Date Received for Clearance Process (MM/YY/DD)

8/8/02

INFORMATION CLEARANCE FORM

A. Information Category

- [ ] Abstract
- [ ] Summary
- [ ] Visual Aid
- [ ] Full Paper
- [ ] Journal Article
- [ ] Internet
- [ ] Software
- [x] Report
- [ ] Other ____________

B. Document Number RPP-11306

C. Title

EVALUATION OF LOW-ACTIVITY WASTE FEED SUPPLEMENTAL TREATMENT OPTIONS BY THE C3T MISSION ACCELERATION INITIATIVE TEAM FOR THE OFFICE OF RIVER PROTECTION

D. Internet Address

E. Required Information

1. Is document potentially Classified? [x] No [ ] Yes (MANDATORY)

See below for signature

Manager's Signature Required

If Yes ____________ [ ] No [ ] Yes Classified

ADC Signature Required

2. References in the Information are Applied Technology [x] No [ ] Yes

Export Controlled Information [x] No [ ] Yes

3. Does Information Contain the Following: (MANDATORY)

a. New or Novel (Patentable) Subject Matter? [x] No [ ] Yes

If "Yes", Disclosure No.: ____________

b. Information Received in Confidence, Such as Proprietary and/or Inventions?

[x] No [ ] Yes If "Yes", Affix Appropriate Legends/Notices.

c. Copyrights? [x] No [ ] Yes If "Yes", Attach Permission.

d. Trademarks? [x] No [ ] Yes If "Yes", Identify in Document.

4. Is Information requiring submission to OSTI? [ ] No [x] Yes

5. Release Level? [x] Public [ ] Limited

F. Complete for a Journal Article

1. Title of Journal N/A

G. Complete for a Presentation

1. Title for Conference or Meeting N/A
2. Group Sponsoring ____________
3. Date of Conference ____________
4. City/State ____________
5. Will Information be Published in Proceedings? [ ] No [ ] Yes
6. Will Material be Handed Out? [ ] No [ ] Yes

H. Author/Requestor

A. F. Choho — AFChoho 7-30-02

(Print and Sign)

Responsible Manager

R. E. Raymond — RE Raymond

(Print and Sign)

I. Reviewers

	Yes	Print	Signature	Public Y/N (If N, complete J)
General Counsel	[x]	S. J. Bensussen	SJB	(Y) / N
Office of External Affairs	[ ]			Y / N
DOE-~~RL~~ ORP	[x]	B. M. Mauss	B.M. Mauss	(Y) / N
Other	[ ]			Y / N
Other	[ ]			Y / N

J. If Information Includes Sensitive Information and is not to be released to the Public indicate category below.

- [ ] Applied Technology
- [ ] Personal/Private
- [ ] Proprietary
- [ ] Business-Sensitive
- [ ] Predecisional
- [ ] UCNI
- [ ] Protected CRADA
- [ ] Export Controlled
- [ ] Procurement-Sensitive
- [ ] Patentable
- [ ] Other (Specify) ____________

Information Clearance Approval

APPROVED FOR RELEASE — OFFICIAL DOCUMENT — CW — 8/8/02

K. If Additional Comments, Please Attach Separate Sheet

A-6001-401 (12/00)

RPP-11306
Revision 0

Evaluation of Low-Activity Waste Feed Supplemental Treatment Options by the C3T Mission Acceleration Initiative Team for the Office of River Protection

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.

Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-99RL14047

RPP-11306
Revision 0

Evaluation of Low-Activity Waste Feed Supplemental Treatment Options by the C3T Mission Acceleration Initiative Team for the Office of River Protection

Prepared By
A. F. Choho
Numatec Hanford Corporation

K. A. Gasper
CH2MHILL Hanford Group, Inc.

Approval Designator Not Applicable

Date Published
July 2002

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.

