values)~~

Assume that LTM Phase 2 Emissions from PROC = Sum of the DST Routine Emissions.

Table G.3.1.22 Radionuclide Emission Rates for the In Situ Fill and Cap Alternative

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF5W	~~1.7E-03~~ 0.00	TF6W	~~1.7E-03~~ 0.00	--	--
Cs-137	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.33 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	2.7E-05	TF7E	2.7E-05	TF8E	~~2.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 8.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	~~1.6E-03~~ 8.20 E-08	TF6W	~~1.6E-03~~ 4.24 E-05
	WESF	2.6E-06	--	--	--	--
I-129	TF6E	2.3E-05	TF7E	2.3E-05	TF5W	~~3.7E-05~~ 0.00
	TF6W	3.7E-05	--	--	--	--
Pu-239	TF6E(1)	2.9E-09	TF7E(1)	2.9E-09	TF10E(1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
Stet	TF4W	~~1.0E-03~~ 0.00	TF5W(1)	~~1.6E-03~~ 8.10 E-09	TF6W(1)	~~1.6E-03~~ 2.40 E-08
	EVAP(1)	~~1.4E-04~~ [illegible]	WESF	2.4E-07	--	--
Sr-90	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-03~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.10E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 1.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.44 E-06	TF5W(2)	~~3.1E-01~~ 3.11E-06
	TF6W(2)	~~1.1E-01~~ 5.00 E-06	EVAP(2)	~~8.0E-05~~ [illegible]	WESF	5.1E-06

Stet

Notes:
Ci/yr = Curie per year
-- indicates no additional sources or emission rates.

(1) alpha assumed as Pu 239

(2) Beta assumed as Sr-90

Table G.3.1.23 Radionuclide Emission Rates for the In Situ Vitrification Alternative

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF6W	~~8.0E-09~~ 0.00	IS6W	2.0E-07	--	--
C-14	IS6W	1.1E+03	--	--	--	--
Cs-137	TF1E	~~3.4E-05~~ 2.40 E-08	TF2E	~~2.1E-04~~ 2.33 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	2.7E-05	TF7E	2.7E-05	TF8E	~~3.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 8.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	8.2E-08	IS6W	7.0E-05
	WESF	2.6E-06	--	--	--	--
I-129	TF6E	2.3E-05	TF7E	2.3E-05	IS6W	~~3.2E-00~~ 7.6E+00
Pu-239	TF6E(1)	2.9E-09	TF7E(1)	2.9E-09	TF10E(1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	TF4W	~~1.0E-03~~ 0.00	TF5W(1)	8.1E-09	TF6W	~~2.4E-07~~ 0.00
	IS6W	6.6E-08	EVAP	~~1.4E-04~~ [illegible]	WESF	2.4E-07
Ru-106	IS6W	7.6E-14	--	--	--	--
Sm-151	IS6W	1.3E-06	--	-- Stet	--	--
Sr-90	TF1E	~~2.4E-05~~ 1.60 E-08	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-03~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 1.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.44 E-06	TF5W(2)	3.1E-06
	TF6W(2)	9.1E-08	IS6W	1.4E-04	EVAP(2)	~~8.0E-05~~ [illegible]
	WESF	5.1E-06	--	--	--	--
Zr-93	IS6W	7.8E-09	--	--	--	--

Notes:
Ci/yr = Curie per year
-- indicates no additional sources or emission rates.

(1) alpha assumed to be Pu 239
(2) Beta assumed to be Sr 90

Stet

Table G.3.1.24 Radionuclide Emission Rates for the Ex Situ Intermediate Separations Alternative

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF6W	~~3.2E-03~~ 0.00	STH	2.1E-03	–	–
Cs-137	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.33 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	2.7E-05	TF7E	2.7E-05	TF8E	~~2.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 8.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	8.2E-08	TF6W	~~3.1E-03~~ 8.1E-05
	STH	1.5E-00	WESF	2.6E-06	–	–
I-129	TF6E	2.3E-05	TF7E	2.3E-05	TF6W	6.9E-05
	STL	~~8.4E-01~~ 2.2E+00	–	–	–	–
Pu-239	TF6E(1)	2.9E-09	TF7E(1)	2.9E-09	TF10E(1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	TF4W	~~1.0E-03~~ 0.00	TF5W(1)	8.1E-09	TF6W(1)	~~3.0E-03~~ 4.50 E-08
	STH	2.3E-03	EVAP(1)	~~1.4E-04~~ Stet	WESF	2.4E-07
Sr-90	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-03~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 1.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.44 E-06	TF5W(2)	3.1E-06
	TF6W(2)	~~2.1E-01~~ 9.33 E-06	~~TF6W~~ STH	1.4E-04	EVAP(2)	~~8.0E-05~~ Stet
	WESF	5.1E-06	–	–	–	–
Tc-99	STH	1.3E-04	–	–	–	–

Note:
Ci/yr = Curie per year
– indicates no additional sources or emission rates.
Emission rates shown are for the operational phase of the alternative. Emission rates for the construction phase are the same as those shown for the No Action alternative (tank waste) (Table G.3.1.19). No radionuclides will be emitted from the construction areas.

(1) alpha assumed as Pu239

(2) Beta assumed as Sr90

C-14 STL 3.1E+02 Ci/yr

Radionuclide emissions for STH & STL are Annual Averages
Annual Peak Values = 1.7 X Annual Average

Table G.3.1.25 Radionuclide Emission Rates for the Ex Situ No Separations Alternative

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF6W	~~3.2E-03~~ 0.00	SMIN	3.8E-03	–	–
C-14	SMIN	~~3.8E-02~~ 3.8E+02	–	–	–	–
Cs-137	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.33 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	2.7E-05	TF7E	2.7E-05	TF8E	~~2.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.201 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 8.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	8.2E-08	TF6W	~~3.1E-03~~ 8.10 E-05
	SMIN	2.5E-00	WESF	2.6E-06	–	–
I-129	TF6E	2.3E-05	TF7E	2.3E-05	TF6W	6.9E-05
	SMIN	~~1.1E-00~~ 2.7E+00	–	–	–	–
Pu-239	TF6E	2.9E-09(1)	TF7E	2.9E-09(1)	TF10E(1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	TF4W	~~1.0E-03~~ 0.00	TF5W	8.1E-09	TF6W	~~3.0E-03~~ 4.50 E-08
	SMIN	3.9E-03	EVAP	~~1.4E-04~~	WESF	2.4E-07
Sr-90	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-03~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~9.4E-04~~ 1.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.64 E-06	TF5W(2)	3.1E-06
	TF6W(2)	~~2.1E-01~~ 9.33 E-06	SMIN	3.9E-00	EVAP(2)	~~8.0E-05~~
	WESF	5.1E-06	–	–	–	–
Tc-99	SMIN	1.2E-03	–	–	–	–

Note:
Ci/yr = Curie per year
– indicates no additional sources or emission rates.
Emission rates shown are for the operational phase of the alternative. Emission rates for the construction phase are the same as those shown for the No Action alternative (tank waste) (Table G.3.1.19). No radionuclides will be emitted from the construction areas.

Set

(1) alpha assumed as Pu239

(2) Beta assumed as Sr 90

SMIN Radionuclide emissions represent annual averages
Peak annual emission = 1.7 x Annual Average.

Table G.3.1.26 Radionuclide Emission Rates for the Ex Situ Extensive Separations Alternative

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF6W	~~3.2E-03~~ 0.00	ESEP	2.7E-03	--	--
C-14	ESEP	3.1 ~~2.8E-02~~ +02	--	--	--	--
Cs-137	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.33 E-07	TF3E	~~9.1E-03~~ 1.00 E-07
	TF6E	2.7E-05	TF7E	2.7E-05	TF8E	~~2.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 8.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	8.2E-08	TF6W	~~3.1E-03~~ 8.10 E-05
	ESEP	8.9E-01	WESF	2.6E-06	--	--
I-129	TF6E	2.3E-05	TF7E	2.3E-05	TF6W	6.9E-05
	ESEP	~~8.9E-01~~ 2.2E+00	--	--	--	--
Pu-239	TF6E(1)	2.9E-09	TF7E(1)	2.9E-09	TF10E(1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	TF4W	~~1.0E-03~~ 0.00	TF5W(1)	8.1E-09	TF6W(1)	~~3.0E-03~~ 4.50 E-08
	EVAP(1)	~~1.4E-04~~	ESEP	8.4E-04	WESF	2.4E-07
Ru-106	ESEP	1.0E-09	--	--	--	--
Sm-151	ESEP	1.7E-02	--	--	--	--
Sr-90	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-03~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 1.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.44 E-06	TF5W(2)	3.1E-06
	TF6W(2)	~~2.1E-01~~ 9.33 E-06	EVAP(2)	~~8.0E-05~~	ESEP	1.4E-00
	WESF	5.1E-06	--	--	--	--
Tc-99	ESEP	8.4E-04	--	--	--	--
Zr-93	ESEP	1.1E-04	--	--	--	--

Note:
Ci/yr = Curie per year
-- indicates no additional sources or emission rates.
Emission rates shown are for the operational phase of the alternative. Emission rates for the construction phase are the same as those shown for the No Action alternative (tank waste) (Table G.3.1.19). No radionuclides will be emitted from the construction areas.

(1) alpha assumed as Pu 239

(2) Beta assumed as Sr 90

ESEP Radionuclide emissions represent annual Averages.
Peak Annual = 1.7 x Annual Average

Table G.3.1.13 Emission Rates for the Ex Situ/In Situ Combination Alternative - Construction Phase

Pollutant	Source	Emission Rate (g/sec)
Criteria Pollutants		
Sulfur Oxides	TF5W	8.7E-04
	TF6W	0.24
	TA1W	3.6E-03
	TA2W	1.9E-02
	TA3W	3.6E-03
	TA1E	3.6E-03
	TA2E	3.6E-03
	PROC	8.0E-02
Carbon Monoxide	TF5W	1.9E-02
	TF6W	5.2E-01
	TA1W	4.8E-02
	TA2W	2.5E-01
	TA3W	4.8E-02
	TA1E	4.8E-02
	TA2E	4.8E-02
	PROC	6.17E+01
Nitrogen Dioxide	TF5W	7.3E-02
	TF6W	1.19E+00
	TA1W	1.6E-01
	TA2W	8.3E-01
	TA3W	1.6E-01
	TA1E	1.6E-01
	TA2E	1.6E-01
	PROC	5.86E+00
PM-10	TF5W	5.2E-03
	TF6W	6.7E-01
	TA1W	3.7E-02
	TA2W	1.94E-01
	TA3W	3.7E-02
	TA1E	3.7E-02
	TA2E	3.7E-02
	PROC	3.54E+00
	BTCH	1.20E+00
Hazardous Air Pollutants		
Formaldehyde	TF5W	1.81E-05
	TF6W	2.08E-04
	TA1W	4.67E-05
	TA2W	2.45E-04
	TA3W	4.67E-05
	TA1E	4.67E-05
	TA2E	4.67E-05
	PROC	1.51E-03

Notes:
g/sec = Grams per second
Additional emissions from tank farms and evaporator would occur as shown in Table G.3.1.2.

Table [redacted] Emission Rates for the Ex Situ/In Situ Combination Alternative 2 - Operation Phase

Pollutant	Source	Emission Rates (g/sec)
Criteria Pollutants		
Sulfur Oxides	TF5W, TF6W	3.5E-04
	ST-H	2.0E-03
	ST-L	2.6E-01
Carbon Monoxide	TF5W, TF6W	7.6E-03
	ST-H	9.0E-02
	ST-L	3.0E+00
Nitrogen Dioxide	TF5W, TF6W	2.9E-02
	ST-H	2.0E-03
	ST-L	1.8E-01
PM-10	TF6W	5.2E-03
	TF5W	1.3E-02
	BTCH	2.4E-01
Hazardous Air Pollutants		
Formaldehyde	TF5W, TF6W	7.2E-06
[redacted]	[redacted]	[redacted]
Arsenic Compounds	ST-H	1.4E-10
	ST-L	3.1E-10
Beryllium Compounds	ST-H	3.6E-12
	ST-L	2.2E-12
Cadmium Compounds	ST-H	1.3E-09
	ST-L	2.7E-09
Cobalt Compounds	ST-H	1.5E-10
	ST-L	7.7E-11
Chromium Compounds	ST-H	7.5E-09
	ST-L	2.0E-07
Manganese Compounds	ST-H	3.7E-08
	ST-L	2.3E-08
Lead Compounds	ST-H	4.6E-09
	ST-L	3.3E-09
Antimony Compounds	ST-H	3.3E-10
	ST-L	1.2E-10
Selenium Compounds	ST-H	4.0E-10
	ST-L	1.0E-09
Nickle Compounds	ST-H	2.7E-05
	ST-L	1.1E-09
Hydrogen Chloride	ST-H	8.5E-04
	ST-L	3.4E-03
Iodine	ST-H	9.0E-07
	ST-L	4.6E-04
Ammonia	ST-H	0.0
	ST-L	3.7E-02
Silver Oxide	ST-H	6.0E-11
	ST-L	3.8E-11
Boric Oxide	ST-H	4.2E-10
	ST-L	1.1E-09

Notes:
g/sec = Grams per second

7/2/96 Corrected

G.3.1.14 Ex Situ/In Situ Combination 1

Table ~~G.3.1.3~~ Emission Rates for the ~~Ex-Situ Intermediate Separations~~ Alternative - Operation Phase (cont'd)

Pollutant	Source	Emission Rate (g/sec)
Calcium Oxide	ST-H	0 0
	ST-L	4.8E-06 ~~9.6E-06~~
Ferric Oxide	ST-H	1.1E-06 ~~2.12E-06~~
	ST-L	2.0E-08 ~~4.0E-08~~
Magnesium Oxide	ST-H	8.0E-09 ~~1.58E-08~~
	ST-L	4.8E-06 ~~9.5E-06~~
Tellurium Trioxide	ST-H	3.1E-10 ~~6.19E-10~~
	ST-L	1.0E-11 ~~2.1E-11~~
Uranium Trioxide	ST-H	1.4E-06 ~~2.81E-06~~
	ST-L	1.4E-07 ~~2.9E-07~~
Vanadium Pentoxide	ST-H	6.3E-11 ~~1.26E-10~~
	ST-L	2.6E-11 ~~5.2E-11~~
Zinc Oxide	ST-H	1.6E-09 ~~3.23E-09~~
	ST-L	1.6E-09 ~~3.3E-09~~
Zirconium Oxide	ST-H	6.8E-07 ~~1.36E-06~~
	ST-L	2.8E-08 ~~5.7E-08~~
Fluoride	ST-H	1.3E-02 ~~2.71E-02~~
	ST-L	1.1E-02 ~~2.24E-02~~
Nitric Acid	ST-H	2.5E-03 ~~5.06E-03~~
	ST-L	2.1E-03 ~~4.18E-03~~
Barium Oxide	ST-H	2.1E-09 ~~4.17E-09~~
	ST-L	5.0E-10 ~~1.0E-09~~

Notes:
g/sec = Grams per second
In addition, routine and retrieval emissions from tank farms and evaporator would occur as shown in Table G.3.1.3.

this table should have been in previous issue. Add here now.

Table G.3.1.27 Radionuclide Emission Rates for the Ex Situ/In Situ Combination Alternative

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF5W	~~1.7E-03~~ 0.00	TF6W	~~1.7E-03~~ 0.00	~~STL~~ STH	~~1.9E-03~~ Stet
C-14	STL	~~2.7E-02~~ 2.8E+02	–	–	–	–
Cs-137	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.33 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	2.7E-05	TF7E	2.7E-05	TF8E	~~2.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 5.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	~~1.6E-03~~ 4.24 E-05	TF6W	~~1.6E-03~~ 4.24 E-05
	~~STL~~ STH	1.3E-00	WESF	2.6E-06	–	–
I-129	TF6E	2.3E-05	TF7E	2.3E-05	TF5W	~~3.6E-05~~ 3.68
	TF6W	~~3.6E-05~~ 3.68	STL	~~7.6E-01~~ 1.9 ~~2.0~~ E+00	–	–
Pu-239	TF6E (1)	2.9E-09	TF7E (1)	2.9E-09	TF10E (1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	TF4W	~~1.0E-03~~ 0.00	TF5W (1)	~~1.6E-03~~ 2.40 E-08	TF6W (1)	~~1.6E-03~~ 2.40 E-08
	~~STL~~ STH	2.1E-03	EVAP (1)	Stet ~~1.4E-04~~	WESF	2.4E-07
Sr-90	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-03~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 1.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.44 E-06	TF5W (2)	~~1.1E-01~~ 4.98 E-06
	TF6W (2)	1.1E-01 4.98 E-06	~~STL~~ STH	~~2.1E-00~~ 1.3E-4	EVAP (2)	~~8.0E-05~~ 8.18 E-04
	WESF	5.1E-06	–	–	–	–
Tc-99	~~STL~~ STH	1.2E-04	–	–	–	–

Note:
Ci\yr = Curie per year
– indicates no additional sources or emission rates.
Emission rates shown are for the operational phase of the alternative. Emission rates for the construction phase are the same as those shown for the No Action alternative (tank waste) (Table G.3.1.19). No radionuclides will be emitted from the construction areas.

Stet

(1) alpha assumed as Pu-239
(2) Beta assumed as Sr-90

STH & STL Rad emissions are Annual Averages.
Peak annual emissions = 1.7 x Annual Averages

G.3.1.?

Pg 20

Table ~~G.3.1.3~~ Emission Rates for the Ex Situ/In Situ Combination Alternative 2 - Construction Phase

Pollutant	Source	Emission Rate (g/sec)
Criteria Pollutants		
Sulfur Oxides	TF5W	8.7E-04
	TF6W	0.24
	TA1W	3.6E-03
	TA2W	1.9E-02
	TA3W	3.6E-03
	TA1E	3.6E-03
	TA2E	3.6E-03
	PROC	8.0E-02
Carbon Monoxide	TF5W	1.9E-02
	TF6W	5.2E-01
	TA1W	4.8E-02
	TA2W	2.5E-01
	TA3W	4.8E-02
	TA1E	4.8E-02
	TA2E	4.8E-02
	PROC	6.17E+01
Nitrogen Dioxide	TF5W	7.3E-02
	TF6W	1.19E+00
	TA1W	1.6E-01
	TA2W	8.3E-01
	TA3W	1.6E-01
	TA1E	1.6E-01
	TA2E	1.6E-01
	PROC	5.86E+00
PM-10	TF5W	5.2E-03
	TF6W	6.7E-01
	TA1W	3.7E-02
	TA2W	1.94E-01
	TA3W	3.7E-02
	TA1E	3.7E-02
	TA2E	3.7E-02
	PROC	3.54E+00
	BTCH	1.20E+00
Hazardous Air Pollutants		
Formaldehyde	TF5W	1.81E-05
	TF6W	2.08E-04
	TA1W	4.67E-05
	TA2W	2.45E-04
	TA3W	4.67E-05
	TA1E	4.67E-05
	TA2E	4.67E-05
	PROC	1.51E-03

Notes:
g/sec = Grams per second
Additional emissions from tank farms and evaporator would occur as shown in Table G.3.1.2.

Table ~~G-[illegible]~~ Emission Rates for the Ex Situ/In Situ Combination Alternative 2 - Operation Phase

Pollutant	Source	Emission Rates (g/sec)
Criteria Pollutants		
Sulfur Oxides	TF5W, TF6W	3.5E-04 ~~8.9E-04~~
	ST-H	4.1E-03 ~~1.3E-03~~
	ST-L	2.6E-01 ~~8.8E-01~~
Carbon Monoxide	TF5W, TF6W	7.6E-03 ~~1.3E-03~~
	ST-H	1.8E-01 ~~6.0E-01~~
	ST-L	3.0E+00 ~~4.2E+00~~
Nitrogen Dioxide	TF5W, TF6W	2.9E-02 ~~7.3E-02~~
	ST-H	4.0E-03 ~~1.3E-02~~
	ST-L	1.8E-01 ~~6.2E-01~~
PM-10	TF6W	5.2E-03 ~~5.2E-03~~
	TF5W	1.3E-02 ~~3.8E-02~~
	BTCH	2.4E-01 ~~4.7E-01~~
Hazardous Air Pollutants		
Formaldehyde	TF5W, TF6W	7.2E-06 ~~1.8E-05~~
~~Chlorine~~	~~ST-H~~	~~[illegible]~~
	~~ST-L~~	~~[illegible]~~
Arsenic Compounds	ST-H	2.8E-10 ~~9.2E-10~~
	ST-L	3.1E-10 ~~4.2E-10~~
Beryllium Compounds	ST-H	7.2E-12 ~~2.0E-11~~
	ST-L	2.2E-12 ~~3.0E-12~~
Cadmium Compounds	ST-H	2.6E-09 ~~8.2E-09~~
	ST-L	2.7E-09 ~~3.8E-09~~
Cobalt Compounds	ST-H	2.9E-10 ~~9.8E-10~~
	ST-L	7.7E-11 ~~1.1E-10~~
Chromium Compounds	ST-H	1.5E-08 ~~4.9E-08~~
	ST-L	2.0E-07 ~~2.9E-07~~
Manganese Compounds	ST-H	5.4E-08 ~~1.8E-07~~
	ST-L	2.3E-08 ~~2.3E-08~~
Lead Compounds	ST-H	9.3E-09 ~~3.1E-08~~
	ST-L	3.3E-09 ~~4.7E-09~~
Antimony Compounds	ST-H	6.6E-10 ~~2.2E-09~~
	ST-L	1.2E-10 ~~1.7E-10~~
Selenium Compounds	ST-H	8.1E-10 ~~2.7E-09~~
	ST-L	1.0E-09 ~~1.4E-09~~
Nickle Compounds	ST-H	5.4E-05 ~~1.8E-04~~
	ST-L	1.1E-09 ~~1.6E-09~~
Hydrogen Chloride	ST-H	1.7E-03 ~~5.8E-03~~
	ST-L	3.4E-03 ~~4.9E-03~~
Iodine	ST-H	1.8E-06 ~~6.0E-06~~
	ST-L	4.6E-04 ~~6.5E-04~~
Ammonia	ST-H	0.0 ~~0.0~~
	ST-L	3.9E-02 ~~[illegible]~~
Silver Oxide	ST-H	1.2E-10 ~~4.0E-10~~
	ST-L	3.8E-11 ~~5.5E-11~~
Boric Oxide	ST-H	8.4E-10 ~~2.7E-09~~
	ST-L	1.1E-09 ~~1.5E-09~~

Notes:
g/sec = Grams per second

Ex Situ/In Situ Combination 2

Table ~~G.3.1.8~~ Emission Rates for the ~~Ex-Situ Inter-Site Separations~~ Alternative - Operation Phase (cont'd)

Pollutant	Source	Emission Rate (g/sec)	
Calcium Oxide	ST-H	0.0	*
	ST-L	6.7E-06	
Ferric Oxide	ST-H	3.2E-07	*
	ST-L	2.8E-08	
Magnesium Oxide	ST-H	2.3E-09	*
	ST-L	6.6E-06	
Tellurium Trioxide	ST-H	1.0E-10	*
	ST-L	1.5E-11	
Uranium Trioxide	ST-H	4.2E-07	*
	ST-L	2.0E-07	
Vanadium Pentoxide	ST-H	1.9E-11	*
	ST-L	3.6E-11	
Zinc Oxide	ST-H	5.0E-10	*
	ST-L	2.3E-09	
Zirconium Oxide	ST-H	2.0E-07	*
	ST-L	4.0E-08	
Fluoride	ST-H	4.0E-03	*
	ST-L	1.6E-02	
Nitric Acid	ST-H	7.5E-04	*
	ST-L	2.9E-03	
Barium Oxide	ST-H	6.5E-10	*
	ST-L	7.0E-10	

Notes:
g/sec = Grams per second
In addition, routine and retrieval emissions from tank farms and evaporator would occur as shown in Table G.3.1.3.

* 7/2/96 correction

Table G.3.1.27b, Radionuclide Emission Rates for the Ex Situ/In Situ Combination 2 Alternative

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF5W	~~1.7E-03~~ 0.00	TF6W	~~1.7E-03~~ 0.00	~~STL~~ STH	~~1.9E-03~~ ~~5.7E-~~ 5.7E-0
C-14	STL	~~2.7E-02~~ 2.5E+02	–	–	–	–
Cs-137	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.33 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	2.7E-05	TF7E	2.7E-05	TF8E	~~2.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 8.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	~~1.6E-03~~ 4.24 E-05	TF6W	~~1.6E-03~~ 4.24 E-05
	~~STL~~ STH	~~1.3E-00~~ 3.9E-01	WESF	2.6E-06	–	–
I-129	TF6E	2.3E-05	TF7E	2.3E-05	TF5W	~~3.6E-05~~ 3.68 E-05 -3.6
	TF6W	~~3.6E-05~~ 3.68 E-05	STL	~~7.6E-01~~ 1.8	–	–
Pu-239	TF6E(1)	2.9E-09	TF7E(1)	2.9E-09	TF10E(1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	TF4W	~~1.0E-03~~ 0.00	TF5W(1)	~~1.6E-03~~ 2.40 E-08	TF6W(1)	~~1.6E-03~~ 2.40 E-08
	~~STL~~ STH	~~2.1E-03~~ 6.3E-04	EVAP(1)	STET ~~1.4E-04~~	WESF	2.4E-07
Sr-90	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-03~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 1.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	1.1E-03 2.44 E-06	TF5W(2)	~~1.1E-01~~ 4.98 E-06
	TF6W(2)	~~1.1E-01~~ 4.98 E-06	~~STL~~ STH	~~2.1E-00~~	EVAP(2)	~~8.0E-05~~ ← STET
	WESF	5.1E-06	–	– 6.3E-01	–	–
Tc-99	~~STL~~ STH	~~1.2E-04~~ 3.6E-5	–	–	–	–

Note:

Ci/yr = Curie per year

– indicates no additional sources or emission rates.

Emission rates shown are for the operational phase of the alternative. Emission rates for the construction phase are the same as those shown for the No Action alternative (tank waste) (Table G.3.1.19). No radionuclides will be emitted from the construction areas.

(1) alpha assumed as Pu-239

(2) Beta assumed as Sr-90

STH & STL Rad ~~Emission~~ Emissions are Annual Averages

Peak annual Averages = 1.7 X Annual Average

pg 24

Table G.3.1.28 Radionuclide Emission Rates for the Phased Implementation Alternative Phase 1

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF6W	~~8E-09~~ 0.00	SSPI	3.26E-07	NSPI	2.40E-04
C-14	SSPI	4.0E+01	NSPI	7.0E+01	--	--
Cs-137	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.33 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	~~2.7E-05~~ 2.65 E-05	TF7E	~~2.7E-05~~ 2.65 E-05	TF8E	~~2.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 8.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	8.2E-08	WESF	2.60E-06
	SSPI	1.87E-03	NSPI	1.73E-01	--	--
Pu-239	TF6E(1)	~~2.9E-09~~ 2.95 E-09	TF7E(1)	~~2.9E-09~~ 2.95 E-09	TF10E(1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	~~TF4W~~ STET	~~1.0E-03~~ 0.00	TF5W(1)	8.1E-09	TF6W	~~2.4E-07~~ 0.00
	EVAP(1)	Stet ~~1.4E-04~~ [illegible]	WESF	2.4E-07	SSPI	7.90E-08
	NSPI	2.63E-04	--	--	--	--
Sr-90	TF1E	~~2.4E-05~~ 2.60 E-09	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-03~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E+07 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 1.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.44 E-06	TF5W(2)	3.1E-06
	TF6W(2)	9.1E-08	EVAP(2)	Stet ~~8.0E-05~~ 9.48 [illegible]	WESF	5.1E-06
	SSPI	7.20E-05	NSPI	2.67E-01	--	--
Tc-99	SSPI	9.83E-07	--	--	--	--

Notes:
Ci/yr = Curie per year
-- indicates no additional sources or emission rates.

NSPI 1.65E-05

SSPI and NSPI Rad Emissions are annual averages. Peak annual emissions = 1.7 X Annual Averages.

(1) alpha assumed as Pu-239

(2) Beta assumed as Sr-90

I-129	TF6E	2.30E-05	TF7E ~~[illegible]~~	2.30E-05
	SSP	0.22	NSPI	0.22

Table G.3.1.29 Radionuclide Emission Rates for the Phased Implementation Alternative Phase 2

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	~~SSPI~~	~~3.26E-07~~	~~NSPI~~	~~2.40E-04~~	–	–
	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF6W	~~3.2E-03~~ 0.00	STH	1.25E-03	–	–
C-14	STL 1	~~2.60E+02~~ 1.25E+02	~~SSPI~~ STL2	~~4.0E+01~~ 4.25E+02	NSPI	~~1.0E+00~~
Cs-137	~~SSPI~~	~~1.82E-03~~	~~NSPI~~	~~1.73E-01~~	–	–
	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.38 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	2.7E-05	TF7E	2.7E-05	TF8E	~~2.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 3.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	8.2E-08	TF6W	~~3.1E-03~~ 8.1E-05
	STH	~~8.88E-01~~ 7.5E-01	WESF	2.6E-06	–	–
I-129	TF6E	2.3E-05	TF7E	2.3E-05	TF6W	6.9E-05
	STL 1	~~1.79E+01~~ 1.0E+00	STL2	– 1.0E+00	–	–
Pu-239	~~SSPI~~	~~7.90E-08~~	~~NSPI~~	~~2.63E-04~~	–	–
	TF6E (1)	2.9E-09	TF7E (1)	2.9E-09	TF10E (1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	TF4W	~~1.0E-03~~ 0.00	TF5W (1)	8.1E-09	TF6W (1)	~~3.0E-03~~ 4.50 E-08
	STH	~~1.38E-03~~ 1.15E-03	EVAP (1)	~~1.4E-04~~	WESF	2.4E-07
Sr-90	SSPI	7.20E-05	~~NSPI~~	~~2.67E-01~~	–	–
	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-05~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 4.60 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.44 E-06	TF5W (2)	3.1E-06
	TF6W (2)	~~2.1E-01~~ 9.33 E-06	~~TF6W~~	~~1.4E-04~~	EVAP (2)	~~8.0E-05~~
	WESF	5.1E-06	STH	~~1.39E-00~~ 7.06E-05	–	–
Tc-99	STH	~~7.80E-05~~ 6.5E-05	~~SSPI~~	~~9.83E-01~~	–	–

Note:
Ci/yr = Curie per year
– indicates no additional sources or emission rates.
Emission rates shown are for the operational phase of the alternative. Emission rates for the construction phase are the same as those shown for the No Action alternative (tank waste) (Table G.3.1.19). No radionuclides will be emitted from the construction areas.

Stot

(1) alpha assumed as Pu-239
(2) Beta assumed as Sr-90

STH, STL 1, STL2 Emissions are Annual Averages.
Peak Annual Emissions = 1.7x Ann. Ave.

PS 4

Table G.3.1.15 Emission Rates for the Phased Implementation Alternative Phase 1 - Construction Phase

Pollutant	Source	Emission Rate (g/sec)
Criteria Pollutants		
Sulfur Oxides	FCPI	1.93E-01
Carbon Monoxide	FCPI	46.2
Nitrogen Dioxide	FCPI	8.59E+00
PM-10	FCPI BTCH	6.8E+00 3.15E+00
Hazardous Air Pollutants		
Formaldehyde	FCPI	3.50E-05

Notes:
g/sec = Grams per second
Routine emissions from tank farms and evaporator would occur as shown in Table G.3.1.2

P827

Table G.3.1.16 Emission Rates for the Phased Implementation Alternative Phase 1 - Operation Phase

Pollutant	Source	Emission Rates (g/sec)
Criteria Pollutants		
Sulfur Oxides	SSPI	1.358E-01
	NSPI	2.338E-01
Carbon Monoxide	SSPI	2.27E+00
	NSPI	3.78E+00
Nitrogen Dioxide	SSPI	9.589E-02
	NSPI	1.613E-01
PM-10	SSPI	6.215E-03
	NSPI	1.287E-02
Hazardous Air Pollutants		
Chromium Compounds	SSPI	4.78E-08
	NSPI	8.88E-08
Manganese Compounds	SSPI	4.62E-09
	NSPI	3.70E-08
Nickle Compounds	SSPI	1.33E-09
	NSPI	3.70E-09
Fluoride (as HF)	SSPI	3.92E-02
	NSPI	6.69E-02
Nitric Acid	SSPI	8.88E-03
	NSPI	2.37E-02
Ammonia	SSPI	1.08E-02
	NSPI	2.62E-02
Hydrogen Chloride	SSPI	1.07E-03
	NSPI	1.79E-03

Notes:
g/sec = Grams per second
Additional emissions from routine operations and retrieval operations would occur as shown in Table G.3.1.2.
Emission rates of all inorganic compounds are not given; however, negligible impacts similar to those predicted for the Ex Situ Intermediate Separations and Ex Situ No Separations alternatives are expected.

P828

Table G.3.1.17 Emission Rates for the Phased Implementation Alternative Phase 2 - Construction Phase

Pollutant	Source	Emission Rate (g/sec)
Criteria Pollutants		
Sulfur Oxides	TF5W	1.77E-03
	TF6W	1.77E-03
	TA1W	7.18E-03
	TA2W	3.77E-02
	TA3W	7.18E-03
	TA1E	7.18E-03
	TA2E	7.18E-03
	PROC	2.34E-01 ~~2.23E-01~~ *
Carbon Monoxide	TF5W	3.72E-02
	TF6W	3.72E-02
	TA1W	9.69E-02
	TA2W	0.510
	TA3W	9.69E-02
	TA1E	9.69E-02
	TA2E	9.69E-02
	PROC	1.76E+02 ~~[illegible]~~ *
Nitrogen Dioxide	TF5W	1.46E-01
	TF6W	1.46E-01
	TA1W	3.15E-01
	TA2W	1.66
	TA3W	3.15E-01
	TA1E	3.15E-01
	TA2E	3.15E-01
	PROC	1.76E+02 ~~[illegible]~~ *
PM-10	TF5W	1.03E-02
	TF6W	1.03E-02
	TA1W	7.40E-02
	TA2W	3.88E-01
	TA3W	7.40E-02
	TA1E	7.40E-02
	TA2E	7.40E-02
	PROC	7.34E+00 ~~[illegible]~~ *
	BTCH	3.17E+00
Hazardous Air Pollutants		
Formaldehyde	TF5W	3.61E-05
	TF6W	3.61E-05
	TA1W	9.33E-05
	TA2W	4.89E-04
	TA3W	9.33E-05
	TA1E	9.33E-05
	TA2E	9.33E-05
	PROC	4.28E-03 ~~[illegible]~~ *

Notes:
g/sec = Grams per second
Routine emissions from tank farms and evaporator would occur as shown in Table G.3.1.2

7/2/96 corrections

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

PS29

Table G.3.1.18 Emission Rates for The Phased Implementation Alternative Phase 2 - Operation Phase

Pollutant	Source	Emission Rates (g/sec)
Sulfur Oxides	TF5W, TF6W	1.77E-03
	STH	1.38E-02
	STL1	3.78E-01
	STL2	3.78E-01
Carbon Monoxide	TF5W, TF6W	3.72E-02
	STH	6.10E-01
	STL1	4.25E+00
	STL2	4.25E+00
Nitrogen Dioxide	TF5W, TF6W	1.46E-01
	STH	1.31E-02
	STL1	2.57E-01
	STL2	2.57E-01
PM-10	TF5W, TF6W	1.03E-02
Hazardous Air Pollutants		
Formaldehyde	TF5W, TF6W	3.61E-05
Arsenic Compounds	STH	9.20E-10
	STL1	4.40E-10
	STL2	4.40E-10
Beryllium Compounds	STH	2.34E-11
	STL1	3.15E-12
	STL2	3.15E-12
Cadmium Compounds	STH	8.80E-09
	STL1	3.80E-09
	STL2	3.80E-09
Cobalt Compounds	STH	9.80E-10
	STL1	1.10E-10
	STL2	1.10E-10
Chromium Compounds	STH	4.93E-08
	STL1	2.85E-07
	STL2	2.85E-07

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT Table G.3.1.18 Cont'd SHEET NO. pg 30

BY _____ CHKD. _____ JOB NO. _____

Manganese Compounds	STH	1.75E -07
	STL1	3.25E -08
	STL2	3.25E -08
Lead Compounds	STH	3.10E -08
	STL1	4.70E -09
	STL2	4.70E -09
Antimony Compounds	STH	2.21E -09
	STL1	1.15E -10
	STL2	1.15E -10
Selenium Compounds	STH	2.70E -09
	STL1	1.35E -09
	STL2	1.35E -09
Nickel Compounds	STH	1.75E -04
	STL1	1.60E -09
	STL2	1.60E -09
Hydrogen Chloride	STH	5.80E -03
	STL1	4.80E -03
	STL2	4.80E -03
Iodine	STH	6.10E -06
	STL1	7.00E -04
	STL2	7.00E -04
Ammonia	STH	0.0
	STL1	5.60E -02
	STL2	5.60E -02
Silver Oxide	STH	4.01E -10
	STL1	5.50E -11
	STL2	5.50E -11
Boric Oxide	STH	2.65E -06
	STL1	1.50E -09
	STL2	1.50E -09

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT Table G.3.1.18 cont'd SHEET NO. P031

BY _____ CHKD. _____ JOB NO. _____

Pollutant		
Calcium Oxide	STH	0.0
	STL1	4.8E-06
	STL2	4.8E-06
Ferric Oxide	STH	1.0E-06
	STL1	2.0E-08
	STL2	2.0E-08
Magnesium Oxide	STH	1.3E-08
	STL1	4.8E-06
	STL2	4.8E-06
Tellarium Trioxide	STH	3.1E-10
	STL1	1.0E-11
	STL2	1.0E-11
Uranium Trioxide	STH	1.4E-06
	STL1	1.4E-07
	STL2	1.4E-07
Vanadium Pentoxide	STH	1.1E-10
	STL1	2.6E-11
	STL2	2.6E-11
Zinc Oxide	STH	1.6E-09
	STL1	1.6E-09
	STL2	1.6E-09
Zirconium Oxide	STH	6.9E-07
	STL1	2.8E-08
	STL2	2.8E-08
Fluoride	STH	1.3E-02
	STL1	1.1E-02
	STL2	1.1E-02
Nitric Acid	STH	2.5E-03
	STL1	2.1E-03
	STL2	2.1E-03
Barium Oxide	STH	2.1E-09
	STL1	5.0E-10
	STL2	5.0E-10

FORM 91-005-1 (4/81)

Table G.3.1.28 Radionuclide Emission Rates for the Phased Implementation Alternative Phase 1

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF6W	~~8E-09~~ 0.00	SSPI	3.26E-07	NSPI	2.40E-04
C-14	SSPI	4.0E+01	NSPI	7.0E+01	–	–
Cs-137	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.33 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	~~2.7E-08~~ 2.65 E-08	TF7E	~~2.7E-05~~ 2.65 E-08	TF8E	~~2.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 8.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	8.2E-08	WESF	2.60E-06
	SSPI	1.87E-03	NSPI	1.73E-01	–	–
Pu-239	TF6E(1)	~~2.9E-09~~ 2.85 E-09	TF7E(1)	~~2.9E-09~~ 2.95 E-09	TF10E(1)	1.5E-08
	TF1W	~~2.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	~~TF4W~~ STET	~~1.0E-03~~ 0.00	TF5W(1)	8.1E-09	TF6W	~~2.4E-07~~ 0.00
	EVAP(1)	STET ~~1.4E-04~~ NIL	WESF	2.4E-07	SSPI	7.90E-08
	NSPI	2.63E-04	–	–	–	–
Sr-90	TF1E	~~2.4E-05~~ 2.60 E-09	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-03~~ 2.71 E-06
	TF4E	~~2.5E-05~~ 2.80 E-09	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E+07 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 4.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.44 E-06	TF5W(2)	3.1E-06
	TF6W(2)	9.1E-08	EVAP(2)	STET ~~8.0E-05~~ NIL	WESF	5.1E-06
	SSPI	7.20E-05	NSPI	2.67E-01	–	–
Tc-99	SSPI	9.83E-07	–	–	–	–

Notes:
Ci/yr = Curie per year
– indicates no additional sources or emission rates.

NSPI 1.65E-05

(1) alpha assumed as Pu-239

(2) Beta assumed as Sr-90

SSPI and NSPI Rad Emissions are annual averages. Peak annual emissions = 1.7X Annual Averages.

I-129	TF6E	2.30E-05	TF7E	2.30E-05
	SSPI	0.22	NSPI	0.22

Table G.3.1.29 Radionuclide Emission Rates for the Phased Implementation Alternative Phase 2

Radionuclide	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)	Source	Emission Rate (Ci/yr)
Am-241	~~SSPI~~	~~3.26E-07~~	~~NSPI~~	~~2.40E-04~~	–	–
	TF1W	~~7.6E-08~~ 0.00	TF2W	~~4.0E-04~~ 0.00	TF4W	~~1.1E-03~~ 0.00
	TF6W	~~3.2E-03~~ 0.00	STH	1.25E-03	–	–
C-14	STL 1	~~2.60E+02~~ 1.25E+02	~~SSPI~~ STL2	~~4.0E+01~~ 1.25E+02	NSPI	7.0E+01
Cs-137	~~SSPI~~	~~1.82E-03~~	~~NSPI~~	~~1.72E-01~~	–	–
	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~2.1E-04~~ 2.38 E-07	TF3E	~~9.1E-05~~ 1.00 E-07
	TF6E	2.7E-05	TF7E	2.7E-05	TF8E	~~2.4E-05~~ 2.60 E-08
	TF9E	~~2.9E-05~~ 3.20 E-08	TF10E	2.8E-08	TF2W	~~4.3E-04~~ 8.00 E-09
	TF4W	~~1.0E-03~~ 8.40 E-08	TF5W	8.2E-08	TF6W	~~3.1E-03~~ 8.1E-05
	STH	~~8.88E-01~~ 7.5E-01	WESF	2.6E-06	–	–
I-129	TF6E	2.3E-05	TF7E	2.3E-05	TF6W	6.9E-05
	STL 1	~~7.79E-01~~ 1.0E+00	STL2	– 1.0E+00	–	–
Pu-239	~~SSPI~~	~~7.90E-08~~	~~NSPI~~	~~2.63E-04~~	–	–
	TF6E (1)	2.9E-09	TF7E (1)	2.9E-09	TF10E (1)	1.5E-08
	TF1W	~~3.3E-08~~ 0.00	TF2W	~~2.3E-04~~ 0.00	TF3W	~~7.1E-05~~ 0.00
	TF4W	~~1.0E-03~~ 0.00	TF5W (1)	8.1E-09	TF6W (1)	~~3.0E-03~~ 4.50 E-08
	STH	~~1.38E-03~~ 1.15E-03	EVAP (1)	~~1.4E-04~~ STH	WESF	2.4E-07
Sr-90	SSPI	7.20E-05	~~NSPI~~	~~2.60E-01~~	–	–
	TF1E	~~2.4E-05~~ 2.60 E-08	TF2E	~~5.4E-06~~ 6.00 E-09	TF3E	~~2.5E-05~~ 2.71 E-06
	TF4E	~~3.5E-05~~ 2.80 E-08	TF5E	1.2E-07	TF6E	4.1E-06
	TF7E	4.1E-06	TF8E	~~6.7E-04~~ 7.40 E-07	TF9E	~~8.3E-04~~ 9.10 E-07
	TF10E	1.6E-07	TF11E	6.6E-08	TF2W	~~2.4E-04~~ 1.10 E-07
	TF3W	~~7.0E-02~~ 0.00	TF4W	~~1.1E-03~~ 2.44 E-06	TF5W (2)	3.1E-06
	TF6W (2)	~~2.1E-01~~ 9.33 E-06	~~TF6W~~	~~1.4E-04~~	EVAP (2)	~~8.0E-05~~
	WESF	5.1E-06	STH	~~1.39E-00~~ 7.06E-05	–	–
Tc-99	STH	~~7.80E-05~~ 6.5E-05	~~SSPI~~	~~9.83E-01~~	–	–

Note:
Ci/yr = Curie per year
– indicates no additional sources or emission rates.
Emission rates shown are for the operational phase of the alternative. Emission rates for the construction phase are the same as those shown for the No Action alternative (tank waste) (Table G.3.1.19). No radionuclides will be emitted from the construction areas.

Stot

(1) alpha assumed as Pu-239
(2) Beta assumed as Sr-90

STH, STL 1, STL2 Emissions are Annual Averages. Peak Annual Emissions = 1.7x Ann. Ave.

JACOBS ENGINEERING GROUP INC.

pg 34.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

Phase 2 of Phased Implementation Revised to include 2 LAW Plants.

Phase 2 stack LOCATION

for New LAW PLANT

X Coord = 574220
Y Coord = 135,170

STACK Height & Release Parameters
SAME AS ORIGINAL Phase 2 LAW PLANT.

FORM 91-005-1 (4/81)

Attachment
Tank Farm Routine Rad. Emissions. Developed from the Hanford Site Air Operating Permit Application DOE/RL-95-07

TABLE 5.3.1 SOURCE TYPES AND LOCATIONS.

TANK FARM	SOURCE NAME **	SOURCE LOCATION*		ELEVATION OF CENTER (m)	SOURCE TYPE
		x coord.	y coord.		
BY	TF1E	573556	137442	200	AREA
BX	TF2E	573556	137282	200	AREA
B	TF3E	573771	137252	200	AREA
C	TF4E	575075	136493	200	AREA
AN	TF5E	575332	136378	205	AREA
AZ	TF6E	575365	136279	205	AREA
AY	TF7E	575281	136157	205	AREA
AX	TF8E	575380	136159	205	AREA
A	TF9E	575310	136015	210	AREA
AW	TF10E	575304	135806	210	AREA
AP	TF11E	575481	135747	210	AREA
T	TF1W	566738	136662	210	AREA
TY	TF2W	566715	136373	210	AREA
TX	TF3W	566689	136146	210	AREA
U	TF4W	566744	135000	205	AREA
S&SY	TF5W	566750	134399	205	AREA
SX	TF6W	566746	134162	205	AREA
	TA1W	566833	136570	210	AREA
	TA2W	566886	134878	205	AREA
	TA3W	566930	134444	205	AREA
	TA1E	573755	137383	200	AREA
	TA2E	575163	136336	200	AREA
SITE C	PROC	573879	135229	215	AREA
	BTCH	571332	135953	225	AREA
	SMIN	574425	135978	215	AREA
	ST-L	574120	135901	215	AREA
	ST-H	574410	135978	215	AREA

Notes: * Location of area sources represents southwest corner of area (coordinates in meters)
** Tank farm sources have the prefix "TF", transfer annex areas have the prefix "TA"; source IDs ending in "E" are located in the 200 East area, while those ending in "W" are located in the 200 West area. Other sources are defined as follows:

PROC = Vitrification process facility construction emissions
BTCH = Concrete batch plant emissions
SMIN = Minimal pretreatment process stack
ST-L = TPA low level waste process stack
ST-H = TPA high level waste process stack

Coordinate locations are given consistent with ASI coordinate system.

summary TANK FARM ROUTINE RAD EMISSIONS

		Am241	Cs137	Pu239	Sr90	alpha	beta	I129	
241A	TF9E	0	3.20E-08	0	9.10E-07				
241AX	TF8E	0	2.60E-08	0	7.40E-07				
241B	TF3E	0	1.00E-07	0	2.71E-06				
241BX	TF2E		2.33E-07	0	6.00E-09				
241BY	TF1E	0	2.60E-08	0	2.60E-08				
241C	TF4E	0	0	0	2.80E-08				
296AN	TF5E				1.20E-07				
296AP	TF11E				6.60E-08				
296AW	TF10E		2.80E-08		1.60E-07	1.50E-08			
296AYAZ	AZ=TF6E, AY=TF7E		5.30E-05		8.20E-06	5.70E-09		4.60E-05	
241S	StSY=TF5W	0	8.20E-08	0	2.41E-06				
241SX	TF6W	0	8.00E-09	0	2.40E-07				
241T	TF1W	0	7.60E-08	0	2.30E-08				
241TX	TF3W	0	9.60E-08	0	0				
241TY	TF2W		8.00E-09		1.10E-07				
241U	TF4W		8.40E-08	0	2.44E-06				
296SX	TF6W						9.10E-08		
296SY	StSY=TF5W					8.10E-09	7.00E-07		
TANK FARM TOTALS		0.00E+00	5.38E-05	0.00E+00	1.82E-05	2.88E-08	7.91E-07	4.60E-05	
242A Evaporator - Periodic Operation						2.10E-05	1.20E-05		
242A Evaporator - Continuous Operation						1.41E-04	8.04E-05		

New

Tank Farm Emissions From Current Operations					
					138
Tank Farm 241-A (5 Single-Shell tanks)		Avg Exit Velocity .0242 (ft/sec)		Area 5 (sq. ft)	
Passive Ventilation		Avg Exit Temperature 138 (F)		Height 3 (ft)	Total
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m^3)	Area (ft^2)
Carbon Monoxide	3.38E+00	3.38E+00	3.86E-04	3.13E-02	5
Nitrogen Oxide	2.04E-01	2.04E-01	2.32E-05	1.88E-03	5
1,3-Butadiene	1.47E-02	1.47E-02	1.68E-06	1.36E-04	5
2-Hexanone	2.67E-01	2.67E-01	3.05E-05	2.47E-03	5
2-Pentanone	4.24E-01	4.24E-01	4.84E-05	3.92E-03	5
Acetone	5.09E+00	5.09E+00	5.81E-04	4.71E-02	5
Acetonitrile	2.45E+00	2.45E+00	2.80E-04	2.27E-02	5
Benzene	1.17E-01	1.17E-01	1.33E-05	1.08E-03	5
Heptane	2.99E-01	2.99E-01	3.42E-05	2.77E-03	5
Methyl N-Amyl Ketone	2.89E-01	2.89E-01	3.30E-05	2.68E-03	5
N-Hexane	3.12E-01	3.12E-01	3.56E-05	2.89E-03	5
Nonane	1.63E-01	1.63E-01	1.86E-05	1.51E-03	5
Octane	1.70E-01	1.70E-01	1.95E-05	1.58E-03	5
Toluene	2.37E-02	2.37E-02	2.71E-06	2.20E-04	5
Ammonia	2.34E+01	2.34E+01	2.67E-03	2.17E-01	5
Phosphoric Acid, Tributyl Ester	6.12E-01	6.12E-01	6.99E-05	5.67E-03	5
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m^3)	
Americium-241 Ci/yr	3.06E-07	0.00E+00	0.00E+00	0.00E+00	5
Cesium-137 Ci/yr	7.44E-05	3.20E-08	3.65E-12	3.43E-15	5
Plutonium-239 Ci/yr	1.53E-07	0.00E+00	0.00E+00	0.00E+00	5
Strontium-090 Ci/yr	1.96E-03	9.10E-07	1.04E-10	6.06E-14	5

Tank Farm 241-AX (4 Single-Shell tanks)		Avg Exit Velocity .0225 (ft/sec)		Area 4 (sq. ft)		
Passive Ventilation		Avg Exit Temperature 105.25 (		Height 3 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m^3)	Area (ft^2)	Velocity (ft/s)
Carbon Monoxide	2.52E+00	2.48E+00	2.83E-04	3.08E-02	4	0.0225
Nitrogen Oxide	1.52E-01	1.52E-01	1.73E-05	1.89E-03	4	0.0225
1,3-Butadiene	1.10E-02	1.03E-02	1.18E-06	1.28E-04	4	0.0225
2-Hexanone	1.99E-01	1.99E-01	2.27E-05	2.48E-03	4	0.0225
2-Pentanone	3.16E-01	2.80E-01	3.19E-05	3.48E-03	4	0.0225
Acetone	3.80E+00	3.80E+00	4.33E-04	4.72E-02	4	0.0225
Acetonitrile	1.83E+00	1.83E+00	2.09E-04	2.28E-02	4	0.0225
Benzene	8.69E-02	8.69E-02	9.92E-06	1.08E-03	4	0.0225
Heptane	2.23E-01	2.23E-01	2.55E-05	2.77E-03	4	0.0225
Methyl N-Amyl Ketone	2.16E-01	2.16E-01	2.46E-05	2.68E-03	4	0.0225
N-Hexane	2.32E-01	2.32E-01	2.65E-05	2.89E-03	4	0.0225
Nonane	1.21E-01	1.21E-01	1.38E-05	1.51E-03	4	0.0225
Octane	1.27E-01	1.27E-01	1.45E-05	1.58E-03	4	0.0225
Toluene	1.77E-02	1.77E-02	2.02E-06	2.20E-04	4	0.0225
Ammonia	1.74E+01	1.74E+01	1.99E-03	2.17E-01	4	0.0225
Phosphoric Acid, Tributyl Ester	4.56E-01	4.56E-01	5.21E-05	5.68E-03	4	0.0225
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m^3)		
Americium-241 Ci/yr	2.28E-07	0.00E+00	0.00E+00	0.00E+00	4	0.0225
Cesium-137 Ci/yr	5.54E-05	2.60E-08	2.97E-12	3.74E-15	4	0.0225
Plutonium-239 Ci/yr	1.14E-07	0.00E+00	0.00E+00	0.00E+00	4	0.0225
Strontium-090 Ci/yr	1.46E-03	7.40E-07	8.45E-11	6.62E-14	4	0.0225

Tank Farm 241-B (16 Single-Shell tanks)		Avg Exit Velocity .1938 (ft/sec)		Area 5.78 (sq. ft)		
Passive Ventilation		Avg Exit Temperature 66.94 (F		Height 3 (ft)	Total	Average
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m^3)	Area (ft^2)	Velocity (ft/s)
Carbon Monoxide	9.62E+00	9.62E+00	1.10E-03	9.61E-03	5.78	0.1938125
Nitrogen Oxide	7.94E-01	5.79E-01	6.61E-05	5.79E-04	5.78	0.1938125
1,3-Butadiene	4.18E-02	4.18E-02	4.77E-06	4.18E-05	5.78	0.1938125
2-Hexanone	7.60E-01	7.60E-01	8.68E-05	7.60E-04	5.78	0.1938125
2-Pentanone	1.21E+00	1.21E+00	1.38E-04	1.21E-03	5.78	0.1938125
Acetone	1.45E+01	1.45E+01	1.65E-03	1.45E-02	5.78	0.1938125
Acetonitrile	6.98E+00	6.98E+00	7.97E-04	6.98E-03	5.78	0.1938125
Benzene	3.32E-01	3.32E-01	3.79E-05	3.31E-04	5.78	0.1938125
Heptane	8.51E-01	8.51E-01	9.72E-05	8.51E-04	5.78	0.1938125
Methyl N-Amyl Ketone	8.23E-01	8.23E-01	9.40E-05	8.23E-04	5.78	0.1938125
N-Hexane	8.87E-01	8.87E-01	1.01E-04	8.87E-04	5.78	0.1938125
Nonane	4.62E-01	4.62E-01	5.28E-05	4.62E-04	5.78	0.1938125
Octane	4.85E-01	4.85E-01	5.53E-05	4.84E-04	5.78	0.1938125
Toluene	6.75E-02	6.75E-02	7.71E-06	6.75E-05	5.78	0.1938125
Ammonia	6.65E+01	6.65E+01	7.60E-03	6.65E-02	5.78	0.1938125
Phosphoric Acid, Tributyl Ester	1.74E+00	1.74E+00	1.99E-04	1.74E-03	5.78	0.1938125
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m^3)		
Americium-241 Ci/yr	8.34E-07	0.00E+00	0.00E+00	0.00E+00	5.78	0.1938125
Cesium-137 Ci/yr	2.03E-04	1.00E-07	1.14E-11	1.16E-15	5.78	0.1938125
Plutonium-239 Ci/yr	4.17E-07	0.00E+00	0.00E+00	0.00E+00	5.78	0.1938125
Strontium-090 Ci/yr	5.34E-03	2.71E-06	3.09E-10	1.95E-14	5.78	0.1938125