P. O. Box 1500
Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-99RL14047

Chris Willingham
Clearance Approval

8/8/02
Date

EVALUATION OF LOW-ACTIVITY WASTE FEED SUPPLEMENTAL TREATMENT OPTIONS BY THE C3T MISSION ACCELERATION INITIATIVE TEAM FOR THE OFFICE OF RIVER PROTECTION

EVALUATORS

Jimmy Bell, Independent Consultant
Robbie Biyani, Washington State Department of Ecology
Joel Case, DOE, Idaho (attended days 1, 2 only)
Suzanne Dahl, Washington State Department of Ecology
Bill Hewitt, YAHSGS LLC
Bill Holtzscheiter, Westinghouse Savannah River Co., Savannah River Testing Co.
Kenneth Lang, DOE, Headquarters, EM-42
Vince Maio, Mixed Waste / TFA (voting day 3 only)
Billie Mauss, DOE, Office of River Protection
Richard Raymond, CH2MHill Hanford Group
Roger Stanley, Washington State Department of Ecology
Russ Treat, Dade, Moeller & Associates
Nancy Uziemblo, Washington State Department of Ecology
Don Wodrich, Independent Consultant (voting day 3 only)

This page intentionally left blank.

CONTENTS

APPENDICES

FIGURES

TABLES

TERMS

C3T	Cleanup Constraints and Challenges Team
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
HLW	high-level waste
ILAW	immobilized low-activity waste
LAW	low-activity waste
MAI	Mission Acceleration Initiative
MTG/D	metric tons of glass per day
ORP	Office of River Protection
RCRA	*Resource Conservation Act of 1976*
RPP	River Protection Project
SST	single-shell tank
WTP	Waste Treatment Plant

This page intentionally left blank.

EVALUATION OF LOW-ACTIVITY WASTE FEED SUPPLEMENTAL TREATMENT OPTIONS BY THE C3T MISSION ACCELERATION INITIATIVE TEAM FOR THE OFFICE OF RIVER PROTECTION

1.0 INTRODUCTION AND BACKGROUND

The U.S. Department of Energy (DOE), Office of River Protection (ORP), is responsible for the remediation of the Hanford Site tank farms, including the 53 million gallons of highly radioactive mixed waste contained in 149 single-shell tanks (SST) and 28 double-shell tanks (DST). ORP manages the River Protection Project (RPP). Under the RPP, wastes retrieved from the tanks will be partitioned to separate the highly radioactive constituents from the very large volumes of chemical wastes that exist in the tanks. The volume of waste is the result of chemicals used in various Hanford Site processes, chemicals that were added to the tanks to reduce tank corrosion, and chemicals used in reprocessing and extraction of cesium and strontium. The highly radioactive constituents are to be vitrified, stored onsite, and ultimately disposed of as high-level waste (HLW) in the offsite national repository. The less radioactive chemical waste, referred to as low-activity waste (LAW), also would be vitrified and then disposed of onsite in trenches that comply with the *Resource Conservation Act of 1976* (RCRA)[1] and in compliance with DOE O 435.1, *Radioactive Waste Management.*

Under a consent order[2] entered into by the Washington State Department of Ecology (Ecology), the U.S. Environmental Protection Agency, and the ORP, the vitrification of all Hanford Site tank waste is to be completed by 2028. However, meeting the 2028 treatment completion date presents significant technical and fiscal challenges. The current Tri-Party Agreement-compliant RPP baseline is predicated on a phased approach wherein a 30-metric tons of glass per day (MTG/D) LAW vitrification facility and a 1.5 MTG/D HLW vitrification facility will treat at least the first 10 percent of the waste by 2018. HLW treatment capacity will need to be increased to 12 MTG/D and the LAW treatment capacity increased to 120 MTG/D in 2018 in order to complete waste processing by 2028, based on the preferred approach in DOE/EIS-0189, *Tank Waste Remediation System Hanford Site, Richland, Washington, Final Environmental Impact Statement.* According to DOE/EIS-0189, the additional capacity is attained by doubling the capacity of an initial Waste Treatment Plant (WTP) and constructing a second WTP with the same expanded throughput.

The high capital expense associated with the above approach has resulted in consideration being given to enhancing initial WTP processing capability and eliminating the second WTP. This approach better utilizes the WTP investment capital but will not complete tank waste treatment until 2046.

---

[1] The state of Washington implements a U.S. Environmental Protection Agency-authorized hazardous waste management program via the *Washington Administrative Code*, Section 173-303, "Dangerous Waste Regulations." References to RCRA in this document in the context of Tri-Party Agreement cleanup remedies refer to Washington's Dangerous Waste Regulations.

[2] *Hanford Federal Facility Agreement and Consent Order*, also referred to as the Tri-Party Agreement.

Accordingly, the Mission Acceleration Initiative (MAI) was developed to allow tank waste treatment to be completed by 2028. Figure 1-1 presents a conceptual pathway to complete waste treatment by 2028. This acceleration would be accomplished through a combination of (1) increasing the HLW and LAW treatment capacities in the initial facilities brought on line in 2007 to 6 MTG/D and 60 MTG/D, respectively,[3] and (2) deploying supplemental treatment technologies to treat wastes determined to be non-HLW.[4] Option 2 may include pretreatment of the waste to produce the non-HLW fraction or may use any excess capacity in the WTP. This accelerated approach enables tank waste treatment to be completed by 2028 with all tank-HLW[5] vitrified. The MAI assumes that LAW treatment in the WTP would increase to 60 MTG/D with LAW immobilization being accomplished by vitrification and a supplemental immobilization technique. Even with the LAW treatment increase, a gap (illustrated by the bracket in Figure 1-1) remains between the quantity of LAW that could be treated in the LAW treatment plant by 2028 and the total quantity.

From May 21 - 23, 2002, the Cleanup Constraints and Challenges Team (C3T) MAI Subgroup, together with invited experts, held a workshop to evaluate flow sheet options for the MAI to close that gap. Although the options assumed skid-mounted treatment units that could ostensibly operate independently of the WTP, the participants were instructed to also consider whether key treatment components would be of value if used in conjunction with the WTP (i.e., waste from pretreatment operations being fed into a supplemental immobilization unit).[6] It was stressed that "skid mounting" could be interpreted in very different ways, from simply constructing "skid-mounted" offsite and transporting to a permanent hosting facility, to total mobility and outdoor operation. Additionally, the options were considered with the objective of a demonstration with radioactive waste in the 5 gal/min throughput range within the next 3 to 5 years. All of the options were targeted for use in closing the LAW treatment gap in a manner that would accelerate cleanup and risk reduction but would maintain cleanup quality.

A LAW treatment gap exists between the MAI conceptual capacity of the WTP and the waste treatment capacity if all tank waste treated by 2028 were predominantly high-sodium saltcake wastes in the tanks. Accordingly, the flow sheets for the supplemental tank waste treatment options focused on saltcake wastes retrieved from SSTs. For purposes of the workshop evaluations, the flow sheets were focused on treating wastes from 68 SSTs that have been tentatively identified as candidates for such treatment options. Each of the SSTs selected has saltcake inventories of at least 50,000 gal.

---

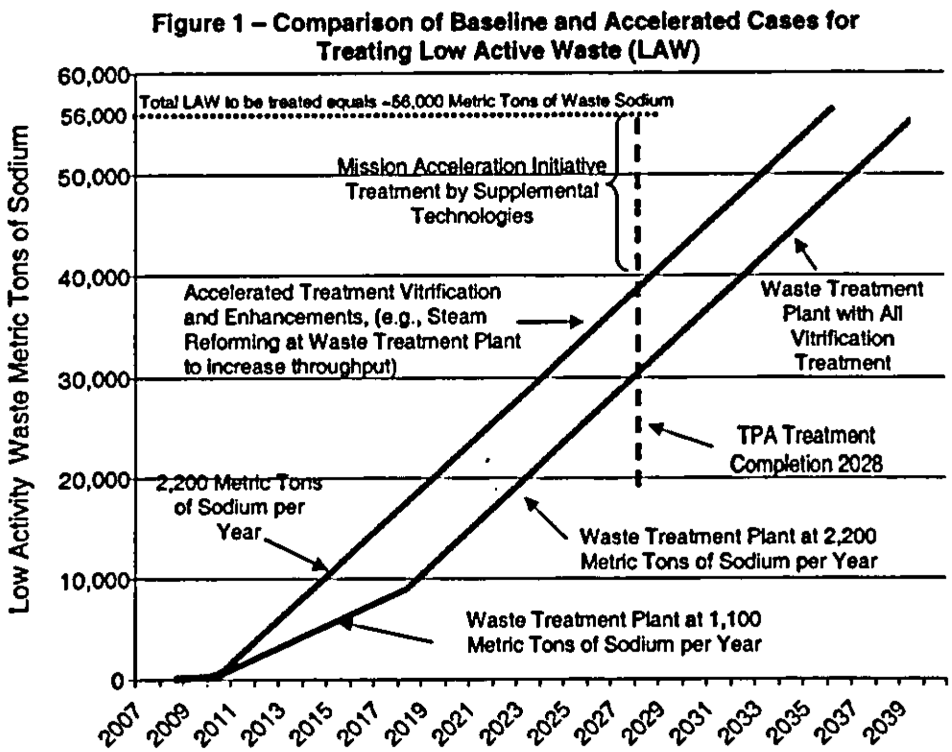
[3] The LAW treatment throughput would be equivalent to 60 MTG/D; however, not all LAW would be vitrified (i.e., alternative waste forms could be used to supplement vitrification).