Tank Farm Emissions From Current Operations						
					67.75	70
Tank Farm 241-BX (12 Single-Shell tanks)		Avg Exit Velocity .1595 (ft/sec)		Area 6.12 (sq. ft)		
Passive Ventilation		Avg Exit Temperature 67.75 (F		Height 3 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m^3)	Area (ft^2)	Velocity (ft/s)
Carbon Monoxide	7.56E+00	7.56E+00	8.63E-04	8.67E-03	6.12	0.1595
Nitrogen Oxide	4.55E-01	4.55E-01	5.19E-05	5.22E-04	6.12	0.1595
1,3-Butadiene	3.29E-02	3.29E-02	3.75E-06	3.77E-05	6.12	0.1595
2-Hexanone	5.98E-01	5.98E-01	6.82E-05	6.86E-04	6.12	0.1595
2-Pentanone	9.48E-01	9.48E-01	1.08E-04	1.09E-03	6.12	0.1595
Acetone	1.14E+01	1.14E+01	1.30E-03	1.31E-02	6.12	0.1595
Acetonitrile	5.49E+00	5.49E+00	6.26E-04	6.29E-03	6.12	0.1595
Benzene	2.61E-01	2.61E-01	2.98E-05	2.99E-04	6.12	0.1595
Heptane	6.69E-01	6.69E-01	7.64E-05	7.67E-04	6.12	0.1595
Methyl N-Amyl Ketone	6.47E-01	6.47E-01	7.39E-05	7.42E-04	6.12	0.1595
N-Hexane	6.97E-01	6.97E-01	7.96E-05	8.00E-04	6.12	0.1595
Nonane	3.64E-01	3.64E-01	4.15E-05	4.17E-04	6.12	0.1595
Octane	3.81E-01	3.81E-01	4.35E-05	4.37E-04	6.12	0.1595
Toluene	5.31E-02	5.31E-02	6.06E-06	6.09E-05	6.12	0.1595
Ammonia	5.23E+01	5.23E+01	5.97E-03	6.00E-02	6.12	0.1595
Phosphoric Acid, Tributyl Ester	1.37E+00	1.37E+00	1.56E-04	1.57E-03	6.12	0.1595
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m^3)		
Americium-241 Ci/yr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.12	0.1595
Cesium-137 Ci/yr	4.60E-04	2.33E-07	2.66E-11	3.09E-15	6.12	0.1595
Plutonium-239 Ci/yr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.12	0.1595
Strontium-090 Ci/yr	1.17E-05	6.00E-09	6.85E-13	4.95E-17	6.12	0.1595

Tank Farm 241-BY (12 Single-Shell tanks)		Avg Exit Velocity .06996 (ft/se		Area 7.94 (sq. ft)		
Passive Ventilation		Avg Exit Temperature 95.83 (F		Height 3 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m^3)	Area (ft^2)	Velocity (ft/s)
Carbon Monoxide	4.06E+00	4.06E+00	4.63E-04	8.18E-03	7.94	0.069958333
Nitrogen Oxide	2.51E-01	2.51E-01	2.87E-05	5.06E-04	7.94	0.069958333
1,3-Butadiene	1.76E-02	1.76E-02	2.01E-06	3.55E-05	7.94	0.069958333
2-Hexanone	3.24E-01	3.24E-01	3.70E-05	6.53E-04	7.94	0.069958333
2-Pentanone	5.16E-01	5.16E-01	5.89E-05	1.04E-03	7.94	0.069958333
Acetone	6.16E+00	6.16E+00	7.03E-04	1.24E-02	7.94	0.069958333
Acetonitrile	2.95E+00	2.95E+00	3.37E-04	5.95E-03	7.94	0.069958333
Benzene	1.42E-01	1.42E-01	1.62E-05	2.86E-04	7.94	0.069958333
Heptane	3.69E-01	3.69E-01	4.21E-05	7.43E-04	7.94	0.069958333
Methyl N-Amyl Ketone	3.50E-01	3.50E-01	4.00E-05	7.06E-04	7.94	0.069958333
N-Hexane	3.96E-01	3.96E-01	4.52E-05	7.98E-04	7.94	0.069958333
Nonane	1.97E-01	1.97E-01	2.25E-05	3.98E-04	7.94	0.069958333
Octane	2.09E-01	2.09E-01	2.39E-05	4.22E-04	7.94	0.069958333
Toluene	3.12E-02	3.12E-02	3.57E-06	6.30E-05	7.94	0.069958333
Ammonia	3.13E+01	3.13E+01	3.58E-03	6.32E-02	7.94	0.069958333
Phosphoric Acid, Tributyl Ester	7.33E-01	7.33E-01	8.37E-05	1.48E-03	7.94	0.069958333
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m^3)		
Americium-241 Ci/yr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.94	0.069958333
Cesium-137 Ci/yr	4.35E-05	2.60E-08	2.97E-12	6.07E-16	7.94	0.069958333
Plutonium-239 Ci/yr	1.30E-08	0.00E+00	0.00E+00	0.00E+00	7.94	0.069958333
Strontium-090 Ci/yr	5.01E-05	2.60E-08	2.97E-12	3.77E-16	7.94	0.069958333

Tank Farm 241-C (13 Single-Shell tanks)		Avg Exit Velocity .01854 (ft/se		Area 12.79 (sq. ft)		
Passive Ventilation		Avg Exit Temperature 78.08 (F		Height 3 (ft)	Total	Average
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m^3)	Area (ft^2)	Velocity (ft/s)
Carbon Monoxide	5.77E+00	5.77E+00	6.59E-04	3.09E-02	10.79	0.019363636
Nitrogen Oxide	3.95E-01	3.95E-01	4.51E-05	1.87E-03	12.79	0.018538462
1,3-Butadiene	2.51E-02	2.51E-02	2.87E-06	1.35E-04	10.79	0.019363636
2-Hexanone	4.56E-01	4.56E-01	5.21E-05	2.45E-03	10.79	0.019363636
2-Pentanone	7.24E-01	7.24E-01	8.26E-05	3.88E-03	10.79	0.019363636
Acetone	8.70E+00	8.70E+00	9.93E-04	4.66E-02	10.79	0.019363636
Acetonitrile	4.19E+00	4.19E+00	4.78E-04	2.25E-02	10.79	0.019363636
Benzene	1.99E-01	1.99E-01	2.27E-05	1.07E-03	10.79	0.019363636
Heptane	5.11E-01	5.11E-01	5.83E-05	2.74E-03	10.79	0.019363636
Methyl N-Amyl Ketone	4.93E-01	4.93E-01	5.63E-05	2.64E-03	10.79	0.019363636
N-Hexane	5.32E-01	5.32E-01	6.08E-05	2.85E-03	10.79	0.019363636
Nonane	2.78E-01	2.78E-01	3.17E-05	1.49E-03	10.79	0.019363636
Octane	2.91E-01	2.91E-01	3.32E-05	1.56E-03	10.79	0.019363636
Toluene	4.05E-02	4.05E-02	4.62E-06	2.17E-04	10.79	0.019363636
Ammonia	4.55E+01	4.55E+01	5.19E-03	2.15E-01	12.79	0.018538462
Phosphoric Acid, Tributyl Ester	1.05E+00	1.05E+00	1.19E-04	5.60E-03	10.79	0.019363636
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m^3)		
Americium-241 Ci/yr	1.18E-07	0.00E+00	0.00E+00	0.00E+00	12.79	0.018538462
Cesium-137 Ci/yr	4.35E-06	0.00E+00	0.00E+00	0.00E+00	12.79	0.018538462
Plutonium-239 Ci/yr	1.42E-06	0.00E+00	0.00E+00	0.00E+00	12.79	0.018538462
Strontium-090 Ci/yr	5.10E-05	2.80E-08	3.20E-12	1.08E-15	12.79	0.018538462

Tank Farm Emissions From Current Operations						
296-AN 8 Source Emissions Roll-Up		Avg Exit Velocity 18.2 (ft/sec)		Area .54 (sq. ft)		
Active Ventilation		Avg Exit Temperature 110 (F)		Height 14.92 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m^3)	Area (ft^2)	Velocity (ft/s)
Nitrogen Oxide	3.63E-01	3.63E-01	4.14E-05	4.13E-05	0.54	18.2
1, 3-Butadiene	2.62E-02	2.62E-02	2.99E-06	2.99E-06	0.54	18.2
2-Hexanone	4.77E-01	4.77E-01	5.45E-05	5.44E-05	0.54	18.2
2-Pentanone	7.58E-01	7.58E-01	8.65E-05	8.63E-05	0.54	18.2
Acetone	9.07E+00	9.07E+00	1.04E-03	1.03E-03	0.54	18.2
Acetonitrile	4.38E+00	4.38E+00	5.00E-04	4.99E-04	0.54	18.2
Benzene	2.08E-01	2.08E-01	2.37E-05	2.37E-05	0.54	18.2
Heptane	5.33E-01	5.33E-01	6.09E-05	6.08E-05	0.54	18.2
Methyl N-Amyl Ketone	5.16E-01	5.16E-01	5.89E-05	5.88E-05	0.54	18.2
N-Hexane	5.56E-01	5.56E-01	6.35E-05	6.34E-05	0.54	18.2
Nonane	2.90E-01	2.90E-01	3.31E-05	3.31E-05	0.54	18.2
Octane	3.04E-01	3.04E-01	3.47E-05	3.46E-05	0.54	18.2
Toluene	4.24E-02	4.24E-02	4.84E-06	4.83E-06	0.54	18.2
		Ci/yr	Ci/hr	grams/m^3		
Strontium-90		1.20E-07	1.37E-11	9.84E-17	0.54	18.2
Total Alpha		None Detected			0.54	18.2
Tank Farm Emissions From Current Operations						

296-AP 9 Source Emissions Roll-Up		Avg Exit Velocity 35.8 (ft/sec)		Area .54 (sq. ft)		
Active Ventilation		Avg Exit Temperature 110 (F)		Height 13.33 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m^3)	Area (ft^2)	Velocity (ft/s)
Nitrogen Oxide	4.15E-01	4.15E-01	4.74E-05	2.41E-05	0.54	35.8
1, 3-Butadiene	2.99E-02	2.99E-02	3.42E-06	1.73E-06	0.54	35.8
2-Hexanone	5.45E-01	5.45E-01	6.22E-05	3.16E-05	0.54	35.8
2-Pentanone	8.65E-01	8.65E-01	9.88E-05	5.01E-05	0.54	35.8
Acetone	1.04E+01	1.04E+01	1.19E-03	6.04E-04	0.54	35.8
Acetonitrile	5.01E+00	5.01E+00	5.72E-04	2.90E-04	0.54	35.8
Benzene	2.38E-01	2.38E-01	2.71E-05	1.38E-05	0.54	35.8
Heptane	6.10E-01	6.10E-01	6.96E-05	3.53E-05	0.54	35.8
Methyl N-Amyl Ketone	5.90E-01	5.90E-01	6.73E-05	3.42E-05	0.54	35.8
N-Hexane	6.36E-01	6.36E-01	7.26E-05	3.68E-05	0.54	35.8
Nonane	3.31E-01	3.31E-01	3.78E-05	1.92E-05	0.54	35.8
Octane	3.47E-01	3.47E-01	3.97E-05	2.01E-05	0.54	35.8
Toluene	4.84E-02	4.84E-02	5.53E-06	2.81E-06	0.54	35.8
		Ci/yr	Ci/hr	grams/m^3		
Strontium-90		6.60E-08	7.53E-12	2.75E-17	0.54	35.8
Tank Farm Emissions From Current Operations						

296-AW 7 Source Emissions Roll-Up		Avg Exit Velocity 30 (ft/sec)		Area .54 (sq. ft)		
Active Ventilation		Avg Exit Temperature 110 (F)		Height 15.75 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m^3)	Area (ft^2)	Velocity (ft/s)
Nitrogen Oxide	3.11E-01	3.11E-01	3.55E-05	2.15E-05	0.54	30
1, 3-Butadiene	2.25E-02	2.25E-02	2.57E-06	1.56E-06	0.54	30
2-Hexanone	4.09E-01	4.09E-01	4.67E-05	2.83E-05	0.54	30
2-Pentanone	6.50E-01	6.50E-01	7.42E-05	4.49E-05	0.54	30
Acetone	7.79E+00	7.79E+00	8.90E-04	5.39E-04	0.54	30
Acetonitrile	3.76E+00	3.76E+00	4.29E-04	2.60E-04	0.54	30
Benzene	1.79E-01	1.79E-01	2.04E-05	1.24E-05	0.54	30
Heptane	4.57E-01	4.57E-01	5.22E-05	3.16E-05	0.54	30
Methyl N-Amyl Ketone	4.43E-01	4.43E-01	5.05E-05	3.06E-05	0.54	30
N-Hexane	4.77E-01	4.77E-01	5.45E-05	3.30E-05	0.54	30
Nonane	2.49E-01	2.49E-01	2.84E-05	1.72E-05	0.54	30
Octane	2.60E-01	2.60E-01	2.97E-05	1.80E-05	0.54	30
Toluene	3.63E-02	3.63E-02	4.14E-06	2.51E-06	0.54	30
		Ci/yr	Ci/hr	grams/m^3		
Cesium-137		2.80E-08	3.20E-12	2.24E-17	0.54	30
Strontium-90		1.60E-07	1.83E-11	7.96E-17	0.54	30
Total Alpha (Pu-239)		1.50E-08	1.71E-12	1.68E-14	0.54	30
Tank Farm Emissions From Current Operations						

296-AYAZ 5 Source Emissions Roll-Up		Avg Exit Velocity 31.91 (ft/sec)		Area 1.77 (sq. ft)		
Active Ventilation		Avg Exit Temperature 110 (F)		Height 50 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m^3)	Area (ft^2)	Velocity (ft/s)
Nitrogen Oxide	2.08E-01	2.08E-01	2.37E-05	4.12E-06	1.77	31.91
1, 3-Butadiene	1.50E-02	1.50E-02	1.71E-06	2.97E-07	1.77	31.91
2-Hexanone	2.73E-01	2.73E-01	3.12E-05	5.41E-06	1.77	31.91
2-Pentanone	4.33E-01	4.33E-01	4.94E-05	8.58E-06	1.77	31.91
Acetone	5.20E+00	5.20E+00	5.93E-04	1.03E-04	1.77	31.91
Acetonitrile	2.50E+00	2.50E+00	2.86E-04	4.96E-05	1.77	31.91
Benzene	1.19E-01	1.19E-01	1.36E-05	2.36E-06	1.77	31.91
Heptane	3.05E-01	3.05E-01	3.48E-05	6.04E-06	1.77	31.91
Methyl N-Amyl Ketone	2.95E-01	2.95E-01	3.37E-05	5.85E-06	1.77	31.91
N-Hexane	3.18E-01	3.18E-01	3.64E-05	6.31E-06	1.77	31.91
Nonane	1.66E-01	1.66E-01	1.90E-05	3.29E-06	1.77	31.91
Octane	1.74E-01	1.74E-01	1.99E-05	3.45E-06	1.77	31.91
Toluene	2.42E-02	2.42E-02	2.77E-06	4.80E-07	1.77	31.91
		Ci/yr	Ci/hr	grams/m^3		
Cesium-137		5.30E-05	6.05E-09	1.22E-14	1.77	31.91
Strontium-90		8.20E-06	9.36E-10	1.17E-15	1.77	31.91
Iodine-129		4.60E-05	5.25E-09	5.18E-09	1.77	31.91
Total Alpha (Pu-239)		5.70E-09	6.51E-13	1.83E-15	1.77	31.91
Tank Farm Emissions From Current Operations						

242A 6 Source Emissions Roll-UP		Avg Exit Velocity 37.8 (ft/sec)		Area 9.62 (sq. ft)					
Active Ventilation		Avg Exit Temperature 117 (F)		Height 22 (ft)					
					Operating release				
	Continuous Ops	Periodic Ops	Periodic Ops	Continuous	Concentration				
Emissions	Potential (tons/yr)	Actual (tons/yr)	Actual (kg/hr)	Actual (kg/hr)	g/m^3	Area (ft^2)	Velocity (ft/s)		
2-Hexanone	3.80E-04	2.88E-05	2.98E-06	3.94E-05	1.06E-06	9.62	37.8		
Acetone	1.06E-01	7.98E-03	8.27E-04	1.10E-02	2.97E-04	9.62	37.8		
Methyl Isobutyl Ketone	7.25E-03	5.44E-04	5.64E-05	7.51E-04	2.03E-05	9.62	37.8		
N-Butyl Alcohol	8.00E-01	6.00E-02	6.22E-03	8.29E-02	2.24E-03	9.62	37.8		
Ammonia	1.00E-01	7.51E-03	7.78E-04	1.04E-02	2.80E-04	9.62	37.8		
	Ci/yr Actual	Ci/yr Actual		Ci/hr - Continuous Op.	grams/m^3				
Total Alpha (Ci) (Pu)	1.41E-04	2.10E-05		1.61E-08	7.00E-12	9.62	37.8		
Total Beta (Ci) (Sr-90)	8.04E-05	1.20E-05		9.18E-09	1.78E-15	9.62	37.8		
note: total alpha and beta taken from WHC-SD-WM-EV-099 and are from 1987 evaporator operations (11 MM gal run, Capacity=73.6 MM gal/yr so continuous ops =6.7 times periodic)									
note: evaporator emissions are the sum of the building ventilation and the vessel vent systems which each have a stack. The shorter stack was chosen as the release point for all emissions.									
Tank Farm Emissions From Current Operations									

		Avg Exit Velocity .36 (ft/s)		Area 1.08 (ft2)		
241-S Tank Farm (12 Single-Shell Tanks)		Avg Exit Temperature 94.2 (F)		Height 3 (ft)		
Passive Ventilation						
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m3)	Area (ft2)	Velocity (ft/s)
Carbon Monoxide	1.14E-02	1.14E-02	1.30E-06	3.28E-05	1.08	0.36
Nitrogen Oxide	6.86E-04	7.44E-04	8.49E-08	2.14E-06	1.08	0.36
1,3-Butadiene	4.96E-05	5.37E-05	6.13E-09	1.55E-07	1.08	0.36
2-Hexanone	9.01E-04	9.76E-04	1.11E-07	2.81E-06	1.08	0.36
2-Pentanone	1.43E-03	1.55E-03	1.77E-07	4.46E-06	1.08	0.36
Acetone	1.72E-02	1.86E-02	2.12E-06	5.35E-05	1.08	0.36
Acetonitrile	8.27E-03	8.96E-03	1.02E-06	2.58E-05	1.08	0.36
Benzene	3.94E-04	4.26E-04	4.87E-08	1.23E-06	1.08	0.36
Heptane	1.01E-03	1.09E-03	1.25E-07	3.15E-06	1.08	0.36
Methyl N-Amyl Ketone	9.76E-04	1.06E-03	1.21E-07	3.04E-06	1.08	0.36
N-Hexane	1.05E-03	1.14E-03	1.30E-07	3.28E-06	1.08	0.36
Nonane	5.48E-04	5.94E-04	6.78E-08	1.71E-06	1.08	0.36
Octane	5.75E-04	6.23E-04	7.11E-08	1.79E-06	1.08	0.36
Toluene	8.00E-05	8.67E-05	9.90E-09	2.50E-07	1.08	0.36
Ammonia	7.88E-02	8.54E-02	9.75E-06	2.46E-04	1.08	0.36
Phosphoric Acid, Tributyl Ester	1.91E-03	2.24E-03	2.55E-07	6.44E-06	1.08	0.36
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m3)		
Americium-241	9.36E-07	0.00E+00	0.00E+00	0.00E+00	1.08	0.36
Cesium 137	2.28E-04	8.20E-08	9.36E-12	2.73E-15	1.08	0.36
Plutonium-239	4.68E-07	0.00E+00	0.00E+00	0.00E+00	1.08	0.36
Strontium-090	6.00E-03	2.41E-06	2.75E-10	4.99E-14	1.08	0.36

Tank Farm Emissions From Current Operations						
241-SX Tank Farm (2 Single-Shell Tanks)		Avg Exit Velocity .014 (ft/s)		Area 2 (ft2)		
Passive Ventilation		Avg Exit Temperature 76.5 (F)		Height 3 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m3)	Area (ft2)	Velocity (ft/s)
Carbon Monoxide	8.78E-04	8.78E-04	1.00E-07	3.51E-05	2	0.014
Nitrogen Oxide	5.28E-05	5.28E-05	6.03E-09	2.11E-06	2	0.014
1,3-Butadiene	3.82E-06	3.82E-06	4.36E-10	1.53E-07	2	0.014
2-Hexanone	6.94E-05	6.94E-05	7.92E-09	2.78E-06	2	0.014
2-Pentanone	1.10E-04	1.10E-04	1.26E-08	4.41E-06	2	0.014
Acetone	1.32E-03	1.32E-03	1.51E-07	5.30E-05	2	0.014
Acetonitrile	6.38E-04	6.38E-04	7.28E-08	2.55E-05	2	0.014
Benzene	3.02E-05	3.02E-05	3.45E-09	1.21E-06	2	0.014
Heptane	7.78E-05	7.78E-05	8.88E-09	3.11E-06	2	0.014
Methyl N-Amyl Ketone	7.52E-05	7.52E-05	8.58E-09	3.01E-06	2	0.014
N-Hexane	8.10E-05	8.10E-05	9.25E-09	3.24E-06	2	0.014
Nonane	4.22E-05	4.22E-05	4.82E-09	1.69E-06	2	0.014
Octane	4.42E-05	4.42E-05	5.05E-09	1.77E-06	2	0.014
Toluene	6.16E-06	6.16E-06	7.03E-10	2.46E-07	2	0.014
Ammonia	6.08E-03	6.08E-03	6.94E-07	2.43E-04	2	0.014
Phosphoric Acid, Tributyl Ester	1.59E-04	1.59E-04	1.82E-08	6.36E-06	2	0.014
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m3)		
Americium-241	7.20E-08	0.00E+00	0.00E+00	0.00E+00	2	0.014
Cesium 137	1.74E-05	8.00E-09	9.13E-13	3.70E-15	2	0.014
Plutonium-239	3.60E-08	0.00E+00	0.00E+00	0.00E+00	2	0.014
Strontium-090	4.60E-04	2.40E-07	2.74E-11	6.91E-14	2	0.014

Tank Farm Emissions From Current Operations						
241-T Tank Farm (16 Single-Shell Tanks)		Avg Exit Velocity .0246 (ft/s)		Area 16 (ft2)		
Passive Ventilation		Avg Exit Temperature 65.2 (F)		Height 3 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m3)	Area (ft2)	Velocity (ft/s)
Carbon Monoxide	1.21E-02	1.21E-02	1.39E-06	3.45E-05	16	0.024625
Nitrogen Oxide	7.30E-04	7.30E-04	8.34E-08	2.08E-06	16	0.024625
1,3-Butadiene	5.28E-05	5.28E-05	6.02E-09	1.50E-07	16	0.024625
2-Hexanone	9.59E-04	9.59E-04	1.09E-07	2.73E-06	16	0.024625
2-Pentanone	1.52E-03	1.52E-03	1.74E-07	4.32E-06	16	0.024625
Acetone	1.83E-02	1.83E-02	2.09E-06	5.19E-05	16	0.024625
Acetonitrile	8.80E-03	8.80E-03	1.01E-06	2.50E-05	16	0.024625
Benzene	4.19E-04	4.19E-04	4.78E-08	1.19E-06	16	0.024625
Heptane	1.07E-03	1.07E-03	1.23E-07	3.05E-06	16	0.024625
Methyl N-Amyl Ketone	1.04E-03	1.04E-03	1.19E-07	2.95E-06	16	0.024625
N-Hexane	1.12E-03	1.12E-03	1.28E-07	3.18E-06	16	0.024625
Nonane	5.84E-04	5.84E-04	6.66E-08	1.66E-06	16	0.024625
Octane	6.12E-04	6.12E-04	6.98E-08	1.74E-06	16	0.024625
Toluene	8.52E-05	8.52E-05	9.72E-09	2.42E-07	16	0.024625
Ammonia	8.39E-02	8.39E-02	9.58E-06	2.39E-04	16	0.024625
Phosphoric Acid, Tributyl Ester	3.75E-03	2.20E-03	2.51E-07	6.24E-06	16	0.024625
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m3)		
Americium-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	16	0.024625
Cesium 137	1.68E-04	7.60E-08	8.68E-12	2.50E-15	16	0.024625
Plutonium-239	3.60E-08	0.00E+00	0.00E+00	0.00E+00	16	0.024625
Strontium-090	3.84E-05	2.30E-08	2.63E-12	4.70E-16	16	0.024625
					16	0.024625

Tank Farm Emissions From Current Operations						
241-TX Tank Farm (18 Single-Shell Tanks)		Avg Exit Velocity .1816 (ft/s)		Area 5.82 (ft2)		
Passive Ventilation		Avg Exit Temperature 72.3 (F)		Height 3 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m3)	Area (ft2)	Velocity (ft/s)
Carbon Monoxide	1.06E-02	1.06E-02	1.21E-06	1.13E-05	5.82	0.18155
Nitrogen Oxide	6.91E-04	6.91E-04	7.89E-08	7.32E-07	5.82	0.18155
1,3-Butadiene	4.58E-05	4.58E-05	5.23E-09	4.85E-08	5.82	0.18155
2-Hexanone	8.32E-04	8.32E-04	9.50E-08	8.82E-07	5.82	0.18155
2-Pentanone	1.32E-03	1.32E-03	1.51E-07	1.40E-06	5.82	0.18155
Acetone	1.59E-02	1.59E-02	1.81E-06	1.68E-05	5.82	0.18155
Acetonitrile	7.64E-03	7.64E-03	8.73E-07	8.10E-06	5.82	0.18155
Benzene	3.63E-04	3.63E-04	4.15E-08	3.85E-07	5.82	0.18155
Heptane	9.32E-04	9.32E-04	1.06E-07	9.88E-07	5.82	0.18155
Methyl N-Amyl Ketone	9.01E-04	9.01E-04	1.03E-07	9.55E-07	5.82	0.18155
N-Hexane	9.71E-04	9.71E-04	1.11E-07	1.03E-06	5.82	0.18155
Nonane	5.06E-04	5.06E-04	5.78E-08	5.37E-07	5.82	0.18155
Octane	5.31E-04	5.31E-04	6.06E-08	5.62E-07	5.82	0.18155
Carbon Tetrachloride	3.91E-06	3.91E-06	4.46E-10	1.35E-07	0.09	0.36
Ethyl Butyl Ketone	1.31E-05	1.31E-05	1.50E-09	4.53E-07	0.09	0.36
Methyl Chloride	5.78E-07	5.78E-07	6.60E-11	2.00E-08	0.09	0.36
Tetrahydrofuran	1.01E-06	1.01E-06	1.15E-10	3.49E-08	0.09	0.36
Toluene	3.91E-06	3.91E-06	4.46E-10	4.14E-09	5.82	0.18155
Ammonia	1.31E-05	1.31E-05	1.50E-09	1.39E-08	5.82	0.18155
Phosphoric Acid, Tributyl Ester	5.78E-07	5.78E-07	6.60E-11	6.13E-10	5.82	0.18155
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m3)		
Americium-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.82	0.18155
Cesium 137	1.85E-04	9.60E-08	1.10E-11	1.18E-15	5.82	0.18155
Plutonium-239	1.70E-08	0.00E+00	0.00E+00	0.00E+00	5.82	0.18155
Strontium-090	2.84E-07	0.00E+00	0.00E+00	0.00E+00	5.82	0.18155

Tank Farm Emissions From Current Operations						
241-TY Tank Farm (6 Single-Shell Tanks)		Avg Exit Velocity .0253 (ft/s)		Area 5.79 (ft2)		
Passive Ventilation		Avg Exit Temperature 66.0 (F)		Height 3 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m3)	Area (ft2)	Velocity (ft/s)
Carbon Monoxide	4.68E-03	4.68E-03	5.34E-07	3.57E-05	5.79	0.025333333
Nitrogen Oxide	2.82E-04	2.82E-04	3.21E-08	2.15E-06	5.79	0.025333333
1,3-Butadiene	2.03E-05	2.03E-05	2.32E-09	1.55E-07	5.79	0.025333333
2-Hexanone	3.70E-04	3.70E-04	4.22E-08	2.82E-06	5.79	0.025333333
2-Pentanone	5.86E-04	5.86E-04	6.69E-08	4.48E-06	5.79	0.025333333
Acetone	7.04E-03	7.04E-03	8.04E-07	5.38E-05	5.79	0.025333333
Acetonitrile	3.39E-03	3.39E-03	3.87E-07	2.59E-05	5.79	0.025333333
Benzene	1.61E-04	1.61E-04	1.84E-08	1.23E-06	5.79	0.025333333
Heptane	4.14E-04	4.14E-04	4.72E-08	3.16E-06	5.79	0.025333333
Methyl N-Amyl Ketone	4.00E-04	4.00E-04	4.57E-08	3.06E-06	5.79	0.025333333
N-Hexane	4.31E-04	4.31E-04	4.92E-08	3.29E-06	5.79	0.025333333
Nonane	2.25E-04	2.25E-04	2.57E-08	1.72E-06	5.79	0.025333333
Octane	2.36E-04	2.36E-04	2.69E-08	1.80E-06	5.79	0.025333333
Toluene	3.28E-05	3.28E-05	3.75E-09	2.51E-07	5.79	0.025333333
Ammonia	3.24E-02	3.24E-02	3.69E-06	2.47E-04	5.79	0.025333333
Phosphoric Acid, Tributyl Ester	8.47E-04	8.47E-04	9.67E-08	6.47E-06	5.79	0.025333333
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m3)		
Americium-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.79	0.025333333
Cesium 137	1.18E-05	8.00E-09	9.13E-13	7.07E-16	5.79	0.025333333
Plutonium-239	6.00E-09	0.00E+00	0.00E+00	0.00E+00	5.79	0.025333333
Strontium-090	2.17E-04	1.10E-07	1.26E-11	6.04E-15	5.79	0.025333333

Tank Farm Emissions From Current Operations						
241-U Tank Farm (16 Single-Shell Tanks)		Avg Exit Velocity .0236 (ft/s)		Area 16.0 (ft2)		
Passive Ventilation		Avg Exit Temperature 75.6 (F)		Height 3 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m3)	Area (ft2)	Velocity (ft/s)
Carbon Monoxide	1.16E-02	1.16E-02	1.33E-06	3.45E-05	16	0.0235625
Nitrogen Oxide	7.00E-04	7.00E-04	7.99E-08	2.08E-06	16	0.0235625
1,3-Butadiene	5.05E-05	5.05E-05	5.77E-09	1.50E-07	16	0.0235625
2-Hexanone	9.19E-04	9.19E-04	1.05E-07	2.73E-06	16	0.0235625
2-Pentanone	1.46E-03	1.46E-03	1.66E-07	4.33E-06	16	0.0235625
Acetone	1.75E-02	1.75E-02	2.00E-06	5.20E-05	16	0.0235625
Acetonitrile	8.43E-03	8.43E-03	9.63E-07	2.51E-05	16	0.0235625
Benzene	1.08E-03	1.08E-03	1.23E-07	3.21E-06	16	0.0235625
Heptane	1.03E-03	1.03E-03	1.17E-07	3.05E-06	16	0.0235625
Methyl N-Amyl Ketone	9.95E-04	9.95E-04	1.14E-07	2.96E-06	16	0.0235625
N-Hexane	1.07E-03	1.07E-03	1.22E-07	3.18E-06	16	0.0235625
Nonane	5.59E-04	5.59E-04	6.38E-08	1.66E-06	16	0.0235625
Octane	5.86E-04	5.86E-04	6.69E-08	1.74E-06	16	0.0235625
Toluene	7.49E-05	7.49E-05	8.55E-09	2.23E-07	16	0.0235625
Ammonia	8.04E-02	8.04E-02	9.18E-06	2.39E-04	16	0.0235625
Phosphoric Acid, Tributyl Ester	2.10E-03	2.10E-03	2.40E-07	6.25E-06	16	0.0235625
	(Ci/yr)	(Ci/yr)	(Ci/hr)	(g/m3)		
Americium-241	9.54E-07	0.00E+00	0.00E+00	0.00E+00	16	0.0235625
Cesium 137	2.32E-04	8.40E-08	9.59E-12	2.89E-15	16	0.0235625
Plutonium-239	4.77E-07	0.00E+00	0.00E+00	0.00E+00	16	0.0235625
Strontium-090	6.11E-03	2.44E-06	2.79E-10	5.21E-14	16	0.0235625

Tank Farm Emissions From Current Operations						
296-SX 14 Source Emissions Roll-Up		Avg Exit Velocity 10.6 (ft/s)		Area 9.62 (ft2)		
Passive Ventilation		Avg Exit Temperature 165 (F)		Height 15 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m3)	Area (ft2)	Velocity (ft/s)
Carbon Monoxide	2.24E-01	2.24E-01	2.56E-05	2.46E-06	9.62	10.6
Nitrogen Oxide	7.43E-04	7.43E-04	8.48E-08	8.16E-09	9.62	10.6
1,3-Butadiene	5.36E-05	5.36E-05	6.12E-09	5.89E-10	9.62	10.6
2-Hexanone	9.77E-04	9.77E-04	1.12E-07	1.07E-08	9.62	10.6
2-Pentanone	1.55E-03	1.55E-03	1.77E-07	1.70E-08	9.62	10.6
Acetone	1.86E-02	1.86E-02	2.12E-06	2.04E-07	9.62	10.6
Acetonitrile	8.96E-03	8.96E-03	1.02E-06	9.84E-08	9.62	10.6
Benzene	4.26E-04	4.26E-04	4.86E-08	4.68E-09	9.62	10.6
Heptane	1.09E-03	1.09E-03	1.24E-07	1.20E-08	9.62	10.6
Methyl N-Amyl Ketone	1.06E-03	1.06E-03	1.21E-07	1.16E-08	9.62	10.6
N-Hexane	1.14E-03	1.14E-03	1.30E-07	1.25E-08	9.62	10.6
Nonane	5.94E-04	5.94E-04	6.78E-08	6.52E-09	9.62	10.6
Octane	6.23E-04	6.23E-04	7.11E-08	6.84E-09	9.62	10.6
Toluene	8.67E-05	8.67E-05	9.90E-09	9.52E-10	9.62	10.6
Ammonia	4.17E+00	4.17E+00	4.76E-04	4.58E-05	9.62	10.6
Phosphoric Acid, Tributyl Ester	2.24E-03	2.24E-03	2.56E-07	2.46E-08	9.62	10.6
Total Alpha		None Detected				
Total Beta		9.10E-08	1.04E-11		9.62	10.6

Tank Farm Emissions From Current Operations						
296-SY 4 Source Emissions Roll-Up		Avg Exit Velocity 33.3 (ft/s)		Area .35 (ft2)		
Passive Ventilation		Avg Exit Temperature 110 (F)		Height 11 (ft)		
Emissions	Potential (Kg/yr)	Actual (Kg/yr)	Actual (Kg/hr)	Concentration (g/m3)	Area (ft2)	Velocity (ft/s)
Carbon Monoxide	5.16E-02	5.16E-02	5.89E-06	4.96E-06	0.35	33.3
Nitrogen Oxide	1.72E-04	1.72E-04	1.96E-08	1.65E-08	0.35	33.3
1,3-Butadiene	1.24E-05	1.24E-05	1.42E-09	1.19E-09	0.35	33.3
2-Hexanone	2.25E-04	2.25E-04	2.57E-08	2.16E-08	0.35	33.3
2-Pentanone	3.58E-04	3.58E-04	4.09E-08	3.44E-08	0.35	33.3
Acetone	4.30E-03	4.30E-03	4.91E-07	4.13E-07	0.35	33.3
Acetonitrile	2.07E-03	2.07E-03	2.36E-07	1.99E-07	0.35	33.3
Benzene	9.83E-05	9.83E-05	1.12E-08	9.44E-09	0.35	33.3
Heptane	2.52E-04	2.52E-04	2.88E-08	2.42E-08	0.35	33.3
Methyl N-Amyl Ketone	2.44E-04	2.44E-04	2.79E-08	2.34E-08	0.35	33.3
N-Hexane	2.63E-04	2.63E-04	3.00E-08	2.53E-08	0.35	33.3
Nonane	1.37E-04	1.37E-04	1.56E-08	1.32E-08	0.35	33.3
Octane	1.44E-04	1.44E-04	1.64E-08	1.38E-08	0.35	33.3
Toluene	2.00E-05	2.00E-05	2.28E-09	1.92E-09	0.35	33.3
Ammonia	9.63E-01	9.63E-01	1.10E-04	9.25E-05	0.35	33.3
Phosphoric Acid, Tributyl Ester	5.15E-04	5.16E-04	5.89E-08	4.96E-08	0.35	33.3
Total Alpha		8.1E-09	9.25E-13			
Total Beta		7.00E-07	7.99E-11			

Pg 1/3
3 pages + Attachment

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering / Cost Capsule Alternatives, Repository fee for FEIS.

ORIGINATOR Colin Henderson DATE 8/21/96

REVISION NO. C

OBJECTIVE Revise the capsule alternative cost estimates to refelect the latest repository fee methodology for the Final EIS.

METHODOLOGY Update the capsule cost estimates using the new cost data obtained from DOE- RW relative to repository fees.

ASSUMPTIONS Same as previous revisions (copy attached).

(Continue on another sheet if necessary)

JC Henderson 8/21/96
SIGNATURE/DATE

CHECKED/DATE

CALCULATION & RESULTS

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 2/3

BY _____ CHKD. _____ REVC. JOB NO. _____

CAPSULE Overpack & Ship Alternative Cost Est.

MODIFICATIONS INCLUDE USE of A 0.61 x 4.57 m Canister.

Since Loading (capsules/canister) is limited to 5 based on conservative assumption in WHC data package.

The same number of HMPC's and canisters (100 HMPCs/400 canisters) as before for the overpack and ship alternative

FROM OCRWM DATA using INERMEDIATE SEPARATIONS AS A BASE the ADDITIONAL 100 HMPCS would Cost.

by using the equation Repository fee = 1.2474 (#HMPC) + 1295.5
(see Repository fee Calc for development of EQUATION)

Overpack & Ship + Intermediate Sep = 3150 HMPCs

Repository fee = 1.2474 (3150) + 1295.5 = 5220 million $94

Intermediate Sep = 5100

Overpack & Ship = 5220 - 5100 = 120 million $94

OR 120 x 1.035 = 124 million $95

Vitrify w/ Tankwaste Alt.

Previous waste Volume = 400 m^3

New Canisters = 1.17 m^3

Number Canisters = $\frac{400 m^3}{1.17 m^3/can}$ = 342 Canisters

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 3/3

BY _____ CHKD. _____ JOB NO. _____

342 Canisters = 86 HMPC's

Repository fee using Intermediate separations as a basis

Rep fee = 1.2474 (3050 + 86) + 1295.5

Rep fee = $5,207 (94 $)

Original INT Sep = $5,100, (94)

Vitrify w/ Tank Waste = 5207 - 5100 = $107 (94)

OR

107 x 1,035 = $111 million (95)

Capsule Repository fee for

Vitrify With tank Waste = $111 million 95

FORM 91-005-1 (4/81)

Attachment

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGR / COST - CAPSULE ALTERNATI

3/18/9

ORIGINATOR D. Stein DATE ~~2/6/96~~

REVISION NO. ~~A~~ B C

OBJECTIVE IDENTIFY THE COST FOR THE CAPSULE ALTERNATIVES DISCUSSE IN THE TWRS EIS - MODIFY PER PROPOSED DRAFT EIS (SMALL CANISTER)

METHODOLOGY SAME AS REV 0 BUT ALSO USE NEW REPOSITORY COST ESTIMATES PER PROPOSE DRAFT EIS CONDITION

ASSUMPTIONS

Rev B - Revised repository fee per latest direction — $360,000 per canister (1995 $)

(Continue on another sheet if necessary)

D. Stein
SIGNATURE

CHK: C Henderson 3/25/96

CALCULATION & RESULTS ATTACHED

Rev C 7/16/96

JACOBSFORMS\CALCFR.SET

JACOBS ENGINEERING GROUP INC.

DATE ~~2/12/96~~ 3/18/96 SUBJECT Rev B&C ~~Rev A~~ SHEET NO. 1-2

BY DSkin CHKD. JOB NO.

CAPSULE OVERPACK + SHIP ALTERNATIVE

Cost Estimate

Modification per proposed Draft EIS use of 61 x 305 cm canister as a standard 457 Rev C

previously 68 x 457 cm canister was estimated for this alternative

Since max loading of 5 capsules per canister, the 61 x 305 cm canister will still be able to easily hold the 5 capsules. Therefore the same # of HMPCs (100) and # of canisters (400) as before

The new costs will however have to be estimated based on new repository fees estimated per DEIS

new inter. sep. for DEIS has 33,386 canisters and costs $6,500 million in repository fees.

Variation from this inter. sep. case has 44,500 canisters and costs $7,800 million

Therefore Δ 11,114 canisters cost Δ $1,300 million or $0.117 million each

repository fee = $0.117 million / canister x 400 canisters

repository fee = $46.8 million

3/18/96 revision per #340,000/canister repository fee (1995)

repository fee = 0.36 million/canister x 400 canisters = $144 million

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

The New Canister Size For Overpack & Ship is 61 x 457 cm. Previous Assumptions limited the number of capsules per canister to 5. This assumption is conservative (e.g., more capsules could fit in a larger canister). The same Assumption on capsule loading will be maintained so the number of canisters and HMPC's does not change.

Total HMPCs = 100
Total Canisters = 400

From OCRWM Data using Intermediate Separations as a base the additional 100 HMPC's would cost:

Using the Equation Repository Fee = 1.2474 (# HMPC) + 1295.5

Over Pack & Ship + Int Sep = 3150 waste Packages.

Rep Fee = 1.2474 (3150) + 1295.5 = 5220 million $94

Int Sep Rep fee = 5100

Delta = Over Pack & Ship = 5220 - 5100 = 120 million $94

or 120 x 1.035 = 124 million

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 2/6/96 SUBJECT Rev B ~~Rev A~~ SHEET NO. 2-2

BY DSkin CHKD. JOB NO.

operating cost, which includes cost of canisters, HMPCs and casks will be same as previous because same numbers are used and costs should be similar.

VITRIFY WITH TANK WASTE ALTERNATIVE

Cost Estimate

250 canisters @ 1.6 m^3/canister for a total Δ volume of 400 m^3 was previously estimated for Cs/Sr Capsules from Ext Sep table 9-14

We now have ~~0.62~~ 1.17 m^3/canister or

$\frac{1.6\ m^3}{\cancel{0.62}\ 1.17\ m^3} \times 250 = \cancel{645}\ 342$ canisters (86 HMPCs)

~~repository fee = \$0.117 million/canister × 645 canisters~~

~~repository fee = \$75.4 million~~

3/18/96 revision $360,000 per canister repository fee (1995 \$)

repository fee = \$0.36 million/can × 645 can = \$232 million

		Δ #	Δ cost
Δ op. cost	\$10,000/canister	342 (645 − 250)	0.92 ~~3.9~~ milli
	\$25,000/HMPC	86 (161 − 63)	0.6 ~~2.5~~ milli
	\$60,000/cask	(161 − 63)	1.4 ~~5.8~~ milli
			\$ ~~12.2~~ milli
			\$2.9

base cost = \$34 million

Δ cost = \$2.9 ~~12~~ million

new op. cost = \$37 ~~46~~ million

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

Repository Fee -

Vitrify w/ Tank Waste.

342 Canisters
86 HMPC's

Using Intermediate Separations as a basis.

Repository Fee = 1.2474 (#HMPCs) + 1295.5

Vit w/ Tank Waste + Int Sep = 3136 HMPC

Cost = 1.2474 (3136) + 1295.5 = $5,207 (94 $)

Original Int. Sep = 5100 (94 $)

Δ = 5207 - 5100 = 107 (94 $)

95 = 1.035 x 94.

= 1.035 x 107 = 111 million 95 $

Capsule Repository Fee Vitrify w/ Tank Waste

= 111 million 95 $.

FORM 91-005-1 (4/81)

TWRS ALTERNATIVE C[illegible] SUMMARY

Cost Component		Capsules No Action	Capsules Onsite Disposal	Capsules Overpack and Ship	Vitrify with Tank Waste
Current Operations		$112	$377	$377	$315
Transfer System Upgrades(in current ops)					
Research and Development					
	Wast Retrieval and Transfer				
	Treatment			$14	$5
	Total R&D	$0	$0	$14	$5
Capital					
	Waste Retrieval and Transfer				
	Treatment		$83	$32	$36
	Closure		$5		
	Total Capital Costs	$0	$88	$32	$36
Operating					
	Waste Retrieval and Transfer				
	Treatment		$226	$34	37 $46 ~~$34~~
	Total Operating Costs	$0	$226	$34	37 $46 ~~$34~~
Monitoring and Maintenance					$1
D&D			$6	$6	$6
Repository Fee			$0	124 ~~$[illegible]~~ ~~$15~~	111 ~~$[illegible]~~ ~~$75~~ ~~$[illegible]~~
					~~[illegible]~~ 511
Total Cost (1995)		$112	$697	607 ~~$510~~ ~~$120~~	~~641~~ ~~$489~~ ~~$100~~
Total Cost summary in billions of dollars		$0.11	$0.70	~~$0.51~~ ~~$0.48~~ 0.59	~~.52~~ ~~$0.48~~ ~~$0.11~~ .51

The Overpack and Ship disposal fee is based on sending other wastes to the repository under the Intermediate Separations alternative. If no wastes other than capsules are sent to the repository the disposal fee would be approx. $3,385 million 1995 dollars.

~~Rev A~~

Rev ~~B~~ C

3/18/96

7/16/96

Stein, David

From: Stein, David
To: Henderson, Colin
Subject: Capsule Alternatives Cost Revision(Repository Fee Change)
Date: Monday, March 18, 1996 1:54PM

Incorporating the revised Repository Fee method ($360,000 per canister) results in the following for the Capsule Alternatives:

Rev C.

CAPSULE ALTERNATIVES

	OVERPACK AND SHIP (millions)	VITRIFY WITH TANK WASTE (millions)
Current Operations	$377	$315
R&D	$14	$5
Capital	$32	$36
Operating	$34	~~$46~~ 37
M&M	—	$1
D&D	$6	$6
Repository Fee	~~$144~~ 124	~~$232~~ 111
Total	~~$607~~ 587	~~$641~~ 511

RECEIVED MAR 19 1996

25 pages + Appended Material
PS1/25

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering / Waste Loading & Blending Modifications to Support Final EIS.

ORIGINATOR Colin Henderson DATE 7/28/96

REVISION NO. 0

OBJECTIVE Using Previous Waste Loading Calculations (See Calc. dated 2/21/96) Revise HLW & LAW Volumes, Plant Sizes, and Canister Counts based on information obtained following release of DRAFT EIS.

METHODOLOGY Use WHC data packages as a basis, calculate HLW and LAW Volumes.

ASSUMPTIONS Noted. This calculation supersedes similar calculation dated 2/21/96

(Continue on another sheet if necessary)

J C Henderson 8/1/96
SIGNATURE/DATE

(RDW) 8-1-96
CHECKED/DATE

CALCULATION & RESULTS
ATTACHED

JACOBS\FORMS\CALCVR.SHT

1. HLW glass for any of the ex situ alternatives involving separations is calculated at 20 wt % waste oxides. The waste oxides exclude silica and sodium.
2. The HLW for the No Separations case is calculated at 20 wt % sodium oxide.
Note: EA glass limits are 17% Na_2O and 4.3% Li_2O and each Li_2O is equivalent to 2 Na_2O so the EA glass is equivalent to 25% Na_2O without any Li_2O. The privatization RFP states that the HLW glass will be 25 wt % waste oxides not counting the Na_2O or SiO_2.
3. The LAW glass composition is calculated at 15 wt % Na_2O.
4. The canister size for all HLW is set at 1.17 m^3 (2X canister), except No Separations Vit and Calcination HLW canister is 10 m^3
5. The material balances contained in the WHC data packages were used to calculate the waste oxides for the HLW and LAW streams.
6. Sensitivity analysis will be done for the Intermediate Separations alternative at 15 wt %, and 40 wt % waste oxide loading.
7. The material balance for the Intermediate Separations case was used for the Phased Implementation alternative and was modified by using the Extensive Separations material balance separations efficiencies for Tc, and TRU elements.
8. For purposes of interim onsite storage and transportation to the repository 4 of the 2x and 1 of the 10 m^3 canisters are assumed to be placed into an HMPC or similar packaging and would be repackaged at the repository.
9. The Intermediate Separations and Phased Implementation alt. Cs/Ba, Sr/Y inventory in the LAW stream was taken from calculation for LAW vault inventory revisions for FEIS.
Cs+Ba=10 MCi, Sr+Y=6.8 MCi.
10. The Combination alternatives were developed by summing the chemical and radiological constituents in the tanks that would be retrieved, converting the chemicals to waste oxides, apportioning the waste oxides between HLW and LAW based on the same separations percentage as the Intermediate Separations flowsheet, adding the waste oxides together and calculating the mass of HLW and LAW similar to the other alternatives.

Pg 3/25

Assumptions:							
1. HLW glass waste oxide loading basis to be 20 wt% sodium oxides							
2. Using the WHC engineering data package material balance calculate the waste oxide loading							
and adjust mass of the glass produced to achieve a 20 wt % sodium oxide loading							
	Input		Frit	Output			
	Stream1		stream407	stream437			
	liquids	solids					
Volume kilo-liters	5.85E+05						
Specific Gravity	1.21E+00						
Cs and Ba, (MCi)	6.28E+01	5.28E+00		6.79E+01			
Sr and Y, (MCi)	2.10E+00	1.05E+02		1.07E+02			
Tc, (MCi)	2.61E-02	5.89E-03		3.18E-02			
Am, (MCi)	8.61E-03	9.51E-02		1.04E-01			
Np, (MCi)	1.03E-05	9.29E-05		1.03E-04			
Pu-239, (MCi)	1.67E-03	2.47E-02		2.64E-02			
Pu-240, (MCi)	4.14E-04	6.28E-03		6.70E-03			
Pu-241,(MCi)	1.49E-03	7.34E-02		7.48E-02			
Total TRU, (MCi)	1.22E-02	2.00E-01		2.12E-01			
Total MCi	6.49E+01	1.11E+02		1.76E+02			
Total Mass Flow (MT)	7.10E+05	1.94E+04	2.50E+05	3.57E+05			
Total Cr, (MT)	5.15E+01	1.32E+02		1.84E+02			
Total Na, (MT)	6.51E+04	1.24E+03		6.63E+04			
Total Si, (MT)	5.65E+00	5.24E+02	9.56E+04	9.61E+04			
Total P, (MT)	8.42E+02	7.80E+02		1.62E+03			
Total NO2-, (MT)	9.54E+03	7.38E+01					
Total NO3-, (MT)	1.06E+05	1.03E+03					
AG+	3.28E-01	1.38E+00					
AG2O				1.83E+00			
AL+3		2.37E+03					
AL2O3			1.00E+04	1.79E+04			
AL(OH)4-	4.83E+03						
AM+3	2.51E-03	2.77E-02					
AM2O3				3.32E-02			
AS+5	7.70E-01	4.98E-01					
AS2O5				1.95E+00			
B+3	5.19E-01	9.94E-01					
B2O3				4.87E+00			
BA+2	7.91E-01	3.09E+00					
BAO				4.33E+00			
BE+2	8.19E-02	7.61E-03					
BEO				2.48E-01			
BI+3	6.76E+01	1.96E+02					
BI2O3				2.94E+02			
C14	7.43E-04	4.53E-04					
CA+2	1.67E+01	1.33E+02					
CANCRINITE		2.70E+03					
CAO			3.55E+04	3.58E+04			
CD+2	2.09E+00	7.93E+00					

CDO				1.14E+01			
CE+3	2.37E+00	2.35E+02					
CE2O3				2.78E+02			
CL-	3.11E+02	3.49E+00					
CL2							
CO							
CO2							
CO3-2	3.37E+03	2.25E+02					
CR+3		1.32E+02					
CR2O3				2.68E+02			
CR(OH)4-	1.19E+02						
CS+	8.19E-01	9.25E-02					
CS2O				9.65E-01			
CU+2	1.77E-01	7.46E-01					
CUO				1.16E+00			
CUSO4							
F-	1.12E+03	5.97E+01					
F2							
FE+3	1.44E+01	7.63E+02					
FE2O3				1.23E+03			
H2							
H2O	5.07E+05						
H2S							
HG							
HG+2	9.49E-01	9.00E-03					
I-	5.46E+02	2.02E+01					
I2							
K+	2.19E-01	2.10E+01					
K2O				2.56E+01			
KEROSENE							
LA+3	2.19E-01	2.10E+01					
LA2O3				2.49E+01			
LI+	5.77E-03	2.46E-02					
LI2O				6.53E-02			
MG+2	9.65E-01	1.10E+01					
MGO				1.98E+01			
MNO2	2.17E+01	2.09E+02		2.31E+02			
MO+6	4.87E+00	8.01E-01					
MOO3				8.51E+00			
N2							
NA+	6.51E+04	7.77E+02					
NA2O				8.94E+04			
NH3							
NI+3	4.07E+00	6.57E+00					
NI2FECN6		5.00E+02					
NI2O3				1.50E+01			
NIO				2.27E+02			
NO							
NO2							

NO2-	9.54E+03	7.38E+01					
NO3-	1.06E+05	1.03E+03					
NP+4	1.46E-02	1.32E-01					
NPO2				1.66E-01			
O2							
OH-	6.44E+03	5.00E+03					
PB+4	1.96E+00	3.28E+00					
PBO2				6.05E+00			
PO4-3	2.58E+03	2.39E+03					
P2O5				3.71E+03			
P2O5:24W		5.21E-01					
PU+4	2.88E-02	4.27E-01					
PUO2				5.16E-01			
S							
SI+4	5.65E+00	7.90E+01					
SIO2			2.04E+05	2.06E+05			
SO2							
SO4-2	2.01E+03	3.97E+01					
SR+2	3.75E-01	3.64E+01					
SRO				4.33E+01			
TCO2							
TCO4-	2.52E+00	5.68E-01					
TC2O7				2.94E+00			
TOC	1.42E+03	1.16E+02					
UO2+2	8.52E+01	1.58E+03					
UO3				1.76E+03			
V+5	6.20E-02	1.88E-01					
V2O5				4.46E-01			
W+6	7.47E-01						
WO2				4.41E-01			
WO3				9.42E-01			
ZN+2	3.59E+00	9.45E-01					
ZNO				5.65E+00			
ZR+4	4.48E-01	2.77E+02					
ZRO2				7.07E+02			
ZRO2:2H2	2.15E+01	4.09E+02					
WHC data package basis:							
mass waste oxides				1.08E+05			
waste loading (wt%)				30%			
sodium oxide loading				25%			

Pg 6/25

20 wt. % sodium oxide loading							
Blending factor			1	1.2	1.5	2	3.5
Mass of glass required to achieve 20% sodium loading, M			4.47E+05	5.36E+05	6.71E+05	8.94E+05	1564500
additional frit required (equals increased glass) MT			9.00E+04	1.79E+05	3.14E+05	5.37E+05	1.21E+06
total glass formers required, MT			3.40E+05	4.29E+05	5.64E+05	7.87E+05	1.46E+06
Waste Loading (Na20 wt. %)			20%	17%	13%	10%	6%
Waste Loading (waste oxides)			24%	20%	16%	12%	7%
glass density (MT/m^3)	2.63						
cullet packing fraction	0.7						
Waste volume (m^3)			2.43E+05	2.91E+05	3.64E+05	4.86E+05	8.50E+05
Canister Volume (m^3)	10						
Number of Canisters (1x)			2.43E+04	2.91E+04	3.64E+04	4.86E+04	8.50E+04
Number of Canisters per HMPC		1					
Number of HMPCs			2.43E+04	2.91E+04	3.64E+04	4.86E+04	8.50E+04
Number of trips @ 10 HMPCs /trip			2.43E+03	2.91E+03	3.64E+03	4.86E+03	8.50E+03
Facility Sizing							
Schedule	14 yrs						
Capacity MT/day	200						
Overall efficiency, %, based on 14 yrs @ 200 mt/day			~~44%~~	~~52%~~	~~66%~~	~~87%~~	~~153%~~
Required capacity MT/day (assuming 14 yrs ops, 60% OE)				~~175~~	~~219~~	~~292~~	~~510~~
Required operating duration yrs (assuming 200 MT/day, 60% OE)				12	~~15.31~~	~~20~~	~~36~~
Required operating duration (including 2 yrs start up)				14			

P8 7/25

Assumptions:

1. HLW glass waste oxide loading basis to be ~20 wt% waste oxides (excluding Na2O and SiO2) following a 1.2 blending factor

2. Using the WHC engineering data package material balance calculate the waste oxide loading and adjust mass of the glass produced to achieve a 20 wt % waste oxide loading

3. LAW glass sodium oxide loading basis is to be 15 wt%

	Input Stream			LAW			HLW			HLW fraction
	STREAM 1			407	437		314	344		(mass in HLW/
	solids	liquids		FRIT	GLASS		FRIT	GLASS		total mass)
Volume kilo-liters										
Specific Gravity										
Cs and Ba, (MCi)	5.28E+00	6.28E+01			1.00E+01			5.81E+01		8.53E-01
Sr and Y, (MCi)	1.05E+02	2.10E+00			6.80E+00			1.00E+02		9.37E-01
Tc, (MCi)	5.89E-03	2.61E-02			2.59E-02			5.91E-03		1.86E-01
Am, (MCi)	9.51E-02	8.61E-03			8.60E-03			9.52E-02		9.17E-01
Np, (MCi)	9.29E-05	1.03E-05			1.03E-05			9.29E-05		9.00E-01
Pu-239, (MCi)	2.47E-02	1.67E-03			1.67E-03			2.47E-02		9.37E-01
Pu-240, (MCi)	6.28E-03	4.14E-04			4.14E-04			6.28E-03		9.38E-01
Pu-241,(MCi)	7.34E-02	1.49E-03			1.48E-03			7.34E-02		9.80E-01
Total TRU, (MCi)	2.00E-01	1.22E-02			1.22E-02			2.00E-01		9.43E-01
Total MCi	1.11E+02	6.49E+01			2.43E+00			1.73E+02		9.86E-01
Total Mass Flow (MT)	1.94E+04	7.10E+05		2.81E+05	3.87E+05		1.36E+04	2.51E+04		
Total Cr, (MT)	1.32E+02	5.15E+01			1.44E+02			3.96E+01		2.16E-01
Total Na, (MT)	1.24E+03	6.51E+04			7.18E+04			2.33E+03		3.14E-02
Total Si, (MT)	5.24E+02	5.65E+00		1.07E+05	1.07E+05		5.29E+03	5.83E+03		
Total P, (MT)	7.80E+02	8.42E+02			1.35E+03			2.72E+02		1.68E-01
Total NO2-, (MT)	7.38E+01	9.54E+03								
Total NO3-, (MT)	1.03E+03	1.06E+05								
AG+	1.38E+00	3.28E-01								
AG2O					3.52E-01			1.48E+00		8.08E-01
AL+3	2.37E+03									
AL2O3				1.32E+04	1.94E+04			1.73E+03		2.18E-01
AL(OH)4-		4.83E+03								
AM+3	2.77E-02	2.51E-03								
AM2O3					2.76E-03			3.05E-02		9.17E-01
AS+5	4.98E-01	7.70E-01								
AS2O5					1.18E+00			7.66E-01		3.94E-01
B+3	9.94E-01	5.19E-01								
B2O3					1.67E+00		1.75E+03	1.76E+03		8.57E-01
BA+2	3.09E+00	7.91E-01								
BAO					8.81E-01			3.45E+00		7.97E-01
BE+2	7.61E-03	8.19E-02								
BEO					2.27E-01			2.16E-02		8.69E-02
BI+3	1.96E+02	6.76E+01								
BI2O3					7.52E+01			2.19E+02		7.44E-01
C14	4.53E-04	7.43E-04								
CA+2	1.33E+02	1.67E+01								
CANCRINITE	2.70E+03									
CAO				3.87E+04	3.87E+04			1.89E+02		
CD+2	7.93E+00	2.09E+00								
CDO					2.38E+00			9.06E+00		7.92E-01
CE+3	2.35E+02	2.37E+00								
CE2O3					2.79E+00			2.76E+02		9.90E-01
CL-	3.49E+00	3.11E+02								
CL2										
CO										
CO2										
CO3-2	2.25E+02	3.37E+03								
CR+3	1.32E+02									
CR2O3					2.11E+02			5.79E+01		2.15E-01
CR(OH)4-		1.19E+02								
CS+	9.25E-02	8.19E-01								
CS2O					6.83E-03			9.58E-01		9.93E-01
CU+2	7.46E-01	1.77E-01								
CUO					2.21E-01			9.34E-01		8.09E-01
CUSO4										
F-	5.97E+01	1.12E+03								
F2										
FE+3	7.63E+02	1.44E+01								
FE2O3					2.06E+01			1.21E+03		9.83E-01
H2										
H2O		5.07E+05								
H2S										

Pg 8/25

HG										
HG+2	9.00E-03	9.49E-01								
I-	2.02E+01	5.46E+02								
I2										
K+	2.10E+01	2.19E-01								
K2O					2.65E-01			2.53E+01		9.90E-01
KEROSENE										
LA+3	2.10E+01	2.19E-01								
LA2O3					2.58E-01			2.46E+01		9.90E-01
LI+	2.46E-02	5.77E-03								
LI2O					1.24E-02		5.00E+02	5.03E+02		9.96E-01
MG+2	1.10E+01	9.65E-01								
MGO					1.60E+00			1.88E+01		9.22E-01
MNO2	2.09E+02	2.17E+01			2.16E+01			2.09E+02		9.06E-01
MO+6	8.01E-01	4.87E+00								
MOO3					7.29E+00			1.22E+00		1.43E-01
N2										
NA+	7.77E+02	6.51E+04								
NA2O					9.68E+04			3.14E+03		3.14E-02
NH3										
NI+3	6.57E+00	4.07E+00								
NI2FECN6	5.00E+02									
NI2O3					5.72E+00			9.27E+00		6.18E-01
NIO					1.50E-02			2.27E+02		1.00E+00
NO										
NO2										
NO2-	7.38E+01	9.54E+03								
NO3-	1.03E+03	1.06E+05								
NP+4	1.32E-01	1.46E-02								
NPO2					1.66E-02			1.50E-01		9.00E-01
O2										
OH-	5.00E+03	6.44E+03								
PB+4	3.28E+00	1.96E+00								
PBO2					2.26E+00			3.79E+00		6.26E-01
PO4-3	2.39E+03	2.58E+03								
P2O5					3.09E+03			6.22E+02		1.68E-01
P2O5:24W	5.21E-01									
PU+4	4.27E-01	2.88E-02								
PUO2					3.26E-02			4.84E-01		9.37E-01
S										
SI+4	7.90E+01	5.65E+00								
SIO2				2.29E+05	2.29E+05		1.13E+04	1.25E+04		1.00E+00
SO2										
SO4-2	3.97E+01	2.01E+03								
SR+2	3.64E+01	3.75E-01								
SRO					4.00E-01			4.29E+01		9.91E-01
TCO2										
TCO4-	5.68E-01	2.52E+00								
TC2O7					2.39E+00			5.45E-01		1.86E-01
TOC	1.16E+02	1.42E+03								
UO2+2	1.58E+03	8.52E+01								
UO3					9.02E+01			1.67E+03		9.49E-01
V+5	1.88E-01	6.20E-02								
V2O5					1.11E-01			3.35E-01		7.51E-01
W+6		7.47E-01								
WO2					2.91E-05			4.41E-01		1.00E+00
WO3					9.40E-01			2.06E-03		2.19E-03
ZN+2	9.45E-01	3.59E+00								
ZNO					4.46E+00			1.19E+00		2.11E-01
ZR+4	2.77E+02	4.48E-01								
ZRO2					6.49E-01			6.90E+02		9.99E-01
ZRO2:2H2	4.09E+02	2.15E+01								
WHC Data Package Basis:										
Mass LAW waste oxides					106544.7302					
LAW waste loading (waste oxide)					28%					
LAW waste loading (sodium oxide)					25%					
Mass HLW waste oxides								7.26E+03		
HLW waste loading (waste oxides)										
HLW WOL (- Na2O, - SiO2)								29%		
HLW WOL (all tank waste)								46%		
HLW										

PS 9/25

20 wt. % waste oxide loading								
Blending factor			1	1.2	1.5	2	3.5	
Mass of glass required for 12,200 "long" can @ 1.2 Blend , MT			31287.18603	37544.62324	46930.77905	62574.37207	109505.1511	
additional frit required (equals increased glass) MT			6.19E+03	1.24E+04	2.18E+04	3.75E+04	8.44E+04	
total frit required, MT			1.98E+04	2.60E+04	3.54E+04	5.11E+04	9.80E+04	
WOL (- Na2O, - SiO2)			23%	20%	15%	12%	7%	
WOL (with all tank wastes)			37%	31%	25%	18%	11%	
glass density (MT/m^3)	2.63							
cullet packing fraction	0.7	(LAW only)						
Waste volume (m^3)			1.19E+04	1.43E+04	1.78E+04	2.38E+04	4.16E+04	
Canister Volume (m^3)	1.17							
Number of Canisters (2x)			1.02E+04	1.22E+04	1.53E+04	2.03E+04	3.56E+04	
Nu. of Canisters /HMPC	4							
Number of HMPCs			2.54E+03	3.05E+03	3.81E+03	5.08E+03	8.90E+03	
Number of trips @ 10 HMPCs /trip			254	305	381	508	890	
HLW Facility Sizing								
Schedule	14 yrs							
Capacity MT/day	20							
Overall efficiency, %			~~31%~~	37%	~~46%~~	~~61%~~	~~107%~~	
Required capacity MT/day (assuming 14 yrs ops, 60% OE)			~~10.20~~	12.25	~~15.31~~	~~20.41~~	~~35.72~~	
Required operating duration yrs (assuming 20 MT/day, 60% OE)				9	~~10.71~~	~~14.29~~	~~25.00~~	
Required operating duration, yrs, including 2 yrs. start up				11				
15 wt % waste oxide loading								
Mass of glass required to achieve 15% wo loading MT			4.84E+04	5.81E+04	7.26E+04	9.68E+04	1.69E+05	
Volume (m^3)			1.84E+04	2.21E+04	2.76E+04	3.68E+04	6.44E+04	
Number of Canisters (1x)			1.57E+04	1.89E+04	2.36E+04	3.15E+04	5.50E+04	
Additional Glass Formers Req, MT			2.33E+04	3.30E+04	4.75E+04	7.17E+04	1.44E+05	
Total Glass Formers, MT			3.69E+04	4.66E+04	6.11E+04	8.53E+04	1.58E+05	
40 wt % waste oxide loading								
Mass of glass required to achieve 40% wo loading MT			1.81E+04	2.18E+04	2.72E+04	3.63E+04	6.35E+04	
Volume (m^3)			6.90E+03	8.28E+03	1.03E+04	1.38E+04	2.41E+04	
Number of Canisters (1x)			5.90E+03	7.08E+03	8.85E+03	1.18E+04	2.06E+04	
Additional Glass Formers Req, MT			-6.95E+03	-3.32E+03	2.12E+03	1.12E+04	3.84E+04	
Total Glass Formers Req, MT			6.65E+03	1.03E+04	1.57E+04	2.48E+04	5.20E+04	
LAW								
15 wt. % sodium oxide loading								
Blending factor			1	1.25	1.5	2	3.5	
Mass of glass required to achieve 15% wo loading, MT			6.45E+05	8.07E+05	9.68E+05	1.29E+06	2.26E+06	
additional frit required (equals increased glass) MT			2.58E+05	4.20E+05	5.81E+05	9.04E+05	1.87E+06	
total frit required, MT			5.39E+05	7.01E+05	8.62E+05	1.18E+06	2.15E+06	
glass density (MT/m^3)	2.63							
cullet packing fraction	0.7							
Waste volume (m^3)			3.51E+05	3.81E+05	4.68E+05	6.43E+05	1.17E+06	
Number of 5300 m^3 vaults			66	72	88	121	221	
LAW facility sizing								
Schedule, years	14							
Capacity MT/day	200							
Overall efficiency, %			~~63%~~	~~79%~~	~~95%~~	~~126%~~	~~221%~~	
Required capacity MT/day (assuming 14 yrs ops, 60% OE)			~~210.48~~	~~263.10~~	~~315.72~~	~~420.96~~	~~736.68~~	
Required operating duration yrs (assuming 200 MT/day, 60% OE)			15	~~18.42~~	~~22.10~~	~~29.47~~	~~51.57~~	

Pg 10/25

Required operating duration, yrs (with 2 yrs start up)				17					
10 wt. % sodium oxide loading									
Blending factor				1	1.25		2	3.5	
Mass of glass required to achieve 10				9.68E+05	1.21E+06		1.94E+06	3.39E+06	
Additional Glass Formers , MT				5.81E+05	8.23E+05		1.55E+06	3.00E+06	
Total Glass Formers, MT				8.62E+05	1.10E+06		1.83E+06	3.28E+06	
Waste volume, m^3				5.26E+05	6.57E+05		1.05E+06	1.84E+06	
Number of 5,300 m^3 vaults				99	124		198	347	
25 wt. % sodium oxide loading									
Blending factor				1	1.25		2	3.5	
Mass of glass required to achive 25 wt % Na2O				3.87E+05	4.84E+05		7.74E+05	1.36E+06	
Additional Glass Formers, MT				0.00E+00	9.70E+04		3.87E+05	9.68E+05	
Total Glass Formers, MT				2.81E+05	3.78E+05		6.68E+05	1.25E+06	
Waste Volume				210320.478	262900.5975		420640.956	736121.673	
Number of 5,300 m^3 vaults				40	50		79	139	

Assumptions:

1. HLW glass waste oxide loading basis to be ~20 wt% waste oxides (excluding Na2O and SiO2) following a 1.2 blending factor
2. Using the WHC engineering data package material balance calculate the waste oxide loading and adjust mass of the glass produced to achieve a 20 wt % waste oxide loading not counting the SiO2 or the Na2O

	Input Stream			LAW			HLW			HLW fraction
	STREAM 1			407	437		1314	1344		
	solids	liquids		FRIT	GLASS		FRIT	GLASS		
Volume kilo-liters		5.84E+05								
Specific Gravity		1.21E+00								
Cs and Ba, (MCi)	7.60E+00	6.72E+01			6.86E-02			7.46E+01		0.997326203
Sr and Y, (MCi)	1.37E+02	1.41E+00			1.40E-02			1.37E+02		0.989812875
Tc, (MCi)	5.89E-03	2.61E-02			1.53E-04			3.17E-02		0.990934667
Am, (MCi)										
Np, (MCi)										
Pu-239, (MCi)										
Pu-240, (MCi)										
Pu-241,(MCi)										
Total TRU, (MCi)	1.92E-01	1.52E-02			1.20E-03			2.06E-01		0.994208494
Total MCi	1.45E+02	6.87E+01			8.39E-02			2.12E+02		0.992044923
Total Mass Flow (MT)	2.37E+04	7.06E+05		2.65E+05	3.86E+05		8.73E+02	1.32E+03		
Total Cr, (MT)										
Total Na, (MT)										
Total Si, (MT)										
Total P, (MT)										
Total NO2-, (MT)										
Total NO3-, (MT)										
AG+	1.38E+00	3.28E-01								
AG2O					4.07E-01			1.43E+00		
AL+3	2.37E+03									
AL2O3				1.16E+04	1.93E+04			1.94E+02		
AL(OH)4-		4.83E+03								
AM+3	2.77E-02	2.51E-03								
AM2O3					3.41E-05			3.32E-02		
APM-								3.44E-03		
AS+5	4.98E-01	7.70E-01								
AS2O5					4.33E-01			1.51E+00		
B+3	9.94E-01	5.19E-01								
B2O3					4.82E+00		1.22E+02	1.22E+02		
BA+2	3.09E+00	7.91E-01								
BAO					8.76E-01			3.46E+00		
BE+2	7.61E-03	8.19E-02								
BEO					5.53E-02			1.93E-01		
BI+3	1.96E+02	6.76E+01								
BI2O3					2.90E+02			3.45E+00		
C14	4.53E-04	7.43E-04								
CA+2	1.33E+02	1.67E+01								
CANCRINITE	2.70E+03									
CAO				3.84E+04	3.86E+04			2.34E+00		
CD+2	7.93E+00	2.09E+00								
CDO					1.13E+01			1.26E-01		
CE+3	2.35E+02	2.37E+00								
CE2O3					2.75E+02			3.40E+00		
CL-	3.49E+00	3.11E+02								
CL2										
CO										
CO2										
CO3-2	2.25E+02	3.37E+03								
CR+3	1.32E+02									
CR2O3					2.67E+02			1.38E+00		
CR(OH)4-		1.19E+02								

Pg 12/25

CS+	9.25E-02	8.19E-01								
CS2O					8.85E-04			9.64E-01		
CU+2	7.46E-01	1.77E-01								
CUO					2.57E-01			8.99E-01		
CUSO4										
F-	5.97E+01	1.12E+03								
F2										
FE+3	7.63E+02	1.44E+01								
FE2O3					3.74E+03			4.24E+01		
H2										
H2O		5.07E+05			2.11E-04			1.10E+00		
H2S										
HG										
HG+2	9.00E-03	9.49E-01								
HGO					2.07E+00					
I-	2.02E+01	5.46E+02								
I2										
K+	2.10E+01	2.19E-01								
K2O					2.55E+01			2.34E-02		
KEROSENE										
LA+3	2.10E+01	2.19E-01								
LA2O3					2.46E+01			3.04E-01		
LI+	2.46E-02	5.77E-03								
LI2O					6.53E-02		1.32E+01	1.32E+01		
MG+2	1.10E+01	9.65E-01								
MGO					1.96E+01			2.20E-01		
MNO2	2.09E+02	2.17E+01			2.31E+02			1.08E-01		
MO+6	8.01E-01	4.87E+00								
MOO3					1.03E+01			9.24E-02		
N2										
NA+	3.21E+03	6.26E+04								
NA2O					9.65E+04		2.40E+01	6.59E+01		
NH3										
NI+3	6.57E+00	4.07E+00								
NI2FECN6	5.00E+02									
NI2O3					2.62E+02			2.82E+00		
NIO					1.06E-03			1.20E+00		
NO										
NO2										
NO2-	7.38E+01	9.54E+03								
NO3-	1.03E+03	1.06E+05								
NP+4	1.32E-01	1.46E-02								
NPO2					6.52E-03			1.66E-01		
O2										
OH-	6.80E+03	4.64E+03								
PB+4	3.28E+00	1.96E+00								
PBO2					1.35E+00			4.71E+00		
PO4-3	2.39E+03	2.58E+03								
P2O5					3.68E+03			3.96E+01		
P2O5:24W	5.21E-01									
PU+4	4.27E-01	2.88E-02								
PUO2					5.42E-03			5.11E-01		
S										
SI+4	7.90E+01	5.65E+00								
SIO2				2.15E+05	2.16E+05		7.13E+02	7.52E+02		
SO2										
SO3					6.22E+03			1.92E-03		
SO4-2	3.97E+01	2.01E+03								
SR+2	3.64E+01	3.75E-01								
SRO					4.41E-03			4.33E+01		
TCO2										
TCO4-	5.68E-01	2.52E+00								
TC2O7					1.41E-02			2.92E+00		

TIO2					3.16E-02			3.51E-04		
TOC	1.16E+02	1.42E+03								
UO2+2	1.58E+03	8.52E+01								
UO3								2.77E+00		
U3O8					1.08E+00			1.15E-02		
V+5	1.88E-01	6.20E-02								
V2O5					9.92E-02			3.47E-01		
W+6		7.47E-01								
WO2					1.09E-06			2.26E-04		
WO3					2.10E-01			7.33E-01		
ZN+2	9.45E-01	3.59E+00								
ZNO					3.17E+01			4.31E-01		
ZR+4	2.77E+02	4.48E-01								
ZRO2					6.99E+02			8.55E+00		
ZRO2:2H2	4.09E+02	2.15E+01								
Mass LAW waste oxides					121198.787					
LAW waste loading (waste oxides)					31%					
LAW waste loading (sodium oxide)					25%					
Mass HLW waste oxides								3.42E+02		
HLW waste loading(-Na,-Si)								26%		
HLW WOL (all tank waste)								34%		
HLW										
20 wt. % waste oxide loading										
Blending factor				1	1.2	1.5	2	3.5		
Mass of glass required to achieve 20% wo loading, MT				1462.562899	1755.075479	2193.844349	2925.1258	5118.970148		
additional frit required (equals increased glass) MT				1.43E+02	4.35E+02	8.74E+02	1.61E+03	3.80E+03		
total frit required, MT				1.02E+03	1.31E+03	1.75E+03	2.48E+03	4.67E+03		
WOL (-Na,- Si)				23%	20%	16%	12%	7%		
WOL (all tank waste)				31%	25%	20%	15%	9%		
glass density (MT/m^3)	2.63									
cullet packing fraction	0.7	(LAW only)								
Waste volume (m^3)				5.56E+02	6.67E+02	8.34E+02	1.11E+03	1.95E+03		
Canister Volume (m^3)	1.17									
Number of Canisters (2x)				4.75E+02	5.70E+02	7.13E+02	9.51E+02	1.66E+03		
Nu. of Canisters /HMPC	4									
Number of HMPCs				1.19E+02	1.43E+02	1.78E+02	2.38E+02	4.16E+02		
Number of trips @ 10 HMPCs /trip				12	14	18	24	42		
HLW Facility Sizing										
Schedule	14 yrs									
Capacity MT/day	1									
Overall efficiency, %				~~29%~~	~~34%~~	~~43%~~	~~57%~~	~~100%~~		
Required capacity MT/day (assuming 14 yrs ops, 60% OE)				~~0.48~~	~~0.57~~	~~0.72~~	~~0.95~~	~~1.67~~		
Required operating duration yrs (assuming 1 MT/day, 60% OE)					8	~~10.02~~	~~13.36~~	~~23.37~~		
Required operating duration , yrs (includes 2 yrs start up)					10					
LAW										
15 wt. % sodium oxide loading										
Blending factor				1	1.25	1.5	2	3.5		
Mass of glass required to achieve 15% wo loading, MT				6.43E+05	8.04E+05	9.65E+05	1.29E+06	2.25E+06		
additional frit required (equals increased glass) MT				2.57E+05	4.18E+05	5.79E+05	9.01E+05	1.87E+06		
total frit required, MT				5.22E+05	6.83E+05	8.44E+05	1.17E+06	2.13E+06		

Pg 14/25

glass density (MT/m^3)	2.63									
cullet packing fraction	0.7									
Waste volume (m^3)				3.49E+05	4.37E+05	5.24E+05	6.99E+05	1.22E+06		
Number of 5300 m^3 vaults				66	83	99	132	231		
LAW facility sizing										
Schedule, years	19									
Capacity MT/day	200									
Overall efficiency, %				~~46%~~	~~58%~~	~~70%~~	~~93%~~	~~162%~~		
Required capacity MT/day (assuming 19 yrs ops, 60% OE)				~~154.61~~	~~193.26~~	~~231.92~~	~~309.22~~	~~541.14~~		
Required operating duration yrs (assuming 200 MT/day, 60% OE)				15	~~18.36~~	~~22.03~~	~~29.38~~	~~51.41~~		
Required operation duration, yrs (including 2 yrs start up)				17						

P8 15/25

Assumptions:

1. HLW glass waste oxide loading basis to be ~ 20 wt% waste oxides with a 1.2 blending factor (excluding Na2O and SiO2)
2. Using the WHC engineering data package material balance calculate the waste oxide loading and adjust mass of the glass produced to achieve a 20 wt % waste oxide loading
3. LAW glass sodium oxide loading basis is to be 15 wt%

	Input Stream			LAW			HLW			HLW fraction
	STREAM 1	converted to		407	437		314	344		from Int. Sep.
		oxides		FRIT	GLASS		FRIT	GLASS		
Volume kilo-liters										
Specific Gravity										
Cs and Ba, (MCi)	6.66E+01				9.78E+00			5.68E+01		8.53E-01
Sr and Y, (MCi)	8.29E+01				5.26E+00			7.76E+01		9.37E-01
Tc, (MCi)	2.94E-02				2.39E-02			5.46E-03		1.86E-01
Am, (MCi)	7.98E-02				6.61E-03			7.32E-02		9.17E-01
Np, (MCi)	1.38E-04				1.38E-05			1.24E-04		9.00E-01
Pu-239, (MCi)	1.66E-04				1.05E-05			1.55E-04		9.37E-01
Pu-240, (MCi)	4.08E-03				2.52E-04			3.83E-03		9.38E-01
Pu-241,(MCi)	4.67E-02				9.23E-04			4.58E-02		9.80E-01
Total TRU, (MCi)	1.48E-01				8.51E-03			1.39E-01		9.43E-01
Total MCi	1.50E+08				2.08E+06			1.48E+08		9.86E-01
Total Mass Flow (MT)				3.28E+05			1.17E+04			
Total Cr, (MT)										2.16E-01
Total Na, (MT)										3.14E-02
Total Si, (MT)										
Total P, (MT)										1.68E-01
Total NO2-, (MT)										
Total NO3-, (MT)										
AG+	0.50337									
AG2O		5.41E-01			1.04E-01			4.37E-01		8.08E-01
AL+3	1681.486									
AL2O3		6.38E+03		1.54E+04	2.04E+04			1.39E+03		2.18E-01
AL(OH)4-	5968.793									
AM+3										
AM2O3										9.17E-01
AS+5	1.0285									
AS2O5		1.58E+00			9.56E-01			6.21E-01		3.94E-01
B+3	0.6485									
B2O3		2.09E+00			2.99E-01		1.51E+03	1.51E+03		8.57E-01
BA+2	1.1804									
BAO		1.32E+00			2.68E-01			1.05E+00		7.97E-01
BE+2	131.8917									
BEO		3.66E+02			3.35E+02			3.18E+01		8.69E-02
BI+3	2.21859									
BI2O3		2.47E+00			6.32E-01			1.84E+00		7.44E-01
C14										
CA+2	62.2086									
CANCRINITE										
CAO		8.71E+01		4.52E+04	4.52E+04			7.85E+01		9.02E-01
CD+2	5.6576									
CDO		6.46E+00			1.34E+00			5.12E+00		7.92E-01
CE+3	153.1929									
CE2O3		1.79E+02			1.80E+00			1.78E+02		9.90E-01
CL-	260.9235									
CL2										
CO										
CO2										
CO3-2	2240.289									
CR+3	64.3875									
CR2O3		9.63E+01			7.56E+01			2.07E+01		2.15E-01
CR(OH)4-	102.4395									
CS+										
CS2O								0.00E+00		9.93E-01
CU+2	0.4759									
CUO		5.96E-01			1.14E-01			4.82E-01		8.09E-01

Pg 16/25

CUSO4										
F-	739.1503									
F2										
FE+3	509.9566									
FE2O3		7.29E+02			1.22E+01			7.17E+02		9.83E-01
H2										
H20										
H2S										
HG										
HG+2	0.7113									
I-										
I2										
K+	353.4002									
K2O		4.21E+02			4.37E+00			4.17E+02		9.90E-01
KEROSENE										
LA+3	3.1199									
LA2O3		3.66E+00			3.80E-02			3.62E+00		9.90E-01
LI+	0.0243									
LI2O		5.21E-02			2.14E-04		4.31E+02	4.31E+02		9.96E-01
MG+2	1.173									
MGO		8.92E-01			7.00E-02			8.22E-01		9.22E-01
MNO2	105.73	1.67E+02			1.57E+01			1.52E+02		9.06E-01
MO+6	5.0199									
MOO3		7.53E+00			6.45E+00			1.08E+00		1.43E-01
N2										
NA+	45382.16									
NA2O		6.12E+04			5.92E+04			1.92E+03		3.14E-02
NH3										
NI+3	137.5048									
NI2FECN6	223.597									
NI2O3		2.50E+02			9.54E+01			1.55E+02		6.18E-01
NIO										1.00E+00
NO										
NO2										
NO2-	6495.108									
NO3-	71426.9									
NP+4										
NPO2										9.00E-01
O2										
OH-	5131.203									
PB+4	3.0014									
PBO2		3.47E+00			1.29E+00			2.17E+00		6.26E-01
PO4-3	2824.588									
P2O5		2.11E+03			1.76E+03			3.54E+02		1.68E-01
P2O5:24W										
PU+4										
PUO2										9.37E-01
S										
SI+4										
SIO2	890.9147	7.03E+02		2.67E+05	2.67E+05		9.72E+03	1.04E+04		1.00E+00
SO2										
SO4-2	1597.07									
SR+2	31.928									
SRO		3.77E+01			3.49E-01			3.74E+01		9.91E-01
TCO2										
TCO4-										
TC2O7										1.86E-01
TOC	931.291									
UO2+2	1.5866									
UO3		1.59E+03			8.13E+01			1.50E+03		9.49E-01
V+5	0.0694									
V2O5		1.24E-01								7.51E-01
W+6	11.328									
WO2										1.00E+00
WO3		1.43E+01			1.43E+01			3.12E-02		2.19E-03

Pg 17/25

ZN+2	2.9658									
ZNO		3.69E+00			2.91E+00			7.77E-01		2.11E-01
ZR+4	16.2216									
ZRO2		2.19E+01			2.06E-02			2.19E+01		9.99E-01
ZRO2:2H2										
Waste Oxides Total (MT)					6.66E+04			7.70E+03		
Waste Oxides Less Na & Si								5.08E+03		
HLW										
20 wt. % waste oxide loading										
Blending factor				1	1.2	1.5	2	3.5		
Mass of glass required				2.19E+04	2.63E+04	3.28E+04	4.38E+04	7.66E+04		
glass formers required MT				1.42E+04	1.86E+04	2.51E+04	3.61E+04	6.89E+04		
WOL (- Na2O, - SiO2)				23%	20%	15%	12%	7%		
WOL (with all tank wastes)				35%	29%	23%	18%	10%		
Glass Formers Required										
B2O3 (MT)				1.83E+03	2.39E+03	3.23E+03	4.64E+03	8.87E+03		
Li2O (MT)				5.22E+02	6.83E+02	9.25E+02	1.33E+03	2.54E+03		
SiO2 (MT)				1.18E+04	1.54E+04	2.09E+04	3.00E+04	5.73E+04		
glass density (MT/m^3)	2.63									
cullet packing fraction	0.7	(LAW only)								
Waste volume (m^3)				8.32E+03	9.99E+03	1.25E+04	1.66E+04	2.91E+04		
Canister Volume (m^3)	1.17									
Number of Canisters (2x)				7.11E+03	8.54E+03	1.07E+04	1.42E+04	2.49E+04		
Nu. of Canisters /HMP	4									
Number of HMPCs				1.78E+03	2.13E+03	2.67E+03	3.56E+03	6.22E+03		
Number of trips @ 10 HMPCs /trip				178	213	267	356	622		
HLW Facility Sizing										
Schedule	14 yrs									
Capacity MT/day	8									
Overall efficiency, %				~~35%~~	~~45%~~	~~61%~~	~~88%~~	~~169%~~		
Required capacity MT/day (assuming 14 yrs ops, 60% OE)				~~4.63~~	~~6~~	~~8~~	~~12~~	~~22~~		
Required operating duration yrs (assuming 8 MT/day, 60% OE)				~~12.95~~	11	~~23~~	~~33~~	~~63~~		
Required operating duration (2 yrs start up)					13					
LAW										
15 wt. % sodium oxide loading										
Blending factor				1	1.25	1.5	2	3.5		
Mass of glass required to achieve 15% wo loading, MT				3.95E+05	4.94E+05	5.92E+05	7.90E+05	1.38E+06		
total frit required, MT				3.28E+05	4.27E+05	5.26E+05	7.23E+05	1.32E+06		

Pg 18/25

Glass formers										
Al2O3				1.54E+04	2.01E+04	2.47E+04	3.40E+04	6.18E+04		
CaO				4.52E+04	5.88E+04	7.24E+04	9.96E+04	1.81E+05		
SiO2				2.68E+05	3.48E+05	4.28E+05	5.89E+05	1.07E+06		
glass density (MT/m^3)	2.63									
cullet packing fraction	0.7									
Waste volume (m^3)				2.15E+05	2.68E+05	3.22E+05	4.29E+05	7.51E+05	########	
Number of 5300 m^3 vaults				40	51	61	81	142		
LAW facility sizing										
Schedule, years	14									
Capacity MT/day	120									
Overall efficiency, %				~~64%~~	~~81%~~	~~97%~~	~~129%~~	~~225%~~		
Required capacity MT/day (assuming 15 yrs ops, 60% OE)				~~120~~	~~150~~	~~180~~	~~240~~	~~421~~		
Required operating duration yrs (assuming 120 MT/day, 60% OE)				15	~~19~~	~~23~~	~~30~~	~~53~~		
Operating duration (with 2 yrs start up)				17						

P819/25

Assumptions:
1. HLW glass waste oxide loading basis to be 20 wt% waste oxides (excluding Na2O and SiO2)
2. Using the WHC engineering data package material balance calculate the waste oxide loading and adjust mass of the glass produced to achieve a 20 wt % waste oxide loading
3. LAW glass sodium oxide loading basis is to be 15 wt%

	Input Stream	Input	LAW		HLW		HLW fraction
	STREAM 1	converted to	407	437	314	344	from Int. Sep.
		oxides	FRIT	GLASS	FRIT	GLASS	
Volume kilo-liters							
Specific Gravity							
Cs and Ba, (MCi)	63.774			9.37E+00		5.44E+01	8.53E-01
Sr and Y, (MCi)	43.032			2.73E+00		4.03E+01	9.37E-01
Tc, (MCi)	0.0274			2.23E-02		5.09E-03	1.86E-01
Am, (MCi)	0.0763			6.32E-03		7.00E-02	9.17E-01
Np, (MCi)	0.0001			9.98E-06		9.00E-05	9.00E-01
Pu-239, (MCi)	0.0076			4.81E-04		7.12E-03	9.37E-01
Pu-240, (MCi)	0.0019			1.18E-04		1.78E-03	9.38E-01
Pu-241,(MCi)	0.0189			3.74E-04		1.85E-02	9.80E-01
Total TRU, (MCi)	0.1053			6.05E-03		9.92E-02	9.43E-01
Total MCi	115.095			1.59E+00		1.14E+02	9.86E-01
Total Mass Flow (MT)			1.91E+05		6.88E+03		
Total Cr, (MT)							2.16E-01
Total Na, (MT)							3.14E-02
Total Si, (MT)							
Total P, (MT)							1.68E-01
Total NO2-, (MT)							
Total NO3-, (MT)							
AG+	5.05E-01						
AG2O		5.43E-01		1.04E-01		4.39E-01	8.08E-01
AL+3	4.33E+02						
AL2O3		3.51E+03	8.98E+03	1.17E+04		7.66E+02	2.18E-01
AL(OH)4-	5.02E+03						
AM+3							
AM2O3	0.02452	2.45E-02		2.03E-03		2.25E-02	9.17E-01
AS+5	1.04E+00						
AS2O5		1.59E+00		9.66E-01		6.27E-01	3.94E-01
B+3	9.68E-01						
B2O3		3.12E+00		4.47E-01	8.85E+02	8.88E+02	8.57E-01
BA+2	2.89E+00						
BAO		3.23E+00		6.57E-01		2.57E+00	7.97E-01
BE+2	6.61E-02						
BEO		1.84E-01		1.68E-01		1.60E-02	8.69E-02
BI+3	2.05E+01						
BI2O3		2.29E+01		5.85E+00		1.70E+01	7.44E-01
C14							
CA+2	3.21E+01						
CANCRINITE							
CAO		4.49E+01	2.63E+04	2.63E+04		4.05E+01	9.02E-01
CD+2	6.14E+00						
CDO		7.01E+00		1.46E+00		5.55E+00	7.92E-01
CE+3	8.75E+01						
CE2O3		1.02E+02		1.03E+00		1.01E+02	9.90E-01
CL-	2.62E+02						
CL2							
CO							
CO2							
CO3-2	1.88E+03						
CR+3	3.31E+01						
CR2O3		5.05E+01		3.97E+01		1.09E+01	2.15E-01
CR(OH)4-	9.93E+01						
CS+							
CS2O		4.88E-01		3.46E-03		4.85E-01	9.93E-01
CU+2	5.82E-01						
CUO		7.28E-01		1.39E-01		5.89E-01	8.09E-01
CUSO4							
F-	1.22E+02						
F2							
FE+3	2.33E+02						

FE2O3		3.33E+02			5.58E+00		3.28E+02	9.83E-01
H2								
H20								
H2S								
HG								
HG+2	1.35E-01							
I-								
I2								
K+	3.63E+02							
K2O		4.33E+02			4.49E+00		4.29E+02	9.90E-01
KEROSENE								
LA+3	1.93E+01							
LA2O3		2.27E+01			2.35E-01		2.24E+01	9.90E-01
LI+	2.46E-02							
LI2O		5.27E-02			2.17E-04	2.53E+02	2.53E+02	9.96E-01
MG+2	9.33E+00							
MGO		7.10E+00			5.57E-01		6.54E+00	9.22E-01
MNO2	7.37E+01	1.17E+02			1.09E+01		1.06E+02	9.06E-01
MO+6	5.10E+00							
MOO3		7.64E+00			6.55E+00		1.10E+00	1.43E-01
N2								
NA+	2.63E+04							
NA2O		3.55E+04			3.44E+04		1.12E+03	3.14E-02
NH3								
NI+3	5.91E+01							
NI2FECN6	8.62E+01							
NI2O3		1.05E+02			4.00E+01		6.49E+01	6.18E-01
NIO								1.00E+00
NO								
NO2								
NO2-	4.57E+03							
NO3-	3.99E+04							
NP+4								
NPO2		1.34E-01			1.34E-02		1.21E-01	9.00E-01
O2								
OH-	2.25E+03							
PB+4	4.79E+00							
PBO2		5.53E+00			2.07E+00		3.46E+00	6.26E-01
PO4-3	1.32E+03							
P2O5		9.89E+02			8.23E+02		1.66E+02	1.68E-01
P2O5:24W								
PU+4								
PUO2		1.50E-01			9.44E-03		1.40E-01	9.37E-01
S								
SI+4								
SIO2	4.59E+02	4.59E+02		1.56E+05	1.56E+05	5.72E+03	6.18E+03	1.00E+00
SO2								
SO4-2	1.06E+03							
SR+2	3.73E-01							
SRO		4.41E-01			4.07E-03		4.37E-01	9.91E-01
TCO2								
TCO4-								
TC2O7		2.54E+00			2.07E+00		4.71E-01	1.86E-01
TOC	1.10E+03							
UO2+2	1.69E+00							
UO3		8.67E+02			4.44E+01		8.23E+02	9.49E-01
V+5								
V2O5								7.51E-01
W+6	1.99E+00							
WO2								1.00E+00
WO3		2.50E+00			2.50E+00		5.47E-03	2.19E-03
ZN+2	3.26E+00							
ZNO		4.06E+00			3.20E+00		8.54E-01	2.11E-01
ZR+4	2.72E+01							
ZRO2		3.67E+01			3.45E-02		3.67E+01	9.99E-01
ZRO2:2H2								
Waste Oxides Total (MT)					3.81E+04		4.51E+03	
Waste Oxides Less Na & Si							2.94E+03	

p821/25

HLW								
20 wt. % waste oxide loading								
Blending factor			1	**1.2**	1.5	2	3.5	
Mass of glass required			1.27E+04	**1.52E+04**	1.90E+04	2.53E+04	4.43E+04	
frit required MT			8.15E+03	**1.07E+04**	1.45E+04	2.08E+04	3.98E+04	
WOL (- Na2O, - SiO2)			23%	**20%**	15%	12%	7%	
WOL (with all tank wastes)			36%	**30%**	24%	18%	10%	
Glass Formers Required								
B2O3 (MT)			1.05E+03	**1.37E+03**	1.86E+03	2.68E+03	5.12E+03	
Li2O (MT)			3.00E+02	**3.93E+02**	5.33E+02	7.66E+02	1.46E+03	
SiO2 (MT)			6.77E+03	**8.87E+03**	1.20E+04	1.73E+04	3.31E+04	
glass density (MT/m^3)	2.63							
cullet packing fraction	0.7	(LAW only)						
Waste volume (m^3)			~~4.81E+03~~	**5.78E+03**	~~7.22E+03~~	~~9.63E+03~~	~~1.68E+04~~	
Canister Volume (m^3)	1.17							
Number of Canisters (2x)			~~4.11E+03~~	**4.94E+03**	~~6.17E+03~~	~~8.23E+03~~	~~1.44E+04~~	
Nu. of Canisters /HMPC	4							
Number of HMPCs			~~1.03E+03~~	**1.23E+03**	~~1.54E+03~~	~~2.06E+03~~	~~3.60E+03~~	
Number of trips @ 10 HMPCs /trip			~~103~~	**123**	✓ ~~154~~	~~206~~	~~360~~	
HLW Facility Sizing								
Schedule	14 yrs							
Capacity MT/day	**4.5**							
Overall efficiency, %			~~35%~~	~~46%~~	~~63%~~	~~90%~~	~~173%~~	
Required capacity MT/day (assuming 14 yrs ops, 60% OE)			~~2.66~~	~~3.48~~	~~4.72~~	~~6.79~~	~~12.98~~	
Required operating duration yrs (assuming 4.5 MT/day, 60% OE)			~~12.00~~	**11**	~~22.00~~	~~32.00~~	~~61.00~~	
Required Operating duration, yrs (including 2 yrs start up)				**13**				
LAW								
15 wt. % sodium oxide loading								
Blending factor			1	1.25	1.5	2	3.5	
Mass of glass required to achieve 15% wo loading, MT			**2.29E+05**	2.87E+05	3.44E+05	4.59E+05	8.03E+05	
total glass formers required, MT			**1.91E+05**	2.48E+05	3.06E+05	4.20E+05	7.64E+05	
glass density (MT/m^3)	2.63							
cullet packing fraction	0.7							
Glass formers (MT)								
Al2O3			**8.98E+03**	1.17E+04	1.44E+04	1.98E+04	3.59E+04	
CaO			**2.63E+04**	3.42E+04	4.21E+04	5.79E+04	1.05E+05	
SiO2			**1.56E+05**	2.02E+05	2.49E+05	3.43E+05	6.23E+05	
Waste volume (m^3)			**1.25E+05**	1.56E+05	1.87E+05	2.49E+05	4.36E+05	
Number of 5300 m^3 vaults			**24**	29	35	47	82	
LAW facility sizing								
Schedule, years	14							
Capacity MT/day	200							
Overall efficiency, %			~~22%~~	~~28%~~	~~34%~~	~~45%~~	~~79%~~	
Required capacity MT/day (assuming 15 yrs ops, 60% OE)			**70**	~~87~~	~~105~~	~~140~~	~~244~~	
Required operating duration yrs (assuming 70 MT/day, 60% OE)			**15**	~~18.70~~	~~22.44~~	~~29.92~~	~~52.35~~	
Operating duration (including 2 yrs start up)			**17**					

P822/25

Mass of calcined waste,MT	1.68E+05
Volume of Calcined Waste, m^3	6.70E+04
Number of Canisters @ 10 m^3	10300
Number of Canisters @ .62 m^3	154700
Number of HMPCs @ 1 10m^3 can/HMPC	10300

P8 23/25

Assumptions:
1. Phased Implementation Separations and Treatment is similar to Intermediate Separations
except the separations for Sr, Tc, and TRU elements are taken from Extensive Separations
2. HLW glass waste oxide loading basis to be ~20 wt% waste oxides
not counting the Na2O or SiO2 in the waste feed stream following a 1.2 blend factor
3. Using the WHC engineering data package material balance calculate the waste oxide loading
and adjust mass of the glass produced to achieve a 20 wt % waste oxide loading
4. LAW glass sodium oxide loading basis is to be 15 wt%

	Input Stream			LAW			HLW		
	STREAM 1			407	437		314	344	
	solids	liquids		FRIT	GLASS		FRIT	GLASS	HLW fraction
Volume kilo-liters									
Specific Gravity									
Cs and Ba, (MCi)	5.28E+00	6.28E+01			1.00E+01			5.81E+01	0.85311
Sr and Y, (MCi)	1.05E+02	2.10E+00			6.80E+00			1.00E+02	0.9365
Tc, (MCi)	5.89E-03	2.61E-02			3.20E-04			3.17E-02	0.99
Am, (MCi)	9.51E-02	8.61E-03			1.04E-03			1.03E-01	0.99
Np, (MCi)	9.29E-05	1.03E-05			1.03E-06			1.02E-04	0.99
Pu-239, (MCi)	2.47E-02	1.67E-03			2.64E-04			2.61E-02	0.99
Pu-240, (MCi)	6.28E-03	4.14E-04			6.69E-05			6.63E-03	0.99
Pu-241,(MCi)	7.34E-02	1.49E-03			7.49E-04			7.41E-02	0.99
Total TRU, (MCi)	2.00E-01	1.22E-02			2.12E-03			2.10E-01	0.99
Total MCi	1.11E+02	6.49E+01			1.76E+00			1.74E+02	0.99
Total Mass Flow (MT)	1.94E+04	7.10E+05		2.81E+05	3.87E+05		1.36E+04	2.51E+04	
Total Cr, (MT)	1.32E+02	5.15E+01			1.44E+02			3.96E+01	
Total Na, (MT)	1.24E+03	6.51E+04			7.18E+04			2.33E+03	
Total Si, (MT)	5.24E+02	5.65E+00		1.07E+05	1.07E+05		5.29E+03	5.83E+03	
Total P, (MT)	7.80E+02	8.42E+02			1.35E+03			2.72E+02	
Total NO2-, (MT)	7.38E+01	9.54E+03							
Total NO3-, (MT)	1.03E+03	1.06E+05							
AG+	1.38E+00	3.28E-01							
AG2O					3.52E-01			1.48E+00	
AL+3	2.37E+03								
AL2O3				1.32E+04	1.94E+04			1.73E+03	
AL(OH)4-		4.83E+03							
AM+3	2.77E-02	2.51E-03							
AM2O3					2.76E-03			3.05E-02	
AS+5	4.98E-01	7.70E-01							
AS2O5					1.18E+00			7.66E-01	
B+3	9.94E-01	5.19E-01							
B2O3					1.67E+00		1.75E+03	1.76E+03	
BA+2	3.09E+00	7.91E-01							
BAO					8.81E-01			3.45E+00	
BE+2	7.61E-03	8.19E-02							
BEO					2.27E-01			2.16E-02	
BI+3	1.96E+02	6.76E+01							
BI2O3					7.52E+01			2.19E+02	
C14	4.53E-04	7.43E-04							
CA+2	1.33E+02	1.67E+01							
CANCRINITE	2.70E+03								
CAO				3.87E+04	3.87E+04			1.89E+02	
CD+2	7.93E+00	2.09E+00							
CDO					2.38E+00			9.06E+00	
CE+3	2.35E+02	2.37E+00							
CE2O3					2.79E+00			2.76E+02	
CL-	3.49E+00	3.11E+02							
CL2									
CO									
CO2									
CO3-2	2.25E+02	3.37E+03							
CR+3	1.32E+02								
CR2O3					2.11E+02			5.79E+01	
CR(OH)4-		1.19E+02							
CS+	9.25E-02	8.19E-01							
CS2O					6.83E-03			9.58E-01	
CU+2	7.46E-01	1.77E-01							
CUO					2.21E-01			9.34E-01	
CUSO4									
F-	5.97E+01	1.12E+03							
F2									

Pg 24/25

FE+3	7.63E+02	1.44E+01								
FE2O3					2.06E+01			1.21E+03		
H2										
H2O		5.07E+05								
H2S										
HG										
HG+2	9.00E-03	9.49E-01								
I-	2.02E+01	5.46E+02								
I2										
K+	2.10E+01	2.19E-01								
K2O					2.65E-01			2.53E+01		
KEROSENE										
LA+3	2.10E+01	2.19E-01								
LA2O3					2.58E-01			2.46E+01		
LI+	2.46E-02	5.77E-03								
LI2O					1.24E-02		5.00E+02	5.03E+02		
MG+2	1.10E+01	9.65E-01								
MGO					1.60E+00			1.88E+01		
MNO2	2.09E+02	2.17E+01			2.16E+01			2.09E+02		
MO+6	8.01E-01	4.87E+00								
MOO3					7.29E+00			1.22E+00		
N2										
NA+	7.77E+02	6.51E+04								
NA2O					9.68E+04			3.14E+03		
NH3										
NI+3	6.57E+00	4.07E+00								
NI2FECN6	5.00E+02									
NI2O3					5.72E+00			9.27E+00		
NIO					1.50E-02			2.27E+02		
NO										
NO2										
NO2-	7.38E+01	9.54E+03								
NO3-	1.03E+03	1.06E+05								
NP+4	1.32E-01	1.46E-02								
NPO2					1.66E-02			1.50E-01		
O2										
OH-	5.00E+03	6.44E+03								
PB+4	3.28E+00	1.96E+00								
PBO2					2.26E+00			3.79E+00		
PO4-3	2.39E+03	2.58E+03								
P2O5					3.09E+03			6.22E+02		
P2O5:24W	5.21E-01									
PU+4	4.27E-01	2.88E-02								
PUO2					3.26E-02			4.84E-01		
S										
SI+4	7.90E+01	5.65E+00								
SIO2				2.29E+05	2.29E+05		1.13E+04	1.25E+04		
SO2										
SO4-2	3.97E+01	2.01E+03								
SR+2	3.64E+01	3.75E-01								
SRO					4.00E-01			4.29E+01		
TCO2										
TCO4-	5.68E-01	2.52E+00								
TC2O7					2.94E-02			2.91E+00		
TOC	1.16E+02	1.42E+03								
UO2+2	1.58E+03	8.52E+01								
UO3					9.02E+01			1.67E+03		
V+5	1.88E-01	6.20E-02								
V2O5					1.11E-01			3.35E-01		
W+6		7.47E-01								
WO2					2.91E-05			4.41E-01		
WO3					9.40E-01			2.06E-03		
ZN+2	9.45E-01	3.59E+00								
ZNO					4.46E+00			1.19E+00		
ZR+4	2.77E+02	4.48E-01								
ZRO2					6.49E-01			6.90E+02		
ZRO2:2H2	4.09E+02	2.15E+01								
HLW										
20 wt. % waste oxide loading										
Blending factor				1	1.2	1.5	2	3.5		

Mass of glass required to achieve12,200 (2X) can @1.2 blend, MT				3.13E+04	3.76E+04	4.69E+04	6.26E+04	1.10E+05	
additional frit required (equals increased glass) MT				6.20E+03	1.25E+04	2.18E+04	3.75E+04	8.44E+04	
total frit required, MT				1.98E+04	2.61E+04	3.54E+04	5.11E+04	9.80E+04	
WOL (- Na2O, - SiO2)				23%	20%	15%	12%	7%	
WOL (with all tank wastes)				37%	31%	24%	18%	10%	
glass density (MT/m^3)	2.63								
cullet packing fraction	0.7	(LAW only)							
Waste volume (m^3)				1.19E+04	1.43E+04	1.79E+04	2.38E+04	4.17E+04	
Canister Volume (m^3)	1.17								
Number of Canisters (1x)				1.02E+04	1.22E+04	1.53E+04	2.03E+04	3.56E+04	
Nu. of Canisters /HMPC	4								
Number of HMPCs				2.54E+03	3.05E+03	3.81E+03	5.09E+03	8.90E+03	
Number of trips @ 10 HMPCs /trip				254	305	381	509	890	
HLW Facility Sizing									
Phase 1 HLW = 1plant @ 1 mt/day, 6 yrs, 60% OE			Phase 1 HLW produced (MT)		1314				
Schedule (years) =	~~17~~								
Phase 2 Requirements									
Required capacity MT/day (assuming 17 yrs ops, 70% OE)				~~6.90~~	~~8.34~~	~~10.51~~	~~14.11~~	~~24.92~~	
Required operating duration yrs (assuming 10 MT/day, 70% OE)				~~11.74~~	14	~~17.86~~	~~23.98~~	~~42.36~~	
Required operating duration (including 2 yrs start up)					16				
LAW									
15 wt. % sodium oxide loading									
Blending factor				1	1.25	1.5	2	3.5	
Mass of glass required to achieve 15% wo loading, MT				6.45E+05	8.07E+05	9.68E+05	1.29E+06	2.26E+06	
additional frit required (equals increased glass) MT				2.58E+05	4.20E+05	5.81E+05	9.04E+05	1.87E+06	
total frit required, MT				5.39E+05	7.01E+05	8.62E+05	1.18E+06	2.15E+06	
glass density (MT/m^3)	2.63								
cullet packing fraction	0.7								
Waste volume (m^3) (total Phase 1 + Phase 2)				3.51E+05	4.38E+05	5.26E+05	7.01E+05	1.23E+06	
Number of 5300 m^3 vaults				66	83	99	132	231	
LAW facility sizing									
Phase 1 LAW =2 plants @ 20 mt/day, 5 yrs op, 60 % OE			Phase 1 LAW produced (MT)		43800	(minimum @ 5 yrs ops)			
Phase 1 LAW =2 plants@ 20 mt/day, 10 yrs op, 60% OE			Phase 1 LAW produced (MT)		87600	(maximum @ 10 yrs ops)			
Phase 1 =5-9 yrs, using 5 yrs requires larger Phase 2 plants (more conservative sizing)									
Schedule, years	13								
Capacity MT/day	200								
Phase 2 LAW total capacity (Each LAW Plant would have 1/2 of total capacity)									
Overall efficiency, %				63%	~~80%~~	~~97%~~	~~131%~~	~~233%~~	
Required capacity MT/day (assuming 13 yrs ops, 70% OE)				181.10	~~229.68~~	~~278.25~~	~~375.39~~	~~666.83~~	
Required operating duration yrs (assuming 200 MT/day, 70% OE)				12	~~14.93~~	~~18.09~~	~~24.40~~	~~43.34~~	
Required operating duration, yrs, (including 2 yrs start up)				14					

RL-F-1325.5# DEF012
(04/93)

United States Government | Department of Energy

memorandum

Richland Operations Office

DATE: APR 29 1996

REPLY TO ATTN OF: WDD:WJT 96-WDD-011

SUBJECT: INDEPENDENT REVIEW OF HANFORD HIGH LEVEL WASTE VOLUME

TO: Distribution List

An independent review was commissioned to assess the high-level waste volume, resulting from the enhanced sludge washing treatment and immobilization of Hanford tank waste. The report of this independent review is attached.

The results of this review are accepted and will be used for planning purposes by DOE.

If you have any questions on this, please call me at (509) 372-3864 or Ken Lang at (301) 903-7453.

William J. Taylor, Director
Waste Disposal Division

Kenneth T Lang, Team Leader
Hanford Office
Office of Tank Waste Remediation System

Attachment

Appended Material to
Waste Loading & blending Calc.
CH. 8/1/96

7.4.6.2

96-WDD-011

Dist. List

w/attach:
D. Button, WDD
N. Brown, WDD
P. Certa, WHC
P. Colten, PNNL
R. Gilbert, WDD
C. Haass, MSD
L. Holton, PNNL
J. Honeyman, WHC
M. Hunemuller, DOE-HQ
M. Johnson, WHC
M. Kupfer, WHC
C. Mylar, DOE-HQ
R. Orme, WHC
D. Pepson, DOE-HQ
J. Plodinec, WSRC
D. Strachan, ANL
C. Sohn, MSD
H. Sutter, SAIC
W. Taylor, WDD
D. Washenfelder, WHC

INDEPENDENT REVIEW TEAM REPORT

INTRODUCTION AND SUMMARY

The EIS leading to decisions about the fate of the waste in the HLW tanks at Hanford is scheduled to be released for public comment in March, 1996. It is important that the information in the EIS have a firm technical foundation so that sound decisions about the fate of the waste can be made. The Independent Review Team (IRT) was empaneled to examine the technical bases of one of the more important facets of the EIS - the number of canisters of HLW glass which would be produced from the waste in the Hanford tanks (The membership of the IRT is contained in Attachment 1; the Statement of Work in Attachment 2).