[4] Non-HLW is waste that is deemed not to be HLW due to its origin (e.g., TRU waste from decladding operations) or due to waste incidental to reprocessing determinations in accord with DOE M 435.1-1, *Radioactive Waste Management Manual.*

[5] Hanford Site cesium and strontium capsules were not addressed by this action team.

[6] The flow sheets presented to the workshop participants were intended to facilitate the workshop evaluations, not to limit the ways that treatment technologies could be beneficially deployed to meet ORP's treatment objectives. For example, a 5 gal/min flow rate was used for the flow sheets but a net flow rate of approximately 7 gal/min would be required to close the gap on a 24-7 basis.

Figure 1-1. Mission Acceleration Initiative Cases for Treating Low-Activity Waste.



The combination of accelerated LAW treatment in the WTP and supplemental technologies provides a pathway to complete waste treatment by 2028.

The core LAW treatment technologies used in the flow sheets are the product of prior technology studies by DOE conducted over the past decade (e.g., by the Tanks Focus Area and the DOE Office of Environmental Management) as well as technologies that have been developed and in some cases successfully deployed by private industry. In order to allow the May workshop evaluations to be focused on a manageable number of alternatives, a preliminary screening was conducted by ORP in early April. The screening resulted in selection of nine flow sheet options (options one through seven, plus two variants) for evaluation at the May workshop. The options were based on mass balance and other technical and programmatic data developed for the technologies during April and early May. The evaluator panel included twelve members and two backups. The screening process is described in Appendix A.

This page intentionally left blank.

2.0 OPTIONS EVALUATED AND INFORMATION REVIEWED

Figure 2-1 summarizes the technologies that were used in the nine flow sheet options evaluated. All nine options start with a "Selective Dissolution" step, which would be accomplished as part of the baseline tank retrieval process (salt dissolution). Selective dissolution takes advantage of the high solubility of cesium and technetium to separate the first fraction of the dissolution stream to the WTP, via the DST system, leaving a waste stream with significantly reduced radionuclide content as the feed for supplemental treatment processes. The expected effectiveness of such a separation was discussed among the evaluators, and serious reservations were expressed by a few evaluators regarding the extrapolation of partitioning factors measured in test tubes at equilibrium to phenomena occurring in a tank-size salt bed. The evaluators decided to not include this step in their evaluation and to take no credit for the separations provided by it, although most appeared to believe the technology will work to some extent. CH2M HILL Hanford Group, Inc., will measure the effectiveness of selective dissolution within the next few months during the planned low-volume density gradient proof-of-concept test of salt dissolution retrieval in tank 241-U-107.

In all nine options, selective dissolution is followed by a solid-liquid separation step. This step is expected to effectively separate strontium and transuranics contained in suspended solids as these are essentially insoluble. The saltcake wastes being considered for these options do not have appreciable organic complexants, so there is essentially no soluble strontium or transuranic constituents. The solid-loaded effluent from the solid-liquid separation will be returned to the DST system for treatment by the WTP. Table 2-1 describes the steps specific to each option.