The goal of the IRT was to ensure that the number of canisters projected in the EIS:

• Adequately reflected the uncertainties associated with the current understanding of the inventory and especially the chemistry (degree of blending which will be achieved, separation factors in pretreatment processes, and vitrification process limits) of Hanford HLW. The IRT interpreted this as ensuring that the range of possible canister production values provided adequate upper and lower bounds for decision-making.

• Provided an appropriate median case (a sort of "expectation value") for detailed analysis and planning.

The IRT accomplished this through a series of briefings and discussions with cognizant Hanford Site personnel, and examinations of key documents (The list of briefings is contained in Attachment 3, and the documents provided to the IRT is contained in Attachment 4).

The IRT has concluded that the current range, and median value, of the number of canisters which will be produced from Hanford HLW contained in the EIS (13800 to 70000, and 33400, respectively) are conservative. However, the Hanford site has made significant progress in better defining key input since the EIS values were originally developed. Based on this progress, the IRT has concluded that a range of 13800 to 50000 canisters better reflects the current state of understanding, and that a value of 23000 canisters provides a more representative case for policy decision making.

The IRT recognizes that selection of the values in the EIS has been controversial and contentious. The IRT has concluded that this is due to a fundamental misunderstanding of the bases of the current calculations. Improved clarity in the presentation of the bases, coupled with better communications, would help to avoid this sort of problem in the future. In this report, we have attempted to provide a clearer exposition of the bases of the calculations.

EIS CANISTER PRODUCTION VALUES

Calculation

Canister production values are calculated in the following manner. The total inventory of waste on a mass basis is partitioned into soluble ("salt cake") and insoluble ("sludge") portions. The insoluble portion is assumed to undergo water-washing during which residual soluble material is removed by dilution. The resulting solids then undergo caustic leaching during which additional material in the "sludge," most notably aluminum, is dissolved. It is assumed that there is perfect blending of the "sludge" material.

It is assumed that 1% of the soluble material remains with the insolubles. The rest of the soluble

material undergoes ion exchange, and the separated cesium is combined with the insoluble material at the high-level waste processing plant. Glass-forming additives are blended with the waste mixture and then vitrified. The amount of additives is selected so that the minimum volume of glass is produced, consistent with constraints on the solubility of waste components (e.g., Cr) in the glass.

For the EIS,[1] a total inventory dating back to the 1977 EIS (with periodic subsequent updates) was used as the starting point (This is referred to as the EIS inventory). This was partitioned into the soluble and insoluble portions, called "salt cake" and "sludge," based on the judgement of experienced personnel. It is important to note that this partition was somewhat artificial, in that it did not necessarily represent actual salt cake or sludge. If an element was not assigned to the soluble fraction, i.e. "salt cake," it was assumed to be contained only in the "sludge." Thus, the small portion of sludge which is found in actual salt cake was not included in the "salt cake" used for the EIS calculations. It was assumed that the "sludge" and "salt cake" were each perfectly blended.

The "sludge" and "salt cake" were then cascaded through the process (via the flowsheet model), using values for water-washing and caustic-leaching efficiencies reflecting the state of understanding up to 1994. The amount of glass-forming additives used to produce glass was the minimum amount necessary to ensure that the glass satisfied solubility limits for waste oxides such as Cr, Al, and Fe (These limits approximated plant operating limits rather than the true solubilities, and thus were representative of what might be achieved in operations). This led to an estimate of 13800 canisters, which is presented in the EIS as a lower bound on the number of canisters, since perfect blending of the waste is not possible.

To develop a "planning case" for the number of canisters, a nominal waste oxide loading of 20 wt% (= actual waste loading less Na and Si contained in the waste) was assumed. In this case, the actual waste loading was about 31 wt%.[2] The EIS waste inventory was used and a blending factor of 1.5 was assumed (The blending factor reflects the additional glass produced because of imperfect blending). This led to a projection of 33800 canisters. A maximum upper bound to the number of canisters was obtained by applying a blending factor of 5 to the lower bound case. This was based on subjective assessments of the possible effectiveness of blending. This latter figure led to a canister count of 70000, which is presented in the EIS as an upper bound.

Sources of Uncertainty

There are five major sources of uncertainty in the calculations described above. The IRT considered each of these in evaluating the canister production values in the EIS.

• Inventory. Both the total mass of oxides, and the partitioning of materials into soluble and insoluble fractions, can affect the accuracy of the calculations. Over the last few years, LANL has been reconstructing the total inventory. Agnew (LANL) has utilized the information used to develop the EIS inventory, as well as other information from nuclear materials production and

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[1] Throughout this document, when an Environmental Impact Statement is referred to as "the EIS," Draft C of the 1996 EIS is meant. There have been earlier Environmental Impact Statements - these are referred to by their date.

[2] Hanford waste is unique in the DOE complex because it contains substantial amounts of glass-forming oxides. Thus, to make a specific silicate glass, fewer chemicals are needed as additives. This results in higher waste loadings than for other DOE waste glasses, which often is misunderstood.

waste operations at the Hanford Site. The total mass of waste constituting the LANL inventory is smaller than the EIS inventory, and attempts to accurately represent actual sludge and salt cake. Table 1 lists the LANL inventory, and the EIS inventory. The relationship between the two is shown in the last column. The total inventory developed by LANL is smaller, primarily due to smaller amounts of sodium, nitrate, and phosphate. However, species subject to glass processing limits (e.g., Cr, Al, Fe) are significantly enriched in the LANL inventory. Thus, even though the LANL inventory is smaller, it is likely to provide an upper bound for the amount of glass to be produced. Efforts are underway to reconcile the two inventories, and, more importantly, to bring the LANL inventory into agreement with analyses of actual wastes. The IRT concluded that the actual inventory will most likely be somewhere in between the two shown in Table 1.

• Amount retrieved. For the calculations, it was assumed that 99% of the waste in the tanks would be retrieved. Given the refractory nature of some of the material in the tank, it is not clear that this will be achieved. If it is not, then the calculated number of canisters will be overestimated (It is very improbable that more than 99% of the waste will be removed from the tanks.).

• Blending factor. The values in the EIS are based on the assumption that all of the insoluble material is perfectly blended. In practice, this is unlikely to be achieved.

• Pretreatment efficiencies. The flowsheet is based on a water wash to remove soluble species, followed by caustic leaching of the insolubles. The values in the EIS reflect the best judgement based on incomplete experimental work. Thus, these constitute a potentially significant source of uncertainty (The uncertainties in these factors are discussed in more detail in Attachment 5.).

• Glass processing limits. The number of canisters in the EIS is based on adding the minimum amount of glass-forming materials necessary to meet glass solubility limits, as known in 1994. No attempt was made to optimize the glass composition, nor was an effort made to determine whether the glass could actually be produced.

As implied above, an increase in either the total inventory or in the amount of a single component does not necessarily mean an increase in the number of canisters. Since the number of canisters is calculated based on meeting glass processing limits, only a few critical elements affect the calculation. The most important elements appear to be Cr, P, Na and Al. Of these, Cr and P appear to be the most critical. These elements are nearly at the upper limit suggested by glass composition studies carried out by Hanford Site personnel, and thus determine the amount of glass produced.

EVALUATION OF EIS VALUES

The IRT examined each of the canister production values in the EIS. The IRT has concluded that the lower bound is, in fact, an appropriate lower bound. However, neither the planning value nor the upper bound reflect the progress made in the last two years in understanding waste inventory and waste pretreatment. While both of these values are conservative, better values are available.

Lower Bound

The lower bound value of 13800 was evaluated by comparing it to more realistic calculations, and by examining the effects of the uncertainties identified above on the calculated value. The IRT has concluded that the EIS value is a credible lower bound to the number of canisters which will be produced.

A new estimate of the total number of canisters has recently been made using a modified EIS inventory (Minor increases were made in the amounts of Al and Cr to address accounting errors; a

minor decrease was made in the PO_4^{3-} content to take into account transfers of phosphate waste to the waste cribs). The waste was partitioned into insoluble and soluble fractions based on the LANL effort. Thus, although the total inventory was not very different from that used for the EIS, the partition of elements between sludge and salt cake was more realistic. Water washing and caustic leaching efficiencies were modified to reflect the more current values of Colton. This led to a projected canister count of 14600, indicating that the EIS value of 13800 is probably a lower bound.

The IRT also considered the effects of the other uncertainties listed above. Since perfect blending is assumed, the EIS value is certainly a lower bound compared to a more realistic case. In order to examine the effects of glass processing limits, the glass compositions for both the EIS and the modified EIS basis were examined. These are shown in Table 2. The total waste loading for the EIS glass is 46.5 wt%, including the Na and Si in the waste (As noted later, this waste loading factor is an important source of misunderstanding over these calculations.). Use of the LANL inventory would require more canisters, because of the higher Cr content, again indicating that the EIS value is a lower bound. Because of the lower amounts of Na and Si in the LANL inventory, the waste loading for this glass decreases to 43.3 wt%. Projected DWPF and West Valley glass compositions are shown in Attachments 6 and 7. Comparing Table 2 and the attachments, the Hanford glass compositions are within the range of compositions defined by the other two sites, even though the nominal waste loadings are considerably different. Thus, while clearly an underestimate of the number of canisters, the calculation leads to a glass composition which could be processed in current production facilities.

Johnson also looked at the effects of all of the uncertainties, except for blending, on the number of canisters. He allowed each of the various sources of uncertainty to vary between a high, medium and low value, and assigned a probability value 0.25, 0.50, and 0.25, respectively (This approximates a normal distribution about the median value). Using the EIS inventory, he constructed a cumulative distribution function for the amount of glass which would be produced (The number of canisters is this value divided by 0.62). This is shown as Case 1 in Figure 1.

The y-axis shows the probability of producing no more than the amount of glass indicated on the x-axis. As the Figure shows, there is less than a 10 % probability that the number of canisters produced will be less than the 13800 value in the EIS (This corresponds to 8500 m^3 of glass). The IRT thus has concluded that this is an appropriate lower bound for use in the EIS.

Upper Bound and Median Value

The median and upper bound values in the EIS were based on subjective judgements of what the likely effects of the uncertainties identified earlier might be. The value of 70000 canisters is based on the assumption that the total uncertainties in processing, particularly in blending, will lead to a five-fold increase in the number of canisters compared to the lower bound. The factor of was taken from an earlier system study; but its bases have been superseded by the more recent data. Calculations recently performed by Certa show that any realistic feed pretreatment scenarios consistent with the current flowsheet give rise to no more than 20% more glass than a perfectly blended inventory.

Similarly, there is no basis for arbitrarily reducing the waste loading, as is done in the planning case. It is unlikely that a plant operator would do so without reason. The IRT has concluded that selection of a specific waste loading thus overly constrains the calculation of the number of canisters, in an artificial manner. As a result, overly conservative values are calculated.

For this reason, the IRT developed a median and an upper bound value to evaluate the corresponding values in the EIS. As a starting point for the upper bound, the LANL inventory was chosen

because it would produce more glass than the EIS inventory, as can be seen in Figure 1 (comparing Case 2 - LANL inventory to Case 1 - EIS inventory). This case used glass processing limits which are somewhat more restrictive than necessary, and thus would produce more glass. To produce an upper bound, the IRT selected the glass production value which corresponds to a 95% probability that it will not be exceeded - 26000 m^3. This value was multiplied by the factor of 1.2 obtained from Certa, and converted to canisters by dividing by 0.62. This results in a value of 50000 canisters. Based on this value, the IRT concludes that the 70000 value in the EIS is not only conservative, but overly so. Because the 50000 canister value developed by the IRT reflects the progress made in the last two years, it provides a more appropriate upper bound than the 70000 canister value.

As a starting point for the median value, the LANL value was again used. However, the IRT used values for the glass processing limits which reflected expert judgement applied to glass processing. This corresponds to the assumption that between now and the time glass production begins, means will be found to either increase solubility limits in the glass or decrease the amount of limiting components such as Cr going into the glass (e.g., through enhanced pretreatment). The IRT used Case 4 in Figure 1. Since a median value is most appropriate for the planning value, the amount of glass corresponding to a probability of 0.5 was used - 12000 m^3. Using the same blending factor and converting from glass volume to canisters in the same manner as for the upper bound, a value of 23000 is obtained. The IRT thus concludes that the 33400 value in the EIS is conservative. Again, the IRT's value is more consistent with the current understanding of Hanford waste behavior.

CONCLUSIONS AND TECHNICAL RECOMMENDATIONS

The IRT has completed a review of the number of canisters of waste glass which will be produced from Hanford tank wastes. Based on this review, the following conclusions were drawn:

- The current range, and median value, of the number of canisters which will be produced from Hanford HLW contained in the EIS (13800 to 70000, and 33400, respectively) are conservative.

- A range of 13800 to 50000 canisters, and a median value of 23000 canisters, better reflects the current state of understanding of Hanford waste than the EIS estimates. The value of 23000 canisters provides a more representative case for detailed planning of environmental impacts.

- In spite of the apparent high waste loading factors, the projected glass compositions are in the same range as nominal DWPF and West Valley glasses. As noted earlier, the high waste loading is deceptive due to the large amount of Na and Si contained in Hanford HLW.

Based on this review, the IRT makes the following technical recommendations:

- Completion of ongoing studies. As noted above, reconciliation of inventory data with the results of tank samples is not yet complete. Validation of assumptions about the efficiency of water washing and caustic leaching are also not yet completed. The IRT does not expect that new results will significantly change the total number of canisters which will be produced. However, it is imperative that these studies be brought to a conclusion, so that contingencies for the uncertainties in the inventory and in the washing and caustic leaching efficiencies can be minimized. In particular, further work is needed with Redox sludge, since this is the major source of Cr in the waste.

- Improvement of current models for decision-making. It appears that sufficient conservatism has been incorporated into the calculations performed by Johnson (Figure 1), so that the statistical uncertainties in the data have been appropriately addressed. However, an estimate of the standard

deviation in the experimentally determined washing factors needs to be correlated to the range of washing factors used in Johnson's calculations. In particular, the IRT recommends examining a broader range of Na washing factors. In addition, a blending factor should be included to provide more complete calculations.

• Use of the Johnson study to prioritize further work. The IRT was impressed by the wealth of information contained in the Johnson study. In particular, his results clearly show the importance of gaining as much information as possible about the amount of Cr in the waste, and the efficiency of removal of Cr during pretreatment. This study provides valuable insight into the relative importance of different factors and needs to be used to prioritize further work in these areas.

NOTE ON COMMUNICATION OF TECHNICAL BASES

The IRT recognizes that selection of the values in the EIS has been controversial and contentious. Based on the IRT's experience, this is due in large part to miscommunication of the technical bases of the calculated values in the EIS. This miscommunication resulted in misconceptions on the part of those not involved in performing those calculations. Improved clarity in the presentation of the bases, coupled with better communications, would help to avoid this sort of problem in the future. In particular, calculations which result in numbers of canisters also result in associated glass compositions. Hanford Site personnel should present these in the context of the DWPF and West Valley glass compositions. This would help to avoid misconceptions about the very deceptive waste oxide loadings quoted in several of the studies.

ACKNOWLEDGEMENT

The IRT is grateful for the patience shown by Hanford Site personnel in presenting material, and fielding a large number of questions.

Table 1. Total inventories of Hanford waste: EIS basis, and LANL inventory.

Component	EIS (MT)	LANL (MT)	LANL / EIS
Al^{3+}	2.96E03	5.26E03	1.78
Bi^{3+}	2.61E02	6.64E02	2.54
Ca^{2+}	1.28E02	5.36E02	4.18
Cancrinite[a]	2.70E03	1.94E03	0.719
Cl^-	4.15E02	3.50E02	0.843
CO_3^{2-}	1.66E03	2.73E03	1.64
Cr^{3+}	2.68E02	7.47E02	2.79
F^-	8.12E02	5.39E02	0.663
Fe^{3+}	6.31E02	2.59E03	4.10
K^+	5.53E01	1.31E02	2.37
La^{3+}	1.88E00	4.01E01	21.3
Mn^{4+}	1.0E02	1.75E01	0.146
Na^+	5.73E04	2.97E04	0.513
Ni^{2+}	2.03E02	2.10E02	1.03
NO_2^-	6.52E03	5.57E03	0.852
NO_3^-	1.00E05	4.28E04	0.426
OH^-	1.06E04	1.70E04	1.60
Pb^{4+}	2.83E01	1.32E01	0.466
PO_4^{3-}	4.73E03	3.91E03	0.827
Si^{4+}	1.45E01	9.41E01	6.49
SO_4^{2-}	1.65E03	4.32E03	2.62
Sr^{2+}	3.60E01	1.57E02	4.36
UO_2^{2+}	1.61E03	1.92E03	1.19
Zr^{4+}	3.82E02	9.36E01	0.245
Total Organic Carbon	4.73E02	2.99E02	0.633
TOTAL	1.94E05	1.22E05	0.629

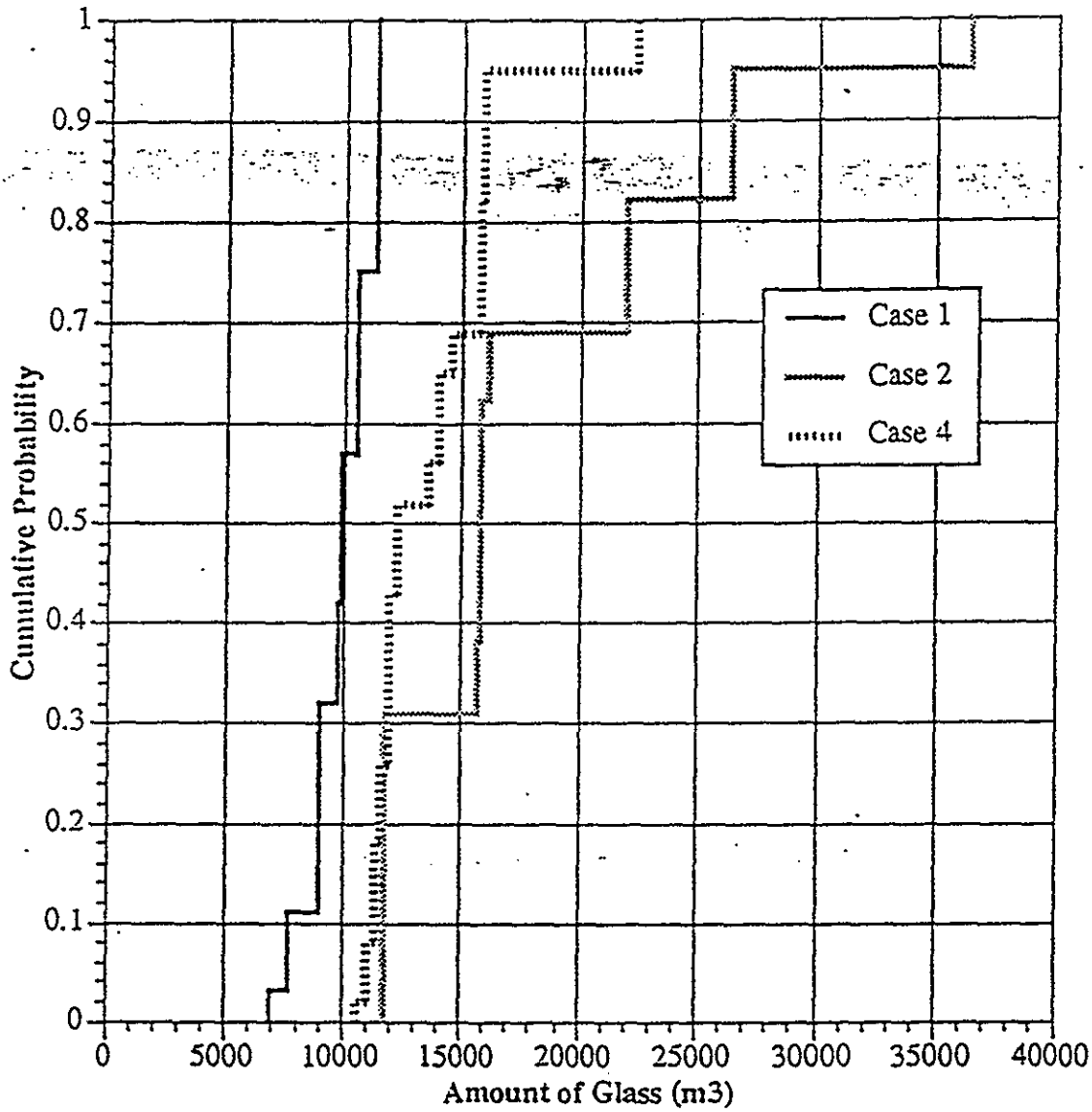
[a] Chemical composition: $2NaAlSiO_4{:}0.52NaNO_3{:}0.68H_2O$.

Table 2. Glass compositions based on EIS and modified EIS inventories.

	EIS glass composition (wt%)			Modified EIS glass composition (wt%)		
Component	Waste	Additives	Glass	Waste	Additives	Glass
Fraction[a]	46.6	53.4		50.9	49.1	
Al2O3	6.0	0	6.0	9.3	0	9.3
B2O3	0	9.7	9.7	0	7.0	7.0
CaO	1.0	0	1.0	0.8	0	0.8
Fe2O3	5.1	0	5.1	4.5	0	4.5
Li2O	0	2.7	2.7	0	2.0	2.0
Na2O	11.8	0	11.8	12.3	0	12.3
P2O5	2.3			1.6	0	1.6
SiO2	4.9	41.1	46.1	5.9	40.1	46.0
UO3	6.8	0	6.8	6.7	0	6.7
ZrO2	3.3	0	3.3	3.8	0	3.8
Other	5.4	0	5.4	6.0	0	6.0

[a] Fraction of glass produced by waste or additives, in wt%.

Figure 1. Projected glass production for various scenarios.



Attachment 1

Independent Review Team Membership

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STATEMENT OF WORK
HANFORD HLW CANISTER PROJECTION ASSESSMENT

Background

The Department of Energy (DOE) and the Washington Department of Ecology are preparing an Environmental Impact Statement (EIS) to assess the environmental impacts of the Hanford Tank Waste Remediation System. The document is being prepared to meet the requirements of the National Environmental Policy Act. Included in this EIS are assumptions for low activity waste (LAW) and high-level waste (HLW) loading estimates, tank waste blending factors, and estimates of the total number of canisters of both immobilized LAW and HLW glass likely to be produced during the vitrification process.

In order to assure the analysis in the EIS is technically defensible and the analysis methodology is understandable to the general public both HQ/EM and RL have agreed to establish an Independent Review Team (IRT).

Scope of Work

The IRT will convene and be presented the TWRS HLW volume analysis. The IRT will establish any additional data requirements necessary to provide a technically supportable estimate of the Hanford waste tank contents which would be delivered for high level waste immobilization. The team will provide their requirements to both HQ/EM and RL. HQ/EM and RL will collect the necessary information and provide the information to the team in a timely fashion.

The IRT will evaluate the TWRS process, technical basis, and available data in order to develop an independent assessment of the results from the analysis conducted on the tank waste. The focus of the evaluation will be on the high level waste fraction to be vitrified. The presentations to the IRT will include the sources of data used to establish the mass, the uncertainties in the data, the uncertainties in the mass amount, and a conservative determination of the mass which should be used to provide an upper bound of waste delivered for immobilization. This conservative upper bound, if determined to be appropriate by the IRT, will be used in the EIS for the case of enhanced sludge washing. If the IRT does not accept the conservative upper bound currently used in the draft EIS then the IRT will present to HQ/EM and RL a recommended upper bound and the basis for the recommendation. The methodology for the analysis, a clear audit trail showing the data quality, and level of uncertainty will also be provided.

Only the operations used in the EIS description of Enhanced Sludge Washing will be used in the determination of separations. Available data on the process should be used to assess efficiencies of separations including the assessment of uncertainty.

Schedule/Deliverables

To insure the results of the independent review team are usable, the review team will present a schedule following their initial meeting, recognizing that time is of the essence. Attempts should not be made to compromise quality of the resulting assessment as the impacts of getting an incomplete assessment would be significant.

William J. Taylor
Director, Waste Disposal Division
Richland Operations Office

Ken Lang
TWRS Team Leader, EM-38
Office of Waste Management

March 1, 1996

Attachment 3

PROPOSED WORKSHOP AGENDA - HANFORD HLW CANISTER PROJECTION ASSESSMENT

March 4-8, 1996
3170 George Washington Way
Sigma IV Building, Moon Room
Richland, Washington

March 4, 1996

7:30	Independent Review Team (IRT) Meet for breakfast at Tower Inn	H. Sutter D. Stracken J. Plodinec L. Holton
9:00	Introductory Remarks/Expectations	W. Taylor
9:15	TWRS Reference Processing Strategy	R. Gilbert
9:30	Tank Waste Inventory	M. Kupfer
11:00	Enhanced Sludge Washing	D. Washenfelder
12:30	Lunch	
1:30	Blending Strategies	P. Certa
2:30	Glass Processing/Waste Oxide Limitations	N. Brown
3:30	TWRS Flowsheet	R. Orme
4:30	Decision Analysis Model	M. Johnson
5:15	Hanford Canister Projection	R. Gilbert
5:45	Adjourn	

ADDITIONAL ATTENDEES: BILL ROOT, CAROLYN HAASS

March 5-8

The schedule details for March 5-8 will be developed by the morning of March 5, 1996 by the IRT in conjunction with the Hanford team.

WORKSHOP AGENDA - HANFORD HLW CANISTER PROJECTION ASSESSMENT
March 4-8, 1996
3170 George Washington Way
Sigma IV Building, Moon Room
Richland, Washington

March 4, 1996

1. TWRS Reference Processing Strategy

2. Tank Waste Inventory

- History of TWRS Waste Inventory Development
- Adjustments to FY 1994 Inventory for FY 1995 Rev. 1 Flowsheet
- Comparison of Rev. 1 Inventory and LANL Model
- Reconciliation activities for TWRS Inventory and LANL Model

3. Enhanced Sludge Washing

- TWRS Rev. 1 Inventory distribution among SSTs using LANL Tank Layering Model LA-UR-94-4269, Rev. 1 (1995); among DSTs using tank samples from WHC 74A20-96-30 Appendix B (1996)
- Division of SST inventory between saltcake and sludge using Tank Layering Model
- Saltcake 99% water solubility basis from RHO-SA-51 (1980); assignment of insoluble fraction to sludge inventory (zero sums)
- Sludge water solubility basis from 27 samples in PNL-10512 (1995)
- Sludge caustic solubility basis from PNL-10512 and TWRSPP-95-024 (1995)
- Match of empirical caustic solubility sample data with expected solubility for Al and PO4
- Example derivation of insoluble Al using TWRS Process Flowsheet WHC-SD-WM-TI-613 Rev. 1 (1995)
- Solubility variation treatment by the Decision Analysis Model in WHC-EP-0874 (1995)

4. Glass Processing/Waste Oxide Limitations

- Comparison of TWRS Rev. 0 and Rev. 1 HLW glass volumes
- Limiting component loadings for various canister counts compared to EWVP-CVS component limits

5. TWRS flowsheet

- Key assumptions used in the Rev. 1 process flowsheet affecting HLW glass volume and bases: tank inventories; retrieval rate and performance; sludge settling, wash steps, and duration; HLW melter volatility

WORKSHOP AGENDA - HANFORD HLW CANISTER PROJECTION ASSESSMENT (cont.)

March 5, 1996

6. Blending Strategies

- Description of physical plant modelling and incidental waste mixing
- Model operation and inputs
- Effect of reduced HLW glass loadings on blend factor

7. Decision Analysis Model

- Development, operation, and validation of model
- Model parameters relevant to HLW glass volume: selection of TWRS Rev. 1 inventory or LANL inventory; treatment of sludge solubility uncertainty; selection of waste oxide loading limits
- Identification of major sensitivities from tornado diagrams
- Calculation of probable outcomes

8. Hanford Canister Projection

- Derivation of [draft] EIS canister projection

(References cited during discussions listed on the following page.)

HANFORD HLW CANISTER PROJECTION ASSESSMENT

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PNL-9814, Revision 2, "The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tank into Characteristic Groups," 1995.

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PNL-8601, "Pretreatment of Plutonium Fishing Plant (PFP) Sludge: Report for the Period October 1990 - March 1992," 1993.

PNL-9747, "Pretreatment of Neutralized Cladding Removal Waste Sludge: Results of the Second Design Basis Experiment," May 1994.

PNL-10712, "Washing and Caustic Leaching of Hanford Tank Sludges: Results of FY 1995 Studies," 1995.

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Westinghouse Hanford Company

WHC-SD-WM-DTP-033, Revision 1, "TWRS Process Flowsheet," 1995.

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Letter, 9554823, "Hanford Federal Facility Agreement and Consent Order Target Milestone M-50-03-T2A, Submit Report Summarizing the Testing of Enhanced Sludge Washing and Related Tank Waste Sludge Pretreatment Methods for Samples of Tank Waste," J. O. Honeyman, WHC, to W. J. Tyler, DOE-RL, September 14, 1995.

Los Alamos National Laboratory

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Pacific Northwest National Laboratory

PNL-9814, Revision 2, "The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tank into Characteristic Groups," 1995.

PNL-10512, Revision 0, "Sludge Pretreatment Chemistry Evaluation: Enhanced Sludge Washing Separation Factors," 1995.

PNL-8558, "Pretreatment of Neutralized Cladding Removal Waste Sludge: Status Report," 1993.

PNL-7758, "Characterization of the First Core Sample of Neutralized Current Acid Waste From Double-Shell Tank 101-AZ," 1989.

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Los Alamos National Laboratory

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ATTACHMENT 5

Uncertainties in Pretreatment Parameters

The object of pretreatment is to reduce the HLW volume before vitrification. The flow sheet incorporates two major pretreatment steps, a "water wash" (actually dilute $NaOH/NaNO_2$) and a caustic leach (3M NaOH), followed by additional washing. The calculation of the amount and composition of waste that remains after pretreatment is an important part of the calculations of the final canister count.

Flow sheet calculations begin by dividing the total waste inventory into water soluble and water insoluble fractions. The former is called "salt cake" and the latter "sludge". The fraction of each of these that remains after each pretreatment step is then calculated.

"Salt cake" is assumed to be 99% water soluble. This is a reasonable assumption since the partitioning into "salt cake" includes only soluble compounds. Real salt cake taken from the tanks is a worst case approximation of the "salt cake" used in the calculations because it may include a number of insoluble compounds that have coprecipitated or become entrained through mixing. Such materials are correctly accounted for in the calculations by apportioning them to the water insoluble sludge fraction. Where they actually reside in the tank is immaterial. The solubility of real salt cake was examined by Schulz. Schulz examined 200-500 g amounts of salt cake taken from eight different SST's. The tanks sampled (116-TX, 105-B, 105-S, 108-S, 109-S, 110-S, 102-SX and 103-SX) represent the two predominant types of salt cake produced by evaporation of Hanford wastes. Schulz' data allows calculation of the insoluble portion of the salt cake on a vol/vol basis. The average value is 0.5% with a maximum value for any tank of 1.2%.

The flow sheet (Revision 0) used in the EIS used limited data and best engineering judgement to apportion the waste into water soluble and insoluble fractions and to calculate the effects of caustic leaching. Calculations have been substantially refined since then. The LANL model (Agnew et. al.) has been used as the basis for apportioning the waste into water soluble and insoluble fractions and to break down the total inventory into individual waste types. Colton has analyzed water leach results for 127 SST sludges obtained during waste characterization studies. Although these results were obtained from a single water wash at a relatively high water to waste ratio (100:1), they provide a reasonable estimate of the results that would be obtained from several washes at a lower ratio. The results were used to calculate a mass weighted average soluble fraction for each component of the sludge.

Calculations of caustic leach factors are based on much more limited data. Rapko et. al., examined sludges from seven tanks. Temer and Villarreal examined sludges from six tanks. Two tanks were examined by both studies, so the combined data covers eleven tanks. The largest uncertainty in the results of these studies is the representativeness of the samples studied. Most of the samples were composites, but often of two or three segments out of a total core of eight or more. The

representativeness of the cores themselves has also been questioned by critics of the Characterization Program. However, the data are the best available and reasonably consistent for the two tanks analyzed by both studies. One major weakness in the studies is that they include samples from only one tank containing redox waste. Redox waste will be a major source of aluminum and chrome which in turn may be major drivers of glass volume.

The calculation of caustic leach factors in the EIS does not depend on experimental studies. It assumes that only aluminum, chromium, and phosphorus leach with caustic. Leach factors for these three elements were determined by a number of assumptions about the compounds formed and the solubility of these compounds in caustic. Colton compared these assumptions with the PNNL experimental work. The calculated and experimental results compare quite well for aluminum and phosphorus with the calculated results being more conservative. The chromium results also compare well, but the calculated results are less conservative.

There is no doubt that present calculations of wash and leach factors are on much more solid ground than they were when the present EIS was written. The data used are the best available at this time and the calculations have been carried out in a straightforward and reasonable manner. Although not without uncertainty, the present wash and leach factors are technically defensible. Uncertainty in the factors has been incorporated into the probabilistic assessment of the canister count.

ATTACHMENT 6

Composition Range for DWPF Waste Glass

	Range (wt. %)	
Component	Minimum	Maximum
SiO_2	44.6	54.4
Al_2O_3	2.9	7.1
B_2O_3	6.9	10.2
CaO	0.8	1.2
MgO	1.3	1.5
Na_2O	8.2	12.1
K_2O	2.1	4.6
Li_2O	3.1	4.6
Fe_2O_3	7.4	12.7
MnO	1.6	3.1
TiO_2	0.6	1.0
U_3O_8	0.5	3.2
ThO_2	0.01	0.8
Group A[a]	0.08	0.2
Group B[b]	0.08	0.9

[a]Isotopes of Tc, Se, Te, Rb and Mo
[b]Isotopes of Ag, Cd, Cr, Pd, Ti, La, Ce, Pr, Pm, Nd, Sm, Tb, Sn, Sb, Co, Zr, Nb, Eu, Np, Am, and Cm.

ATTACHMENT 7

Composition Range for WVDP Glass

	Range (wt. %)	
Component	Minimum	Maximum
SiO_2	38.8	43.2
B_2O_3	11.0	14.8
$K_2O + Li_2O + Na_2O$	14.7	18.8
Fe_2O_3	10.2	13.8
Al_2O_3	5.4	6.6
$BaO + CaO + MgO$	1.2	1.6
MnO	0.7	0.9
P_2O_5	0.0	4.0
ThO_2	3.0	4.1
UO_3	0.5	0.7
ZrO_2	1.1	1.5
Other[a]	1.0	8.0

[a]Includes CeO_2, Cr_2O_3, Cs_2O, CuO, La_2O_3, MoO_3, Nd_2O_3, NiO, PdO, Pr_6O_{11}, Rh_2O_3, RuO_2, SnO_2, TeO_2, Y_2O_3, and ZnO.

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

APR 23 1996

96-WDD-029

Dr. A. L. Trego, President
Westinghouse Hanford Company
Richland, Washington

Dear Dr. Trego:

OFFICE OF TANK WASTE REMEDIATION SYSTEM (TWRS) HIGH-LEVEL WASTE (HLW) CANISTER PROJECTION ASSESSMENT AND PROJECT BASELINE GUIDANCE

An independent review team (IRT) convened in Richland, Washington on March 4-6, 1996, to review the Ex-Situ Intermediate Separations Tank Waste Alternative in the Draft Environmental Impact Statement (EIS) for the TWRS (DOE/EIS-0189). The review was to ensure that the analysis supporting the Intermediate Separations alternative was technically defensible and that the analysis methodology was understandable to the general public. The team's charter and report of its findings and recommendations are enclosed.

Report Conclusions

The team reported its findings as follows:

1. "The current range, and median value, of the number of canisters which will be produced from Hanford HLW contained in the EIS (13,800 to 70,000, and 33,400, respectively) are conservative."

2. "A range of 13,800 to 50,000 canisters, and a median value of 23,000 canisters, better reflects the current state of understanding of Hanford waste than the EIS estimates. The value of 23,000 canisters provides a more representative case for detailed planning of environmental impacts."

3. "In spite of the apparent high waste loading factors, the projected glass compositions are in the same range as nominal Defense Waste Processing Facility and West Valley glasses. As noted earlier, the high waste loading is deceptive due to the large amount of Na and Si contained in Hanford HLW."

Project Baseline Guidance

Westinghouse Hanford Company (WHC) is directed to adopt the median 23,000 canister estimate as the technical baseline for future work. WHC will use this canister estimate as its program planning baseline for purposes of estimating the size of processing facilities and the duration of facility operations and associated capital and expense cost estimates. Future work shall extend from this baseline and be traceable to it.

WHC should use the information and conclusions provided by the IRT to support closure of appropriate Systems Requirements Review Action Plan findings and recommendations.

Multi-Year Program Plan Guidance

The IRT was encouraged by the progress made in defining the tank waste inventory, and in representing uncertainty using the decision model described in WHC-EP-0874, "Decision Analysis Model for Assessment of TWRS Waste Treatment Strategy" (1995). As noted in the technical recommendations of the team's report, however, the studies presented during the review need to be completed for the disposal mission technical basis, as well as to fully utilize the emerging strengths of the decision model. WHC will work to complete the activities identified in the IRT technical recommendations with the limited funds available in Fiscal Year 1997. WHC should work closely with the Tank Focus Area to support this effort as well as complete the required workscope to meet Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Milestone M-50-03, "Complete Evaluation of Enhanced Sludge Washing."

WHC shall continue to plan to retrieve the double shell tank and single shell tank waste and separate the waste into High-Level and Low-Activity fractions. Enhanced sludge washing (caustic leaching and water washing) shall continue to be the reference process for project planning purposes until the decision is made through the TWRS EIS and M-50-03 decision analysis.

The M-50-03 sludge process decision will provide information allowing the Richland Operations Office to establish minimum performance requirements to be used in writing the TWRS Privatization Phase II Request for Proposal.

In-tank enhanced sludge washing is the reference process to support delivery of feed to the private contractors in Phase I of TWRS Privatization. The need to perform the caustic leaching process step for HLW feed in Phase I will be established after the contractor's process, Management and Integration Contractor capabilities, and life cycle costs are better understood.

We appreciate the steadfast support provided by your staff during the review of the HLW canister projection, particularly:

A. L. Boldt
P. J. Certa
M. E. Johnson
M. J. Kupfer
R. M. Orme.
D. J. Washenfelder
N. G. Colton (PNNL)

If you have questions regarding this letter, please contact me on 376-7591, or William J. Taylor on 372-3864.

Sincerely,

for Jackson Kinzer, Assistant Manager
Office of Tank Waste Remediation System

WDD:RG

Enclosure

cc: K. Gasper, WHC
J. Honeyman, WHC
R. Powell, WHC
D. Washenfelder, WHC
G. Mellinger, PNNL

APR 2 3 1996

If you have questions regarding this letter, please contact me on 376-7591, or William J. Taylor on 372-3864.

Sincerely,

ORIGINAL SIGNED BY
CP Bader for

Jackson Kinzer, Assistant Manager
Office of Tank Waste Remediation System

WDD:RG

Enclosure

cc: K. Gasper, WHC
J. Honeyman, WHC
R. Powell, WHC
D. Washenfelder, WHC
G. Mellinger, PNNL

bcc:
R. Gilbert, WDD
N. Brown, WDD
C. Haass, MSD
R. Carreon, WDD
D. Button, WDD
WDD RDG FILE
WDD OFF FILE
CC RDg FILE

RECEIVED
APR 2 5 1996
DOE RL/GCC

OFFICE >	WDD	WDD	AMF	TWR	
SURNAME>	GILBERT	TAYLOR	WIRKKALA	KINZER	
DATE >	[illegible]	[illegible]	~~4/19/96~~	~~4/25/96~~	

(Please Return To Peggy Nazarali, 3-0068 SIGMA IV) DOCUMENT No. 67352

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Eng/ Phase 1 Implementation Phase 2 facility Sizing.

ORIGINATOR Colin Henderson DATE 2/22/96

REVISION NO. 0

OBJECTIVE Calculate the size of the Phase 2 Processing facilities required to process the remainder of the tank wastes following Phase 1.

METHODOLOGY Noted.

ASSUMPTIONS Assume that the volume of HLW & LAW vitrified product is the same as the Intermediate separations alternative

(Continue on another sheet if necessary)

2/21/96
SIGNATURE/DATE

3/6/96
CHECKED/DATE

CALCULATION & RESULTS
ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT Phased Implementation SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

TPA LIMITS:

Complete HLW VIT 12/31/2028

Complete LSW VIT 12/31/2024

Phase 1 LSW Processing begins 2002 Ends 2012

HLW Processing begins 2002 Ends 2008

Phase 2

LSW 2011-2024

HLW= 2011-2028

ASSUMPTIONS:

1) The Phased Implementation alt. waste loading is the SAME as the INT. Separation. Therefore the mass of HLW and LSW produced would be the SAME over the total Phased Implementation alt.

2) Phase 1 consists of 2 plants making 20 mt/day LSW & 1 plant making 1mt/day HLW

3) The operating Efficiency during Phase 1 is 60%

4) The OPERATING Efficiency during Phase 2 would be 70%

5) The Phase 1 HLW Plant would not operate during Phase 2.

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

From the Intermediate Separations Alt.

* Mass of LAW = 8.07E+05 mt
* Mass of HLW = 54400 mt

Phase 1 Waste Processed

LAW = 2x20 mt/day X 365 day/yr X 0.6 (OE) x 10 yr
= 87,600 mt

HLW = 1x1 mt/day x 365 day/yr x 0.6 (OE) x 6 yr
= 1,314 mt.

Therefore during Phase 2 must process a total of

LAW = 8.07E5 - 87,600 = 719,400 mt

HLW = 54400 - 1314 mt = 53,086 mt.

LAW Demo Plants operate for 10 yrs during Phase 2

LAW = 40 mt/day x 10 yrs x 365 X 0.70 (OE)
= 102,200 mt.

Phase 2 High Capacity must then process.

LAW = 719400 - 102,200 = 617,200 mt
HLW = 53,086 mt

* Mass of HLW & LAW Produced under Intermediate Separations are taken from Waste loading and Blending Modifications Calculation Dated 2/21/96. See Attached Pages. LAW stream 437 HLW stream 344 as modified from the TDA Data Package for waste loading & blending

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

Plant Size is then:

$$LSW = \frac{617{,}200}{13\,yrs \times 365 \times .70\ (OE)} = 185\ mt/day$$

$$HLW = \frac{53086\ mt}{17\,yrs \times 365\,day/yr \times .70} = 12.2 \sim 12\ mt/day$$

FORM 91-005-1 (4/81)

Assumptions:										
1. HLW glass waste oxide loading basis to be 20 wt% waste oxides (excluding Na2O and SiO2)										
2. Using the WHC engineering data package material balance calculate the waste oxide loading										
and adjust mass of the glass produced to achieve a 20 wt % waste oxide loading										
3. LAW glass sodium oxide loading basis is to be 15 wt%										
	Input Stream			LAW			HLW			HLW fraction
	STREAM 1			407	437		314	344		
	solids	liquids		FRIT	GLASS		FRIT	GLASS		
Volume kilo-liters										
Specific Gravity										
Cs and Ba, (MCi)	5.28E+00	6.28E+01			4.93E-01			6.74E+01		0.990011751
Sr and Y, (MCi)	1.05E+02	2.10E+00			1.90E+00			1.05E+02		0.980392157
Tc, (MCi)	5.89E-03	2.61E-02			2.59E-02			5.91E-03		0.184745233
Am, (MCi)	9.51E-02	8.61E-03			8.60E-03			9.52E-02		0.917944268
Np, (MCi)	9.29E-05	1.03E-05			1.03E-05			9.29E-05		0.900193798
Pu-239, (MCi)	2.47E-02	1.67E-03			1.67E-03			2.47E-02		0.936670459
Pu-240, (MCi)	6.28E-03	4.14E-04			4.14E-04			6.28E-03		0.93815357
Pu-241,(MCi)	7.34E-02	1.49E-03			1.48E-03			7.34E-02		0.980104153
Total TRU, (MCi)	2.00E-01	1.22E-02			1.22E-02			2.00E-01		0.942507069
Total MCi	1.11E+02	6.49E+01			2.43E+00			1.73E+02		0.98351336
Total Mass Flow (MT)	1.94E+04	7.10E+05		2.81E+05	3.87E+05		1.36E+04	2.51E+04		
Total Cr, (MT)	1.32E+02	5.15E+01			1.44E+02			3.96E+01		
Total Na, (MT)	1.24E+03	6.51E+04			7.18E+04			2.33E+03		
Total Si, (MT)	5.24E+02	5.65E+00		1.07E+05	1.07E+05		5.29E+03	5.83E+03		
Total P, (MT)	7.80E+02	8.42E+02			1.35E+03			2.72E+02		
Total NO2-, (MT)	7.38E+01	9.54E+03								
Total NO3-, (MT)	1.03E+03	1.06E+05								
AG+	1.38E+00	3.28E-01								
AG2O					3.52E-01			1.48E+00		
AL+3	2.37E+03									
AL2O3				1.32E+04	1.94E+04			1.73E+03		
AL(OH)4-		4.83E+03								
AM+3	2.77E-02	2.51E-03								
AM2O3					2.76E-03			3.05E-02		
AS+5	4.98E-01	7.70E-01								
AS2O5					1.18E+00			7.66E-01		
B+3	9.94E-01	5.19E-01								
B2O3					1.67E+00		1.75E+03	1.76E+03		
BA+2	3.09E+00	7.91E-01								
BAO					8.81E-01			3.45E+00		
BE+2	7.61E-03	8.19E-02								
BEO					2.27E-01			2.16E-02		
BI+3	1.96E+02	6.76E+01								
BI2O3					7.52E+01			2.19E+02		
C14	4.53E-04	7.43E-04								
CA+2	1.33E+02	1.67E+01								
CANCRINITE	2.70E+03									
CAO				3.87E+04	3.87E+04			1.89E+02		
CD+2	7.93E+00	2.09E+00								
CDO					2.38E+00			9.06E+00		
CE+3	2.35E+02	2.37E+00								
CE2O3					2.79E+00			2.76E+02		
CL-	3.49E+00	3.11E+02								
CL2										
CO										
CO2										
CO3-2	2.25E+02	3.37E+03								
CR+3	1.32E+02									
CR2O3					2.11E+02			5.79E+01		
CR(OH)4-		1.19E+02								
CS+	9.25E-02	8.19E-01								
CS2O					6.83E-03			9.58E-01		
CU+2	7.46E-01	1.77E-01								
CUO					2.21E-01			9.34E-01		

CUSO4										
F-	5.97E+01	1.12E+03								
F2										
FE+3	7.63E+02	1.44E+01								
FE2O3					2.06E+01			1.21E+03		
H2										
H2O		5.07E+05								
H2S										
HG										
HG+2	9.00E-03	9.49E-01								
I-	2.02E+01	5.46E+02								
I2										
K+	2.10E+01	2.19E-01								
K2O					2.65E-01			2.53E+01		
KEROSENE										
LA+3	2.10E+01	2.19E-01								
LA2O3					2.58E-01			2.46E+01		
LI+	2.46E-02	5.77E-03								
LI2O					1.24E-02		5.00E+02	5.03E+02		
MG+2	1.10E+01	9.65E-01								
MGO					1.60E+00			1.88E+01		
MNO2	2.09E+02	2.17E+01			2.16E+01			2.09E+02		
MO+6	8.01E-01	4.87E+00								
MOO3					7.29E+00			1.22E+00		
N2										
NA+	7.77E+02	6.51E+04								
NA2O					9.68E+04			3.14E+03		
NH3										
NI+3	6.57E+00	4.07E+00								
NI2FECN6	5.00E+02									
NI2O3					5.72E+00			9.27E+00		
NIO					1.50E-02			2.27E+02		
NO										
NO2										
NO2-	7.38E+01	9.54E+03								
NO3-	1.03E+03	1.06E+05								
NP+4	1.32E-01	1.46E-02								
NPO2					1.66E-02			1.50E-01		
O2										
OH-	5.00E+03	6.44E+03								
PB+4	3.28E+00	1.96E+00								
PBO2					2.26E+00			3.79E+00		
PO4-3	2.39E+03	2.58E+03								
P2O5					3.09E+03			6.22E+02		
P2O5:24W	5.21E-01									
PU+4	4.27E-01	2.88E-02								
PUO2					3.26E-02			4.84E-01		
S										
SI+4	7.90E+01	5.65E+00								
SIO2				2.29E+05	2.29E+05		1.13E+04	1.25E+04		
SO2										
SO4-2	3.97E+01	2.01E+03								
SR+2	3.64E+01	3.75E-01								
SRO					4.00E-01			4.29E+01		
TCO2										
TCO4-	5.68E-01	2.52E+00								
TC2O7					2.39E+00			5.45E-01		
TOC	1.16E+02	1.42E+03								
UO2+2	1.58E+03	8.52E+01								
UO3					9.02E+01			1.67E+03		
V+5	1.88E-01	6.20E-02								
V2O5					1.11E-01			3.35E-01		
W+6		7.47E-01								
WO2					2.91E-05			4.41E-01		
WO3					9.40E-01			2.06E-03		
ZN+2	9.45E-01	3.59E+00								
ZNO					4.46E+00			1.19E+00		

ZR+4	2.77E+02	4.48E-01						
ZRO2					6.49E-01			6.90E+02
ZRO2:2H2	4.09E+02	2.15E+01						
WHC Data Package Basis:								
Mass LAW waste oxides					106544.7302			
LAW waste loading (waste oxide)					28%			
LAW waste loading (sodium oxide)					25%			
Mass HLW waste oxides								7.26E+03
HLW waste loading (waste oxides)								
HLW WOL (- Na2O, - SiO2)								29%
HLW WOL (all tank waste)								46%
HLW							Mass of HLW	
20 wt. % waste oxide loading								
Blending factor				1	1.25	1.5	2	3.5
Mass of glass required to achieve 20% wo loading, MT				36293.1358	45366.41975	54439.7037	72586.2716	127025.9753
additional frit required (equals increased glass) MT				1.12E+04	2.03E+04	2.93E+04	4.75E+04	1.02E+05
total frit required, MT *				2.48E+04	3.39E+04	4.29E+04	6.11E+04	1.16E+05
WOL (- Na2O, - SiO2)				20%	16%	13%	10%	6%
WOL (with all tank wastes)				32%	25%	21%	16%	9%
glass density (MT/m^3)	2.63							
cullet packing fraction	0.7	(LAW only)						
Waste volume (m^3)				1.38E+04	1.72E+04	2.07E+04	2.76E+04	4.83E+04
Canister Volume (m^3)	0.62							
Number of Canisters (1x)				2.23E+04	2.78E+04	3.34E+04	4.45E+04	7.79E+04
Nu. of Canisters /HMPC	4							
Number of HMPCs				5.56E+03	6.96E+03	8.35E+03	1.11E+04	1.95E+04
Number of trips @ 10 HMPCs /trip				556	696	835	1113	1948
Glass formulation:								
(ref Ext. Sep Data Pkg.)	acceptable range			1	1.25	1.5	2	3.5
SiO2	42 to 57 wt %			60.07%	64.68%	67.75%	71.59%	76.52%
B2O3	5 to 20 wt %			8.82%	9.63%	10.17%	10.84%	11.71%
Na20	5 to 20 wt %			8.65%	6.92%	5.77%	4.33%	2.47%
Li2O	1 to 7 wt %			2.52%	2.75%	2.91%	3.10%	3.35%
Fe2O3	2 to 15 wt %			3.33%	0.00%	0.00%	0.00%	0.00%
CaO	< or= 10 wt %			0.52%	0.42%	0.35%	0.26%	0.15%
MgO	< or = 8 wt %			0.05%	0.04%	0.03%	0.03%	0.01%
Al2O3	< or = 15 wt %			4.77%	3.81%	3.18%	2.38%	1.36%
ZrO2	< or = 13 wt %			1.90%	1.52%	1.27%	0.95%	0.54%
Cr2O3	< or = 0.5 wt %			0.16%	0.13%	0.11%	0.08%	0.05%
P2O5	< or = 3 wt %			1.71%	1.37%	1.14%	0.86%	0.49%
SO3	< or = 0.5 wt %							
HLW Facility Sizing								
Schedule	14 yrs							
Capacity MT/day	20							
Overall efficiency, %				36%	44%	53%	71%	124%
Required capacity MT/day (assuming 14 yrs ops, 60% OE)				11.84	14.80	17.76	23.67	41.43
Required operating duration yrs (assuming 20 MT/day, 60% OE)					10.36	12.43	16.57	29.00
15 wt % waste oxide loading								
Mass of glass required to achieve 15% wo loading MT				4.84E+04	6.05E+04	7.26E+04	9.68E+04	1.69E+05
Volume (m^3)				1.84E+04	2.30E+04	2.76E+04	3.68E+04	6.44E+04
Number of Canisters (1x)				2.97E+04	3.71E+04	4.45E+04	5.94E+04	1.04E+05
40 wt % waste oxide loading								
Mass of glass required to achieve 40% wo loading MT				1.81E+04	2.27E+04	2.72E+04	3.63E+04	6.35E+04
Volume (m^3)				6.90E+03	8.62E+03	1.03E+04	1.38E+04	2.41E+04

Number of Canisters (1x)				1.11E+04	1.39E+04	1.67E+04	2.23E+04	3.90E+04		
LAW										
						Mass LAW				
15 wt. % sodium oxide loading										
Blending factor				1	1.25	1.5	2	3.5		
Mass of glass required to achieve 15% wo loading, MT				6.45E+05	8.07E+05	9.68E+05	1.29E+06	2.26E+06		
additional frit required (equals increased glass) MT				3.64E+05	5.26E+05	6.87E+05	1.01E+06	1.98E+06		
total frit required, MT				6.45E+05	8.07E+05	9.68E+05	1.29E+06	2.26E+06		
glass density (MT/m^3)	2.63									
cullet packing fraction	0.7									
Waste volume (m^3)				3.51E+05	4.38E+05	5.26E+05	7.01E+05	1.23E+06		
Number of 5300 m^3 vaults				66	83	99	132	231		
LAW facility sizing										
Schedule, years	14									
Capacity MT/day	200									
Overall efficiency, %				63%	79%	95%	126%	221%		
Required capacity MT/day (assuming 14 yrs ops, 60% OE)				210.48	263.10	315.72	420.96	736.68		
Required operating duration yrs (assuming 200 MT/day, 60% OE)				14.73	18.42	22.10	29.47	51.57		
10 wt. % sodium oxide loading										
Blending factor				1	1.25		2	3.5		
Mass of glass required to achieve 10				968000	1210000		1936000	3388000		
Waste volume, m^3				525801.195	657251.4938		1051602.39	1840304.183		
Number of 5,300 m^3 vaults				99	124		198	347		
25 wt. % sodium oxide loading										
Blending factor				1	1.25		2	3.5		
Mass of glass required to achive 25 wt % Na2O				387200	484000		774400	1355200		
Waste Volume				210320.478	262900.5975		420640.956	736121.673		
Number of 5,300 m^3 vaults				40	50		79	139		

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering \ Waste Loading and Blending Modifications to support DEIS Rev C MODIFICATIONS

ORIGINATOR Colin Henderson DATE 2/21/96

REVISION NO. 0

OBJECTIVE Use WHC Rev 0 Data Package flowsheet data to recalculate the HLW & LAW Volumes using Revised Waste Loading, Blending factors, and a Common 0.62m³ Canister

METHODOLOGY Use WHC Data Pkg Material Balance data to Recalculate the HLW & LAW Volumes.

Data Packages WHC-SD-WM-EV-103, -100, -104 ALL Rev 0.

ASSUMPTIONS Noted.

(Continue on another sheet if necessary)

C Henderson 2/21/96
SIGNATURE/DATE

David J Murray 3/5/96
CHECKED/DATE

CALCULATION & RESULTS
ATTACHED

JACOBS\FORMS\CALCVR.SHT

1. HLW glass for any of the ex situ alternatives involving separations is calculated at 20 wt % waste oxides. The waste oxides exclude silica and sodium.
2. The HLW for the No Separations case is calculated at 20 wt % sodium oxide.
Note: EA glass limits are 17% Na_2O and 4.3% Li_2O and each Li_2O is equivalent to 2 Na_2O so the EA glass is equivalent to 25% Na_2O without any Li_2O. The privatization RFP states that the HLW glass will be 25 wt % waste oxides not counting the Na_2O or SiO_2.
3. The LAW glass composition is calculated at 15 wt % Na_2O.
4. The canister size for all HLW is set at 0.62 m^3 (1X canister)
5. The material balances contained in the WHC data packages were used to calculate the waste oxides for the HLW and LAW streams.
6. Sensitivity analysis will be done for the Intermediate Separations alternative at 15 wt %, and 40 wt % waste oxide loading.
7. The material balance for the Intermediate Separations case was used for the Phased Implementation alternative and was modified to account for additional radionuclide separations.
8. For purposes of interim onsite storage and transportation to the repository 4 of the 1x cans are assumed to be placed into an HMPC or similar packaging and would be repackaged at the repository.

Ex Situ alternative comparison

	Waste Loading weight %	Blending Factor	Canister Count (HLW) or, Number of LAW Vaults	Canister Size Vault Size (m^3)	Overall Processing Plant Efficiency	Duration of Operations (years)	Trips to Repository 10 rail cars/train 4 can/HMPC
No Separations							
WHC Data Pkg.	30%	1	21400	10	36%	14	
Proposed DEIS	20%	1.5	587426	0.62	60%	15	14686
Intermediate Separations							
HLW							
WHC Data Pkg.	45%	1	6800	1.26	25%	14	170
Proposed DEIS	20%	1.5	33386	0.62	60%	12	835
LAW							
WHC Data Pkg	25%	1	40	5300	36%	14	
Proposed DEIS	15%	1.25	83	5300	60%	19	
Extensive Separations							
HLW							
WHC Data Pkg.	34%	1	502	0.62	26%	14	13
Proposed DEIS	20%	1.5	1571	0.62	50%	14	39
LAW							
WHC Data Pkg.	25%	1	40	5300	36%	19	
Proposed DEIS	15%	1.25	83	5300	60%	19	
Ex Situ/In Situ Combination							
HLW							
12/95 DEIS	45%	1	3400	1.26	25%	14	85
Proposed DEIS	20%	1.5	16694	0.62	60%	12	418
LAW							
12/95 DEIS	25%	1	20	5300	36%	14	
Proposed DEIS	15%	1.25	42	5300	60%	19	
Phased Implementation							
HLW							
12/95 DEIS	0.45	1	6800	1.26	60% to 70%	Ph1=10, Ph2=14	170
Proposed DEIS	0.2	1.5	33386	0.62	60% to 85%	Ph1=6, Ph2=17	835
LAW							
12/95 DEIS	0.25	1	40	5300	60% to 70%	Ph1=10, Ph2=11	
Proposed DEIS	0.15	1.25	83	5300	60% to 85%	Ph=10, Ph2=13	

Assumptions:							
1. HLW glass waste oxide loading basis to be 20 wt% sodium oxides							
2. Using the WHC engineering data package material balance calculate the waste oxide loading							
and adjust mass of the glass produced to achieve a 20 wt % sodium oxide loading							
	Input		Frit	Output			
	Stream1		stream407	stream437			
	liquids	solids					
Volume kilo-liters	5.85E+05						
Specific Gravity	1.21E+00						
Cs and Ba, (MCi)	6.28E+01	5.28E+00		6.79E+01			
Sr and Y, (MCi)	2.10E+00	1.05E+02		1.07E+02			
Tc, (MCi)	2.61E-02	5.89E-03		3.18E-02			
Am, (MCi)	8.61E-03	9.51E-02		1.04E-01			
Np, (MCi)	1.03E-05	9.29E-05		1.03E-04			
Pu-239, (MCi)	1.67E-03	2.47E-02		2.64E-02			
Pu-240, (MCi)	4.14E-04	6.28E-03		6.70E-03			
Pu-241,(MCi)	1.49E-03	7.34E-02		7.48E-02			
Total TRU, (MCi)	1.22E-02	2.00E-01		2.12E-01			
Total MCi	6.49E+01	1.11E+02		1.76E+02			
Total Mass Flow (MT)	7.10E+05	1.94E+04	2.50E+05	3.57E+05			
Total Cr, (MT)	5.15E+01	1.32E+02		1.84E+02			
Total Na, (MT)	6.51E+04	1.24E+03		6.63E+04			
Total Si, (MT)	5.65E+00	5.24E+02	9.56E+04	9.61E+04			
Total P, (MT)	8.42E+02	7.80E+02		1.62E+03			
Total NO2-, (MT)	9.54E+03	7.38E+01					
Total NO3-, (MT)	1.06E+05	1.03E+03					
AG+	3.28E-01	1.38E+00					
AG2O				1.83E+00			
AL+3		2.37E+03					
AL2O3			1.00E+04	1.79E+04			
AL(OH)4-	4.83E+03						
AM+3	2.51E-03	2.77E-02					
AM2O3				3.32E-02			
AS+5	7.70E-01	4.98E-01					
AS2O5				1.95E+00			
B+3	5.19E-01	9.94E-01					
B2O3				4.87E+00			
BA+2	7.91E-01	3.09E+00					
BAO				4.33E+00			
BE+2	8.19E-02	7.61E-03					
BEO				2.48E-01			
BI+3	6.76E+01	1.96E+02					
BI2O3				2.94E+02			
C14	7.43E-04	4.53E-04					
CA+2	1.67E+01	1.33E+02					

CANCRINITE		2.70E+03					
CAO			3.55E+04	3.58E+04			
CD+2	2.09E+00	7.93E+00					
CDO				1.14E+01			
CE+3	2.37E+00	2.35E+02					
CE2O3				2.78E+02			
CL-	3.11E+02	3.49E+00					
CL2							
CO							
CO2							
CO3-2	3.37E+03	2.25E+02					
CR+3		1.32E+02					
CR2O3				2.68E+02			
CR(OH)4-	1.19E+02						
CS+	8.19E-01	9.25E-02					
CS2O				9.65E-01			
CU+2	1.77E-01	7.46E-01					
CUO				1.16E+00			
CUSO4							
F-	1.12E+03	5.97E+01					
F2							
FE+3	1.44E+01	7.63E+02					
FE2O3				1.23E+03			
H2							
H2O	5.07E+05						
H2S							
HG							
HG+2	9.49E-01	9.00E-03					
I-	5.46E+02	2.02E+01					
I2							
K+	2.19E-01	2.10E+01					
K2O				2.56E+01			
KEROSENE							
LA+3	2.19E-01	2.10E+01					
LA2O3				2.49E+01			
LI+	5.77E-03	2.46E-02					
LI2O				6.53E-02			
MG+2	9.65E-01	1.10E+01					
MGO				1.98E+01			
MNO2	2.17E+01	2.09E+02		2.31E+02			
MO+6	4.87E+00	8.01E-01					
MOO3				8.51E+00			
N2							
NA+	6.51E+04	7.77E+02					
NA2O				8.94E+04			
NH3							
NI+3	4.07E+00	6.57E+00					
NI2FECN6		5.00E+02					
NI2O3				1.50E+01			

NIO				2.27E+02			
NO							
NO2							
NO2-	9.54E+03	7.38E+01					
NO3-	1.06E+05	1.03E+03					
NP+4	1.46E-02	1.32E-01					
NPO2				1.66E-01			
O2							
OH-	6.44E+03	5.00E+03					
PB+4	1.96E+00	3.28E+00					
PBO2				6.05E+00			
PO4-3	2.58E+03	2.39E+03					
P2O5				3.71E+03			
P2O5:24W		5.21E-01					
PU+4	2.88E-02	4.27E-01					
PUO2				5.16E-01			
S							
SI+4	5.65E+00	7.90E+01					
SIO2			2.04E+05	2.06E+05			
SO2							
SO4-2	2.01E+03	3.97E+01					
SR+2	3.75E-01	3.64E+01					
SRO				4.33E+01			
TCO2							
TCO4-	2.52E+00	5.68E-01					
TC2O7				2.94E+00			
TOC	1.42E+03	1.16E+02					
UO2+2	8.52E+01	1.58E+03					
UO3				1.76E+03			
V+5	6.20E-02	1.88E-01					
V2O5				4.46E-01			
W+6	7.47E-01						
WO2				4.41E-01			
WO3				9.42E-01			
ZN+2	3.59E+00	9.45E-01					
ZNO				5.65E+00			
ZR+4	4.48E-01	2.77E+02					
ZRO2				7.07E+02			
ZRO2:2H2	2.15E+01	4.09E+02					
WHC data package basis:							
mass waste oxides				1.08E+05			
waste loading (wt%)				30%			
sodium oxide loading				25%			
20 wt. % sodium oxide loading							
Blending factor			1	1.25	1.5	2	3.5
Mass of glass required to achieve 20% sodium loading, M			4.47E+05	5.59E+05	6.71E+05	8.94E+05	1564500
additional frit required (equals increased glass) MT			9.00E+04	2.02E+05	3.14E+05	5.37E+05	1.21E+06

total frit required, MT			3.40E+05	4.52E+05	5.64E+05	7.87E+05	1.46E+06
Waste Loading (Na20 wt. %)			20%	16%	13%	10%	6%
Waste Loading (waste oxides)			24%	19%	16%	12%	7%
glass density (MT/m^3)	2.63						
cullet packing fraction	0.7						
Waste volume (m^3)			2.43E+05	3.04E+05	3.64E+05	4.86E+05	8.50E+05
Canister Volume (m^3)	0.62						
Number of Canisters (1x)			3.92E+05	4.90E+05	5.87E+05	7.83E+05	1.37E+06
Number of Canisters per HMPC		4					
Number of HMPCs			9.79E+04	1.22E+05	1.47E+05	1.96E+05	3.43E+05
Number of trips @ 10 HMPCs /trip			9.79E+03	1.22E+04	1.47E+04	1.96E+04	3.43E+04
Glass formulation:							
(ref Ext. Sep Data Pkg.	acceptable range	Calculated value					
SiO2	42 to 57 wt %		62.51%	66.33%	68.88%	72.06%	76.15%
B2O3	5 to 20 wt %		0.00%	0.00%	0.00%	0.00%	0.00%
Na20	5 to 20 wt %		20.00%	16.00%	13.33%	10.00%	5.71%
Li2O	1 to 7 wt %		0.00%	0.00%	0.00%	0.00%	0.00%
Fe2O3	2 to 15 wt %		0.28%	0.22%	0.18%	0.14%	0.08%
CaO	< or= 10 wt %		10.87%	11.53%	11.98%	12.53%	13.25%
MgO	< or = 8 wt %		0.00%	0.00%	0.00%	0.00%	0.00%
Al2O3	< or = 15 wt %		4.81%	4.65%	4.54%	4.40%	4.23%
ZrO2	< or = 13 wt %		0.16%	0.13%	0.11%	0.08%	0.05%
Cr2O3	< or = 0.5 wt %		0.06%	0.05%	0.04%	0.03%	0.02%
P2O5	< or = 3 wt %		0.83%	0.66%	0.55%	0.41%	0.24%
SO3	< or = 0.5 wt %						
Facility Sizing							
Schedule	14 yrs						
Capacity MT/day	200						
Overall efficiency, %			44%	55%	66%	87%	153%
Required capacity MT/day (assuming 14 yrs ops, 60% OE)				182	219	292	510
Required operating duration yrs (assuming 200 MT/day, 60% OE)				13	15.31	20	36
15 wt % sodium oxide loading							
Mass of glass required to achieve 15% wo loading MT			5.96E+05			Na2O loadin	15%
Volume (m^3) as cullet			3.24E+05				
Number of Canisters (1x)			5.22E+05				
40 wt % sodium oxide loading							
Mass of glass required to achieve 40% wo loading MT			2.24E+05			Na2O loadin	40%
Volume (m^3) as cullet			1.21E+05				
Number of Canisters (1x)			1.96E+05				

Assumptions:										
1. HLW glass waste oxide loading basis to be 20 wt% waste oxides (excluding Na2Q and SiO2)										
2. Using the WHC engineering data package material balance calculate the waste oxide loading										
and adjust mass of the glass produced to achieve a 20 wt % waste oxide loading										
3. LAW glass sodium oxide loading basis is to be 15 wt%										
	Input Stream			LAW			HLW			HLW fraction
	STREAM 1			407	437		314	344		
	solids	liquids		FRIT	GLASS		FRIT	GLASS		
Volume kilo-liters										
Specific Gravity										
Cs and Ba, (MCi)	5.28E+00	6.28E+01			4.93E-01			6.74E+01		0.990011751
Sr and Y, (MCi)	1.05E+02	2.10E+00			1.90E+00			1.05E+02		0.980392157
Tc, (MCi)	5.89E-03	2.61E-02			2.59E-02			5.91E-03		0.184745233
Am, (MCi)	9.51E-02	8.61E-03			8.60E-03			9.52E-02		0.917944268
Np, (MCi)	9.29E-05	1.03E-05			1.03E-05			9.29E-05		0.900193798
Pu-239, (MCi)	2.47E-02	1.67E-03			1.67E-03			2.47E-02		0.936670459
Pu-240, (MCi)	6.28E-03	4.14E-04			4.14E-04			6.28E-03		0.93815357
Pu-241,(MCi)	7.34E-02	1.49E-03			1.48E-03			7.34E-02		0.980104153
Total TRU, (MCi)	2.00E-01	1.22E-02			1.22E-02			2.00E-01		0.942507069
Total MCi	1.11E+02	6.49E+01			2.43E+00			1.73E+02		0.98351336
Total Mass Flow (MT)	1.94E+04	7.10E+05		2.81E+05	3.87E+05		1.36E+04	2.51E+04		
Total Cr, (MT)	1.32E+02	5.15E+01			1.44E+02			3.96E+01		
Total Na, (MT)	1.24E+03	6.51E+04			7.18E+04			2.33E+03		
Total Si, (MT)	5.24E+02	5.65E+00		1.07E+05	1.07E+05		5.29E+03	5.83E+03		
Total P, (MT)	7.80E+02	8.42E+02			1.35E+03			2.72E+02		
Total NO2-, (MT)	7.38E+01	9.54E+03								
Total NO3-, (MT)	1.03E+03	1.06E+05								
AG+	1.38E+00	3.28E-01								
AG2O					3.52E-01			1.48E+00		
AL+3	2.37E+03									
AL2O3				1.32E+04	1.94E+04			1.73E+03		
AL(OH)4-		4.83E+03								
AM+3	2.77E-02	2.51E-03								
AM2O3					2.76E-03			3.05E-02		
AS+5	4.98E-01	7.70E-01								
AS2O5					1.18E+00			7.66E-01		
B+3	9.94E-01	5.19E-01								
B2O3					1.67E+00		1.75E+03	1.76E+03		
BA+2	3.09E+00	7.91E-01								
BAO					8.81E-01			3.45E+00		
BE+2	7.61E-03	8.19E-02								
BEO					2.27E-01			2.16E-02		
BI+3	1.96E+02	6.76E+01								
BI2O3					7.52E+01			2.19E+02		
C14	4.53E-04	7.43E-04								
CA+2	1.33E+02	1.67E+01								
CANCRINITE	2.70E+03									
CAO				3.87E+04	3.87E+04			1.89E+02		
CD+2	7.93E+00	2.09E+00								
CDO					2.38E+00			9.06E+00		
CE+3	2.35E+02	2.37E+00								
CE2O3					2.79E+00			2.76E+02		
CL-	3.49E+00	3.11E+02								
CL2										
CO										
CO2										
CO3-2	2.25E+02	3.37E+03								
CR+3	1.32E+02									
CR2O3					2.11E+02			5.79E+01		
CR(OH)4-		1.19E+02								
CS+	9.25E-02	8.19E-01								
CS2O					6.83E-03			9.58E-01		
CU+2	7.46E-01	1.77E-01								
CUO					2.21E-01			9.34E-01		

CUSO4										
F-	5.97E+01	1.12E+03								
F2										
FE+3	7.63E+02	1.44E+01								
FE2O3					2.06E+01			1.21E+03		
H2										
H20		5.07E+05								
H2S										
HG										
HG+2	9.00E-03	9.49E-01								
I-	2.02E+01	5.46E+02								
I2										
K+	2.10E+01	2.19E-01								
K2O					2.65E-01			2.53E+01		
KEROSENE										
LA+3	2.10E+01	2.19E-01								
LA2O3					2.58E-01			2.46E+01		
LI+	2.46E-02	5.77E-03								
LI2O					1.24E-02		5.00E+02	5.03E+02		
MG+2	1.10E+01	9.65E-01								
MGO					1.60E+00			1.88E+01		
MNO2	2.09E+02	2.17E+01			2.16E+01			2.09E+02		
MO+6	8.01E-01	4.87E+00								
MOO3					7.29E+00			1.22E+00		
N2										
NA+	7.77E+02	6.51E+04								
NA2O					9.68E+04			3.14E+03		
NH3										
NI+3	6.57E+00	4.07E+00								
NI2FECN6	5.00E+02									
NI2O3					5.72E+00			9.27E+00		
NIO					1.50E-02			2.27E+02		
NO										
NO2										
NO2-	7.38E+01	9.54E+03								
NO3-	1.03E+03	1.06E+05								
NP+4	1.32E-01	1.46E-02								
NPO2					1.66E-02			1.50E-01		
O2										
OH-	5.00E+03	6.44E+03								
PB+4	3.28E+00	1.96E+00								
PBO2					2.26E+00			3.79E+00		
PO4-3	2.39E+03	2.58E+03								
P2O5					3.09E+03			6.22E+02		
P2O5:24W	5.21E-01									
PU+4	4.27E-01	2.88E-02								
PUO2					3.26E-02			4.84E-01		
S										
SI+4	7.90E+01	5.65E+00								
SIO2				2.29E+05	2.29E+05		1.13E+04	1.25E+04		
SO2										
SO4-2	3.97E+01	2.01E+03								
SR+2	3.64E+01	3.75E-01								
SRO					4.00E-01			4.29E+01		
TCO2										
TCO4-	5.68E-01	2.52E+00								
TC2O7					2.39E+00			5.45E-01		
TOC	1.16E+02	1.42E+03								
UO2+2	1.58E+03	8.52E+01								
UO3					9.02E+01			1.67E+03		
V+5	1.88E-01	6.20E-02								
V2O5					1.11E-01			3.35E-01		
W+6		7.47E-01								
WO2					2.91E-05			4.41E-01		
WO3					9.40E-01			2.06E-03		
ZN+2	9.45E-01	3.59E+00								
ZNO					4.46E+00			1.19E+00		

ZR+4	2.77E+02	4.48E-01								
ZRO2					6.49E-01			6.90E+02		
ZRO2:2H2	4.09E+02	2.15E+01								
WHC Data Package Basis:										
Mass LAW waste oxides					106544.7302					
LAW waste loading (waste oxide)					28%					
LAW waste loading (sodium oxide)					25%					
Mass HLW waste oxides								7.26E+03		
HLW waste loading (waste oxides)										
HLW WOL (- Na2O, - SiO2)								29%		
HLW WOL (all tank waste)								46%		
HLW										
20 wt. % waste oxide loading										
Blending factor				1	1.25	1.5	2	3.5		
Mass of glass required to achieve 20% wo loading, MT				36293.1358	45366.41975	54439.7037	72586.2716	127025.9753		
additional frit required (equals increased glass) MT				1.12E+04	2.03E+04	2.93E+04	4.75E+04	1.02E+05		
total frit required, MT				2.48E+04	3.39E+04	4.29E+04	6.11E+04	1.16E+05		
WOL (- Na2O, - SiO2)				20%	16%	13%	10%	6%		
WOL (with all tank wastes)				32%	25%	21%	16%	9%		
glass density (MT/m^3)	2.63									
cullet packing fraction	0.7	(LAW only)								
Waste volume (m^3)				1.38E+04	1.72E+04	2.07E+04	2.76E+04	4.83E+04		
Canister Volume (m^3)	0.62									
Number of Canisters (1x)				2.23E+04	2.78E+04	3.34E+04	4.45E+04	7.79E+04		
Nu. of Canisters /HMPC	4									
Number of HMPCs				5.56E+03	6.96E+03	8.35E+03	1.11E+04	1.95E+04		
Number of trips @ 10 HMPCs /trip				556	696	835	1113	1948		
Glass formulation:										
(ref Ext. Sep Data Pkg.)	acceptable range			1	1.25	1.5	2	3.5		
SiO2	42 to 57 wt %			60.07%	64.68%	67.75%	71.59%	76.52%		
B2O3	5 to 20 wt %			8.82%	9.63%	10.17%	10.84%	11.71%		
Na2O	5 to 20 wt %			8.65%	6.92%	5.77%	4.33%	2.47%		
Li2O	1 to 7 wt %			2.52%	2.75%	2.91%	3.10%	3.35%		
Fe2O3	2 to 15 wt %			3.33%	0.00%	0.00%	0.00%	0.00%		
CaO	< or= 10 wt %			0.52%	0.42%	0.35%	0.26%	0.15%		
MgO	< or = 8 wt %			0.05%	0.04%	0.03%	0.03%	0.01%		
Al2O3	< or = 15 wt %			4.77%	3.81%	3.18%	2.38%	1.36%		
ZrO2	< or = 13 wt %			1.90%	1.52%	1.27%	0.95%	0.54%		
Cr2O3	< or = 0.5 wt %			0.16%	0.13%	0.11%	0.08%	0.05%		
P2O5	< or = 3 wt %			1.71%	1.37%	1.14%	0.86%	0.49%		
SO3	< or = 0.5 wt %									
HLW Facility Sizing										
Schedule	14 yrs									
Capacity MT/day	20									
Overall efficiency, %				36%	44%	53%	71%	124%		
Required capacity MT/day (assuming 14 yrs ops, 60% OE)				11.84	14.80	17.76	23.67	41.43		
Required operating duration yrs (assuming 20 MT/day, 60% OE)					10.36	12.43	16.57	29.00		
15 wt % waste oxide loading										
Mass of glass required to achieve 15% wo loading MT				4.84E+04	6.05E+04	7.26E+04	9.68E+04	1.69E+05		
Volume (m^3)				1.84E+04	2.30E+04	2.76E+04	3.68E+04	6.44E+04		
Number of Canisters (1x)				2.97E+04	3.71E+04	4.45E+04	5.94E+04	1.04E+05		
40 wt % waste oxide loading										
Mass of glass required to achieve 40% wo loading MT				1.81E+04	2.27E+04	2.72E+04	3.63E+04	6.35E+04		
Volume (m^3)				6.90E+03	8.62E+03	1.03E+04	1.38E+04	2.41E+04		

Number of Canisters (1x)				1.11E+04	1.39E+04	1.67E+04	2.23E+04	3.90E+04		
LAW										
15 wt. % sodium oxide loading										
Blending factor				1	1.25	1.5	2	3.5		
Mass of glass required to achieve 15% wo loading, MT				6.45E+05	8.07E+05	9.68E+05	1.29E+06	2.26E+06		
additional frit required (equals increased glass) MT				3.64E+05	5.26E+05	6.87E+05	1.01E+06	1.98E+06		
total frit required, MT				6.45E+05	8.07E+05	9.68E+05	1.29E+06	2.26E+06		
glass density (MT/m^3)	2.63									
cullet packing fraction	0.7									
Waste volume (m^3)				3.51E+05	4.38E+05	5.26E+05	7.01E+05	1.23E+06		
Number of 5300 m^3 vaults				66	83	99	132	231		
LAW facility sizing										
Schedule, years	14									
Capacity MT/day	200									
Overall efficiency, %				63%	79%	95%	126%	221%		
Required capacity MT/day (assuming 14 yrs ops, 60% OE)				210.48	263.10	315.72	420.96	736.68		
Required operating duration yrs (assuming 200 MT/day, 60% OE)				14.73	18.42	22.10	29.47	51.57		
10 wt. % sodium oxide loading										
Blending factor				1	1.25		2	3.5		
Mass of glass required to achieve 10				968000	1210000		1936000	3388000		
Waste volume, m^3				525801.195	657251.4938		1051602.39	1840304.183		
Number of 5,300 m^3 vaults				99	124		198	347		
25 wt. % sodium oxide loading										
Blending factor				1	1.25		2	3.5		
Mass of glass required to achive 25 wt % Na2O				387200	484000		774400	1355200		
Waste Volume				210320.478	262900.5975		420640.956	736121.673		
Number of 5,300 m^3 vaults				40	50		79	139		

Assumptions:								
1. HLW glass waste oxide loading basis to be 20 wt% waste oxides (excluding Na2O and SiO2)								
2. Using the WHC engineering data package material balance calculate the waste oxide loading								
and adjust mass of the glass produced to achieve a 20 wt % waste oxide loading								
not counting the SiO2 or the Na2O								
	Input Stream			LAW			HLW	
	STREAM 1			407	437		1314	1344
	solids	liquids		FRIT	GLASS		FRIT	GLASS
Volume kilo-liters		5.84E+05						
Specific Gravity		1.21E+00						
Cs and Ba, (MCi)	7.60E+00	6.72E+01			6.86E-02			7.46E+01
Sr and Y, (MCi)	1.37E+02	1.41E+00			1.40E-02			1.37E+02
Tc, (MCi)	5.89E-03	2.61E-02			1.53E-04			3.17E-02
Am, (MCi)								
Np, (MCi)								
Pu-239, (MCi)								
Pu-240, (MCi)								
Pu-241,(MCi)								
Total TRU, (MCi)	1.92E-01	1.52E-02			1.20E-03			2.06E-01
Total MCi	1.45E+02	6.87E+01			8.39E-02			2.12E+02
Total Mass Flow (MT)	2.37E+04	7.06E+05		2.65E+05	3.86E+05		8.73E+02	1.32E+03
Total Cr, (MT)								
Total Na, (MT)								
Total Si, (MT)								
Total P, (MT)								
Total NO2-, (MT)								
Total NO3-, (MT)								
AG+	1.38E+00	3.28E-01						
AG2O					4.07E-01			1.43E+00
AL+3	2.37E+03							
AL2O3				1.16E+04	1.93E+04			1.94E+02
AL(OH)4-		4.83E+03						
AM+3	2.77E-02	2.51E-03						
AM2O3					3.41E-05			3.32E-02
APM-								3.44E-03
AS+5	4.98E-01	7.70E-01						
AS2O5					4.33E-01			1.51E+00
B+3	9.94E-01	5.19E-01						
B2O3					4.82E+00		1.22E+02	1.22E+02
BA+2	3.09E+00	7.91E-01						
BAO					8.76E-01			3.46E+00
BE+2	7.61E-03	8.19E-02						
BEO					5.53E-02			1.93E-01
BI+3	1.96E+02	6.76E+01						
BI2O3					2.90E+02			3.45E+00
C14	4.53E-04	7.43E-04						

CA+2	1.33E+02	1.67E+01						
CANCRINITE	2.70E+03							
CAO				3.84E+04	3.86E+04			2.34E+00
CD+2	7.93E+00	2.09E+00						
CDO					1.13E+01			1.26E-01
CE+3	2.35E+02	2.37E+00						
CE2O3					2.75E+02			3.40E+00
CL-	3.49E+00	3.11E+02						
CL2								
CO								
CO2								
CO3-2	2.25E+02	3.37E+03						
CR+3	1.32E+02							
CR2O3					2.67E+02			1.38E+00
CR(OH)4-		1.19E+02						
CS+	9.25E-02	8.19E-01						
CS2O					8.85E-04			9.64E-01
CU+2	7.46E-01	1.77E-01						
CUO					2.57E-01			8.99E-01
CUSO4								
F-	5.97E+01	1.12E+03						
F2								
FE+3	7.63E+02	1.44E+01						
FE2O3					3.74E+03			4.24E+01
H2								
H2O		5.07E+05			2.11E-04			1.10E+00
H2S								
HG								
HG+2	9.00E-03	9.49E-01						
HGO					2.07E+00			
I-	2.02E+01	5.46E+02						
I2								
K+	2.10E+01	2.19E-01						
K2O					2.55E+01			2.34E-02
KEROSENE								
LA+3	2.10E+01	2.19E-01						
LA2O3					2.46E+01			3.04E-01
LI+	2.46E-02	5.77E-03						
LI2O					6.53E-02		1.32E+01	1.32E+01
MG+2	1.10E+01	9.65E-01						
MGO					1.96E+01			2.20E-01
MNO2	2.09E+02	2.17E+01			2.31E+02			1.08E-01
MO+6	8.01E-01	4.87E+00						
MOO3					1.03E+01			9.24E-02
N2								
NA+	3.21E+03	6.26E+04						
NA2O					9.65E+04		2.40E+01	6.59E+01
NH3								
NI+3	6.57E+00	4.07E+00						

NI2FECN6	5.00E+02							
NI2O3					2.62E+02			2.82E+00
NIO					1.06E-03			1.20E+00
NO								
NO2								
NO2-	7.38E+01	9.54E+03						
NO3-	1.03E+03	1.06E+05						
NP+4	1.32E-01	1.46E-02						
NPO2					6.52E-03			1.66E-01
O2								
OH-	6.80E+03	4.64E+03						
PB+4	3.28E+00	1.96E+00						
PBO2					1.35E+00			4.71E+00
PO4-3	2.39E+03	2.58E+03						
P2O5					3.68E+03			3.96E+01
P2O5:24W	5.21E-01							
PU+4	4.27E-01	2.88E-02						
PUO2					5.42E-03			5.11E-01
S								
SI+4	7.90E+01	5.65E+00						
SIO2				2.15E+05	2.16E+05		7.13E+02	7.52E+02
SO2								
SO3					6.22E+03			1.92E-03
SO4-2	3.97E+01	2.01E+03						
SR+2	3.64E+01	3.75E-01						
SRO					4.41E-03			4.33E+01
TCO2								
TCO4-	5.68E-01	2.52E+00						
TC2O7					1.41E-02			2.92E+00
TIO2					3.16E-02			3.51E-04
TOC	1.16E+02	1.42E+03						
UO2+2	1.58E+03	8.52E+01						
UO3								2.77E+00
U3O8					1.08E+00			1.15E-02
V+5	1.88E-01	6.20E-02						
V2O5					9.92E-02			3.47E-01
W+6		7.47E-01						
WO2					1.09E-06			2.26E-04
WO3					2.10E-01			7.33E-01
ZN+2	9.45E-01	3.59E+00						
ZNO					3.17E+01			4.31E-01
ZR+4	2.77E+02	4.48E-01						
ZRO2					6.99E+02			8.55E+00
ZRO2:2H2	4.09E+02	2.15E+01						

Mass LAW waste oxides					121198.787			
LAW waste loading (waste oxides)					31%			
LAW waste loading (sodium oxide)					25%			
Mass HLW waste oxides								3.42E+02
HLW waste loading(-Na,-Si)								26%
HLW WOL (all tank waste)								34%
HLW								
20 wt. % waste oxide loading								
Blending factor				1	1.25	1.5	2	3.5
Mass of glass required to achieve 20% wo loading, MT				1707.54219	2134.42773	2561.313278	3415.08437	5976.397648
additional frit required (equals increased glass) MT				3.88E+02	8.14E+02	1.24E+03	2.10E+03	4.66E+03
total frit required, MT				1.26E+03	1.69E+03	2.11E+03	2.97E+03	5.53E+03
WOL (-Na,- Si)				20%	16%	13%	10%	6%
WOL (all tank waste)				26%	21%	17%	13%	7%
glass density (MT/m^3)	2.63							
cullet packing fraction	0.7	(LAW only)						
Waste volume (m^3)				6.49E+02	8.12E+02	9.74E+02	1.30E+03	2.27E+03
Canister Volume (m^3)	0.62							
Number of Canisters (1x)				1.05E+03	1.31E+03	1.57E+03	2.09E+03	3.67E+03
Nu. of Canisters /HMPC	4							
Number of HMPCs				2.62E+02	3.27E+02	3.93E+02	5.24E+02	9.16E+02
Number of trips @ 10 HMPCs /trip				26	33	39	52	92
Glass formulation:								
(ref Ext. Sep Data Pkg.)	acceptable range			1	1.25	1.5	2	3.5
SiO2	42 to 57 wt %			62.58%	66.39%	68.94%	72.12%	76.21%
B2O3	5 to 20 wt %			10.32%	11.06%	11.55%	12.16%	12.95%
Na20	5 to 20 wt %			4.48%	4.14%	3.91%	3.62%	3.25%
Li2O	1 to 7 wt %			1.11%	1.19%	1.24%	1.31%	1.39%
Fe2O3	2 to 15 wt %			2.48%	0.00%	0.00%	0.00%	0.00%
CaO	< or= 10 wt %			0.14%	0.11%	0.09%	0.07%	0.04%
MgO	< or = 8 wt %			0.01%	0.01%	0.01%	0.01%	0.00%
Al2O3	< or = 15 wt %			11.36%	9.09%	7.57%	5.68%	3.25%
ZrO2	< or = 13 wt %			0.50%	0.40%	0.33%	0.25%	0.14%
Cr2O3	< or = 0.5 wt %			0.08%	0.06%	0.05%	0.04%	0.02%
P2O5	< or = 3 wt %			2.32%	1.86%	1.55%	1.16%	0.66%
SO3	< or = 0.5 wt %			0.00%	0.00%	0.00%	0.00%	0.00%
HLW Facility Sizing								
Schedule	14 yrs							
Capacity MT/day	1							
Overall efficiency, %				33%	42%	50%	67%	117%
Required capacity MT/day (assuming 14 yrs ops, 60% OE)				0.56	0.70	0.84	1.11	1.95

Required operating duration yrs (assuming 1 MT/day, 60% OE)					9.75	11.70	15.59	27.29
15 wt % waste oxide loading								
Mass of glass required to achieve 15% wo loading MT				2.28E+03	2.85E+03	3.42E+03	4.55E+03	7.97E+03
Volume (m^3)				8.66E+02	1.08E+03	1.30E+03	1.73E+03	3.03E+03
Number of Canisters (1x)				1.40E+03	1.75E+03	2.09E+03	2.79E+03	4.89E+03
40 wt % waste oxide loading								
Mass of glass required to achieve 40% wo loading MT				8.54E+02	1.07E+03	1.28E+03	1.71E+03	2.99E+03
Volume (m^3)				3.25E+02	4.06E+02	4.87E+02	6.49E+02	1.14E+03
Number of Canisters (1x)				5.24E+02	6.54E+02	7.85E+02	1.05E+03	1.83E+03

LAW								
15 wt. % sodium oxide loading								
Blending factor				1	1.25	1.5	2	3.5
Mass of glass required to achieve 15% wo loading, MT				6.43E+05	8.04E+05	9.65E+05	1.29E+06	2.25E+06
additional frit required (equals increased glass) MT				2.57E+05	4.18E+05	5.79E+05	9.01E+05	1.87E+06
total frit required, MT				5.22E+05	6.83E+05	8.44E+05	1.17E+06	2.13E+06
glass density (MT/m^3)	2.63							
cullet packing fraction	0.7							
Waste volume (m^3)				3.49E+05	4.37E+05	5.24E+05	6.99E+05	1.22E+06
Number of 5300 m^3 vaults				66	83	99	132	231
LAW facility sizing								
Schedule, years	19							
Capacity MT/day	200							
Overall efficiency, %				46%	58%	70%	93%	162%
Required capacity MT/day (assuming 19 yrs ops, 60% OE)				154.61	193.26	231.92	309.22	541.14
Required operating duration yrs (assuming 200 MT/day, 60%				14.69	18.36	22.03	29.38	51.41
10 wt. % sodium oxide loading								
Blending factor				1	1.25	1.5	2	3.5
Mass of glass required to achieve 10				9.65E+05	1.21E+06	1.45E+06	1.93E+06	3.38E+06
Waste volume, m^3				5.24E+05	6.55E+05	7.86E+05	1.05E+06	1.83E+06
Number of 5,300 m^3 vaults				99	124	148	198	346
25 wt. % sodium oxide loading								
Blending factor				1	1.25	1.5	2	3.5
Mass of glass required to achive 25 wt % Na2O				3.86E+05	4.83E+05	5.79E+05	7.72E+05	1.35E+06
Waste Volume				2.10E+05	2.62E+05	3.15E+05	4.19E+05	7.34E+05
Number of 5,300 m^3 vaults				40	49	59	79	138

Assumptions:										
1. Phased Implementation Separations and Treatment is similar to Intermediate Separations										
except the separations for Sr, Tc, and TRU elements are taken from Extensive Separations										
2. HLW glass waste oxide loading basis to be 20 wt% waste oxides										
not counting the Na2O or SiO2 in the waste feed streatm										
3. Using the WHC engineering data package material balance calculate the waste oxide loading										
and adjust mass of the glass produced to achieve a 20 wt % waste oxide loading										
4. LAW glass sodium oxide loading basis is to be 15 wt%										
	Input Stream			LAW			HLW			
	STREAM 1			407	437		314	344		
	solids	liquids		FRIT	GLASS		FRIT	GLASS		HLW
Volume kilo-liters										fraction
Specific Gravity										
Cs and Ba, (MCi)	5.28E+00	6.28E+01			6.81E-01			6.74E+01		0.99
Sr and Y, (MCi)	1.05E+02	2.10E+00			1.07E+00			1.06E+02		0.99
Tc, (MCi)	5.89E-03	2.61E-02			3.20E-04			3.17E-02		0.99
Am, (MCi)	9.51E-02	8.61E-03			1.04E-03			1.03E-01		0.99
Np, (MCi)	9.29E-05	1.03E-05			1.03E-06			1.02E-04		0.99
Pu-239, (MCi)	2.47E-02	1.67E-03			2.64E-04			2.61E-02		0.99
Pu-240, (MCi)	6.28E-03	4.14E-04			6.69E-05			6.63E-03		0.99
Pu-241,(MCi)	7.34E-02	1.49E-03			7.49E-04			7.41E-02		0.99
Total TRU, (MCi)	2.00E-01	1.22E-02			2.12E-03			2.10E-01		0.99
Total MCi	1.11E+02	6.49E+01			1.76E+00			1.74E+02		0.99
Total Mass Flow (MT)	1.94E+04	7.10E+05		2.81E+05	3.87E+05		1.36E+04	2.51E+04		
Total Cr, (MT)	1.32E+02	5.15E+01			1.44E+02			3.96E+01		
Total Na, (MT)	1.24E+03	6.51E+04			7.18E+04			2.33E+03		
Total Si, (MT)	5.24E+02	5.65E+00		1.07E+05	1.07E+05		5.29E+03	5.83E+03		
Total P, (MT)	7.80E+02	8.42E+02			1.35E+03			2.72E+02		
Total NO2-, (MT)	7.38E+01	9.54E+03								
Total NO3-, (MT)	1.03E+03	1.06E+05								
AG+	1.38E+00	3.28E-01								
AG2O					3.52E-01			1.48E+00		
AL+3	2.37E+03									
AL2O3				1.32E+04	1.94E+04			1.73E+03		
AL(OH)4-		4.83E+03								
AM+3	2.77E-02	2.51E-03								
AM2O3					2.76E-03			3.05E-02		
AS+5	4.98E-01	7.70E-01								
AS2O5					1.18E+00			7.66E-01		
B+3	9.94E-01	5.19E-01								
B2O3					1.67E+00		1.75E+03	1.76E+03		
BA+2	3.09E+00	7.91E-01								
BAO					8.81E-01			3.45E+00		
BE+2	7.61E-03	8.19E-02								
BEO					2.27E-01			2.16E-02		
BI+3	1.96E+02	6.76E+01								
BI2O3					7.52E+01			2.19E+02		
CI4	4.53E-04	7.43E-04								
CA+2	1.33E+02	1.67E+01								
CANCRINITE	2.70E+03									
CAO				3.87E+04	3.87E+04			1.89E+02		
CD+2	7.93E+00	2.09E+00								
CDO					2.38E+00			9.06E+00		
CE+3	2.35E+02	2.37E+00								
CE2O3					2.79E+00			2.76E+02		
CL-	3.49E+00	3.11E+02								
CL2										
CO										
CO2										
CO3-2	2.25E+02	3.37E+03								
CR+3	1.32E+02									
CR203					2.11E+02			5.79E+01		
CR(OH)4-		1.19E+02								
CS+	9.25E-02	8.19E-01								

CS2O					6.83E-03			9.58E-01		
CU+2	7.46E-01	1.77E-01								
CUO					2.21E-01			9.34E-01		
CUSO4										
F-	5.97E+01	1.12E+03								
F2										
FE+3	7.63E+02	1.44E+01								
FE2O3					2.06E+01			1.21E+03		
H2										
H2O		5.07E+05								
H2S										
HG										
HG+2	9.00E-03	9.49E-01								
I-	2.02E+01	5.46E+02								
I2										
K+	2.10E+01	2.19E-01								
K2O					2.65E-01			2.53E+01		
KEROSENE										
LA+3	2.10E+01	2.19E-01								
LA2O3					2.58E-01			2.46E+01		
LI+	2.46E-02	5.77E-03								
LI2O					1.24E-02		5.00E+02	5.03E+02		
MG+2	1.10E+01	9.65E-01								
MGO					1.60E+00			1.88E+01		
MNO2	2.09E+02	2.17E+01			2.16E+01			2.09E+02		
MO+6	8.01E-01	4.87E+00								
MOO3					7.29E+00			1.22E+00		
N2										
NA+	7.77E+02	6.51E+04								
NA2O					9.68E+04			3.14E+03		
NH3										
NI+3	6.57E+00	4.07E+00								
NI2FECN6	5.00E+02									
NI2O3					5.72E+00			9.27E+00		
NIO					1.50E-02			2.27E+02		
NO										
NO2										
NO2-	7.38E+01	9.54E+03								
NO3-	1.03E+03	1.06E+05								
NP+4	1.32E-01	1.46E-02								
NPO2					1.66E-02			1.50E-01		
O2										
OH-	5.00E+03	6.44E+03								
PB+4	3.28E+00	1.96E+00								
PBO2					2.26E+00			3.79E+00		
PO4-3	2.39E+03	2.58E+03								
P2O5					3.09E+03			6.22E+02		
P2O5:24W	5.21E-01									
PU+4	4.27E-01	2.88E-02								
PUO2					3.26E-02			4.84E-01		
S										
SI+4	7.90E+01	5.65E+00								
SIO2				2.29E+05	2.29E+05		1.13E+04	1.25E+04		
SO2										
SO4-2	3.97E+01	2.01E+03								
SR+2	3.64E+01	3.75E-01								
SRO					4.00E-01			4.29E+01		
TCO2										
TCO4-	5.68E-01	2.52E+00								
TC2O7					2.94E-02			2.91E+00		
TOC	1.16E+02	1.42E+03								
UO2+2	1.58E+03	8.52E+01								
UO3					9.02E+01			1.67E+03		
V+5	1.88E-01	6.20E-02								
V2O5					1.11E-01			3.35E-01		
W+6		7.47E-01								
WO2					2.91E-05			4.41E-01		

WO3					9.40E-01			2.06E-03		
ZN+2	9.45E-01	3.59E+00								
ZNO					4.46E+00			1.19E+00		
ZR+4	2.77E+02	4.48E-01								
ZRO2					6.49E-01			6.90E+02		
ZRO2:2H2	4.09E+02	2.15E+01								
WHC Data Package Basis:										
Mass LAW waste oxides					106542.3696					
LAW waste loading (waste oxide)					28%					
LAW waste loading (sodium oxide)					25%					
Mass HLW waste oxides								7.26E+03		
HLW waste loading (waste oxides)								29%		
HLW										
20 wt. % waste oxide loading										
Blending factor				1	1.25	1.5	2	3.5		
Mass of glass required to achieve 20% wo loading, MT				36304.93905	45381.17381	54457.40858	72609.8781	127067.2867		
additional frit required (equals increased glass) MT				1.12E+04	2.03E+04	2.94E+04	4.75E+04	1.02E+05		
total frit required, MT				2.48E+04	3.39E+04	4.30E+04	6.11E+04	1.16E+05		
glass density (MT/m^3)	2.63									
cullet packing fraction	0.7	(LAW only)								
Waste volume (m^3)				1.38E+04	1.73E+04	2.07E+04	2.76E+04	4.83E+04		
Canister Volume (m^3)	0.62									
Number of Canisters (1x)				2.23E+04	2.78E+04	3.34E+04	4.45E+04	7.79E+04		
Nu. of Canisters /HMPC	4									
Number of HMPCs				5.57E+03	6.96E+03	8.35E+03	1.11E+04	1.95E+04		
Number of trips @ 10 HMPCs /trip				557	696	835	1113	1948		
Glass formulation:										
(ref Ext. Sep Data Pkg.)	acceptable range			1	1.25	1.5	2	3.5		
SiO2	42 to 57 wt %			60.08%	64.68%	67.75%	71.59%	76.52%		
B2O3	5 to 20 wt %			8.82%	9.63%	10.17%	10.84%	11.71%		
Na2O	5 to 20 wt %			8.65%	6.92%	5.77%	4.32%	2.47%		
Li2O	1 to 7 wt %			2.52%	2.75%	2.91%	3.10%	3.35%		
Fe2O3	2 to 15 wt %			3.33%	0.00%	0.00%	0.00%	0.00%		
CaO	< or= 10 wt %			0.52%	0.42%	0.35%	0.26%	0.15%		
MgO	< or = 8 wt %			0.05%	0.04%	0.03%	0.03%	0.01%		
Al2O3	< or = 15 wt %			4.77%	3.81%	3.18%	2.38%	1.36%		
ZrO2	< or = 13 wt %			1.90%	1.52%	1.27%	0.95%	0.54%		
Cr2O3	< or = 0.5 wt %			0.16%	0.13%	0.11%	0.08%	0.05%		
P2O5	< or = 3 wt %			1.71%	1.37%	1.14%	0.86%	0.49%		
SO3	< or = 0.5 wt %									
HLW Facility Sizing										
Schedule	14 yrs									
Capacity MT/day	20									
Overall efficiency, %				36%	44%	53%	71%	124%		
Required capacity MT/day (assuming 14 yrs ops, 60% OE)				11.84	14.80	17.76	23.68	41.44		
Required operating duration yrs (assuming 20 MT/day, 60% OE)					10.36	12.43	16.58	29.01		
15 wt % waste oxide loading										
Mass of glass required to achieve 15% wo loading MT				4.84E+04	6.05E+04	7.26E+04	9.68E+04	1.69E+05		
Volume (m^3)				1.84E+04	2.30E+04	2.76E+04	3.68E+04	6.44E+04		
Number of Canisters (1x)				2.97E+04	3.71E+04	4.45E+04	5.94E+04	1.04E+05		
40 wt % waste oxide loading										
Mass of glass required to achieve 40% wo loading MT				1.82E+04	2.27E+04	2.72E+04	3.63E+04	6.35E+04		
Volume (m^3) as cullet				6.90E+03	8.63E+03	1.04E+04	1.38E+04	2.42E+04		
Number of Canisters (1x)				1.11E+04	1.39E+04	1.67E+04	2.23E+04	3.90E+04		

LAW										
15 wt. % sodium oxide loading										
Blending factor				1	1.25	1.5	2	3.5		
Mass of glass required to achieve 15% wo loading, MT				6.45E+05	8.07E+05	9.68E+05	1.29E+06	2.26E+06		
additional frit required (equals increased glass) MT				3.64E+05	5.26E+05	6.87E+05	1.01E+06	1.98E+06		
total frit required, MT				6.45E+05	8.07E+05	9.68E+05	1.29E+06	2.26E+06		
glass density (MT/m^3)	2.63									
cullet packing fraction	0.7									
Waste volume (m^3)				3.51E+05	4.38E+05	5.26E+05	7.01E+05	1.23E+06		
Number of 5300 m^3 vaults				66	83	99	132	231		
LAW facility sizing										
Schedule, years	14									
Capacity MT/day	200									
Overall efficiency, %				63%	79%	95%	126%	221%		
Required capacity MT/day (assuming 14 yrs ops, 60% OE)				210.48	263.10	315.72	420.96	736.68		
Required operating duration yrs (assuming 200 MT/day, 60% OE)				14.73	18.42	22.10	29.47	51.57		
10 wt. % sodium oxide loading										
Blending factor				1			2	3.5		
Mass of glass required to achieve 10				968000			1936000	3388000		
Waste volume, m^3				525801.195			1051602.39	1840304.183		
Number of 5,300 m^3 vaults				99			198	347		
25 wt. % sodium oxide loading										
Blending factor				1			2	3.5		
Mass of glass required to achive 25 wt % Na2O				387200			774400	1355200		
Waste Volume				210320.478			420640.956	736121.673		
Number of 5,300 m^3 vaults				40			79	139		

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING - COST ESTIMATE - PROPOSED DRAFT EIS (Rev C) PHASED IMPLEMENTATION

ORIGINATOR D. STEIN DATE 2/27/96

REVISION NO. 2

OBJECTIVE ESTIMATE COSTS FOR PHASED IMPLEMENTATION BASED ON PROPOSED DRAFT EIS BASIS

METHODOLOGY COMPARE PLANT SIZES TO TPA + EXT. SEP. AND FACTOR AND USE ENGR. JUDGEMENT

ASSUMPTIONS "Six-Tenths" factor rule for estimating plant costs is applicable

(Continue on another sheet if necessary)

SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBSFORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 12/7/95 SUBJECT SHEET NO. 1-15

BY DLS CHKD. JOB NO. 01K47101

Cost Estimate for Phase I (Phased Implementation)

Assumptions:

R+D Costs

Assumed to be "zero" as a separate line item as phase I is itself an R+D program.

Repository Fee

Assumed to be "zero" as HLW will be stored on-site in canisters for future disposal by others. Fee not included here.

Capital Cost

To be estimated from TPA report where applicable using the "six tenths factor" rule.

$$\text{Cost of plant A} = \text{Cost of plant B}\left(\frac{\text{capacity A}}{\text{capacity B}}\right)^{0.6}$$

Operating Cost

To be estimated from TPA report by factoring and using staffing estimate comparisons

Closure Cost

To be factored from TPA based on capital cost ratio.

FORM 01-0051 (4/87)

JACOBS ENGINEERING GROUP INC.

DATE 12/7/95 SUBJECT SHEET NO. 2-15

BY DLS CHKD. JOB NO.

Information and data available

Both Extensive Retrieval (Ex Situ) which is based on The TPA report and Extensive Separations utilize 200 MT/D pretreatment and LLW vitrification plants TPA utilizes a 20 MT/D HLW vitrification plant and Ex. Sep., a 1 MT/D HLW vit. plant.

The pretreatment plants are significantly different in radionuclide separations with phased implementation assumed to be somewhere in between them.

Capital Costs

Since emissions, staffing resources, etc. have already been estimated based on TPA into factoring, capital costs will, where possible, also be based on TPA plants.

Table 9-16 backup (Table F-36), which is attached, will be used as it contains cost for TPA in various catagories.

* The 200 T/D plants (LLW vit., centralized facilities + pretreatment) are assumed to be two identical 100 T/D trains. Then the cost of each 100 T/D train is assumed to be 1/2 the cost of the total 200 T/D plant. The cost of the 100 T/D plant

FORM 81-0061 (4/81)

will be used to estimate the cost of the 20 MTD plant using the six tenths factor rule.

* The pretreatment plant will be assumed to be roughly 1/3 between Intermediate Sep (TBA) and Ext. Sep. (closer to Inter. Sep) and will cost 1/3 between the two.

20 MT/D LLW vitrification plant

$C_{200} = \$1300$ million with $C_{100} = \frac{1}{2} C_{200}$

Then, $C_{100} = \$650$ million

Then, $C_{20} = \frac{C_{100}}{\left(\frac{100}{20}\right)^{0.6}} = \frac{650}{(5)^{0.6}} = \frac{650}{2.62}$

$C_{20} = \$248$ million

20 MT/D Centralized Facilities plant

$C_{200} = 520$ million with $C_{100} = \frac{1}{2} C_{200}$

Then, $C_{100} = \$260$ million

Then, $C_{20} = \frac{C_{100}}{\left(\frac{100}{20}\right)^{0.6}} = \frac{260}{2.62}$

$C_{20} = \$99$ million

JACOBS ENGINEERING GROUP INC.

DATE 12/7 SUBJECT SHEET NO. 4-15

BY DLC CHKD. JOB NO.

1 MT/D HLW vitrification plant

$C_{20} = \$1400$ million

$$C_1 = \frac{1400}{\left(\frac{20}{1}\right)^{0.6}} = \frac{1400}{6.03}$$

$C_1 = \$232$ million

20 MT/D Pretreatment plant

Assume separations to be 1/3 of the way between intermediate sep. & extensive sep.

Info available from Table B10 Cost Summary shows Ext. Ret (Ex Situ) capital at \$5880 million and Ext. Sep. capital at \$7482 million. If capital for different sized HLW vit. plants is deducted then the difference should be a measure of difference in pretreat costs

5880 − 1400 = \$4480 million
total HLW vit 20 T/D Ext. Ret (Ex Situ) or Inter Sep

vs.

7482 − 232 = \$7250 million
total HLW vit 1 T/D estimated Ext. Sep

Then, 7250 − 4480 = 2770 million more for Ext. Sep pretreat than the 380 million for Inter. Sep. pretreat. If we assume each alternative to have the same Cesium portion, then Ext. Sep. total pretreat is estimated to cost 2770 + 380 = 3150

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 12/7 SUBJECT SHEET NO. 7-15

BY DLS CHKD. JOB NO.

Estimate total labor separate based on staffing numbers

Staff years for Operation

		years	staff per yr	staff yrs
(for both plants)	Pretreat/LLW	4	536	2144
(for both plants plus HLW plant)	Pretreat/LLW/HLW	6	578	3468
	D&D	2	961	1922
				7534 staff yrs

for TPA Dual Op. $723 million for 7080 staff yrs or $102,000/staff yr

Therefore

7534 staff yrs X $102,000/staff yr =

$768 million operating labor

Closure Cost

$\frac{\text{Capital phase I}}{\text{Capital ext. retrieval}}$ x closure cost ext. ret = $\frac{1424}{5880}$ x 170

= $41 million

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 12/7 SUBJECT SHEET NO. 8-15

BY DLS CHKD. JOB NO.

Operating Cost (not including labor)

Capital		equip	starting	D+D	ops	LLW can	HLW can	TOTAL
249	pretreat	37	15	62	37	—	4	155
99	central	—	—	—	—	—	—	—
248	LLW vit.	37	15	62	37	2	—	153
232	HLW vit.	35	14	58	6	—	4	117

pretreat 155 x 2 plants = 310
central — x 2 plants = —
LLW vit 153 x 2 plants = 306
HLW vit 117 x 1 plant = 117
$733 million

Total operating cost = 733 + 768
portable above labor

Total op. cost = $1501 million

FORM 81-005-1 (4/87)

JACOBS ENGINEERING GROUP INC.

DATE 2/26/96 SUBJECT SHEET NO. 9-15

BY DLS CHKD. JOB NO.