For each option except option 3 (steam reforming), the following information was provided to the evaluators in a written report, RPP-11131, *Mission Acceleration Initiative Demonstration Information Package*, and verbal presentations:

- Mass balance for the main radionuclides and chemicals of concern for the tank 241-S-112 inventory (used as a representative tank) on a 5 gal/min treatment basis (this included, for each unit operation, estimated separations of the main contaminants [e.g., cesium, strontium, technetium, transuranics, nitrates, sulfates] from the stream to be immobilized)

- Description of the primary equipment and process conditions involved

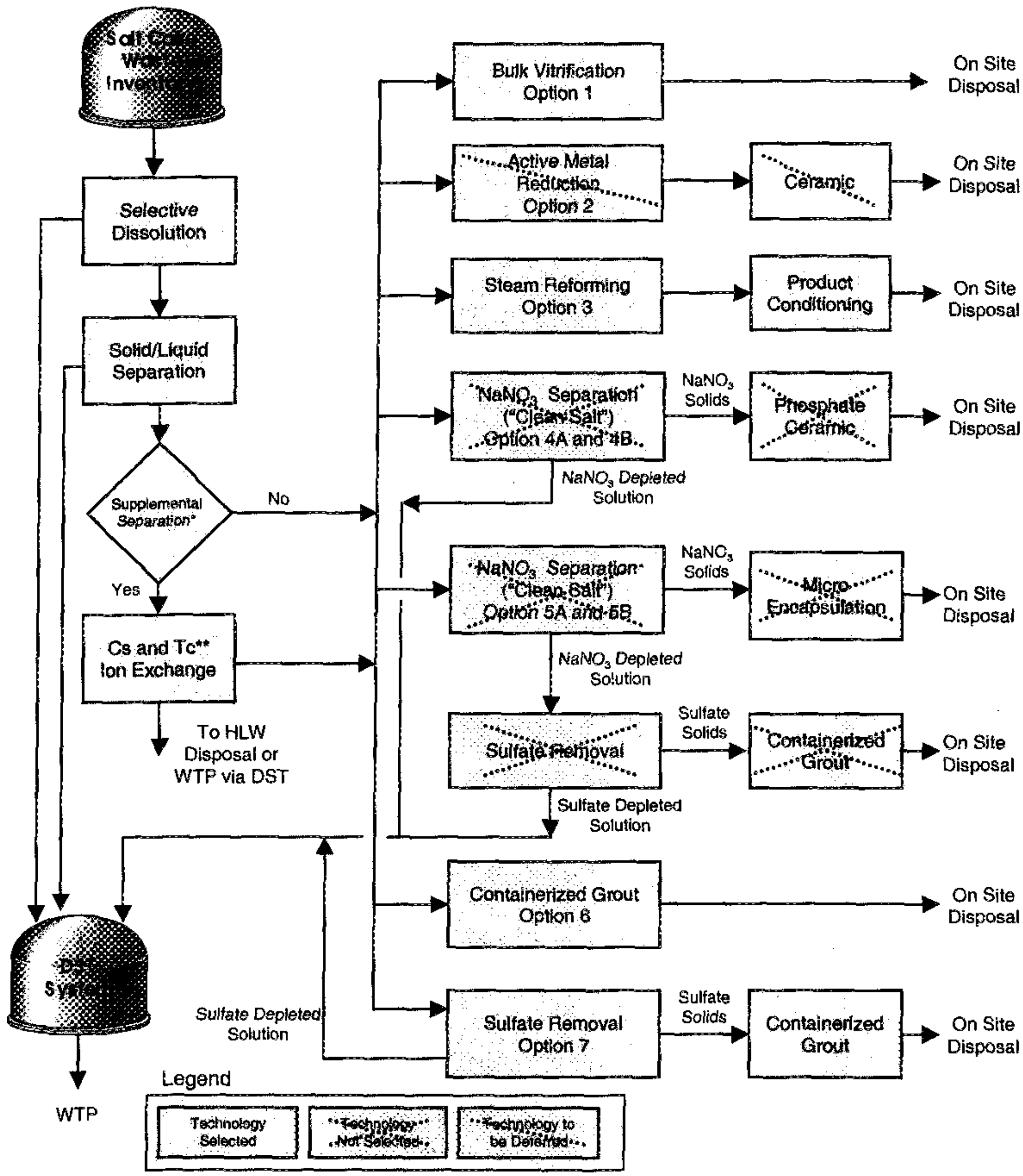
- List of relevant laboratory, pilot, and industrial experience