Continued op. cost of demo plants in phase 2

- Operate pretreat / LAW / central for additional 10 yrs (same as phase 1)
- do not operate HLW in phase 2 (too small)

Operating Cost (not including labor)

	equip	startup	D+D	oper	total
pretreat	37	—	—	37	74
central	—	—	—	—	—
LAW vit.	37	—	—	37	74
HLW vit	—	—	—	—	—

pretreat	74 x 2 plants	=	148
central	— x 2 plants	=	—
LAW vit.	74 x 2 plants	=	148
HLW vit.	—	=	—

$296 million

	labor	years	staff/yr	staff yrs
(for both plants)	pretreat/LAW	10	536	5360

5360 staff yrs x $102,000/staff yr = $547 million

op. cost of demo plants in phase 2

296 + 547 = $843 million

FORM 21-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 2/24/96 SUBJECT SHEET NO. 10 - 15

BY DLS CHKD. JOB NO.

Phase 1 Summary

capital cost	$ 1425	million
operating cost	$ 1500	million
closure costs	$ 41	million
continued operation in phase 2	$ 843	million

FORM 81-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 2/26/96 SUBJECT SHEET NO. 11-15

BY [illegible] CHKD. 12 MT/D HLW, 185 MT/D LAW JOB NO.

Capital Cost for Phase 2 Large Plants

① Consistent with phase 1 demo plants estimate, assume separations in pretreatment are 1/3 between inter. sep & ext. sep.

as $\frac{1}{3} \times \$2770$ million (difference between inter sep + ext. sep) = \$923 million more than inter. sep. pretreatment cost of \$380 million for a total of **\$1303 million**

② Central facilities would be approximately the same as inter. sep. at \$520 million even though it needs to support only 185 MT/D LAW and 12 MT/D HLW.

③ LAW vitrification would be approximately the same as inter. sep. at \$1300 million

④ HLW vitrification would be approximately ½ that of HLW 20 MT/D or $\frac{1400}{2}$ = \$700 million

⑤ The result would be a total capital cost of 1303 (pretreat) + 520 (central) + 1300 (LAW) + 700 (HLW) = \$3823 million

⑥ Assuming a 20% reduction in capital cost as a result of information gathered and optimization from phase 1 demo plants (this is approximately the same as assuming a 20% contingency here vs. 40% previously), yields \$3823 million × (100 − 20)% = **\$3058 million**

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 2/26/96 SUBJECT SHEET NO. 12-15

BY DJS CHKD. JOB NO.

Operating Cost for Phase 2 Large Plants (less operating labor)

Capital	plant	equip	startup	D+D	oper.	LAW vault	HLW can.	total
1042	pretreat	156	58	288	153	—	—	655
416	central	—	—	—	—	—	—	—
1046	LAW vit	43	54	265	141	225	—	828
560	HLW vit.	28	31	154	50	—	239	502
3058								$1985 million

above per similar Table F-36 for Inter. Sep. (attached)

Operating Labor for Phase 2 Large Plants

assume op. labor force is about the same as for the demo plants which comprize 2 separate facilities (this should be conservative)

		years	staff years
pretreat/LAW/HLW dual operation	578 staff/yr	13	7514
HLW only (72% of dual per inter sep case)	417 staff/yr	4	1668
D+D (same as demo plants)	961 staff/yr	2	1922
			11,104 staff yrs

This is approx. 70% of staff yrs estimated for inter sep case. This appears to be reasonable, again taking into account lower production rates here, shorter op. years, and efficiency due to info obtained in demo plants.

11,104 staff yrs × $102,000/staff yr = $1.133 million
(as per TPA)

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 2/26/96 SUBJECT SHEET NO. 13-15

BY DLS CHKD. JOB NO.

Total op cost base = $1985 + 1133 = $3118 million

Δ op. cost per inter. sep for 45% waste oxide loading, 1.15 blend factor for HLW and 15% Na2O loading, 1.25 blend factor for LAW, small canisters (61 x 310 cm) (excluding labor Δ). This Δ takes into account all extra op. costs for the total alternative which will process same waste and product same products as inter. sep. $1493 million *

Total Phase 2 Large plants op cost $4611 million

* Δ HLW $140 million
Δ LAW 175 million
Δ other op cost 1,178 million (vaults, canisters etc)
$1493 million

assume closure cost = $170 million (same as inter sep)

Phase 2 Summary

Capital cost $3058 million

Operating cost $4611 million

Closure cost $170 million

From previous phased impl. (no charge)

WR+T capital $2280 million

WR+T operating $3990 million

FORM 91-005-1 (4/87)

JACOBS ENGINEERING GROUP INC.

DATE 2/26/96 SUBJECT SHEET NO. 14-15

BY DLS CHKD. JOB NO.

Phased Implementation Summary

	Phase 1	Phase 2	Total Phased
Current Op.	4900	3700	8600
Total R+D	0	190	190
Capital			
WR+T	—	2280	2280
Treat.	1425	3058	4483
Closure	41	170	211
Total Capital	1466	5508	6974
Operating			
WR+T	—	3990	3990
Treat.	1500	4611	6111
Demo plants in phase 2	—	843	843
Total Operating	1500	9444	10944
Repository Fee	—	6500	6500
Total	7866 million	25342 million	$33208 million

FORM 91-005-1 (4/81)

F.11 Backup for Table 9-16

Capital Cost

Operating Cost

Table F-36. Total Cost by Unit Operation.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sludge wash	$43	$129	$6	$2	$12	$6			$9		$207
Cesium removal	$380	$276	$57	$21	$105	$56			$83		$975
Centralized facilities	$520										$520
LLW vitrification	$1,300	$624	$179	$68	$332	$176			$264		$2,934
LLW disposal		$16	$9	$4	$17	$9	$225		$14		$294
HLW vitrification	$1,400	$639	$70	$78	$384	$126			$260		$2,957
HLW transportation		$31									$24
HLW disposal								$239		$5,619	$5,858
Total	$3,643	$1,716	$322	$173	$886	$373	$225	$239	$630	$5,619	$13,826

Notes:

Table values are in millions of 1995 dollars.

JE JACOBS ENGINEERING GROUP INC.

251 SOUTH LAKE AVENUE, PASADENA, CALIFORNIA 91101-3063
TELEPHONE (818) 568-7000 FAX (818) 568-7129

FAX TRANSMITTAL

PASADENA OPERATIONS

FAX # (818) 568-7129

DATE: 2/27/96

TO: Colin Henderson FAX #: (509) 736-7504

FIRM: JEG - Kennewick

FROM: D. Stein EXT: (818) 568-7132

PROJECT: 01K47101 (For charging actual Fax) WBS: (For charging time for faxing)

COMMENTS AND MESSAGES:

Following is Phased Impl Summary + cost uncertainty info. Target Value is now slightly higher at $33,208 vs. last estimate of $32,953. Phase 1 + Phase 2 estimates are more consistent now than before. Engr. calc sheets to follow later this afternoon.

Should you not receive 7 pages (including this transmittal sheet) please contact the sender.

DATE/TIME Submitted: _____

MUST BE SENT by: _____ (date) (time)

Date Sent: _____

Time Sent: _____

Operator's Initials: _____

MISC34-004W (6/94)

JACOBS ENGINEERING GROUP INC.

DATE 2/26/96 SUBJECT SHEET NO. 14-15

BY DLS CHKD. JOB NO.

Phased Implementation Summary

	Phase 1	Phase 2	Total Phased
Current Op.	4900	3700	8600
Total R+D	0	190	190
Capital			
WR+T	—	2280	2280
Treat.	1425	3058	4483
Closure	41	170	211
Total Capital	1466	5508	6974
Operating			
WR+T	—	3990	3990
Treat.	1500	4611	6111
Demo plants in phase 2	—	843	843
Total Operating	1500	9444	10944
Repository Fee	—	6500	6500
Total	7866 million	25342 million	$33208 million

FORM 81-006-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 2/27/96 SUBJECT SHEET NO.

BY D Stern CHKD. JOB NO.

Phased Implementation (2/27/96 update)

Target Value $33,208

95% Confidence Range $30,306 – $36,542

FORM 91-005-1 (4/91)

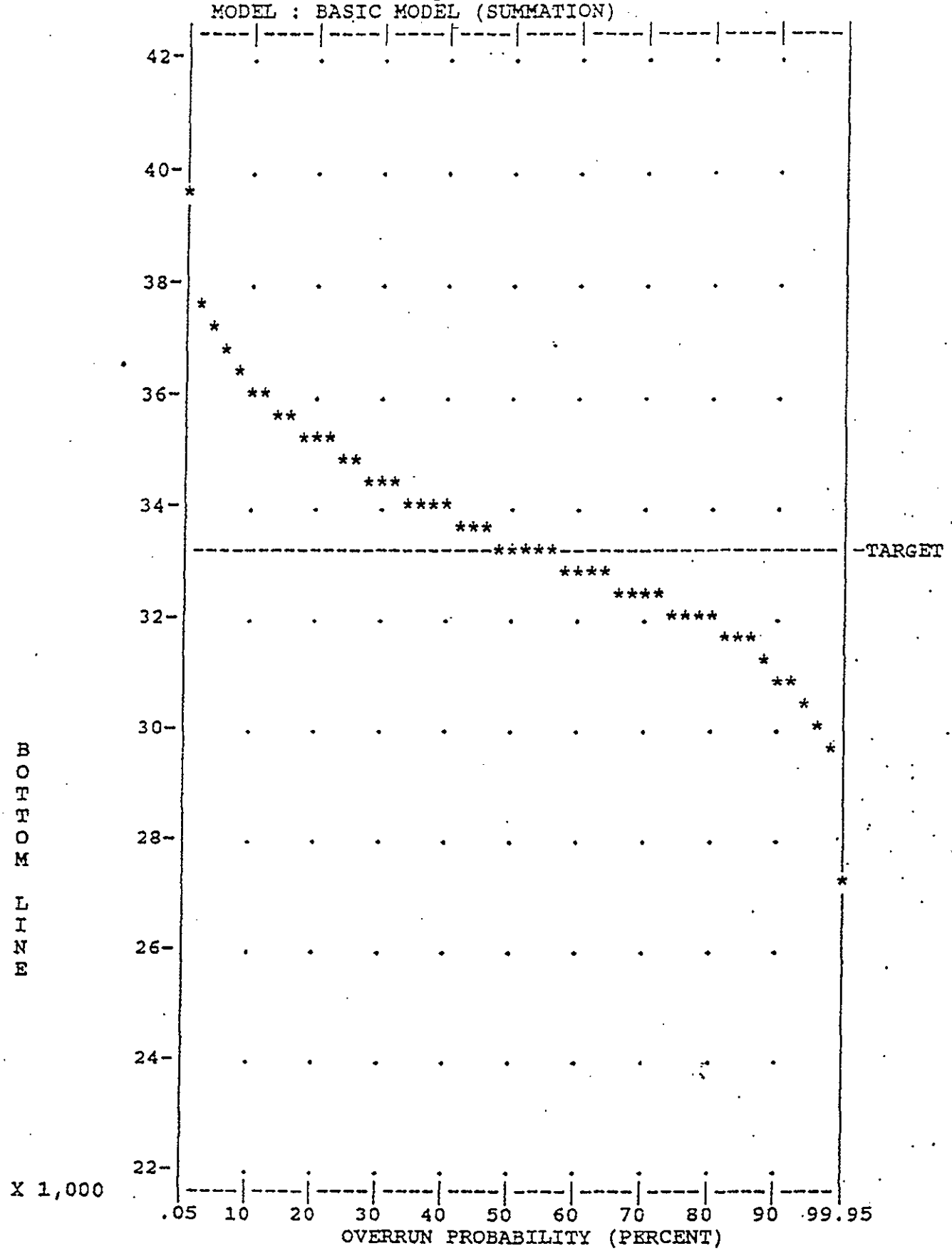
REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 02-27-96

DATA : Phased Implementation case 10B
MODEL : BASIC MODEL (SUMMATION)

NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8600	50	6880	10320
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		0		0	0
4	Capital Waste Ret. & Transfer		2280	50	1824	3876
5	Capital Treament		4483	40	3586	8966
6	Capital Closure		211.00		211.00	211.00
7	Operations Waste Ret. & Transfer		3990	50	3192	6783
8	Operations Treatment		6954	50	5215	6955
9	M & M		0		0	0
10	Repository Fee		6500	95	3900	6501
	TOTAL EXPENSE (INPUT TO REP/PC)		33208		24998 (THEORETICALS)	43802

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 02-27-96
DATA : Phased Implementation case 10B
MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 02-27-96

DATA : Phased Implementation case 10B
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
33208	52 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
5	Capital Treament		----------	++
10	Repository Fee			+++++++++++
7	Operations Waste Ret. & Transfer		-------	++
1	Current Operations		----	++++
4	Capital Waste Ret. & Transfer		----	+
8	Operations Treatment			++++
	NET EFFECT OF FROZEN ELEMENTS			

REP/PC (Ver 4.0) - MGMT REPORT 4 CONTINGENCY PROFILE : 02-27-96

DATA : Phased Implementation case 10B
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	10594	31.9	PCT
99.95	"	6308	19.0	"
95	"	3734	11.2	"
90	"	2865	8.6	"
85	"	2383	7.2	"
80	"	1958	5.9	"
75	"	1567	4.7	"
70	"	1254	3.8	"
65	"	921	2.8	"
60	"	646	2.0	"
55	"	360	1.1	"
50	"	77	.2	"
45	"	-132	-.4	"
40	"	-369	-1.1	"
35	"	-622	-1.9	"
30	"	-886	-2.7	"
25	"	-1101	-3.3	"
20	"	-1384	-4.2	"
15	"	-1745	-5.2	"
10	"	-2210	-6.7	"
5	"	-2902	-8.7	"
0.05	"	-5850	-17.6	"
0	"	-8210	-24.7	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Safety: LCFs from Transportation Accidents RADTRAN 4

ORIGINATOR Michael Harker DATE 02/12/95

REVISION NO. _____

OBJECTIVE Show LCFs from Radiological accidents. Using RADTRAN 4 for the integrated population and the worst urban population. Replaces Old Calcs.

METHODOLOGY See attachment

ASSUMPTIONS See attachment

(Continue on another sheet if necessary)

3/15/96
SIGNATURE/DATE

3/15/96
CHECKED/DATE

CALCULATION & RESULTS
ATTACHED

JACOBS\FORMS\CALCRAD.212

Battelle
Pacific Northwest Laboratories
Battelle Boulevard
P.O. Box 999
Richland, Washington 99352

FACSIMILE TRANSMITTAL

DATE: February 9, 1996

To: Mike Harker
Company: Jacobs Engineering
City/State:
Facsimile #: 736-7504
Telephone #: 736-0616

From: Phil Daling
Facsimile #: 372-4378
Telephone #: 372-4239

Transmittal Consists of [2] Page(s) including cover page.

COMMENTS:

Mike

Here are the revised impact results for the calcination alternative (changed number of cask-loads from 27,100 to 41,500). The revised numbers you will need include the routine worker and public doses and accident risks, both in person-rem and LCFs, and the revised probability of the maximum credible accident in an urban area. These values are in BOLD in the attached spreadsheet. Call me if you have any questions.

Phil

PS I just checked TRANSNET again and they are still down. The attached table was created by multiplying the previous results by the ratio of the new number of shipments to the old number of shipments. I will run the revised case when TRANSNET is available, hopefully some time today.

Revised Calcination Alternative Impacts 2/9/96

Ratio method used as approximation: TRANSNET system down on 2/9/96 so RADTRAN runs not possible

NO SEPARATIONS - CALCINATION

	ROUTINE EXPOSURES							ACCIDENTS	
	Exposures		Health Effects		Latent Cancers		Exposures	Conv.	Latent
Material	Worker	Public	Conversion		Worker	Public	Public	Factor	Cancers
MUST	7.60E-01	2.12E-01	4.00E-04	5.00E-04	3.04E-04	1.06E-04	3.43E-03	4.00E-04	1.37E-06
SST	3.04E-01	8.45E-02	4.00E-04	5.00E-04	1.22E-04	4.23E-05	1.58E-02	4.00E-04	6.32E-06
Cs capsul	2.47E-02	7.37E-03	4.00E-04	5.00E-04	9.88E-06	3.69E-06	1.33E-05	4.00E-04	5.32E-09
Sr capsule	3.01E-02	8.97E-03	4.00E-04	5.00E-04	1.20E-05	4.49E-06	2.02E-08	4.00E-04	8.08E-12
HLW	**1.82E+04**	**8.73E+02**	4.00E-04	5.00E-04	**7.28E+00**	**4.37E-01**	**3.54E-01**	5.00E-04	**1.77E-04**
	1.82E+04	**8.73E+02**			**7.28E+00**	**4.37E-01**	**3.73E-01**		**1.85E-04**

Integrated

Numbers in BOLD are revised values calculated using the ratio of old shipments (27100) to new shipments (41500). See spreadsheet WSTLOAD2.XLS, Sheet labeled COMPARISON

Revised Max Credible Accident Probability

Old ships	New Ships	Ratio	Old Prob.	New Prob	Urban Pop Dose	LCFs
27100	41500	1.531366	2.00E-05	**3.1E-05**	3.40E+03	1.70E+00
			6.00E-09	**9.2E-09**	1.60E+04	8.00E+00

Population doses and LCFs remain the same as before. Only the accident probabilities change.

[4] From: Philip M Daling at ~PNL5 2/7/96 10:16AM (104682 bytes: 1 ln, 1 fl)
To: ^Jacobs Engineering Group at ~DOE_HANFORD_1
cc: Paul S Stansbury at ~PNL41
Subject: TWRS-EIS Transportation Document
---------- Message Contents ----------

Text item 1:

ATTN: Mike Harker

The file containing the revised TWRS-EIS transportation impact results is attached. I will follow this with a formal letter and the computer files on a 3.5-inch disk. The formal package will go out in today's mail.

Thanks

Phil

ATTACHMENT 1

REVISED TRANSPORTATION IMPACT RESULTS

FOR THE TWRS EIS

REVISED TRANSPORTATION IMPACT CALCULATIONS FOR THE TWRS EIS

This attachment provides the revised transportation impact analysis in support of the Tank Waste Remediation System (TWRS) Environmental Impact Statement. The results presented in this attachment include the population dose and latent cancer fatality estimates for the routine (or incident-free) transport, accident risk estimates for potential offsite shipments, and population doses for the maximum credible transportation accidents for the following alternatives:

- **No Separations** including both Vitrification and Calcination subalternatives.
- **Intermediate Separations**, including four subalternatives: base-case waste loading in the high-level tank waste glass without the addition of Cs and Sr from the Waste Encapsulation and Storage Facility (WESF); base-case loading with Cs and Sr from WESF incorporated into the tank waste glass; 15% waste loading without additional Cs and Sr from WESF; and 40% waste loading without Cs and Sr from WESF.
- **Extensive Separations** without Cs and Sr from WESF.
- **Ex-Situ/In-Situ Combination** without Cs and Sr from WESF.
- **Phased-Implementation** without Cs and Sr from WESF.
- **Overpack and Ship Cs and Sr Capsules to Repository.**

Results from the previous analysis[1] are also included that examined two other Cs/Sr capsule disposition options, including; 1) creating HLW glass with Cs and Sr capsule material and, 2) overpacking the capsules and storing them onsite. The revised Cs and Sr source term and overpack inventory will not affect the transportation impacts for the onsite Cs and Sr capsule disposition option. Furthermore, the option of vitrifying the Cs and Sr capsule material in separate campaign from the tank wastes need not be revised.

This attachment presents re-calculated population doses for maximum credible accidents in urban areas, routine (or incident-free) exposures, and integrated accident risk estimates for all the alternatives. Population doses from transportation accidents the correspond to an accident probability of 1 in 1,000,000 (1E-06) over the entire shipping campaign are also provided. This information was not provided in the October letter.

The results presented include offsite transport of treated tank wastes as well as the onsite and offsite transport of Cs and Sr capsules, onsite transport of Miscellaneous Underground Storage (MUST)

---

1 See letter from P. M. Daling to Mike Harker dated October 17, 1995.

liquids, and onsite transport of SST residuals, where appropriate. There were no changes to the input data for onsite transport of MUST liquids, SST residuals, and Cs and Sr capsules so the transportation impact results are unchanged from those transmitted to you in October[2].

DESCRIPTION OF REVISIONS

The main revisions to the analysis have resulted from changes in the radionuclide inventories, shipment capacities, and the addition of new subalternatives. The revisions are described below:

- Significant changes have been made to the treated tank waste radionuclide compositions which have resulted in significant changes in the per-shipment radionuclide inventories used in the transportation impact calculations.

- Treated tank waste shipping configurations have been revised. The revised configuration for all tank wastes includes a 0.62 m^3 canister packaged within a Hanford Multi-Purpose Canister (HMPC). One HMPC is shipped per railcar to the repository. A dedicated train would be used, with a total of ten railcars per train shipment, to transport the loaded HMPCs to the repository.

- A sensitivity study to evaluate a range of vitrified waste loadings was performed. The sensitivity study examined three waste loadings, including 20% waste oxide (base-case), 15% oxides, and 40% oxides. This assumption was applied in the Intermediate Separations Alternative. With respect to transportation impact calculations, the waste loading assumptions affect the per-shipment radionuclide inventories and number of shipments.

- A sensitivity study to evaluate the impacts of adding Cs and Sr capsule material to the vitrification feed was examined. This assumption was applied in the Intermediate Separations Alternative. This affects the per-shipment radionuclide inventories but was assumed not to affect the number of shipments.

- Slight revisions were made to the inventories of Cs-137 and Sr-90 in the WESF capsules. The shipping configuration for overpacked Cs and Sr capsules was also revised. The analysis now assumes that five capsules are to be packaged within canisters that are in turn placed in a HMPC. A total of four canisters are to be placed in each HMPC which would then be shipped in ten-car dedicated trains to the repository. A total of 100 HMPCs (ten train shipments) containing overpacked Cs and Sr capsules were assumed to be shipped.

- The other RADTRAN 4 input parameters (shipping distances, population densities, release fractions, accident rates, etc.) are the same as described in WHC-SD-TP-RPT-016 and the previous revision[2].

---

2 See letter from P. M. Daling to Mike Harker dated October 17, 1995.

REVISED TRANSPORTATION DATA

There were two main revisions to the transportation-related data used in the impact analysis. These included the radionuclide inventory data that were used to determine the shipping cask radionuclide contents and the shipping cask design configuration, which determines the volume of waste per shipment and the number of shipments required to transport the treated tank waste materials offsite.

The basic radionuclide inventory data for the treated tank waste forms (Ci/m^3) were provided by Jacobs Engineering. These data were used to develop per-shipment radionuclide inventories that were input to the RADTRAN 4 computer code. It was assumed that the treated tank wastes would be packaged within 0.62 m^3 canisters which would then be loaded into a Hanford Multi-purpose Canister (HMPC). A total of four canisters would be placed in each HMPC. One HMPC would be placed on a railcar and transported offsite to a disposal facility via dedicated trains (i.e., trains with no other cargo). Each dedicated train was assumed to contain ten HMPC railcars. Even though the shipping scenarios assume the use of dedicated train shipments, each individual cask-load was modeled as a separate shipment. This is the configuration used for transporting treated tank wastes and overpacked Cs and Sr capsules in all the alternatives.

Based on these assumptions and the revised radionuclide inventory data provided by Jacobs Engineering, revised radionuclide source terms (Ci/cask-load) were developed. The revised inventories used in the RADTRAN 4 computer calculations are presented in Table 1. Revised numbers of shipments in each alternative are presented in Table 2. Note that Table 2 includes both the number of cask-loads of material and the number of ten-car dedicated trains required to transport the number of cask-loads produced in each alternative.

RESULTS

The population dose estimates in urban areas for the maximum credible accident scenarios from the RADTRAN 4 calculations are summarized in Table 3. The maximum credible scenarios were defined as those with probabilities greater than one in one-million (1E-06) over the entire shipping campaign. As shown, there were no accident scenario probabilities close to 1E-06 for some of the alternatives. In these situations, the accident scenarios with probabilities nearest to 1E-06 are shown in the table. The table includes the estimated annual frequencies of the maximum credible accidents for which the population doses are reported. These were computed by RADTRAN 4 using the same accident rates (accidents/km), travel fractions in urban population zones, and conditional probabilities of accidents of various severities that were reported in the TWRS EIS transportation impact support document.[3] The revised numbers of shipments reported in Table 2 were used in the calculations. Table 3 also shows the calculated latent cancer fatalities, obtained by multiplying the population dose by 5E-04 LCFs/person-rem, as was done for the support document.

---

3 See WHC-SD-TP-RPT-016 for a description of the input parameters used to calculate the probabilities of transportation accidents.

Table 1. Radionuclide Inventories for Treated Tank Waste Shipments

Radionuclide	Per-shipment Radionuclide Inventory, Ci/shipment		
	No Separations, Vitrified HLW	No Separations, Calcined HLW	Intermediate Separations, base-case loading w/o Cs and Sr material
Am-241	7.08E-01	3.84E+00	1.13E+01
Am-243	2.26E-04	1.23E-03	3.60E-03
Cm-244	8.04E-04	4.35E-03	6.64E-03
Cs-137	2.38E+02	1.29E+03	4.17E+03
Ni-63	1.83E+00	9.93E+00	3.15E+01
Np-237	4.75E-04	2.57E-03	7.43E-03
Pu-238	7.35E-03	3.99E-02	1.24E-01
Pu-239	1.80E-01	9.74E-01	2.93E+00
Pu-240	4.56E-02	2.47E-01	7.55E-01
Pu-241	5.10E-01	2.76E+00	8.78E+00
Ru-106	2.58E-07	1.40E-06	4.28E-06
Sm-151	4.29E+00	2.33E+01	7.43E+01
Sn-126	4.27E-03	2.31E-02	5.63E-02
Sr-90	2.97E+02	1.61E+03	6.31E+03
Tc-99	2.19E-01	1.18E+00	7.10E-01
U-233	8.24E-08	4.47E-07	1.35E-06
U-234	1.44E-06	7.82E-06	2.37E-05
U-235	1.40E-04	7.60E-04	2.37E-03
U-238	3.28E-03	1.78E-02	5.41E-02
Zr-93	2.68E-02	1.45E-01	4.62E-01

Radionuclide	Per-shipment Radionuclide Inventory, Ci/shipment		
	Intermediate Separations, base-case loading w/ Cs and Sr material	Intermediate Separations, 15% oxides loading w/o Cs and Sr material	Intermediate Separations, 40% oxides loading w/o Cs and Sr material
Am-241	1.13E+01	8.45E+00	2.25E+01
Am-243	3.60E-03	2.70E-03	7.21E-03
Cm-244	6.64E-03	4.98E-03	1.33E-02
Cs-137	1.04E+04	3.13E+03	8.33E+03
Ni-63	3.15E+01	2.37E+01	6.31E+01
Np-237	7.43E-03	5.57E-03	1.49E-02
Pu-238	1.24E-01	9.29E-02	2.48E-01
Pu-239	2.93E+00	2.20E+00	5.86E+00
Pu-240	7.55E-01	5.66E-01	1.51E+00
Pu-241	8.78E+00	6.59E+00	1.76E+01
Ru-106	4.28E-06	3.21E-06	8.56E-06
Sm-151	7.43E+01	5.57E+01	1.49E+02
Sn-126	5.63E-02	4.22E-02	1.13E-01
Sr-90	9.02E+03	4.73E+03	1.26E+04
Tc-99	7.10E-01	5.32E-01	1.42E+00
U-233	1.35E-06	1.01E-06	2.70E-06
U-234	2.37E-05	1.77E-05	4.73E-05
U-235	2.37E-03	1.77E-03	4.73E-03
U-238	5.41E-02	4.05E-02	1.08E-01
Zr-93	4.62E-01	3.46E-01	9.23E-01

Radionuclide	Per-shipment Radionuclide Inventory, Ci/shipment		
	Extensive Separations	Phased Implementation	Ex-Situ/In-Situ Combination
Am-241	2.64E+02	1.24E+01	1.73E+01
Am-243	8.45E-02	3.98E-03	6.63E-03
Cm-244	2.91E-01	6.64E-03	1.25E-02
Cs-137	8.87E+04	4.17E+03	7.33E+03
Ni-63	1.07E+01	3.15E+01	5.05E+01
Np-237	1.77E-01	7.43E-03	1.38E-02
Pu-238	2.72E+00	1.28E-01	9.84E-02
Pu-239	6.63E+01	3.12E+00	3.67E+00
Pu-240	1.68E+01	7.90E-01	9.15E-01
Pu-241	1.88E+02	8.85E+00	9.94E+00
Ru-106	9.57E-05	4.28E-06	3.17E-06
Sm-151	0.00E+00	7.43E+01	1.07E+02
Sn-126	1.58E+00	5.63E-02	8.22E-02
Sr-90	1.35E+05	6.36E+03	8.82E+03
Tc-99	8.12E+01	3.82E+00	1.28E+00
U-233	4.65E-08	1.35E-06	2.16E-06
U-234	8.54E-07	2.37E-05	3.83E-05
U-235	8.30E-05	2.37E-03	4.30E-03
U-238	1.93E-03	5.41E-02	9.73E-02
Zr-93	1.21E-01	4.62E-01	6.19E-01

Table 2. Number of Offsite Shipments in Each Alternative

Alternative	No. Of 0.62 m^3 Canisters	No. of Cask-loads[a]	No. Of Dedicated Train Shipments[b]
No Separations			
- Vitrification	587,000	146,860	14,690
- Calcination	108,388	27,100	2,710
Intermediate Separations			
- Base-case	33,400	8,350	840
- 15% Waste Loading	44,500	11,130	1,110
- 40% Waste Loading	16,700	4,170	420
Extensive Separations	1,570	390	40
Phased Implementation	33,400	8,350	840
Ex-Situ/In-Situ Combination	16,700	4,170	420

(a) Shipping casks are loaded with one Hanford Multi-purpose Canister per railcar. Four canisters are contained within a single HMPC.

(b) Ten railcars per dedicated train were assumed.

Table 3. Population Dose Estimates for The Maximum Credible Transportation Accidents In Urban Areas

Alternative	Material	Population Dose, person-rem	No. Of Expected Accidents	Population Risk, LCFs
Intermediate Separations Alternative	HLW glass with Cs and Sr (base-case loading)	9.4E+03	6E-06	5
	HLW glass w/o Cs and Sr (base-case loading)	4.2E+03	6E-06	2
	HLW glass at 15% waste loading, w/o Cs and Sr	3.3E+03	8E-06	2
	HLW glass at 40% waste loading, w/o Cs and Sr	7.9E+03	3E-06	4
No Separations Alternative	HLW calcined w/0 Cs and Sr	3.4E+03 1.6E+04	2E-05 6E-09	2 8
	HLW vitrified w/o Cs and Sr	3.2E+02 3.3E+03	1E-04 3E-08	None (0.2) 2
Extensive Separations	HLW glass w/o Cs and Sr	1.0E+03	2E-06	None (0.5)
Ex-Situ/In-Situ Combination	HLW glass w/o Cs and Sr	7.0E+03	3E-06	4
Phased-Implementation Alternative	HLW glass w/o Cs and Sr	4.2E+03	6E-06	2
Applicable to several alternatives	Overpacked Cs/Sr capsules	4.5E-01 1.5E+02	4E-07 7E-08	None (2E-04) None (0.07)

(a) The frequencies and population doses for two accident severity categories are provided for some shipments because there were no severity category frequencies near 1E-06/yr, the definition of a credible accident used in this study. For these situations, the severity categories closest to 1E-06 expected accidents are shown in the table.

An alternative approach to characterizing the consequences of the maximum credible accident was also explored. RADTRAN 4 offers the option of generating data that can be used to plot a cumulative distribution function of consequences. The data represent the cumulative probabilities of accidents that have consequences equal to or less than the specified value. Therefore, the consequences of accident scenarios whose cumulative probabilities are less than are equal 1E-06 can be can be taken from the curve represented by the cumulative distribution function generated by RADTRAN 4. This has the effect of improving the comparison of alternatives because the accident scenario probability is 1E-06 for all the alternatives, rather than the probabilities given in Table 3. However, it is a more complex concept than that represented by the results in Table 3 and would be far more difficult to explain in an EIS. Consequently, no recommendation is made here on which form of the maximum credible accident results should appear in the EIS.

The cumulative distribution function generated by RADTRAN 4 for the Extensive Separations alternative is shown in Figure 1 for illustration purposes. The points plotted on the figure were calculated by RADTRAN 4 and the figure was created using spreadsheet graphics software. The consequences corresponding to a cumulative probability of 1E-06 were found to be approximately 3E+04 person-rem. This value was reported in Table 4. Similar plots for all the alternatives presented in Table 4 were created using RADTRAN 4 output data and the appropriate consequences were taken from the plots.

As a result of the revised inventories and shipping cask information, all of the routine exposure and accident impact results for each of the alternatives were updated. The revised routine exposures are shown in Table 5 and revised accident impacts are presented in Table 6. Tables 7 and 8 provide the revised routine exposure and accident impact results for the Cs and Sr disposition alternatives. Only the results for the alternative involving overpacking and offsite shipment have changed from the previous analysis.

Table 4. Population Dose Estimates that Correspond to An Accident Probability of 1E-06 Over the Entire Shipping Campaign

Alternative	Material	Population Dose, person-rem	Population Risk, LCFs
Intermediate Separations Alternative	HLW glass with Cs and Sr (base-case loading)	1E+04	5
	HLW glass w/o Cs and Sr (base-case loading)	6E+03	3
	HLW glass at 15% waste loading, w/o Cs and Sr	5E+03	3
	HLW glass at 40% waste loading, w/o Cs and Sr	1E+04	5
No Separations Alternative	HLW calcined w/0 Cs and Sr	4E+03	2
	HLW vitrified w/o Cs and Sr	8E+02	None (0.4)
Extensive Separations	HLW glass w/o Cs and Sr	3E+04	15
Ex-Situ/In-Situ Combination	HLW glass w/o Cs and Sr	9E+03	5
Phased-Implementation Alternative	HLW glass w/o Cs and Sr	6E+03	3
Applicable to several alternatives	Overpacked Cs/Sr capsules	2E+01	None (0.01)

(a) Consequence estimates represent the expected population dose for accident scenarios whose probability of occurrence is 1 in 1,000,000 (1E-06) when integrated over the entire shipping campaign.

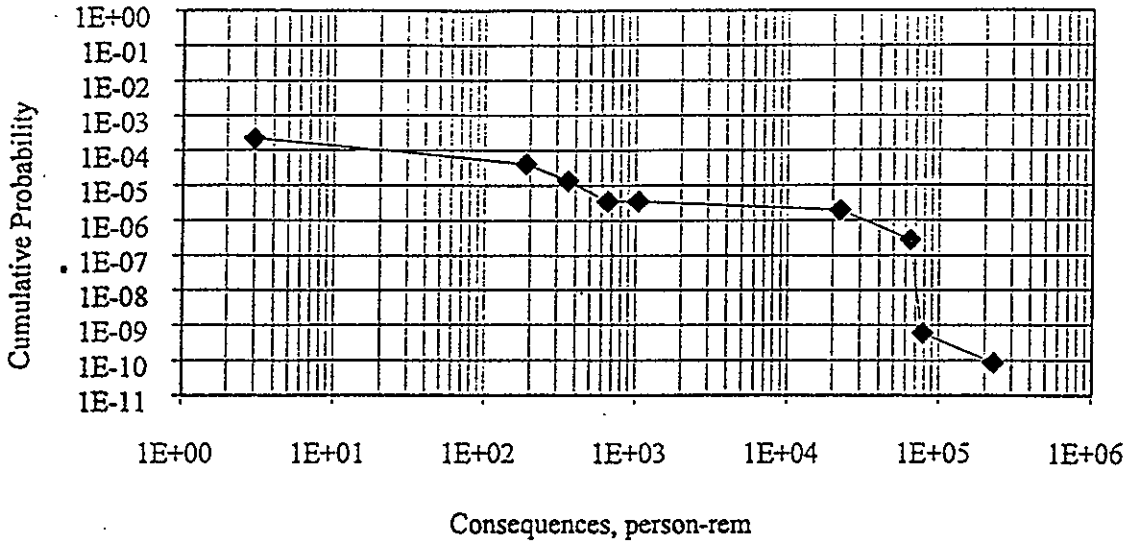


Figure 1. Cumulative Distribution Function for Treated Tank Waste Shipments in the Extensive Separations Alternative

Table 5. Revised Transportation Routine Exposure Results

Material	Population Dose, person-rem		Latent Cancer Fatalities	
	Worker	Public	Worker	Public
Intermediate Separations, Base-case Loading, Cs/Sr Not Added to HLW Glass				
MUST	7.60E-01	2.12E-01	3.04E-04	1.06E-04
SST	3.04E-01	8.45E-02	1.22E-04	4.23E-05
Cs capsules	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsules	3.01E-02	8.97E-03	1.20E-05	4.49E-06
HLW	3.65E+03	1.75E+02	1.46E+00	8.76E-02
TOTAL	**3.65E+03**	**1.76E+02**	**1.46E+00**	**8.78E-02**
Intermediate Separations, Base-Case Loading, Cs/Sr Added to HLW glass				
MUST	7.60E-01	2.12E-01	3.04E-04	1.06E-04
SST	3.04E-01	8.45E-02	1.22E-04	4.23E-05
Cs capsules	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsules	3.01E-02	8.97E-03	1.20E-05	4.49E-06
HLW	3.65E+03	1.75E+02	1.46E+00	8.76E-02
TOTAL	**3.65E+03**	**1.76E+02**	**1.46E+00**	**8.78E-02**
Intermediate Separations Alternative, 15% Waste Oxide Loading				
MUST	7.60E-01	2.12E-01	3.04E-04	1.06E-04
SST	3.04E-01	8.45E-02	1.22E-04	4.23E-05
Cs capsules	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsules	3.01E-02	8.97E-03	1.20E-05	4.49E-06
HLW	4.87E+03	2.34E+02	1.95E+00	1.17E-01
TOTAL	**4.87E+03**	**2.34E+02**	**1.95E+00**	**1.17E-01**
Intermediate Separations Alternative, 40% Waste Oxide Loading				
MUST	7.60E-01	2.12E-01	3.04E-04	1.06E-04
SST	3.04E-01	8.45E-02	1.22E-04	4.23E-05
Cs capsules	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsules	3.01E-02	8.97E-03	1.20E-05	4.49E-06
HLW	1.83E+03	8.77E+01	7.32E-01	4.38E-02
TOTAL	**1.83E+03**	**8.80E+01**	**7.32E-01**	**4.40E-02**

Material	Population Dose, person-rem		Latent Cancer Fatalities	
	Worker	Public	Worker	Public
No Separations Alternative, Vitrified Tank Waste				
MUST	7.60E-01	2.12E-01	3.04E-04	1.06E-04
SST	3.04E-01	8.45E-02	1.22E-04	4.23E-05
Cs capsules	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsules	3.01E-02	8.97E-03	1.20E-05	4.49E-06
HLW	6.43E+04	3.09E+03	2.57E+01	1.54E+00
TOTAL	**6.43E+04**	**3.09E+03**	**2.57E+01**	**1.54E+00**
No Separations Alternative, Calcined Tank Waste				
MUST	7.60E-01	2.12E-01	3.04E-04	1.06E-04
SST	3.04E-01	8.45E-02	1.22E-04	4.23E-05
Cs capsules	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsules	3.01E-02	8.97E-03	1.20E-05	4.49E-06
HLW	1.19E+04	5.70E+02	4.76E+00	2.85E-01
TOTAL	**1.19E+04**	**5.70E+02**	**4.76E+00**	**2.85E-01**
Ex-Situ/In-Situ Combination Alternative				
MUST	7.60E-01	2.12E-01	3.04E-04	1.06E-04
SST	3.04E-01	8.45E-02	1.22E-04	4.23E-05
Cs capsules	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsules	3.01E-02	8.97E-03	1.20E-05	4.49E-06
HLW	1.83E+03	8.77E+01	7.32E-01	4.38E-02
TOTAL	**1.83E+03**	**8.80E+01**	**7.32E-01**	**4.40E-02**
Extensive Separations Alternative				
MUST	7.60E-01	2.12E-01	3.04E-04	1.06E-04
SST	3.04E-01	8.45E-02	1.22E-04	4.23E-05
Cs capsules	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsules	3.01E-02	8.97E-03	1.20E-05	4.49E-06
HLW	1.71E+02	8.19E+00	6.84E-02	4.10E-03
TOTAL	**1.72E+02**	**8.50E+00**	**6.88E-02**	**4.25E-03**

Material	Population Dose, person-rem		Latent Cancer Fatalities	
	Worker	Public	Worker	Public
Phased Implementation Alternative				
MUST	7.60E-01	2.12E-01	3.04E-04	1.06E-04
SST	3.04E-01	8.45E-02	1.22E-04	4.23E-05
Cs capsules	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsules	3.01E-02	8.97E-03	1.20E-05	4.49E-06
HLW	3.65E+03	1.75E+02	1.46E+00	8.76E-02
TOTAL	**3.65E+03**	**1.76E+02**	**1.46E+00**	**8.78E-02**

Table 6. Revised Integrated Population Risks From Transportation Accidents

Material	Population Dose, person-rem	Latent Cancer Fatalities	Material	Population Dose, person-rem	Latent Cancer Fatalities
Intermediate Separations, Base-case Loading, Cs and Sr not added to HLW glass			Intermediate Separations, Base-case Loading, Cs and Sr added to HLW glass		
MUST	3.43E-03	1.37E-06	MUST	3.43E-03	1.37E-06
SST	1.58E-02	6.32E-06	SST	1.58E-02	6.32E-06
Cs capsules	1.33E-05	5.32E-09	Cs capsules	1.33E-05	5.32E-09
Sr capsules	2.02E-08	8.08E-12	Sr capsules	2.02E-08	8.08E-12
HLW	9.25E-02	4.63E-05	HLW	2.06E-01	1.03E-04
TOTAL	**1.12E-01**	**5.39E-05**	**TOTAL**	**2.25E-01**	**1.11E-04**
Intermediate Separations, 15% Waste Oxide Loading			Intermediate Separations, 40% Waste Oxide Loading		
MUST	3.43E-03	1.37E-06	MUST	3.43E-03	1.37E-06
SST	1.58E-02	6.32E-06	SST	1.58E-02	6.32E-06
Cs capsules	1.33E-05	5.32E-09	Cs capsules	1.33E-05	5.32E-09
Sr capsules	2.02E-08	8.08E-12	Sr capsules	2.02E-08	8.08E-12
HLW	9.52E-02	4.76E-05	HLW	8.60E-02	4.30E-05
TOTAL	**1.14E-01**	**5.53E-05**	**TOTAL**	**1.05E-01**	**5.07E-05**

Material	Population Dose, person-rem	Latent Cancer Fatalities	Material	Population Dose, person-rem	Latent Cancer Fatalities
No Separations, Vitrified Tank Waste			**No Separations, Calcined Tank Waste**		
MUST	3.43E-03	1.37E-06	MUST	3.43E-03	1.37E-06
SST	1.58E-02	6.32E-06	SST	1.58E-02	6.32E-06
Cs capsules	1.33E-05	5.32E-09	Cs capsules	1.33E-05	5.32E-09
Sr capsules	2.02E-08	8.08E-12	Sr capsules	2.02E-08	8.08E-12
HLW	1.21E-01	6.05E-05	HLW	2.31E-01	~~1.16E-04~~ 1.77E-(
TOTAL	1.40E-01	6.82E-05	TOTAL	2.50E-01	~~1.23E-04~~ 1.85E-
Ex-Situ/In-Situ Combination			**Extensive Separations**		
MUST	3.43E-03	1.37E-06	MUST	3.43E-03	1.37E-06
SST	1.58E-02	6.32E-06	SST	1.58E-02	6.32E-06
Cs capsules	1.33E-05	5.32E-09	Cs capsules	1.33E-05	5.32E-09
Sr capsules	2.02E-08	8.08E-12	Sr capsules	2.02E-08	8.08E-12
HLW	7.64E-02	3.82E-05	HLW	6.59E-02	3.30E-05
TOTAL	9.56E-02	4.59E-05	TOTAL	8.51E-02	4.06E-05
Phased Implementation					
MUST	3.43E-03	1.37E-06			
SST	1.58E-02	6.32E-06			
Cs capsules	1.33E-05	5.32E-09			
Sr capsules	2.02E-08	8.08E-12			
HLW	9.27E-02	4.64E-05			
TOTAL	1.12E-01	5.40E-05			

Table 7. Revised Transportation Routine Dose Impacts from Cs/Sr Disposition Alternatives

	Population Dose, Person-rem		Latent Cancer Fatalities	
	Worker	Public	Worker	Public
Cesium and Strontium Vitrified				
Cs capsules	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsules	3.01E-02	8.97E-03	1.20E-05	4.49E-06
Glass	1.97E+01	9.46E-01	7.88E-03	4.73E-04
TOTAL	**1.98E+01**	**9.62E-01**	**7.90E-03**	**4.81E-04**
Cesium and Strontium Overpacked, Shipped Offsite for Disposal				
Cs capsule	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsule	3.01E-02	8.97E-03	1.20E-05	4.49E-06
Overpacked capsules	4.38E+01	2.11E+00	1.75E-02	1.06E-03
TOTAL	**4.39E+01**	**2.13E+00**	**1.75E-02**	**1.06E-03**
Cesium and Strontium Overpacked, Stored Onsite				
Cs capsules	2.47E-02	7.37E-03	9.88E-06	3.69E-06
Sr capsules	3.01E-02	8.97E-03	1.20E-05	4.49E-06
Overpacks	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTAL	**5.48E-02**	**1.63E-02**	**2.19E-05**	**8.17E-06**

Table 8. Transportation Accident Impacts of Cs and Sr Disposition Alternatives

Material	Population Risk, person rem	Latent Cancer Fatalities
Cesium and Strontium Vitrified		
Cs capsules	1.33E-05	5.32E-09
Sr capsules	2.02E-08	8.08E-12
Glass	3.10E-02	1.55E-05
TOTAL	**3.10E-02**	**1.55E-05**
Cesium and Strontium Overpacked, Shipped Offsite for Disposal		
Cs capsule	1.33E-05	5.32E-09
Sr capsule	2.02E-08	8.08E-12
Overpacked Capsules	3.44E-05	1.72E-08
TOTAL	**4.77E-05**	**2.25E-08**
Cesium and Strontium Overpacked, Stored Onsite		
Cs capsules	1.33E-05	5.32E-09
Sr capsules	2.02E-08	8.08E-12
Overpacks Offsite	0.00E+00	0.00E+00
TOTAL	**1.33E-05**	**5.33E-09**

RADTRAN4 OUTPUT FILES

RADTRAN4 OUTPUT FILES

The attached 3.5-inch disk provides the RADTRAN4 output files that were developed to model offsite shipments of treated tank wastes and packaged cesium and strontium capsules (filename RADTRAN2.OUT). The output files contain an input echo as the first part of the file so the attached files document both the input parameters used in the calculations as well as the output. The table below is a key to the attached files, listing the files in the order they appear in the file on the attached disk, plus presents the filename and a brief description of the material analyzed in each file. Also on the enclosed disk are the spreadsheet files used to perform some of the calculations documented in this study. These include WSTLOAD2.XLS (calculated per-shipment radionuclide inventories and numbers of shipments), RESULTS5.XLS (calculates total routine exposures and integrated accident risks), and MAX-CRED.XLS (risk curves for each material).

No.	RADTRAN4 Filename	Alternative and Material Analyzed
1	COMBO2.OUT	Ex-situ/In-situ combination alternative, vitrified tank waste without Cs and Sr capsule materials.
2	CSSROP2.OUT	Overpacked Cs and Sr capsules.
3	EXTSEP2.OUT	Extensive separations alternative, vitrified tank waste without Cs and Sr capsule materials.
4	INT152.OUT	Intermediate separations alternative, vitrified tank waste at 15% waste oxide loading.
5	INT402.OUT	Intermediate separations alternative, vitrified tank waste at 40% waste oxide loading.
6	INTBW2.OUT	Intermediate separations alternative, vitrified tank waste at base-case (20%) waste oxide loading.
7	INTBWO2.OUT	Intermediate separations alternative, vitrified tank waste at base-case (20%) waste oxide loading. Cs and Sr capsule material vitrified with tank wastes.
8	NOSEPCW2.OUT	No separations alternative, calcined tank wastes without Cs and Sr capsule materials.
9	NOSEPVW2.OUT	No separations alternative, vitrified tank wastes without Cs and Sr capsule materials.
10	PHASED2.OUT	Phased-implementation alternative, vitrified tank wastes without Cs and Sr capsule materials.

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGR/COST - TANK WASTE ALTERNATIVES - COST UNCERTAINTY

ORIGINATOR D. Stein DATE 2/8/96

REVISION NO. Ø 1 CH. 3/25/

OBJECTIVE DETERMINE RANGE ESTIMATE FOR ALTERNATIVES

METHODOLOGY USE DECISION SCIENCE CORP (DSC) RANGE ESTIMATING PROGRAM for PERSONAL COMPUTERS (REP/PC)

ASSUMPTIONS RANGES FOR CRITICAL COST ITEMS ASSUMED, PROBABILTY OF COST EQUAL TO OR LESS ASSUMED PER ATTACHED BASES.

OUTPUT FILES INCLUDED

(Continue on another sheet if necessary)

SEE Attached Revision Description

SIGNATURE D L Stein

CHECKED: CH. 2/21/96

CALCULATION & RESULTS ATTACHED

JACOBSFORMS\CALCVR.SET

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

CALCULATION: COST UNCERTAINTY

Rev 1 changes:

- Revised Cost Uncertainty to reflect the latest operations cost. (Revised due to canister/waste loading)
- Revised Ex Situ Cases to for repository fee @ $360,000/canister (1995 dollars) also included cost uncertainty calculations for ex situ alternatives
- Included additional characterization cost in the In Situ filled Cap, In Situ Vitrification, and Ex Situ/In Situ Combination alternative. (903 million in the In Situ F&Cap and ISV ALT., 542 million in the COMBO ALT.)

FORM 91-005-1 (4/81)

RECEIVED
MAR 21 1996

Stein, David

From: Stein, David
To: Henderson, Colin
Subject: Hanford TWEIS Alternatives Cost Update
Date: Wednesday, March 20, 1996 1:35PM

Following are Hanford TWEIS Alternatives cost updates with corrections for Treatment Operating Costs. These corrections were noted in the engineering calculations dated 2/20/96, but were never transferred to the final cost tables until now. The operating costs corrections are also presented here for your comparison.

TABLE 1

	PREVIOUS OPERATING COSTS (MILLIONS)	CORRECTED OPERATING COSTS(MILLIONS)
Intermediate Separations	$5,577	$5,509
No Separations(Vitrification)	$23,273	$22,742
No Separations(Calcination)	$8,182	$7,548
ExSitu/InSitu Combination	$2,672	$2,638

TABLE 2

ALTERNATIVE	TOTAL COST(WITH REPOSITORY FEE@$360,000 PER CANISTER) TARGET VALUE (MILLIONS)	95% CONFIDENCE RANGE (MILLIONS)
Intermediate Separations	$37,818	$30,399 —— $40,552
No Separations(Vitrification)	$252,669	$69,475 —— $252,669
No Separations(Calcination)	$85,815	$38,789 —— $86,141
ExSitu/InSitu Combination	$25,526	$22,990 —— $27,913

TABLE 3

ALTERNATIVE	COST EXCLUDING REPOSITORY FEE TARGET VALUE (MILLIONS)	95% CONFIDENCE RANGE (MILLIONS)
Intermediate Separations	$25,798	$23,775 —— $29,741
No Separations(Vitrification)	$41,209	$25,560 —— $43,559
No Separations(Calcination)	$26,015	$22,157 —— $28,708
ExSitu/InSitu Combination	$19,516	$17,956 —— $22,407

These changes should bring the alternatives up to date. Let me know if I can do anything else.

Stein, David

From: Stein, David
To: Henderson, Colin
Subject: TWEIS Cost Uncertainty Update
Date: Monday, March 18, 1996 10:04AM

Following are Hanford TWEIS Alternatives Cost Uncertainty updates which include an increase for tank characterization costs ($903 million for InSitu Fill & Cap and InSitu Vitrification and 60% of $903 or $542 million for InSitu/ExSitu Combo):

ALTERNATIVE	TARGET VALUE (millions)	95% CONFIDENCE RANGE (millions)
InSitu Fill & Cap	$7,884	$6,972 — $8,815
InSitu Vitrification	$16,578	$16,185 — $23,840
InSitu/ExSitu Combo with Repository Fee @ $360,000 per canister($6,010 million)	$25,560	$22,996 — $27,947
InSitu/ExSitu Combo without Repository Fee	$19,550	$17,968 — $22,441
InSitu/ExSitu Combo with Repository Fee @ $5,000 million(Feb 96)	$24,550	$22,466 — $27,151

After reviewing the cost components of the Repository Fee in the TRW Report, I can confirm that there was no double counting when compared to the Westinghouse Data Packages. The Repository Fee included a cost for an outer barrier for the HLW package in which it is placed before insertion into the vault. This outer barrier is either in addition to the MPC or replaces the MPC, I cannot determine which.

RECEIVED
MAR 19 1996

Stein, David

RECEIVED MAR 1 4 1996

From: Stein, David
To: Henderson, Colin
Subject: Hanford TWEIS Alternatives Cost Uncertainty
Date: Wednesday, March 13, 1996 12:51PM

Following are Hanford TWEIS Alternatives Cost Uncertainty Tables with and without Repository Fee (fee has been calculated using $360,000 per canister per latest directive):

TABLE 1

ALTERNATIVE	TOTAL ALTERNATIVE COST(WITH REPOSITORY FEE) TARGET VALUE (millions)	95% CONFIDENCE RANGE (millions)
Intermediate Separations	$37,886	$30,465 — $40,598
No Separations (Vitrification)	$253,200	$69,971 — $253,200
No Separations (Calcination)	$86,449	$39,406 — $86,548
Extensive Separations	$28,544	$27,477 — $36,471
ExSitu/InSitu Combination	$25,018	$22,691 — $27,197
Phased Implementation	$38,728	$31,843 — $41,756
Junior Combo	$19,461	$18,512 — $22,053

Note: For most alternatives, repository fee is so high that it dominates the cost uncertainty. I would recommend that the repository fee be considered as a separate item with no range included and just a note as to how it was calculated; e.g. $360,000 charge per canister.

TABLE 2

ALTERNATIVE	ALTERNATIVE REMEDIATION COST(EXCLUDES REP FEE) TARGET VALUE (millions)	95% CONFIDENCE RANGE (million)
Intermediate Separations	$25,866	$23,818 — $29,808
No Separations (Vitrification)	$41,740	$25,628 — $44,074
No Separations (Calcination)	$26,649	$22,276 — $29,269
Extensive Separations	$27,979	$26,580 — $35,476
ExSitu/InSitu Combination	$19,008	$17,742 — $21,774
Phased Implementation	$26,708	$25,000 — $31,109
Junior Combo	$16,331	$15,089 — $18,633

I will send copies of the model output by Fed Ex this afternoon. Give me a call if you have any questions.

Henderson, Colin

From: Stein, David
To: Henderson, Colin
Subject: Hanford TWEIS Alternatives Cost Update
Date: Wednesday, March 20, 1996 1:35PM

Following are Hanford TWEIS Alternatives cost updates with corrections for Treatment Operating Costs. These corrections were noted in the engineering calculations dated 2/20/96, but were never transferred to the final cost tables until now. The operating costs corrections are also presented here for your comparison.

TABLE 1

	PREVIOUS OPERATING COSTS (MILLIONS)	CORRECTED OPERATING COSTS(MILLIONS)
Intermediate Separations	$5,577	$5,509
No Separations(Vitrification)	$23,273	$22,742
No Separations(Calcination)	$8,182	$7,548
ExSitu/InSitu Combination	$2,672	$2,638

TABLE 2

ALTERNATIVE	TOTAL COST(WITH REPOSITORY FEE@$360,000 PER CANISTER) TARGET VALUE (MILLIONS)	95% CONFIDENCE RANGE (MILLIONS)
Intermediate Separations	$37,818	$30,399 ----- $40,552
No Separations(Vitrification)	$252,669	$69,475 ----- $252,669
No Separations(Calcination)	$85,815	$38,789 ----- $86,141
ExSitu/InSitu Combination	$25,526	$22,990 ----- $27,913

TABLE 3

ALTERNATIVE	COST EXCLUDING REPOSITORY FEE TARGET VALUE (MILLIONS)	95% CONFIDENCE RANGE (MILLIONS)
Intermediate Separations	$25,798	$23,775 ----- $29,741
No Separations(Vitrification)	$41,209	$25,560 ----- $43,559
No Separations(Calcination)	$26,015	$22,157 ----- $28,708
ExSitu/InSitu Combination	$19,516	$17,956 ----- $22,407

These changes should bring the alternatives up to date. Let me know if I can do anything else.

Henderson, Colin

From: Stein, David
To: Henderson, Colin
Subject: TWEIS Cost Uncertainty Update
Date: Monday, March 18, 1996 10:04AM

Following are Hanford TWEIS Alternatives Cost Uncertainty updates which include an increase for tank characterization costs ($903 million for InSitu Fill & Cap and InSitu Vitrification and 60% of $903 or $542 million for InSitu/ExSitu Combo):

ALTERNATIVE	TARGET VALUE (millions)	95% CONFIDENCE RANGE (millions)
InSitu Fill & Cap	$7,884	$6,972 --- $8,815
InSitu Vitrification	$16,578	$16,185 --- $23,840
InSitu/ExSitu Combo with Repository Fee @ $360,000 per canister($6,010 million)	$25,560	$22,996 --- $27,947
InSitu/ExSitu Combo without Repository Fee	$19,550	$17,968 --- $22,441
InSitu/ExSitu Combo with Repository Fee @ $5,000 million(Feb 96)	$24,550	$22,466 --- $27,151

After reviewing the cost components of the Repository Fee in the TRW Report, I can confirm that there was no double counting when compared to the Westinghouse Data Packages. The Repository Fee included a cost for an outer barrier for the HLW package in which it is placed before insertion into the vault. This outer barrier is either in addition to the MPC or replaces the MPC, I cannot determine which.

Henderson, Colin

From: Stein, David
To: Henderson, Colin
Subject: Capsule Alternatives Cost Revision(Repository Fee Change)
Date: Monday, March 18, 1996 1:54PM

Incorporating the revised Repository Fee method ($360,000 per canister) results in the following for the Capsule Alternatives:

	CAPSULE ALTERNATIVES	
	OVERPACK AND SHIP (millions)	VITRIFY WITH TANK WASTE (millions)
Current Operations	$377	$315
R&D	$14	$5
Capital	$32	$36
Operating	$34	$46
M&M	-----	$1
D&D	$6	$6
Repository Fee	$144	$232
Total	$607	$641

JACOBS ENGINEERING GROUP INC.

DATE 2/8/96 SUBJECT SHEET NO. 1-2

BY D. Stern CHKD. JOB NO.

Cost Uncertainty

Cost uncertainty for the various tank waste treatment alternatives has been evaluated using Decision Science Corporation (DSC) Range Estimating Program for personal computers (REP/PC). Typically, Range Estimating applies to one time decisions such as capital investments, engineering cost estimates, and competitive bids. The Range Estimating Program has enjoyed a long and successful record of use since its introduction by DSC in the early 1970s. It has been applied to thousands of diverse problems

by thousands of users. A small sampling of industries using REP/PC includes government, defense, engineering construction, and research.

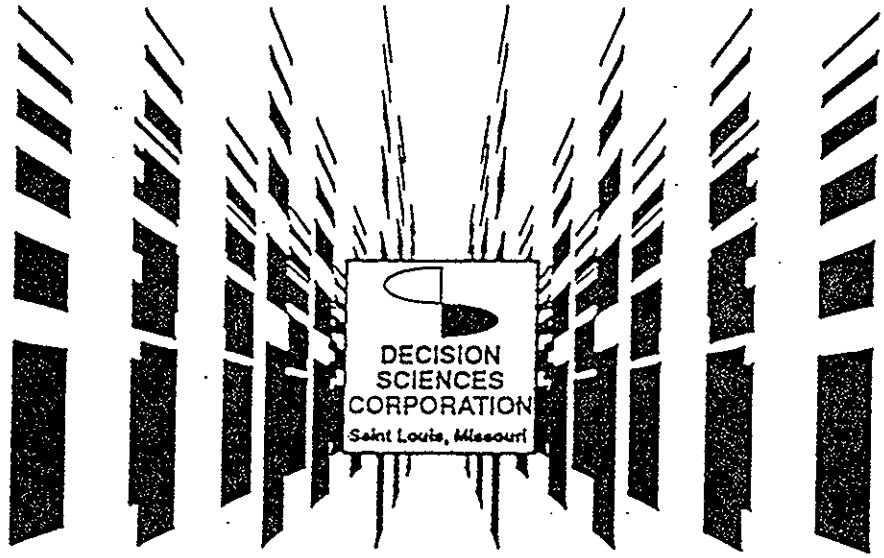
Range Estimating is user friendly and its input heuristics allow the user to specify a simple range rather than require selection of a probability density function. Range Estimating's output heuristics clearly identify, quantify, and rank the risks and opportunities in the decision making problem.

REP/PC™

Range Estimating Program for personal computers

User's Guide

Version 4.0
(July 1993)



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First Edition
July 1993

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JACOBS ENGINEERING GROUP INC.

DATE 2/5/96 SUBJECT HANFORD TWRS PROPOSED DEIS SHEET NO. 1-4

BY D Stein CHKD. JOB NO.

BASIS FOR PROB/RANGE ELEMENTS

NUM	ELEMENT
1	CURRENT OPERATIONS (ALL ALTERNATIVES)
	PROB 50%
	RANGE −20%, +20%
	COMMENT: CONTINUATION OF CURRENT OPERATIONS BASED ON HISTORICAL COSTS. BASIC AMBIVALENCE SHOWN IN PROBABILITY AND RANGE.
2	R+D (WASTE RET. + TRANSFER)
3	R+D (TREATMENT)
6	CAPITAL (CLOSURE)
9	M+M
	COMMENT: NON-CRITICAL FOR ALL ALTERNATIVES

NOTE: THE BASES ESTIMATED HEREIN WERE DISCUSSED AND AGREED UPON IN 2/4/96 MEETING OF D Stein, C Henderson, D Murray (all from JEG). Reviewed and confirmed by L. Selby (JEG cost engr/estimator) on 2/8/96.

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 2/5/94 SUBJECT SHEET NO. 2-4

BY D. Chen CHKD. JOB NO.

NUM	ELEMENT
4	CAPITAL (WASTE RET. + TRANSFER) (ALL ALTERNATIVES)
	PROB 50%
	RANGE −20%, +70%
7	OPERATING (WASTE RET. + TRANSFER) (ALL ALTERNATIVES)
	PROB 50%
	RANGE −20%, +70%

COMMENT: BASIC AMBIVALENCE RE PROBABILITIES. PESSIMISTIC VIEW OF HIGH RANGE DUE TO DIFFICULTY WITH METHODS TO RETRIEVE AND TRANSFER FOR CERTAIN TANKS AND HIGHER CAPITAL REQUIREMENTS AND LONGER OPERATIONAL PERIOD.

FORM 91-005-1 (4/81)

JE JACOBS ENGINEERING GROUP INC.

DATE 2/5/96 SUBJECT

BY D Stein CHKD.

SHEET NO. 3-4

JOB NO.

NUM	ELEMENT	ALTERNATIVE: LONG TERM MANAGE	NO SEP VITR.	NO SEP CALC.	INTER SEP + IN SITU / EX SITU COMBO	PHASED IMPL.	EXT. SEP.	In Situ Vitr.
5	CAPITAL (TREATMENT)							
	PROB	50%	50%	50%	40%	40%	30%	15%
	RANGE	-20%, +20%	-20%, +50%	-20%, +50%	-20%, +100%	-20%, +100%	-20%, +150%	-10%, +300%

Comments: STARTING WITH AMBIVALENCE, PROB. DECREASES WITH COMPLEXITY OF PROCESSES + UNKNOWNS. RANGE ON LOW SIDE STANDARD AT 20% DUE TO 40% CONTINGENCY ALREADY INCLUDED IN CAPITAL. ONLY -10% FOR IN SITU VITR. DUE TO PESSIMISM ON PROCESS. RANGE ON HIGH SIDE INCREASES DUE TO COMPLEXITY OF PROCESSES AND UNKNOWNS.

NUM	ELEMENT	LONG TERM MANAGE	NO SEP VITR.	NO SEP CALC.	INTER SEP + IN SITU / EX SITU COMBO	PHASED IMPL.	EXT. SEP.	In Situ Vitr.
8	OPERATING (TREATMENT)							
	PROB	NON-CRITICAL	75%	75%	65%	65%	55%	15%
	RANGE		-80%, +0%	-60%, +0%	-25%, +0%	-25%, +0%	-15%, +0%	-10%, +200%

Comments: PROB. DECREASES WITH LOWER QUANTITIES OF HLW GLASS GENERATED BY ALTERNATIVE DUE TO LARGE COST EFFECT OF # OF CANISTERS WHICH IS NEAR MAXIMUM FOR BASIS USED HEREIN. IN SITU COSTS VIEWED PESSIMISTICALLY. UPPER RANGE OF +0% DUE TO HIGHEST COSTS USED IN BASIS HEREIN (LOWEST WASTE OXIDE LOADING, SMALLEST CANISTER, HIGH STAFFING). LOWER RANGE BASED ON OP. COSTS FOR NOV 1995 SCENARIO (MORE LIKELY). IN SITU VITR. VIEWED PESSIMISTICALLY DUE TO LONGER OPERATION AND ADDITIONAL GLASS RAW MATERIALS.

JACOBS ENGINEERING GROUP INC.

DATE 2/5/96 SUBJECT

BY [illegible] CHKD.

JOB NO. SHEET NO. 4-4

NUM	ELEMENT	ALTERNATIVE					
		NO. SEP VITR	NO. SEP CALC.	INTER. SEP.	IN SITU/ EX SITU	PHASED IMPL.	EXT SEP.
10	REPOSITORY FEE						
	PROB.	100%	100%	100%	100%	100%	0%
	RANGE	-80%, +0%	-60%, +0%	-40%, +0%	-28%, +0%	-40%, +0%	-0%, +0%

Comments: WITH THE LOW WASTE OXIDE LOADING USED AS A BASIS HERE, AND THE SMALLEST CANISTER SIZE USED AS A BASIS HERE, IT IS BELIEVED THAT THE REPOSITORY FEES ARE AT THE MAXIMUM PROBABLE. THE EXCEPTION IS EXT. SEP. WHERE REPOSITORY COSTS ARE ESSENTIALLY CONSTANT DUE TO SMALL VOLUME OF HLW WASTE FOR ANY SCENARIO. THE LOW RANGE HAS BEEN SET AT REPOSITORY FEE FOR NOV 1995 REPORT USING LARGER CANISTERS AND HIGHER WASTE OXIDE LOADING.

EXPENSE ELEMENTS		
	Absolute	0%
ssimism	Extreme	5%, 10%, 15%
	Moderate	20%, 25%, 30%
	Slight	35%, 40%, 45%
mbivalence		50%
	Slight	55%, 60%, 65%
Optimism	Moderate	70%, 75%, 80%
	Extreme	85%, 90%, 95%
	Absolute	100%

PROFIT ELEMENTS		
	Absolute	100%
Pessimism	Extreme	85%, 90%, 95%
	Moderate	70%, 75%, 80%
	Slight	55%, 60%, 65%
Ambivalence		50%
	Slight	35%, 40%, 45%
Optimism	Moderate	20%, 25%, 30%
	Extreme	5%, 10%, 15%
	Absolute	0%

The Range

A range of possible values is specified for each critical element in the plan. The range is determined by specifying the lowest and highest values the critical element can assume. These lowest and highest values are set so far apart that there is greater than a 98% probability that the actual value of the critical element will materialize within the resulting range. Specifically, the "lowest" value is set so low that there is less than 1 chance in 100 that the actual value will be any lower; similarly, the "highest" value is set so high that there is less than a 1% probability that the actual value will be any higher. Thinking of it another way, the odds are about 99 to 1 against the actual value being lower than the lowest value. Also, the odds are about 99 to 1 against the actual value being higher than the highest value. Qualitatively speaking, the lowest and highest values are set far enough out such that they capture the "rather improbable" but not the "slightly absurd." Quite obviously, if there is substan-

tial uncertainty about the actual value of the critical element, its range will be quite broad. Conversely, a lesser degree of uncertainty will be reflected as a narrower range for the critical element.

NOTE: The lowest and highest values are completely independent of the probability factor. It is quite possible that a given critical element could have a fairly small difference between its target and lowest value and yet have a high probability of its actual value materializing in that narrow part of the range. Examples of this often occur in expense elements where it is not unusual to have a very small chance of the actual exceeding the target but, if it does, the amount by which it can exceed it is very large. Such a range is said to be "highly skewed."

Some people have difficulty with the idea of supplying a range; some even claim that the range is nothing more than a lot of guesswork. But that's precisely why the range is valuable in decision-making; it involves a lot of educated guessing by qualified people. On the other hand, the single-point value involves only a little guessing -- so little, in fact, that it can lead to serious errors in decision-making. There is nothing wrong with guessing. Nobel prizes have been awarded for shrewd guessing! Put another way: with the range, the decision-maker will be approximately correct; with the traditional single-point value, exactly wrong!

February 8, 1996

To: Mark Nelson/David Stein

From: Larry Selby

Subject: Review of REP-PC Risk Analyses

I have reviewed the input of the ten remediation scenarios and generally find them within reasonable ranges. I changed the input of one of the more complicated senarios, generally widening the spread between low and high, (usually by increasing the high end). The results were reasonably close (within about 5 %) which pretty much verifies the suitability of the variables as entered in the program. Certainly the target estimate numbers are not within an accuracy of 5% of total cost at the Order of Magnitude level of the estimates. At this point, very little is to be gained by changing the model and re-running the program.

I would recommend that at some appropriate future time a group of 4 to 6 individuals, most familiar with each of the processes meet, and re-evaluate the entries used in developing the model and then re-run the program. One of these individuals should be one of the estimating team who is familiar the the details of how the estimate (target amount) was developed. Additionally, the smaller items should be dropped, as they tend to distort the results, although they would not affect the actual total cost. I would also warn to resist the temptation to group the small items and treat them as a single item to make the arithmetic appear correct. This also distorts the results. Having used this program a number of times over the past few years I have found that we are frequently too optimistic in entering the highest cost. This number should be the cost that the group is 99% certain cannot or will not be exceeded by even the worst of circumstances. I would also recommend that at the Order of Magnitude estimate level, the contingency applied by the estimator should be considered as a real cost and not considered in arriving at the highest possible cost. More often than not that contingency is required in progressing to estimates prepared from detailed design documents.

REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 02-06-96

DATA : ~~Exsitu Exten.~~ No Action Case 01
MODEL : BASIC MODEL (SUMMATION)

NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		14300	50	11440	17160
2	R&D Waste Ret. & Transfer		0		0	0
3	R&D Treatment		0		0	0
4	Capital Waste Ret. & Transfer		0		0	0
5	Capital Treament		0		0	0
6	Capital Closure		0		0	0
7	Operations Waste Ret. & Transfer		0		0	0
8	Operations Treatment		0		0	0
9	M & M		0		0	0
10	Repository Fee		0		0	0
	TOTAL EXPENSE (INPUT TO REP/PC)		14300		11440 (THEORETICALS)	17160

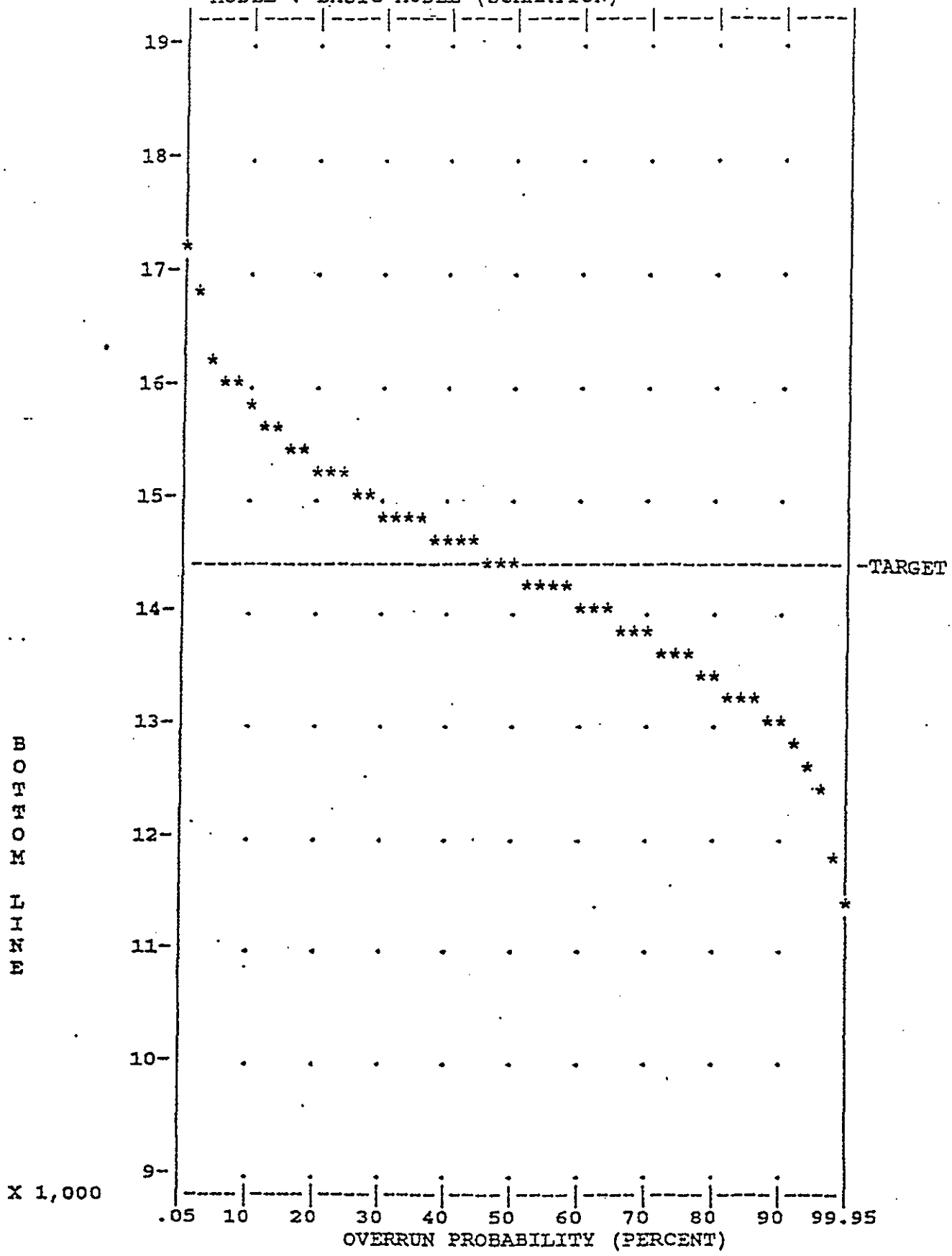
+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

Output file for Range Estimate Tank Waste Alternatives

REP/PC (Ver-4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 02-06-96

DATA : ExSitu Exten. Case 01

MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver-4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 02-06-96

DATA : ExSitu Exten. Case 01
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
14300	51 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
1	Current Operations NET EFFECT OF FROZEN ELEMENTS		----------|	++++++++++++

DATA : ExSitu Exten. Case 01
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	2860	20.0	PCT
99.95	"	2849	19.9	"
95	"	1783	12.5	"
90	"	1430	10.0	"
85	"	1176	8.2	"
80	"	954	6.7	"
75	"	797	5.6	"
70	"	578	4.0	"
65	"	450	3.2	"
60	"	311	2.2	"
55	"	177	1.2	"
50	"	15	.1	"
45	"	-123	-.9	"
40	"	-263	-1.8	"
35	"	-382	-2.7	"
30	"	-576	-4.0	"
25	"	-716	-5.0	"
20	"	-896	-6.3	"
15	"	-1167	-8.2	"
10	"	-1377	-9.6	"
5	"	-1745	-12.2	"
0.05	"	-2839	-19.8	"
0	"	-2860	-20.0	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 02-06-96

DATA : ExSitu Exten. Long-Term Mgmt. Case 02
MODEL : BASIC MODEL (SUMMATION)

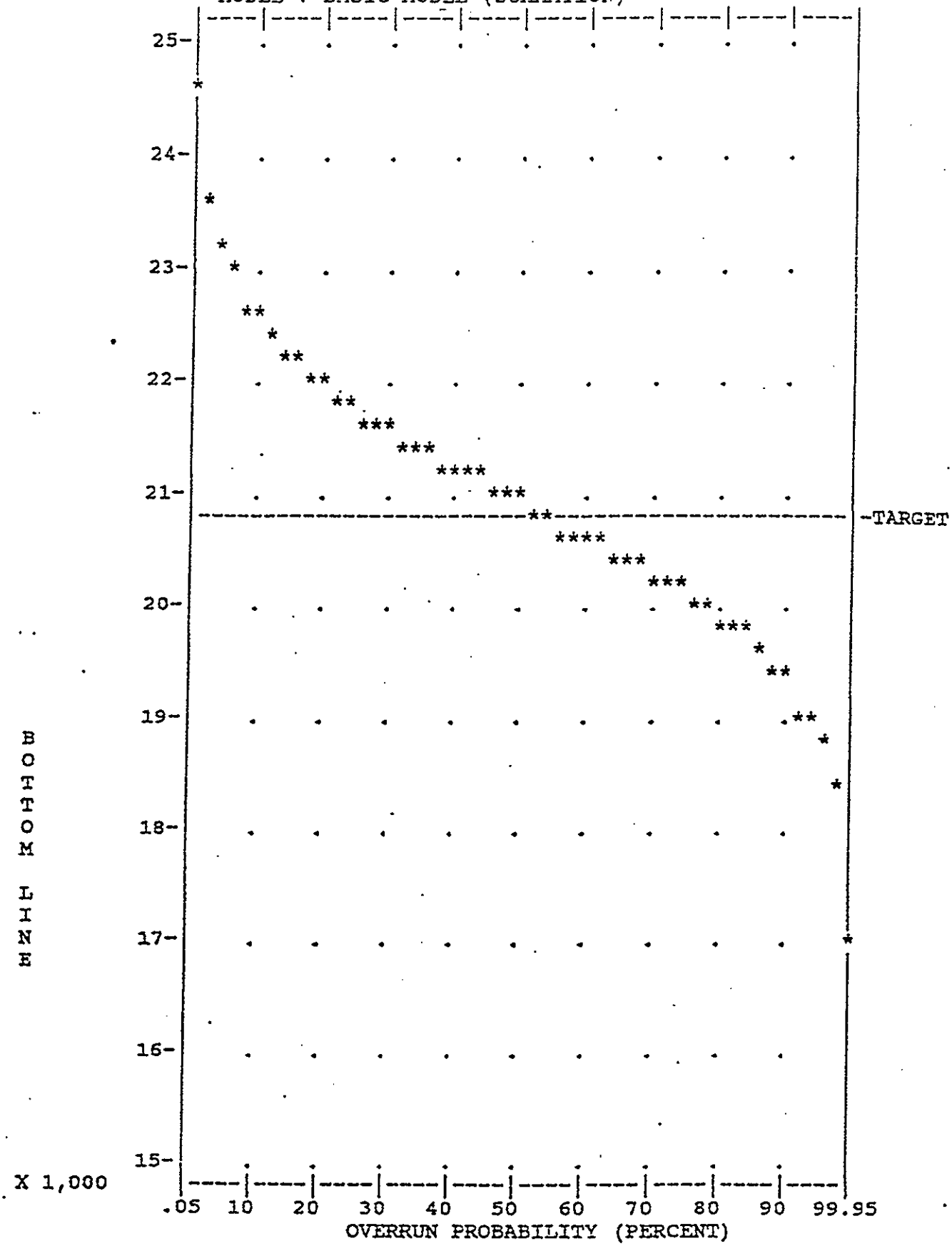
NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		14300	50	11440	17160
2	R&D Waste Ret. & Transfer		100.00		100.00	100.00
3	R&D Treatment		0		0	0
4	Capital Waste Ret. & Transfer		1930	50	1544	3281
5	Capital Treament		4000	50	3200	4800
6	Capital Closure		0		0	0
7	Operations Waste Ret. & Transfer		440		440	440
8	Operations Treatment		0		0	0
9	M & M		0		0	0
10	Repository Fee		0		0	0
	TOTAL EXPENSE (INPUT TO REP/PC)		20770		16724 (THEORETICALS)	25781

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver-4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 02-06-96

DATA : ExSitu Exten.. Case 02

MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 02-06-96

DATA : ExSitu Exten. Case 02
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
20770	54 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
1	Current Operations		----------	++++++++++++
4	Capital Waste Ret. & Transfer		-------	++
5	Capital Treament		----	++++
	NET EFFECT OF FROZEN ELEMENTS			

DATA : ExSitu Exten. Case 02
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	5011	24.1	PCT
99.95	"	3750	18.1	"
95	"	2327	11.2	"
90	"	1771	8.5	"
85	"	1413	6.8	"
80	"	1159	5.6	"
75	"	958	4.6	"
70	"	741	3.6	"
65	"	597	2.9	"
60	"	442	2.1	"
55	"	301	1.5	"
50	"	141	.7	"
45	"	-30	-.1	"
40	"	-201	-1.0	"
35	"	-360	-1.7	"
30	"	-512	-2.5	"
25	"	-697	-3.4	"
20	"	-886	-4.3	"
15	"	-1109	-5.3	"
10	"	-1464	-7.0	"
5	"	-1894	-9.1	"
0.05	"	-3857	-18.6	"
0	"	-4046	-19.5	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-18-96

DATA : InSitu Fill & Cap Case 03
MODEL : BASIC MODEL (SUMMATION)

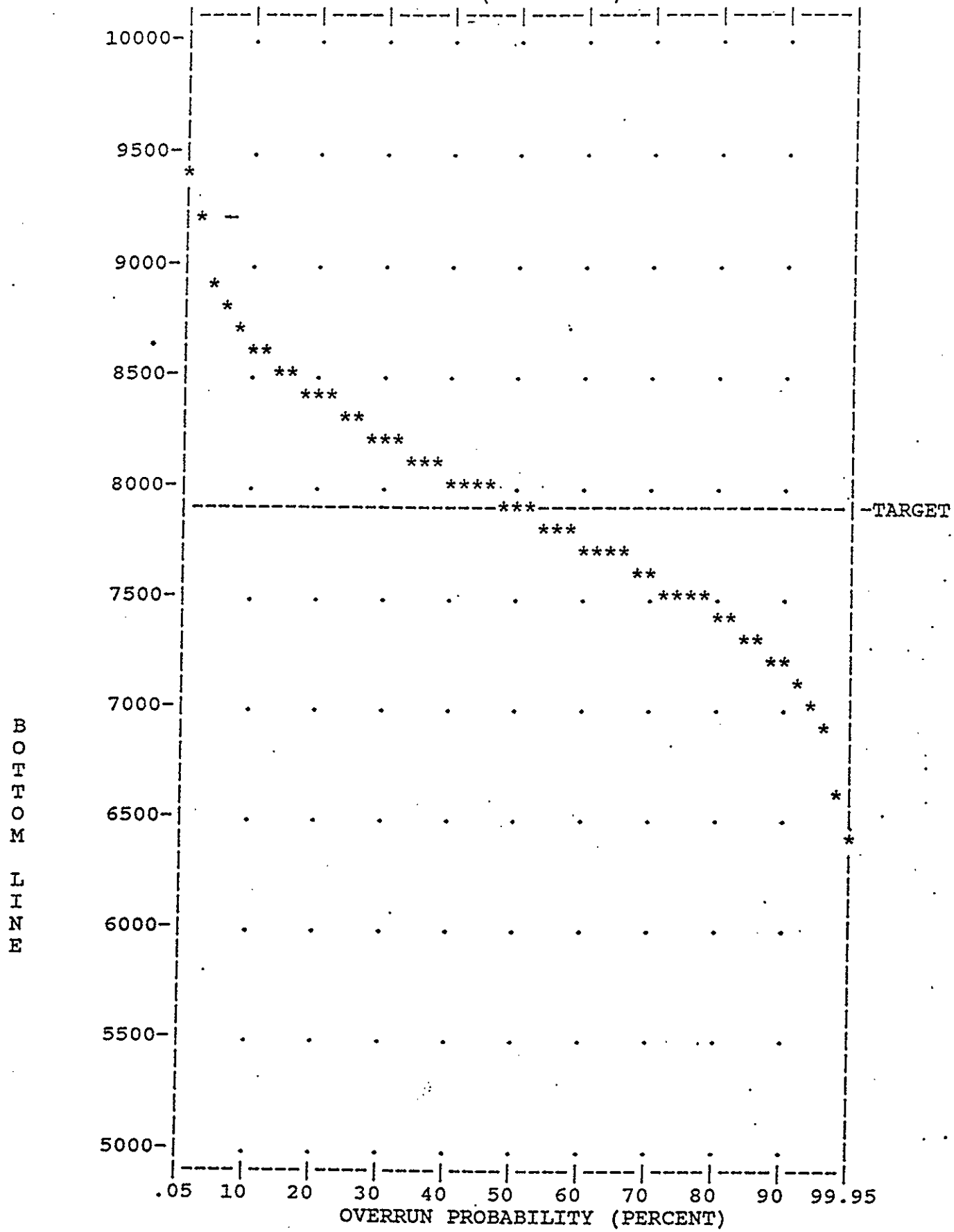
NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		7469	50	5975	8963
2	R&D Waste Ret. & Transfer		0		0	0
3	R&D Treatment		0		0	0
4	Capital Waste Ret. & Transfer		0		0	0
5	Capital Treament		25.00		25.00	25.00
6	Capital Closure		116.00		116.00	116.00
7	Operations Waste Ret. & Transfer		0		0	0
8	Operations Treatment		274		274	274
9	M & M		0		0	0
10	Repository Fee		0		0	0
	TOTAL EXPENSE (INPUT TO REP/PC)		7884		6390 (THEORETICALS)	9378

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-18-96

DATA : InSitu Fill & Cap Case 03

MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-18-96

DATA : InSitu Fill & Cap Case 03
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
7884	51 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
1	Current Operations NET EFFECT OF FROZEN ELEMENTS		----------|	++++++++++++

DATA : InSitu Fill & Cap Case 03
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	1494	19.0	PCT
99.95	"	1488	18.9	"
95	"	931	11.8	"
90	"	747	9.5	"
85	"	614	7.8	"
80	"	498	6.3	"
75	"	416	5.3	"
70	"	302	3.8	"
65	"	235	3.0	"
60	"	163	2.1	"
55	"	92	1.2	"
50	"	8	.1	"
45	"	-64	-.8	"
40	"	-138	-1.7	"
35	"	-200	-2.5	"
30	"	-301	-3.8	"
25	"	-374	-4.7	"
20	"	-468	-5.9	"
15	"	-610	-7.7	"
10	"	-719	-9.1	"
5	"	-912	-11.6	"
0.05	"	-1483	-18.8	"
0	"	-1494	-18.9	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-18-96

DATA : InSitu Vitrification Case 04
MODEL : BASIC MODEL (SUMMATION)

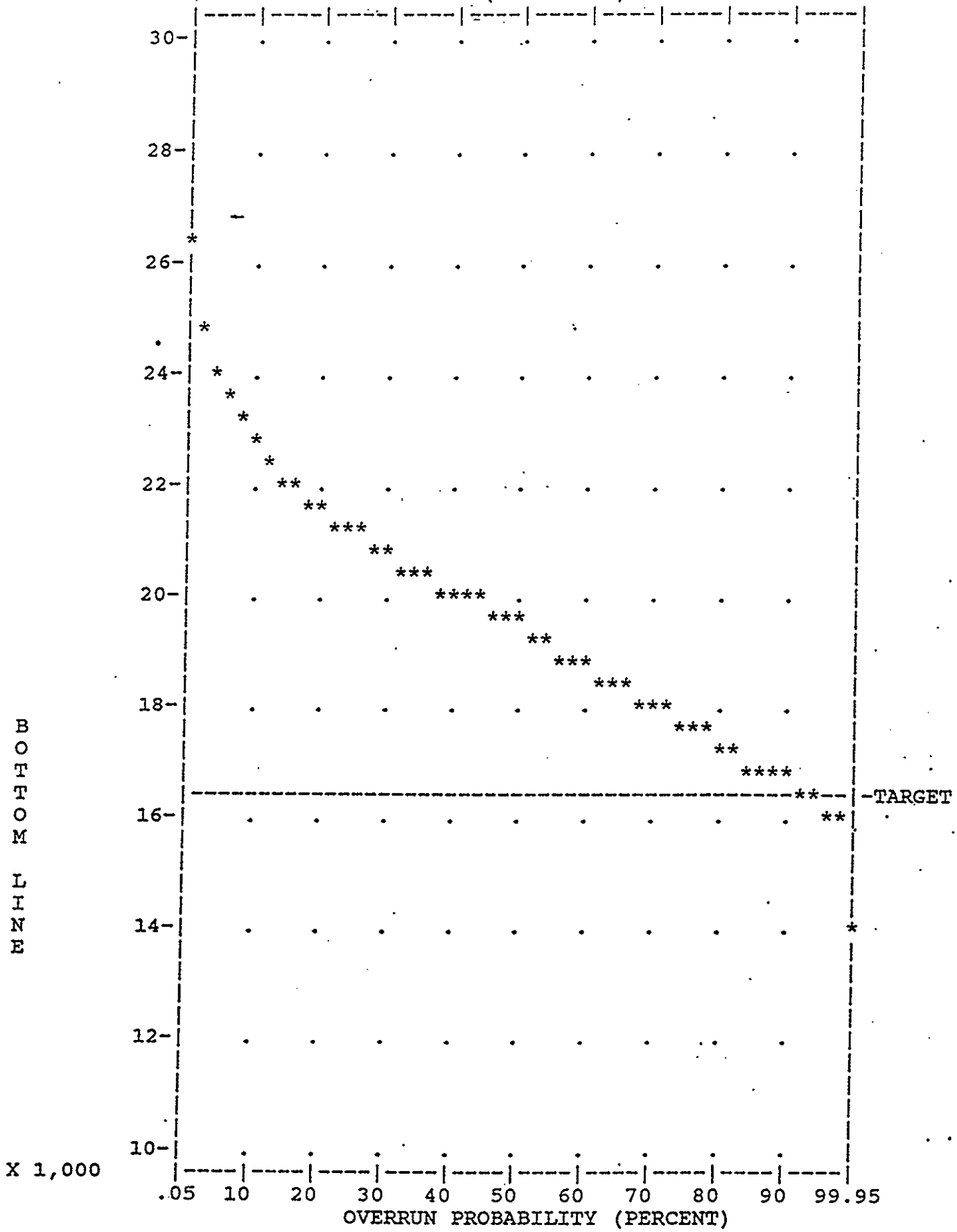
NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8752	50	7002	10502
2	R&D Waste Ret. & Transfer		0		0	0
3	R&D Treatment		70.00		70.00	70.00
4	Capital Waste Ret. & Transfer		0		0	0
5	Capital Treament		4900	15	4410	9600
6	Capital Closure		116.00		116.00	116.00
7	Operations Waste Ret. & Transfer		0		0	0
8	Operations Treatment		2740	15	2466	8220
9	M & M		0		0	0
10	Repository Fee		0		0	0
	TOTAL EXPENSE (INPUT TO REP/PC)		16578		14064 (THEORETICALS)	28508

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-18-96

DATA : InSitu Vitrification Case 04

MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-18-96

DATA : InSitu Vitrification Case 04
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
16578	90 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
8	Operations Treatment		----------|	
5	Capital Treament		----------|	
1	Current Operations		--|++	
	NET EFFECT OF FROZEN ELEMENTS		|	

DATA : InSitu Vitrification Case 04
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	11930	72.0	PCT
99.95	"	9748	58.8	"
95	"	7262	43.8	"
90	"	6052	36.5	"
85	"	5434	32.8	"
80	"	4922	29.7	"
75	"	4538	27.4	"
70	"	4138	25.0	"
65	"	3768	22.7	"
60	"	3494	21.1	"
55	"	3220	19.4	"
50	"	2848	17.2	"
45	"	2500	15.1	"
40	"	2153	13.0	"
35	"	1766	10.7	"
30	"	1359	8.2	"
25	"	1104	6.7	"
20	"	718	4.3	"
15	"	321	1.9	"
10	"	29	.2	"
5	"	-393	-2.4	"
0.05	"	-2400	-14.5	"
0	"	-2514	-15.2	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-20-96

DATA : Inter Sep Case 05
MODEL : BASIC MODEL (SUMMATION)

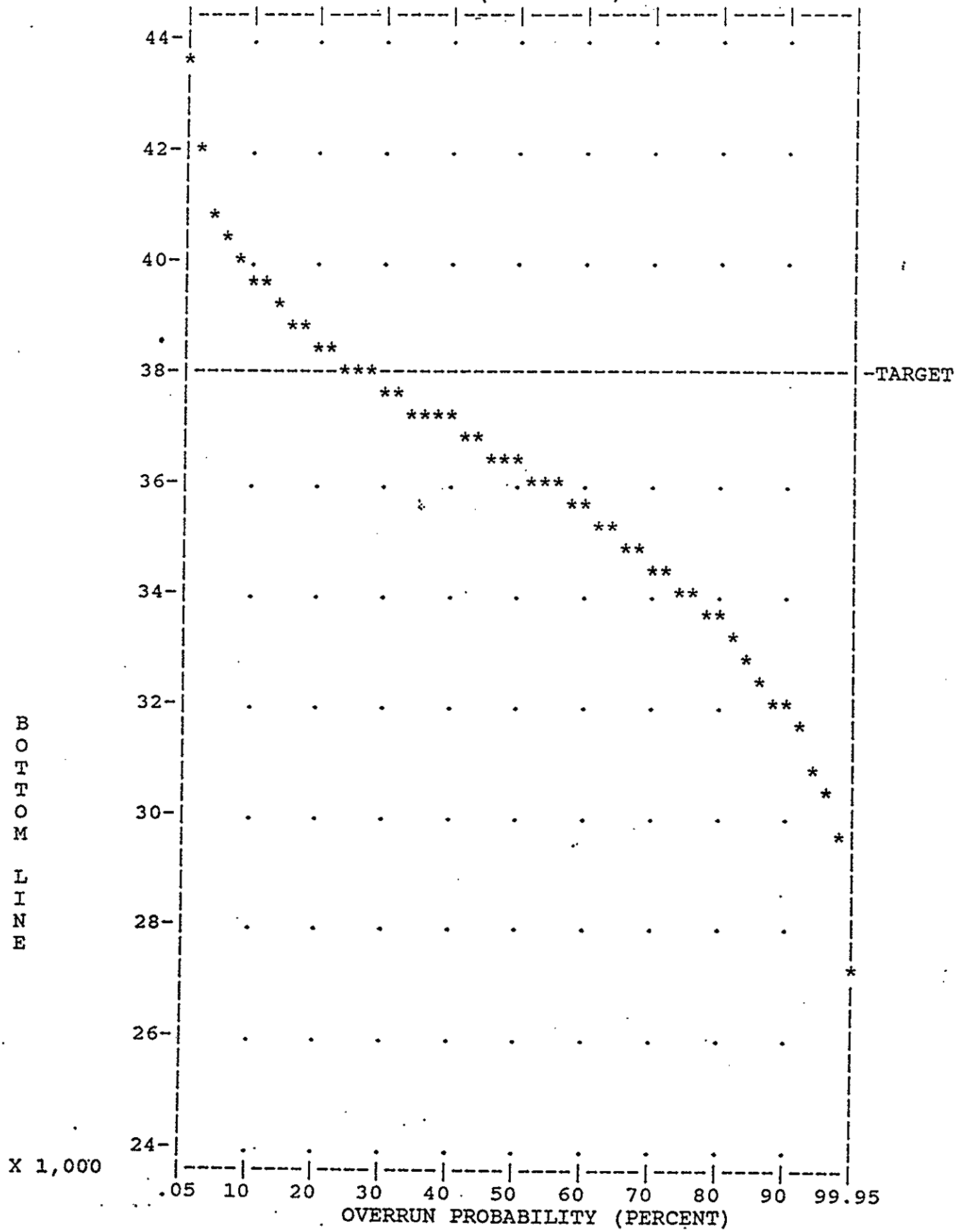
NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8600	50	6880	10320
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		630		630	630
4	Capital Waste Ret. & Transfer		2280	50	824	3876
5	Capital Treatment		3600	40	2880	7200
6	Capital Closure		169.00		169.00	169.00
7	Operations Waste Ret. & Transfer		4820	50	3856	8194
8	Operations Treatment		5509	65	4183	5510
9	M & M		0		0	0
10	Repository Fee		12020	95	3900	12030
	TOTAL EXPENSE (INPUT TO REP/PC)		37818		23512 (THEORETICALS)	48119

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-20-96

DATA : Inter Sep Case 05

MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-20-96

DATA : Inter Sep Case 05
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
37818	29 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
10	Repository Fee			|+++++++++++++
5	Capital Treatment		----|	+
7	Operations Waste Ret. & Transfer		---|	+
4	Capital Waste Ret. & Transfer		-|	+
1	Current Operations		-|	+
8	Operations Treatment		|	+
	NET EFFECT OF FROZEN ELEMENTS		|	

DATA : Inter Sep Case 05
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	10301	27.2	PCT
99.95	"	5713	15.1	"
95	"	2734	7.2	"
90	"	1887	5.0	"
85	"	1256	3.3	"
80	"	678	1.8	"
75	"	191	.5	"
70	"	-125	-.3	"
65	"	-490	-1.3	"
60	"	-804	-2.1	"
55	"	-1135	-3.0	"
50	"	-1576	-4.2	"
45	"	-1889	-5.0	"
40	"	-2362	-6.2	"
35	"	-2778	-7.3	"
30	"	-3219	-8.5	"
25	"	-3857	-10.2	"
20	"	-4403	-11.6	"
15	"	-5223	-13.8	"
10	"	-6014	-15.9	"
5	"	-7419	-19.6	"
0.05	"	-10733	-28.4	"
0	"	-14306	-37.8	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

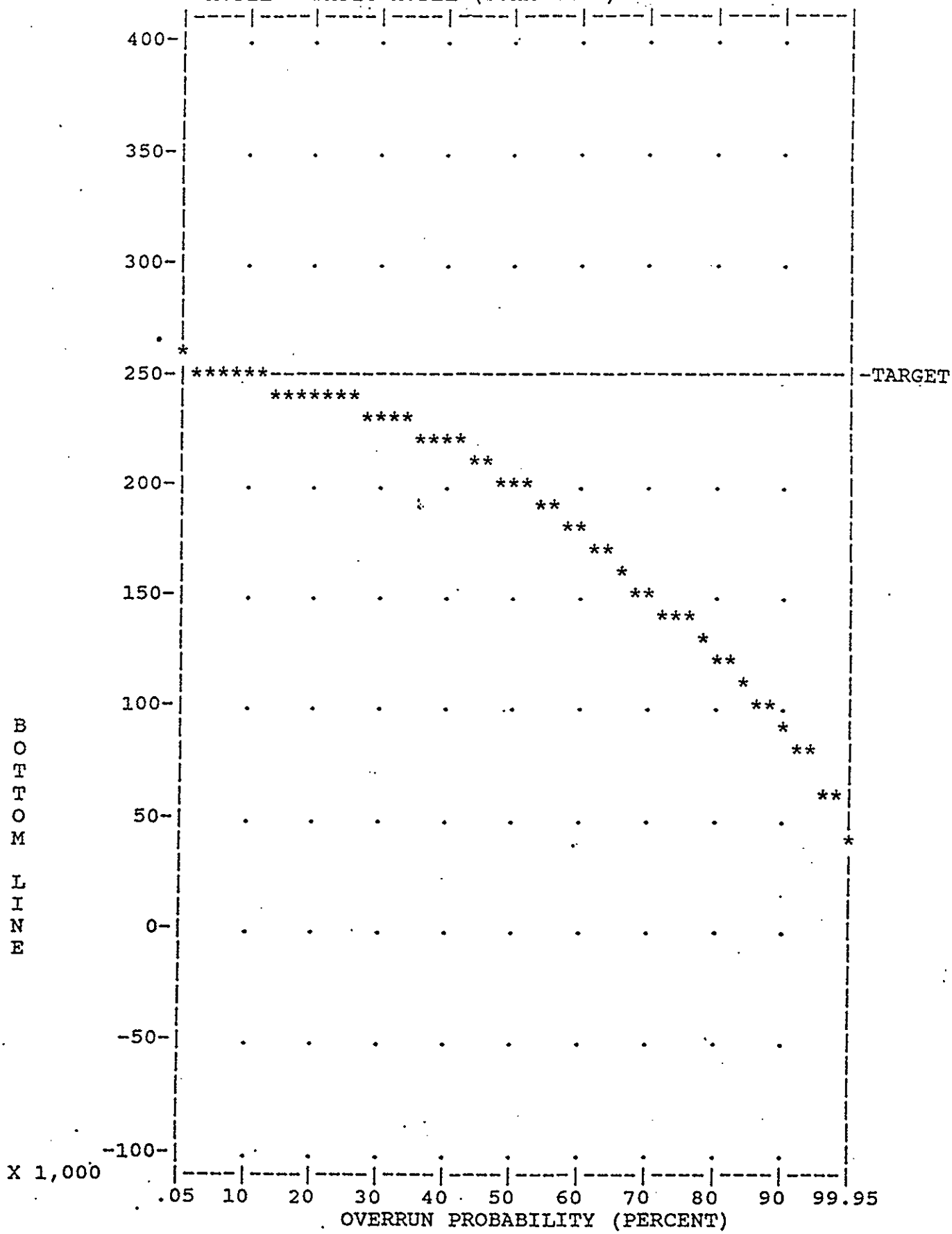
REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-20-96

DATA : No Sep Vitr Case 06
MODEL : BASIC MODEL (SUMMATION)

NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8325	50	6660	9990
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		280		280	280
4	Capital Waste Ret. & Transfer		2280	50	1824	3876
5	Capital Treatment		2610	50	2088	3915
6	Capital Closure		152.00		152.00	152.00
7	Operations Waste Ret. & Transfer		4630	50	3704	7871
8	Operations Treatment		22742	75	4654	22743
9	M & M		0		0	0
10	Repository Fee		211460	95	12900	211461
	PREVIOUS ELEMENT HAS UNUSUAL DATA HOWEVER REP/PC USED THOSE VALUES					
	TOTAL EXPENSE (INPUT TO REP/PC)		252669		32452 (THEORETICALS)	260478

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-20-96
DATA : No Sep Vitr Case 06
MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-20-96

DATA : No Sep Vitr Case 06
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
252669	3 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
10	Repository Fee			|++++++++++++
8	Operations Treatment			|+
7	Operations Waste Ret. & Transfer			|
1	Current Operations			|
4	Capital Waste Ret. & Transfer			|
5	Capital Treatment			|
	NET EFFECT OF FROZEN ELEMENTS			|

REP/PC (Ver 4.0) - MGMT REPORT 4 CONTINGENCY PROFILE : 03-20-96

DATA : No Sep Vitr Case 06
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	7809	3.1	PCT
99.95	"	3990	1.6	"
95	"	-1501	-.6	"
90	"	-4789	-1.9	"
85	"	-8473	-3.3	"
80	"	-12164	-4.8	"
75	"	-16547	-6.5	"
70	"	-21637	-8.6	"
65	"	-28309	-11.2	"
60	"	-33361	-13.2	"
55	"	-42447	-16.8	"
50	"	-52209	-20.7	"
45	"	-63127	-25.0	"
40	"	-74327	-29.4	"
35	"	-88544	-35.0	"
30	"	-102986	-40.8	"
25	"	-114820	-45.4	"
20	"	-129425	-51.2	"
15	"	-149380	-59.1	"
10	"	-163222	-64.6	"
5	"	-183194	-72.5	"
0.05	"	-212325	-84.0	"
0	"	-220217	-87.2	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-20-96

DATA : No Sep Calc Case 07
MODEL : BASIC MODEL (SUMMATION)

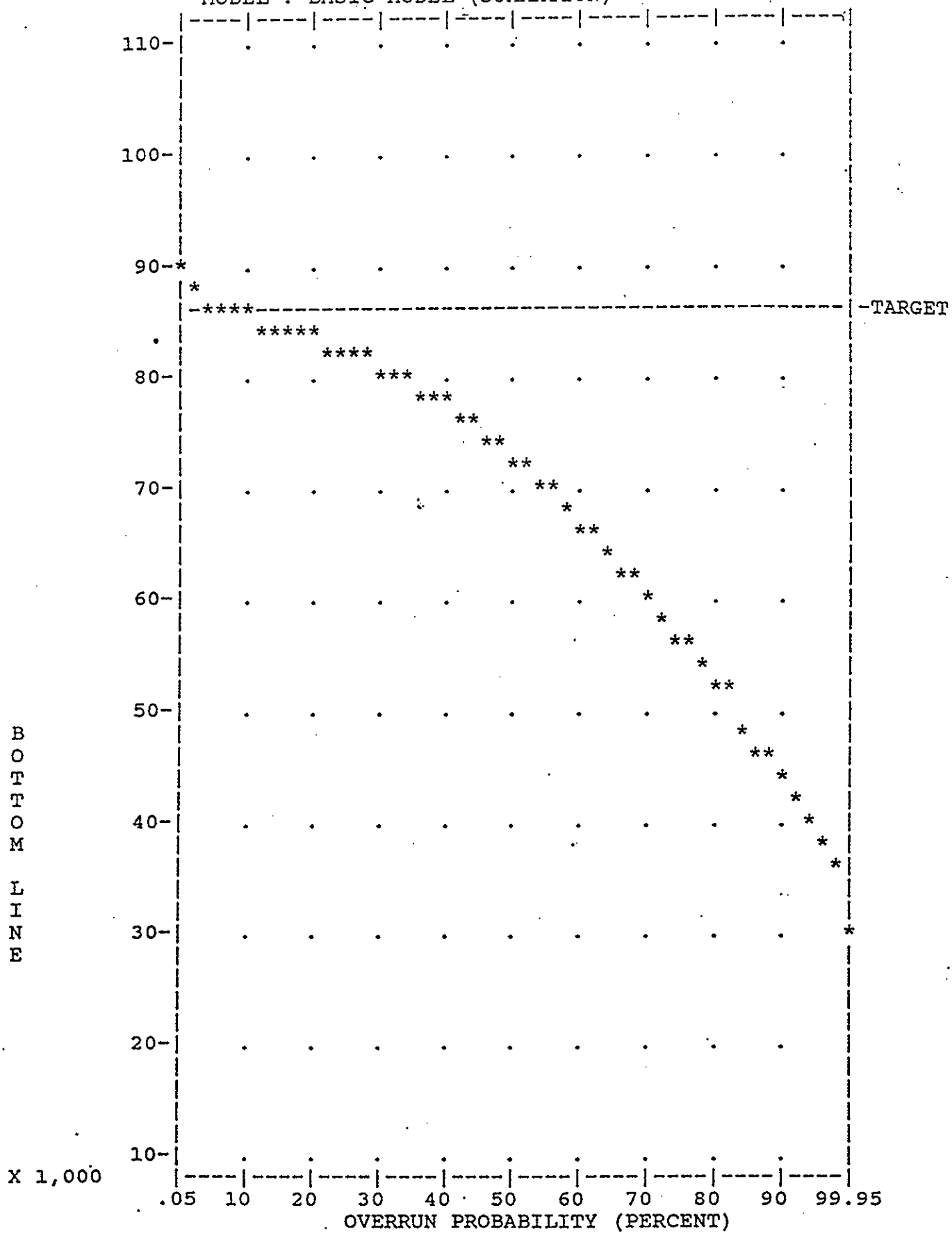
NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8325	50	6660	9990
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		280		280	280
4	Capital Waste Ret. & Transfer		2280	50	1824	3876
5	Capital Treatment		2610	50	2088	3915
6	Capital Closure		152.00		152.00	152.00
7	Operations Waste Ret. & Transfer		4630	50	3704	7871
8	Operations Treatment		7548	75	3273	7549
9	M & M		0		0	0
10	Repository Fee		59800	95	7800	59801
	TOTAL EXPENSE (INPUT TO REP/PC)		85815		25971 (THEORETICALS)	93624

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-20-96

DATA : No Sep Calc Case 07

MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-20-96

DATA : No Sep Calc Case 07
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
85815	6 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
10	Repository Fee			++++++++++++
8	Operations Treatment			+
7	Operations Waste Ret. & Transfer			
1	Current Operations			
4	Capital Waste Ret. & Transfer			
5	Capital Treatment			
	NET EFFECT OF FROZEN ELEMENTS			

DATA : No Sep Calc Case 07
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	7809	9.1	PCT
99.95	"	4249	5.0	"
95	"	326	.4	"
90	"	-756	-.9	"
85	"	-1644	-1.9	"
80	"	-2508	-2.9	"
75	"	-3447	-4.0	"
70	"	-5048	-5.9	"
65	"	-6593	-7.7	"
60	"	-8327	-9.7	"
55	"	-10467	-12.2	"
50	"	-13198	-15.4	"
45	"	-16026	-18.7	"
40	"	-18841	-22.0	"
35	"	-22543	-26.3	"
30	"	-26095	-30.4	"
25	"	-29353	-34.2	"
20	"	-33295	-38.8	"
15	"	-38344	-44.7	"
10	"	-42251	-49.2	"
5	"	-47026	-54.8	"
0.05	"	-55313	-64.5	"
0	"	-59844	-69.7	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-13-96

DATA : Ext Sep Case 08
MODEL : BASIC MODEL (SUMMATION)

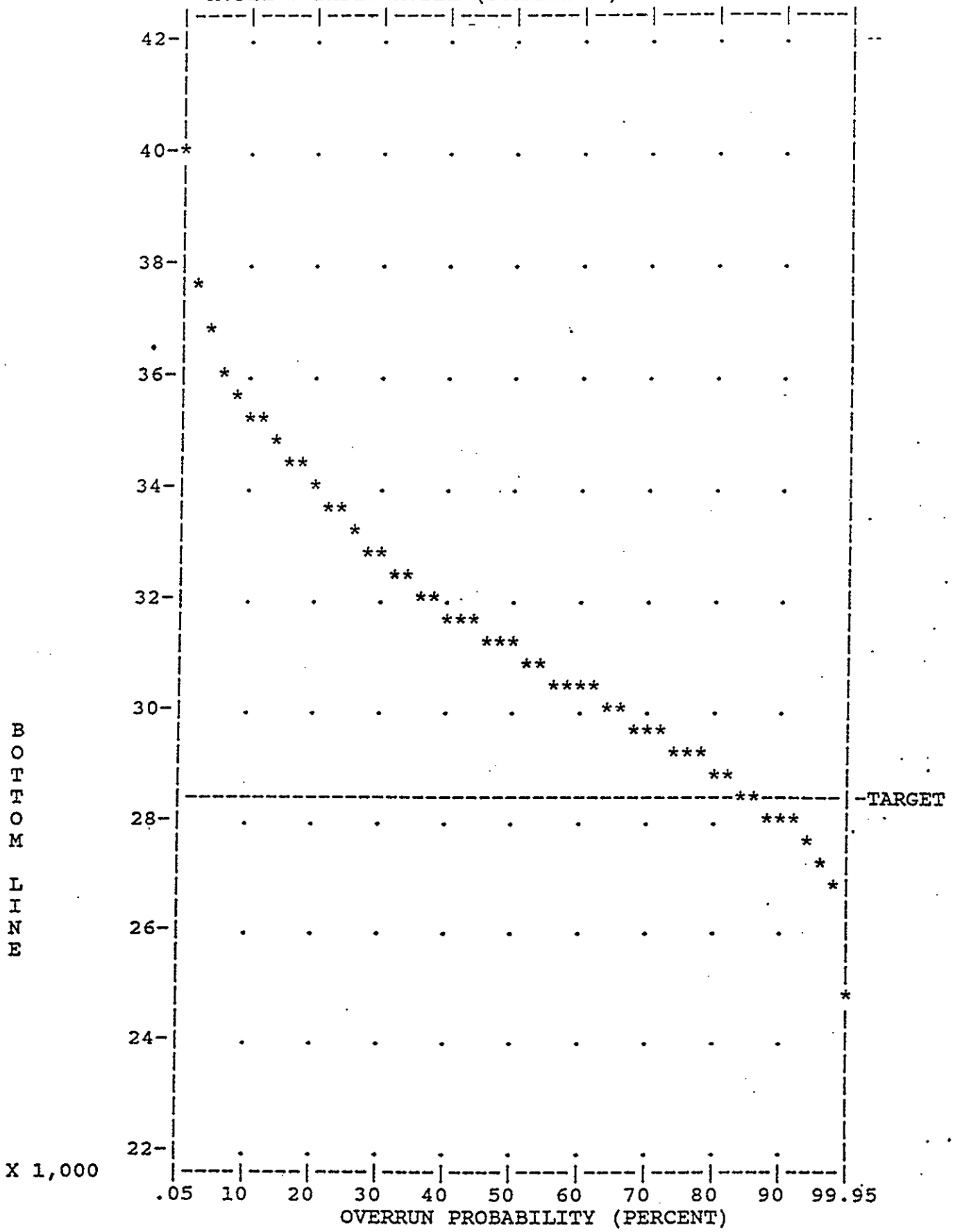
NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8600	50	6880	10320
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		1300		1300	1300
4	Capital Waste Ret. & Transfer		2280	50	1824	3876
5	Capital Treatment		5202	30	4162	13005
6	Capital Closure		170.00		170.00	170.00
7	Operations Waste Ret. & Transfer		4820	50	3856	8194
8	Operations Treatment		5417	55	4604	5418
9	M & M		0		0	0
10	Repository Fee		565	40	564	3400
	TOTAL EXPENSE (INPUT TO REP/PC)		28544		23550 (THEORETICALS)	45873

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-13-96

DATA : Ext Sep Case 08

MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-13-96

DATA : Ext Sep Case 08
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
28544	84 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
5	Capital Treatment		----------|+	
7	Operations Waste Ret. & Transfer		----|+	
10	Repository Fee		----|	
1	Current Operations		--|++	
4	Capital Waste Ret. & Transfer		--|+	
8	Operations Treatment		|+	
	NET EFFECT OF FROZEN ELEMENTS		|	

DATA : Ext Sep Case 08
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	17329	60.7	PCT
99.95	"	11338	39.7	"
95	"	7927	27.8	"
90	"	6814	23.9	"
85	"	6107	21.4	"
80	"	5523	19.4	"
75	"	4877	17.1	"
70	"	4178	14.6	"
65	"	3680	12.9	"
60	"	3235	11.3	"
55	"	2834	9.9	"
50	"	2499	8.8	"
45	"	2127	7.5	"
40	"	1804	6.3	"
35	"	1445	5.1	"
30	"	1052	3.7	"
25	"	706	2.5	"
20	"	366	1.3	"
15	"	-106	-.4	"
10	"	-555	-1.9	"
5	"	-1067	-3.7	"
0.05	"	-3712	-13.0	"
0	"	-4994	-17.5	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

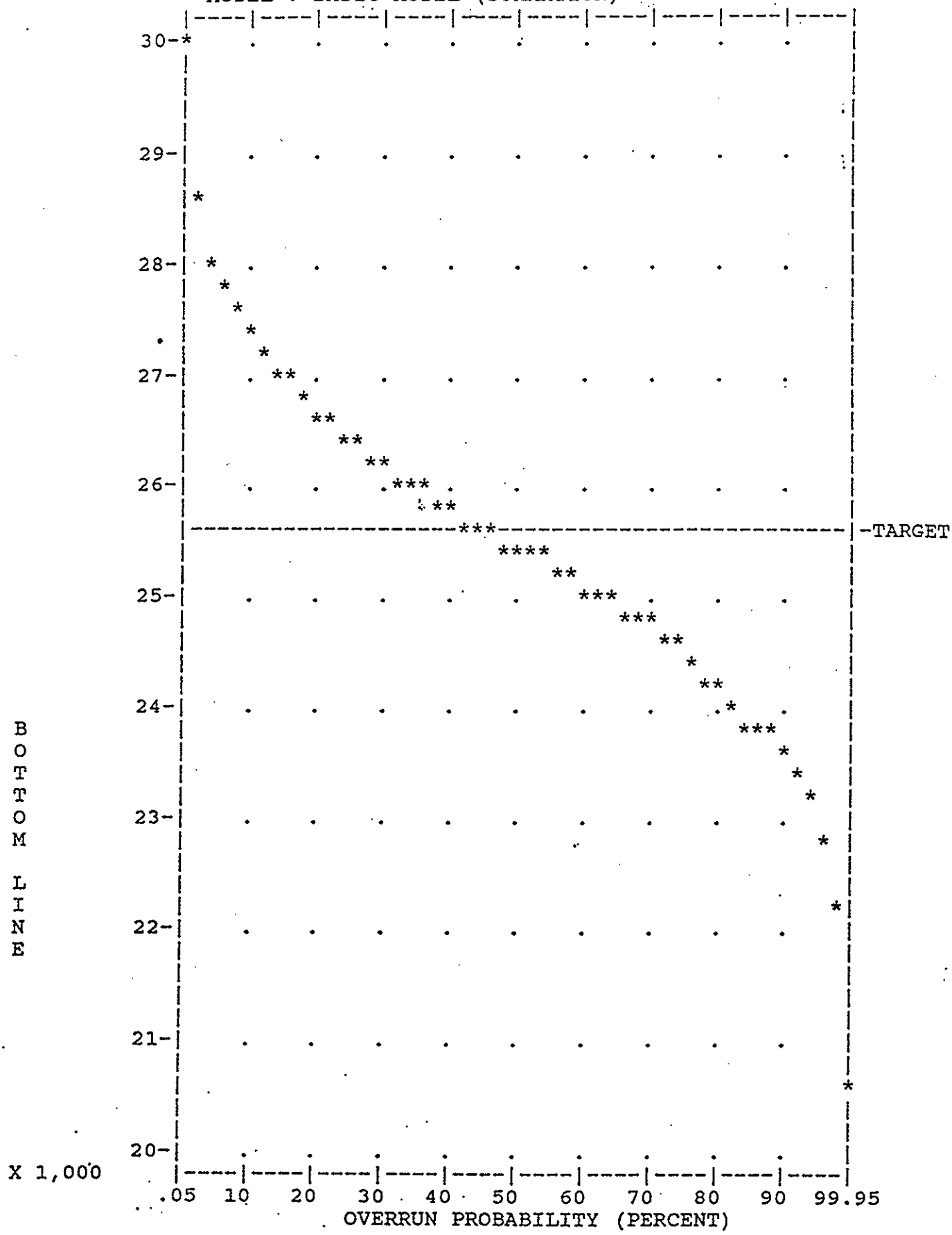
REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-20-96

DATA : ExSitu/InSitu Combo Case 09
MODEL : BASIC MODEL (SUMMATION)

NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		9142	50	7114	10970
2	R&D Waste Ret. & Transfer		186.00		186.00	186.00
3	R&D Treatment		670		670	670
4	Capital Waste Ret. & Transfer		1388	50	1110	2360
5	Capital Treatment		2189	40	1751	4378
6	Capital Closure		137.00		137.00	137.00
7	Operations Waste Ret. & Transfer		3166	50	2533	5382
8	Operations Treatment		2638	65	2004	2639
9	M & M		0		0	0
10	Repository Fee		6010	95	3750	6011
	TOTAL EXPENSE (INPUT TO REP/PC)		25526		19255 (THEORETICALS)	32733

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-20-96
DATA : ExSitu/InSitu Combo Case 09
MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-20-96

DATA : ExSitu/InSitu Combo Case 09
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
25526	47 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
10	Repository Fee			++++++++++++
1	Current Operations		------	++++++
5	Capital Treatment		--------	+
7	Operations Waste Ret. & Transfer		-------	++
4	Capital Waste Ret. & Transfer		---	+
8	Operations Treatment			+++
	NET EFFECT OF FROZEN ELEMENTS			

REP/PC (Ver 4.0) - MGMT REPORT 4 CONTINGENCY PROFILE : 03-20-96

DATA : ExSitu/InSitu Combo Case 09
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	7207	28.2	PCT
99.95	"	4454	17.5	"
95	"	2387	9.4	"
90	"	1865	7.3	"
85	"	1475	5.8	"
80	"	1164	4.6	"
75	"	864	3.4	"
70	"	643	2.5	"
65	"	429	1.7	"
60	"	231	.9	"
55	"	58	.2	"
50	"	-96	-.4	"
45	"	-252	-1.0	"
40	"	-444	-1.7	"
35	"	-649	-2.5	"
30	"	-823	-3.2	"
25	"	-1056	-4.1	"
20	"	-1420	-5.6	"
15	"	-1666	-6.5	"
10	"	-1921	-7.5	"
5	"	-2536	-9.9	"
0.05	"	-4837	-18.9	"
0	"	-6271	-24.6	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

DATA : Phased Impl Case 10
MODEL : BASIC MODEL (SUMMATION)

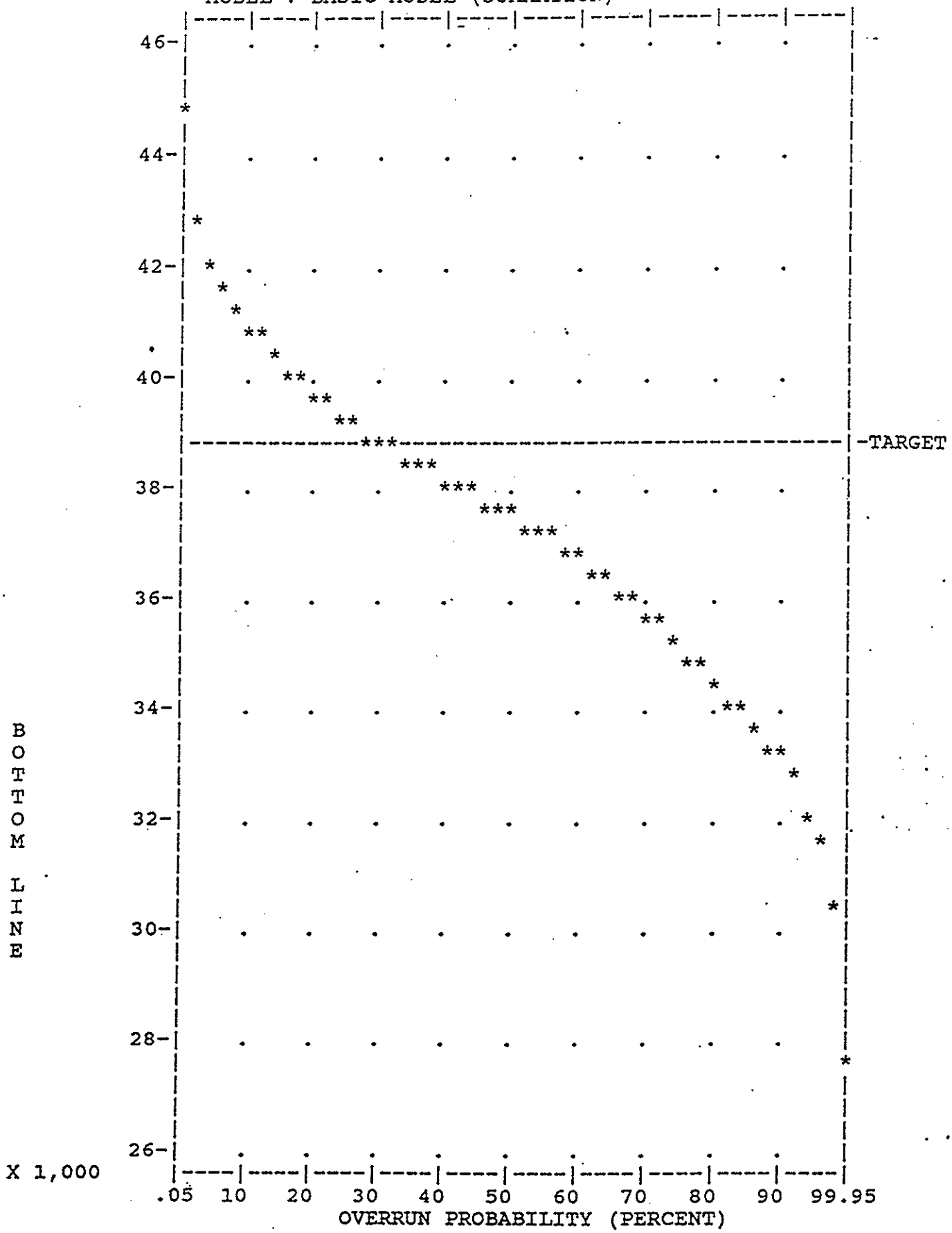
NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8600	50	6880	10320
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		0		0	0
4	Capital Waste Ret. & Transfer		2280	50	1824	3876
5	Capital Treatment		4483	40	3586	8966
6	Capital Closure		211.00		211.00	211.00
7	Operations Waste Ret. & Transfer		3990	50	3192	6783
8	Operations Treatment		6954	50	5215	6955
9	M&M		0		0	0
10	Repository Fee		12020	95	3900	12021
	TOTAL EXPENSE (INPUT TO REP/PC)		38728		24998 (THEORETICALS)	49322

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-12-96

DATA : Phased Impl Case 10

MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-12-96

DATA : Phased Impl Case 10
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
38728	31 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
10	Repository Fee			|+++++++++++++
5	Capital Treatment		-----|	+
7	Operations Waste Ret. & Transfer		--|	+
1	Current Operations		-|	+
4	Capital Waste Ret. & Transfer		-|	
8	Operations Treatment		|	+
	NET EFFECT OF FROZEN ELEMENTS		|	

DATA : Phased Impl Case 10
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	10594	27.4	PCT
99.95	"	6055	15.6	"
95	"	3028	7.8	"
90	"	2224	5.7	"
85	"	1507	3.9	"
80	"	992	2.6	"
75	"	461	1.2	"
70	"	45	.1	"
65	"	-244	-.6	"
60	"	-563	-1.4	"
55	"	-874	-2.3	"
50	"	-1238	-3.2	"
45	"	-1672	-4.3	"
40	"	-2126	-5.5	"
35	"	-2580	-6.7	"
30	"	-3006	-7.8	"
25	"	-3665	-9.5	"
20	"	-4292	-11.1	"
15	"	-4912	-12.7	"
10	"	-5717	-14.8	"
5	"	-6885	-17.8	"
0.05	"	-11080	-28.6	"
0	"	-13730	-35.4	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

JACOBS ENGINEERING GROUP INC.

DATE 2/12/95 SUBJECT SHEET NO.

BY D. Stein CHKD. JOB NO.

Phased Implementation (latest version)

Target Value $32,953

95% Confidence Range $30,226 – $36,542

FORM 61-005-1 (4/81)

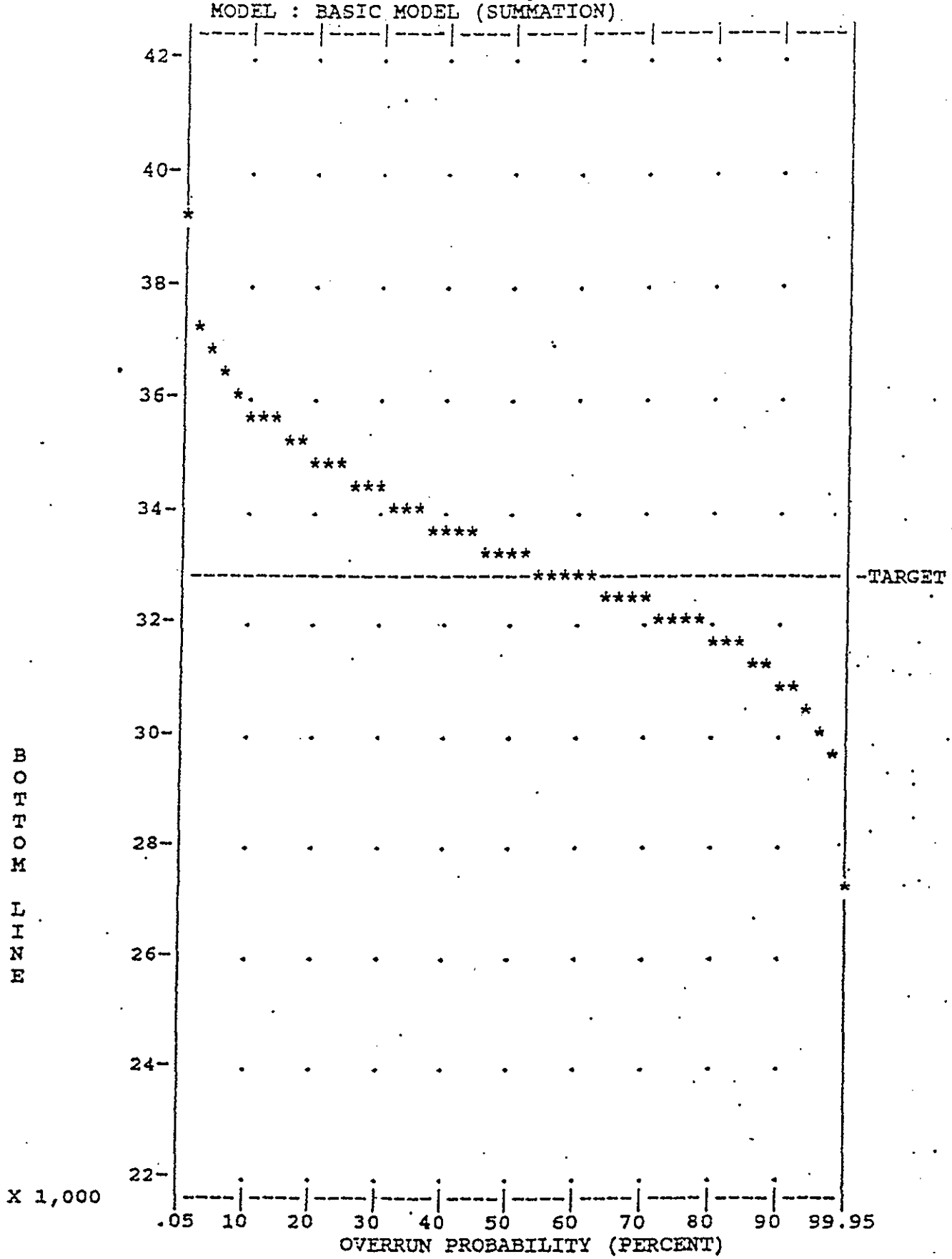
REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 02-12-96

DATA : ExSitu Exten. Sepa.r. Case 10
MODEL : BASIC MODEL (SUMMATION)

NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8600	50	6880	10320
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		0		0	0
4	Capital Waste Ret. & Transfer		2280	50	1824	3876
5	Capital Treament		4305	40	4244	8610
6	Capital Closure		211.00		211.00	211.00
7	Operations Waste Ret. & Transfer		3990	50	3192	6783
8	Operations Treatment		6877	50	5158	6878
9	M & M		0		0	0
10	Repository Fee		6500	95	3900	6501
	TOTAL EXPENSE (INPUT TO REP/PC)		32953		25599 (THEORETICALS)	43369

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 02-12-96
DATA : ExSitu Exten. Sepa.r. Case 10
MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 02-12-96

DATA : ExSitu Exten. Sepa.r. Case 10
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
32953	55 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
5	Capital Treament		----------	
10	Repository Fee			++++++++++++
7	Operations Waste Ret. & Transfer		--------	++
1	Current Operations		----	++++
4	Capital Waste Ret. & Transfer		----	+
8	Operations Treatment			++++
	NET EFFECT OF FROZEN ELEMENTS			

DATA : ExSitu Exten. Sepa.r. Case 10
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	10416	31.6	PCT
99.95	"	6159	18.7	"
95	"	3589	10.9	"
90	"	2782	8.4	"
85	"	2385	7.2	"
80	"	1960	6.0	"
75	"	1599	4.9	"
70	"	1282	3.9	"
65	"	935	2.8	"
60	"	709	2.2	"
55	"	422	1.3	"
50	"	223	.7	"
45	"	2	.0	"
40	"	-257	-.8	"
35	"	-452	-1.4	"
30	"	-682	-2.1	"
25	"	-936	-2.8	"
20	"	-1178	-3.6	"
15	"	-1518	-4.6	"
10	"	-1968	-6.0	"
5	"	-2727	-8.3	"
0.05	"	-5765	-17.5	"
0	"	-7354	-22.3	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

OUTPUT
FOR CASES
EXCLUDING
REPOSITORY
FEE

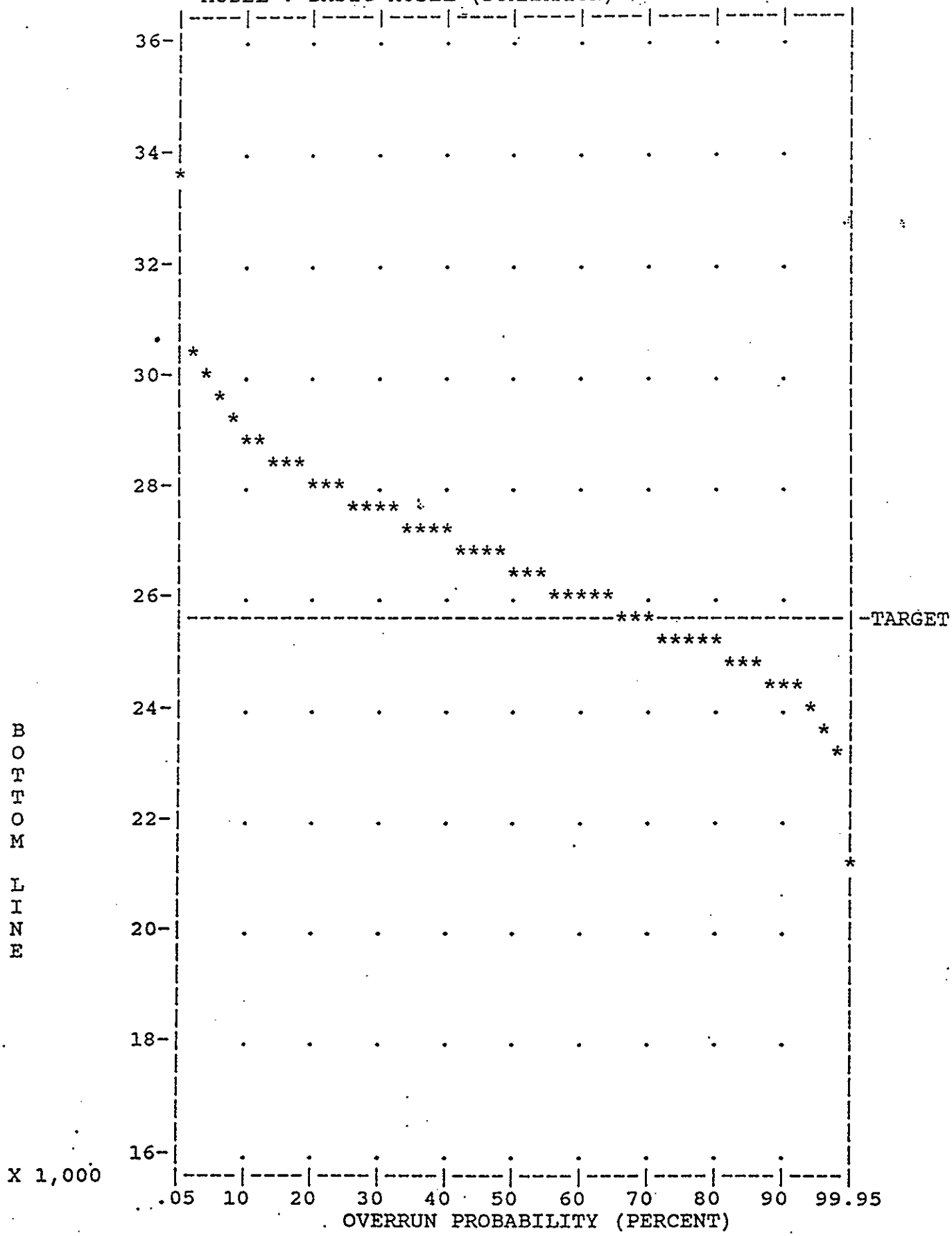
REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-20-96

DATA : Inter Sep w/o Rep Fee Case 05
MODEL : BASIC MODEL (SUMMATION)

NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8600	50	6880	10320
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		630		630	630
4	Capital Waste Ret. & Transfer		2280	50	824	3876
5	Capital Treatment		3600	40	2880	7200
6	Capital Closure		169.00		169.00	169.00
7	Operations Waste Ret. & Transfer		4820	50	3856	8194
8	Operations Treatment		5509	65	4183	5510
9	M & M		0		0	0
	TOTAL EXPENSE (INPUT TO REP/PC)		25798		19612 (THEORETICALS)	36089

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-20-96
DATA : Inter Sep w/o Rep Fee Case 05
MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-20-96

DATA : Inter Sep w/o Rep Fee Case 05
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
25798	64 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
5	Capital Treatment		----------|++	
7	Operations Waste Ret. & Transfer		----------|+++	
4	Capital Waste Ret. & Transfer		-----|++++	
1	Current Operations		-----|+++++	
8	Operations Treatment		|+++++	
	NET EFFECT OF FROZEN ELEMENTS		|	

DATA : Inter Sep w/o Rep Fee Case 05
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	10291	39.9	PCT
99.95	"	7963	30.9	"
95	"	3943	15.3	"
90	"	3111	12.1	"
85	"	2633	10.2	"
80	"	2307	8.9	"
75	"	1991	7.7	"
70	"	1739	6.7	"
65	"	1466	5.7	"
60	"	1218	4.7	"
55	"	973	3.8	"
50	"	690	2.7	"
45	"	431	1.7	"
40	"	239	.9	"
35	"	-23	-.1	"
30	"	-313	-1.2	"
25	"	-574	-2.2	"
20	"	-779	-3.0	"
15	"	-1115	-4.3	"
10	"	-1391	-5.4	"
5	"	-2023	-7.8	"
0.05	"	-4609	-17.9	"
0	"	-6186	-24.0	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

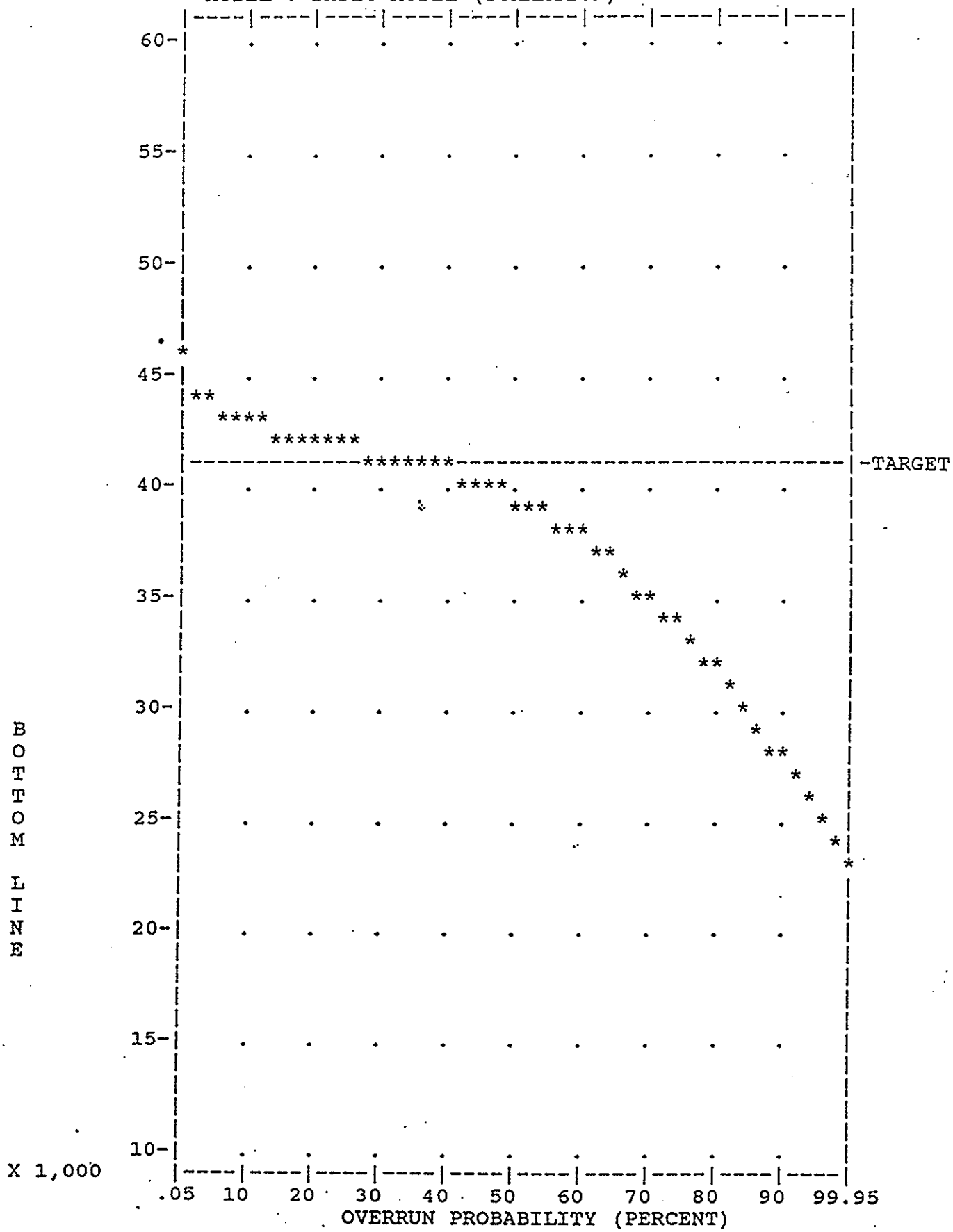
REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-20-96

DATA : No Sep Vitr w/o Rep Fee Case 06
MODEL : BASIC MODEL (SUMMATION)

NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8325	50	6660	9990
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		280		280	280
4	Capital Waste Ret. & Transfer		2280	50	1824	3876
5	Capital Treatment		2610	50	2088	3915
6	Capital Closure		152.00		152.00	152.00
7	Operations Waste Ret. & Transfer		4630	50	3704	7871
8	Operations Treatment		22742	75	4654	22743
9	M & M		0		0	0
	TOTAL EXPENSE (INPUT TO REP/PC)		41209		19552 (THEORETICALS)	49017

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-20-96
DATA : No Sep Vitr w/o Rep Fee Case 06
MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-20-96

DATA : No Sep Vitr w/o Rep Fee Case 06
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
41209	30 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
8	Operations Treatment			|+++++++++++++
7	Operations Waste Ret. & Transfer			--|
1	Current Operations			-|+
4	Capital Waste Ret. & Transfer			-|
5	Capital Treatment			-|
	NET EFFECT OF FROZEN ELEMENTS			|

DATA : No Sep Vitr w/o Rep Fee Case 06
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	7808	19.0	PCT
99.95	"	5239	12.7	"
95	"	2350	5.7	"
90	"	1717	4.2	"
85	"	1181	2.9	"
80	"	758	1.8	"
75	"	434	1.1	"
70	"	11	.0	"
65	"	-328	-.8	"
60	"	-661	-1.6	"
55	"	-1173	-2.8	"
50	"	-1723	-4.2	"
45	"	-2528	-6.1	"
40	"	-3554	-8.6	"
35	"	-4767	-11.6	"
30	"	-6349	-15.4	"
25	"	-7709	-18.7	"
20	"	-9489	-23.0	"
15	"	-11441	-27.8	"
10	"	-13652	-33.1	"
5	"	-15649	-38.0	"
0.05	"	-18707	-45.4	"
0	"	-21657	-52.5	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-20-96

DATA : No Sep Calc w/o Rep Fee Case 07
MODEL : BASIC MODEL -(SUMMATION)

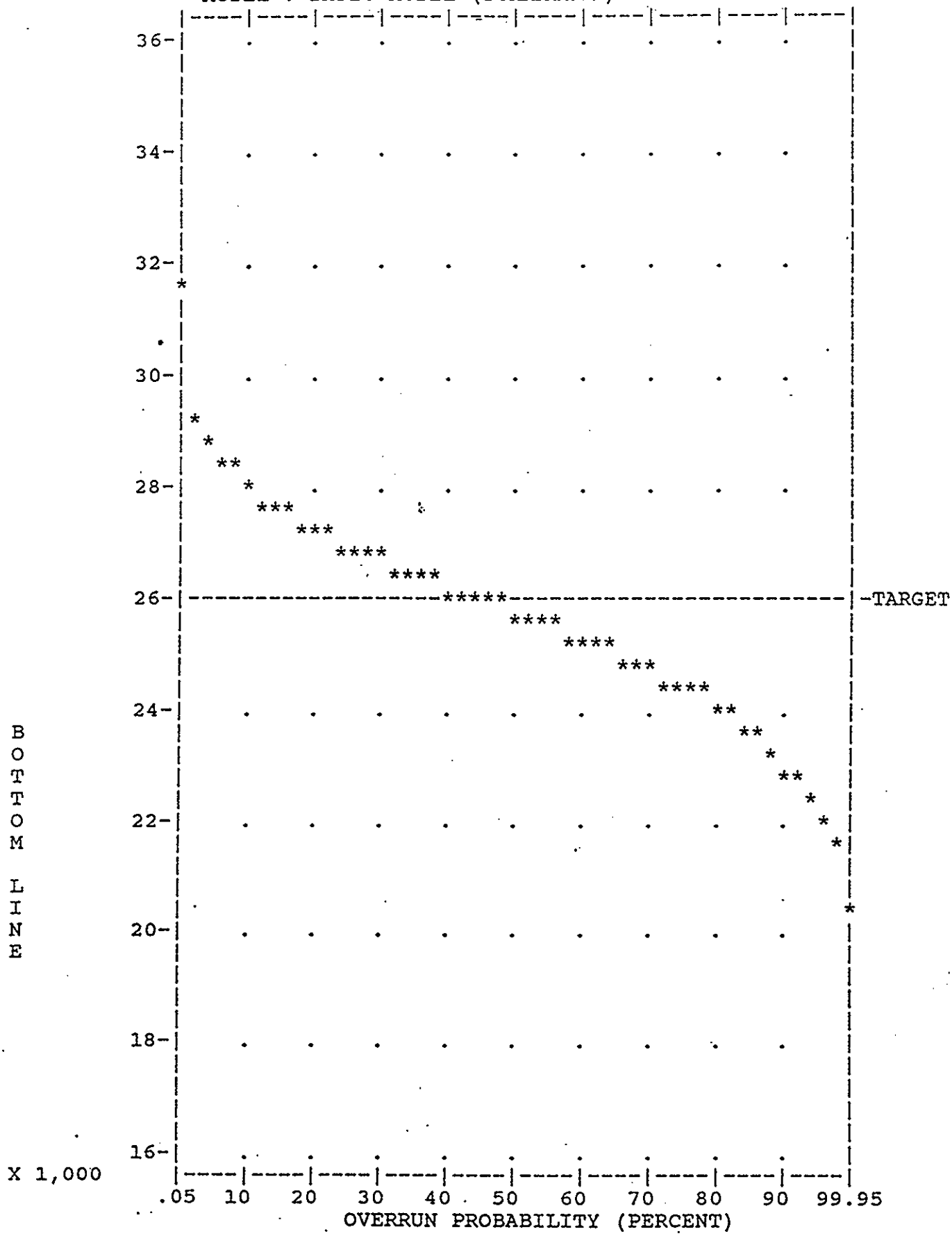
NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8325	50	6660	9990
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		280		280	280
4	Capital Waste Ret. & Transfer		2280	50	1824	3876
5	Capital Treatment		2610	50	2088	3915
6	Capital Closure		152.00		152.00	152.00
7	Operations Waste Ret. & Transfer		4630	50	3704	7871
8	Operations Treatment		7548	75	3273	7549
9	M & M		0		0	0
	TOTAL EXPENSE (INPUT TO REP/PC)		26015		18171	33823
					(THEORETICALS)	

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-20-96

DATA : No Sep Calc w/o Rep Fee Case 07

MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-20-96

DATA : No Sep Calc w/o Rep Fee Case 07
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
26015	43 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
8	Operations Treatment			|+++++++++++++
7	Operations Waste Ret. & Transfer		-------|	++
1	Current Operations		---|	+++
4	Capital Waste Ret. & Transfer		---|	+
5	Capital Treatment		---|	+
	NET EFFECT OF FROZEN ELEMENTS		|	

DATA : No Sep Calc w/o Rep Fee Case 07
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	7808	30.0	PCT
99.95	"	5486	21.1	"
95	"	2693	10.4	"
90	"	1989	7.7	"
85	"	1557	6.0	"
80	"	1194	4.6	"
75	"	905	3.5	"
70	"	630	2.4	"
65	"	425	1.6	"
60	"	155	.6	"
55	"	-69	-.3	"
50	"	-288	-1.1	"
45	"	-511	-2.0	"
40	"	-711	-2.7	"
35	"	-1004	-3.9	"
30	"	-1349	-5.2	"
25	"	-1607	-6.2	"
20	"	-1940	-7.5	"
15	"	-2366	-9.1	"
10	"	-3105	-11.9	"
5	"	-3858	-14.8	"
0.05	"	-5774	-22.2	"
0	"	-7844	-30.1	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

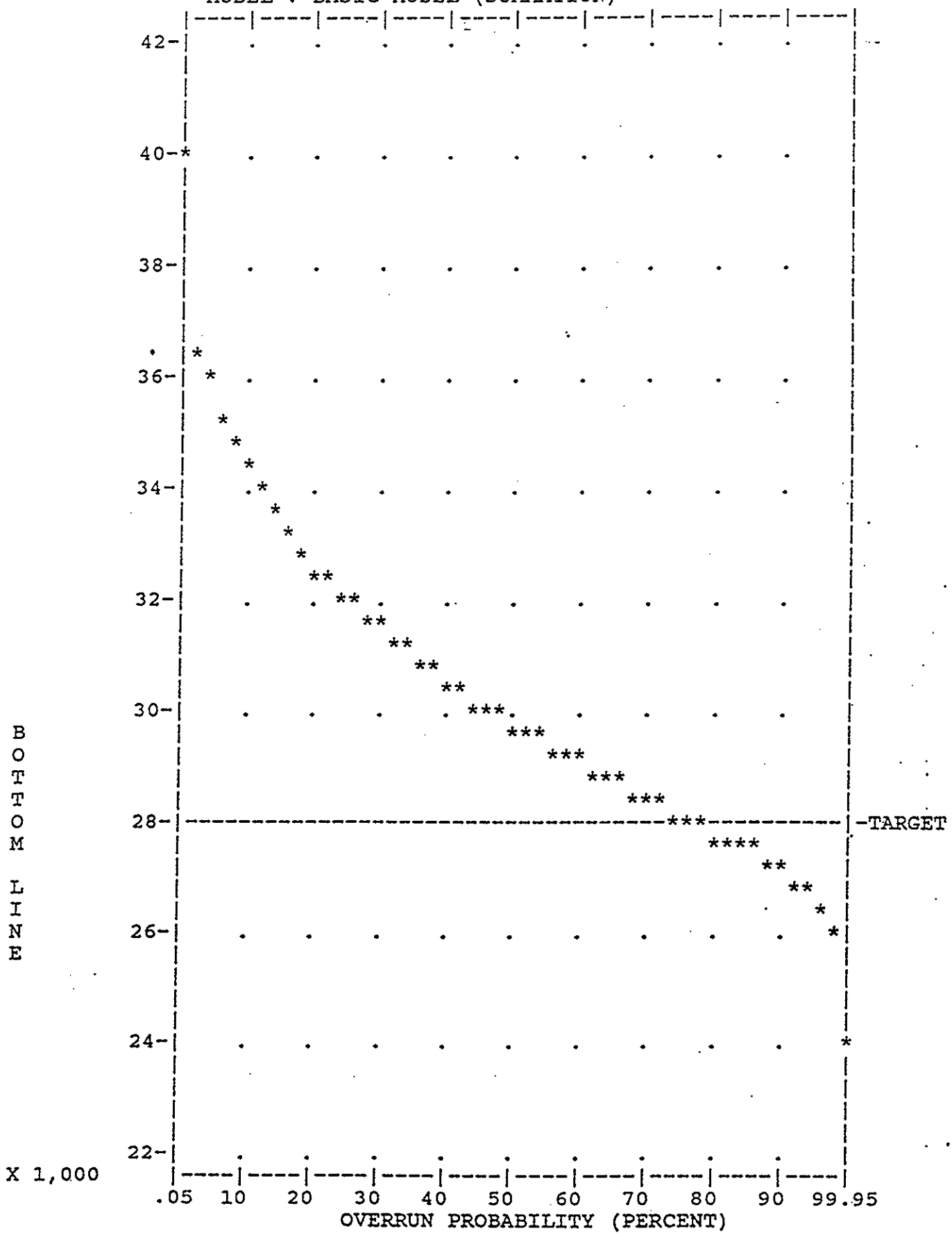
REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-12-96

DATA : Ext Sep w/o Rep Fee Case 08
MODEL : BASIC MODEL (SUMMATION)

NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8600	50	6880	10320
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		1300		1300	1300
4	Capital Waste Ret. & Transfer		2280	50	1824	3876
5	Capital Treament		5202	30	4162	13005
6	Capital Closure		170.00		170.00	170.00
7	Operations Waste Ret. & Transfer		4820	50	3856	8194
8	Operations Treatment		5417	55	4604	5418
9	M & M		0		0	0
	TOTAL EXPENSE (INPUT TO REP/PC)		27979		22986 (THEORETICALS)	42473

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-12-96
DATA : Ext Sep w/o Rep Fee Case 08
MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-12-96

DATA : Ext Sep w/o Rep Fee Case 08
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
27979	77 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
5	Capital Treament		----------|+	
7	Operations Waste Ret. & Transfer		----|+	
1	Current Operations		--|++	
4	Capital Waste Ret. & Transfer		--|+	
8	Operations Treatment		|+	
	NET EFFECT OF FROZEN ELEMENTS		|	

DATA : Ext Sep w/o Rep Fee Case 08
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	14494	51.8	PCT
99.95	"	12109	43.3	"
95	"	7497	26.8	"
90	"	6282	22.5	"
85	"	5365	19.2	"
80	"	4615	16.5	"
75	"	3930	14.1	"
70	"	3464	12.4	"
65	"	3018	10.8	"
60	"	2545	9.1	"
55	"	2144	7.7	"
50	"	1739	6.2	"
45	"	1391	5.0	"
40	"	1061	3.8	"
35	"	755	2.7	"
30	"	477	1.7	"
25	"	146	.5	"
20	"	-185	-.7	"
15	"	-497	-1.8	"
10	"	-814	-2.9	"
5	"	-1399	-5.0	"
0.05	"	-3851	-13.8	"
0	"	-4993	-17.8	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

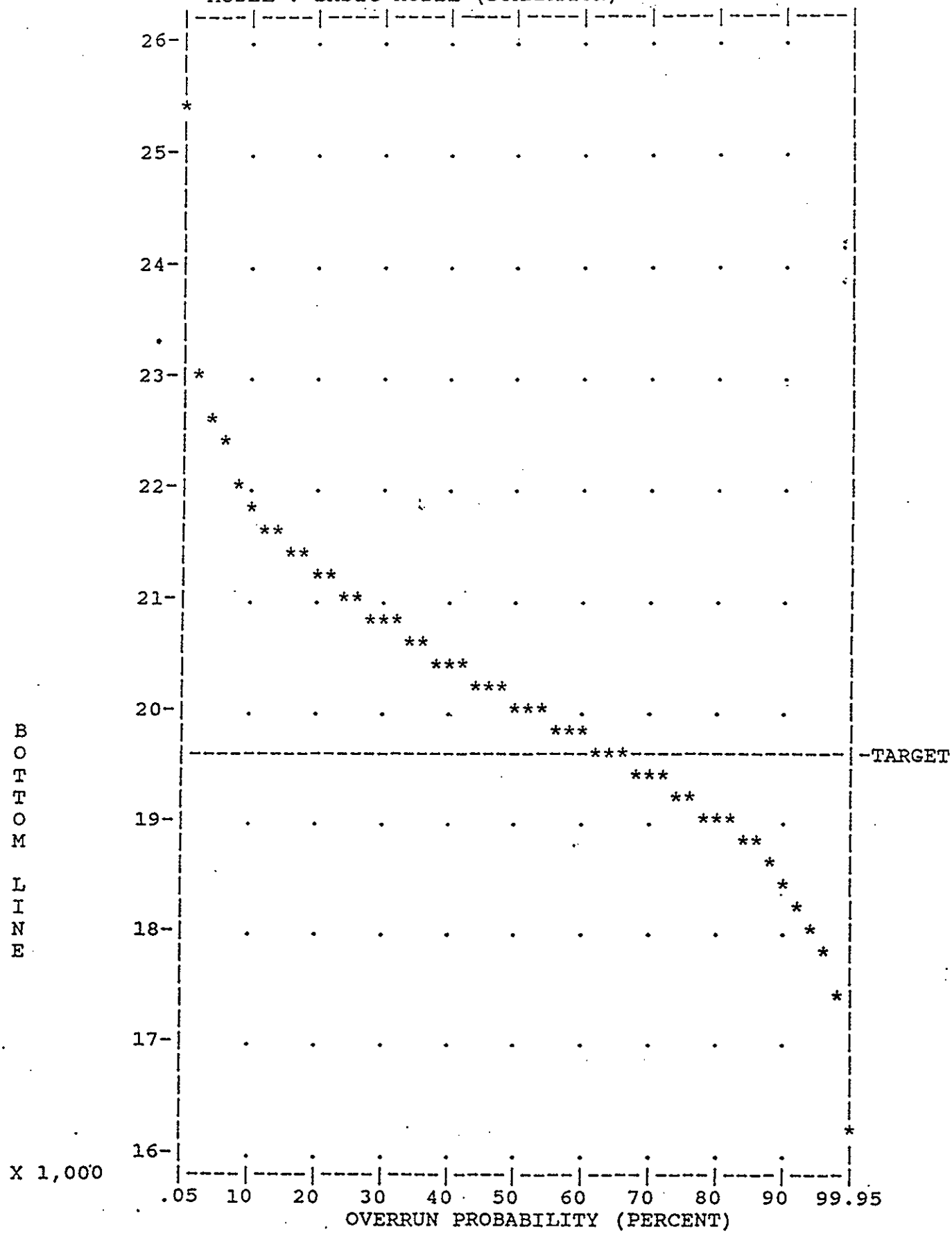
REP/PC (Ver 4.0) - MGMT REPORT 1 RANGE ESTIMATE : 03-20-96

DATA : ExSitu/InSituCombo w/o RF Case09
MODEL : BASIC MODEL (SUMMATION)

NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		9142	50	7114	10970
2	R&D Waste Ret. & Transfer		186.00		186.00	186.00
3	R&D Treatment		670		670	670
4	Capital Waste Ret. & Transfer		1388	50	1110	2360
5	Capital Treatment		2189	40	1751	4378
6	Capital Closure		137.00		137.00	137.00
7	Operations Waste Ret. & Transfer		3166	50	2533	5382
8	Operations Treatment		2638	65	2004	2639
9	M & M		0		0	0
	TOTAL EXPENSE (INPUT TO REP/PC)		19516		15505 (THEORETICALS)	26722

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-20-96
DATA : ExSitu/InSituCombo w/o RF Case09
MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-20-96

DATA : ExSitu/InSituCombo w/o RF Case09
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
19516	66 PCT	0 = .0 PCT

```
NUM ELEMENT                                UNIT     CORRECT        PROTECT

  1 Current Operations                                 ---------|++++++++++
  5 Capital Treatment                             -------------|++
  7 Operations Waste Ret. & Transfer                -----------|+++
  4 Capital Waste Ret. & Transfer                         -----|+
  8 Operations Treatment                                       |++++
    NET EFFECT OF FROZEN ELEMENTS                              |
```

DATA : ExSitu/InSituCombo w/o RF Case09
MODEL : BASIC MODEL -(SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	7206	36.9	PCT
99.95	"	5794	29.7	"
95	"	2891	14.8	"
90	"	2316	11.9	"
85	"	2023	10.4	"
80	"	1750	9.0	"
75	"	1491	7.6	"
70	"	1253	6.4	"
65	"	1085	5.6	"
60	"	907	4.7	"
55	"	718	3.7	"
50	"	542	2.8	"
45	"	367	1.9	"
40	"	211	1.1	"
35	"	38	.2	"
30	"	-137	-.7	"
25	"	-323	-1.7	"
20	"	-488	-2.5	"
15	"	-726	-3.7	"
10	"	-1025	-5.2	"
5	"	-1560	-8.0	"
0.05	"	-3250	-16.6	"
0	"	-4011	-20.5	"

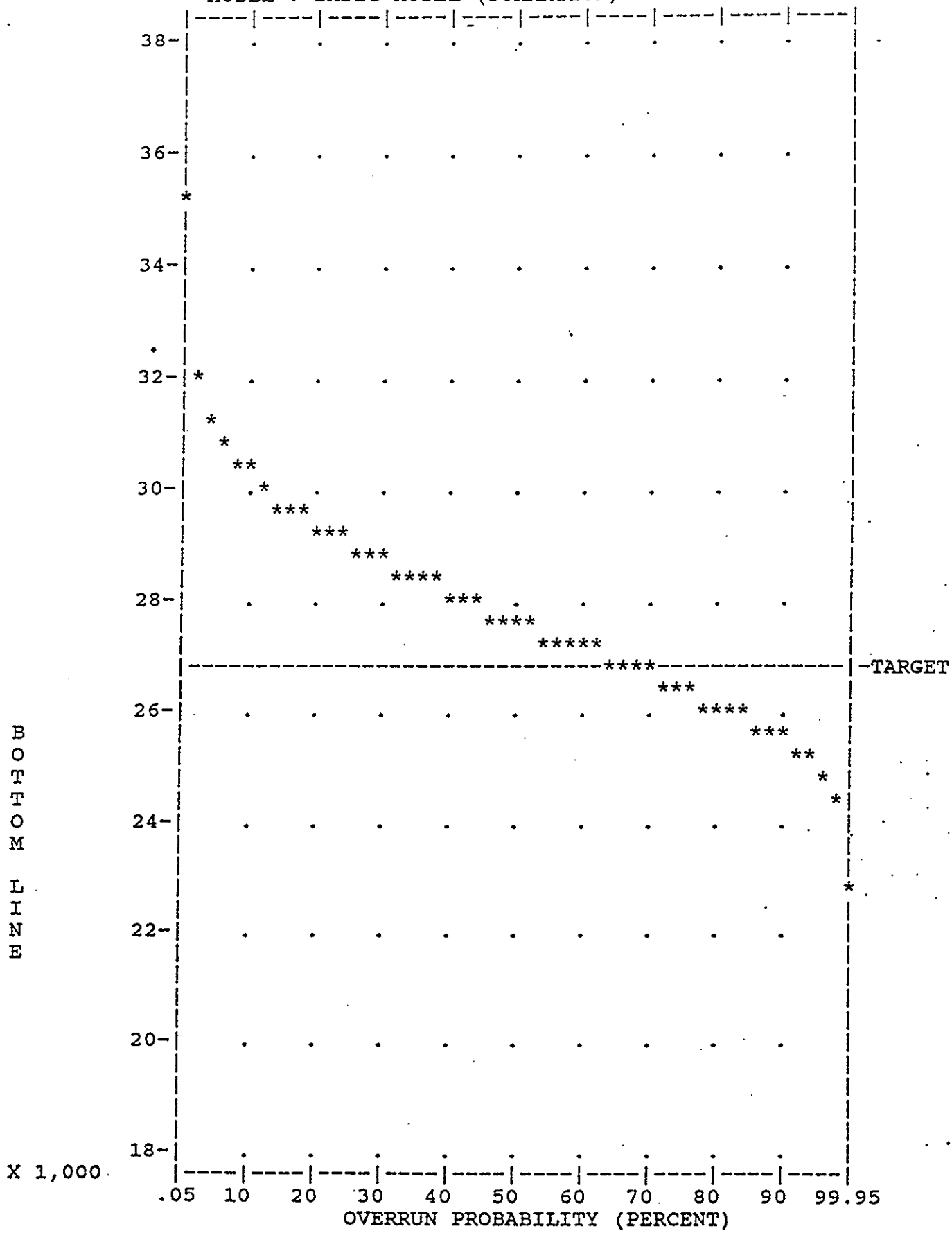
(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)

DATA : Phased Impl w/o Rep Fee Case10
MODEL : BASIC MODEL (SUMMATION)

NUM	ELEMENT	UNIT	TARGET	PROB+	LOW	HIGH
1	Current Operations		8600	50	6880	10320
2	R&D Waste Ret. & Transfer		190.00		190.00	190.00
3	R&D Treatment		0		0	0
4	Capital Waste Ret. & Transfer		2280	50	1824	3876
5	Capital Treatment		4483	40	3586	8966
6	Capital Closure		211.00		211.00	211.00
7	Operations Waste Ret. & Transfer		3990	50	3192	6783
8	Operations Treatment		6954	50	5215	6955
9	M&M		0		0	0
	TOTAL EXPENSE (INPUT TO REP/PC)		26708		21098 (THEORETICALS)	37301

+ PROBABILITY THAT ACTUAL VALUE WILL BE EQUAL TO OR LESS THAN TARGET

REP/PC (Ver 4.0) - MGMT REPORT 2 GRAPHICAL OVERRUN PROFILE : 03-12-96
DATA : Phased Impl w/o Rep Fee Case10
MODEL : BASIC MODEL (SUMMATION)



REP/PC (Ver 4.0) - MGMT REPORT 3 GRAPHICAL PRIORITY PROFILE : 03-12-96

DATA : Phased Impl w/o Rep Fee Case10
MODEL : BASIC MODEL (SUMMATION)

TOTAL EXPENSE	PROB OF OVERRUN	NET EFFECT OF FROZEN ELEMENTS
26708	69 PCT	0 = .0 PCT

NUM	ELEMENT	UNIT	CORRECT	PROTECT
5	Capital Treatment		----------|++	
7	Operations Waste Ret. & Transfer		-------|++	
1	Current Operations		----|++++	
4	Capital Waste Ret. & Transfer		----|+	
8	Operations Treatment		|++++	
	NET EFFECT OF FROZEN ELEMENTS		|	

DATA : Phased Impl w/o Rep Fee Case10
MODEL : BASIC MODEL (SUMMATION)

TO BE THIS CONFIDENT OF NOT HAVING COST OVERRUN		ADD THIS CONTINGENCY ABSOLUTE	RELATIVE	
100	PCT	10593	39.7	PCT
99.95	"	8381	31.4	"
95	"	4401	16.5	"
90	"	3515	13.2	"
85	"	3043	11.4	"
80	"	2637	9.9	"
75	"	2279	8.5	"
70	"	1945	7.3	"
65	"	1676	6.3	"
60	"	1401	5.3	"
55	"	1088	4.1	"
50	"	847	3.2	"
45	"	629	2.4	"
40	"	413	1.6	"
35	"	187	.7	"
30	"	-40	-.1	"
25	"	-379	-1.4	"
20	"	-610	-2.3	"
15	"	-850	-3.2	"
10	"	-1246	-4.7	"
5	"	-1708	-6.4	"
0.05	"	-4019	-15.0	"
0	"	-5610	-21.0	"

(ABOVE RESULTS DERIVED FROM 1000 SIMULATIONS)