- Estimated waste form performance toward radionuclides and chemicals of concern

- Order of magnitude of the cost to deploy the option in a skid-mounted unit, to treat the inventory of one tank (e.g., tank 241-S-112) at approximately 5 gal/min (the cost was provided for comparison purposes only, not as a basis for future project planning)

Best Available Image

Figure 2-1. Low-Activity Waste Supplemental Treatment Options as Evaluated at the May 21-23, 2002, Workshop.



* Clean Salt Option 4A and Option 5A don't include Cs and Tc removal.
** Tc Ion Exchange added as a result of May 21-23 Workshop

CHG0205-6.ppt

Table 2-1. Summary Description for Potential Low-Activity Waste Treatment Options. (2 sheets)

Option	Summary description as evaluated
Option 1 – Bulk Vitrification	The LAW stream is passed through a cesium ion exchange column that contains crystalline silicotitanate to remove cesium (technetium removal was assumed when evaluating this option, but no flow sheet calculations were done in advance of the workshop). This results in a waste stream that is expected to require less shielding for subsequent processing steps. The waste stream is processed by a bulk vitrification step that involves the mixture of the waste with inexpensive glass forming materials (clay or sandy soil) followed by vitrification. Vitrification is performed inside of the eventual disposal container through the use of inserted electrodes and the application of electrical power. The resulting vitrified product is disposed of in the container in which it was processed. Final disposition of the ^{137}Cs-laden crystalline silicotitanate for a demonstration has not been determined but could include processing in the WTP HLW vitrification facility. The eluted technetium is returned to the DST system. All larger scale cesium and technetium ion exchange would likely take place in the WTP.
Option 2 – Active Metal Reduction	The LAW stream is passed through a cesium ion exchange column that contains crystalline silicotitanate to remove cesium (technetium removal was assumed when evaluating this option, but no flow sheet calculations were done in advance of the workshop). This results in a waste stream that is expected to require less shielding for subsequent processing steps. The waste stream is processed through two treatment steps. First, the waste stream is reacted with aluminum metal to form a sodium aluminate. This processing step also results in the destruction of sodium nitrate, nitrite, and hydroxide species. The immobilization step involves the reaction of the sodium aluminate with phosphoric acid to create a phosphate-based ceramic waste form that is placed in containers for disposal. The liquid stream not immobilized in the ceramic waste form is placed into a phosphate-based cement. Again, final disposition of the ^{137}Cs-laden crystalline silicotitanate for a demonstration has not been determined but could include processing in the WTP HLW vitrification facility. The eluted technetium is returned to the DST system. All larger scale cesium and technetium ion exchange would likely take place in the WTP.
Option 3 – Steam Reforming	The LAW stream is passed through a cesium ion exchange column that contains crystalline silicotitanate to remove cesium. (Technetium removal was assumed when evaluating this option, but this step was not included in the flow sheet calculations done in advance of the workshop.) This results in a waste stream that is expected to require less shielding for subsequent processing steps. The waste is processed in a high-temperature fluidized bed under a slight vacuum. Superheated steam and additives are injected into the bed creating both reducing and oxidizing zones. The process destroys nitrates and with the help of additives, incorporates radioisotopes together with sodium, sulfate, chlorine, and fluorine in a granular material that can be placed in containers or grouted. Again, final disposition of the ^{137}Cs-laden crystalline silicotitanate for a demonstration has not been determined but could include processing in the WTP HLW vitrification facility. The eluted technetium is returned to the DST system. All larger scale cesium and technetium ion exchange would likely take place in the WTP.

Table 2-1. Summary Description for Potential Low-Activity Waste Treatment Options. (2 sheets)

Option	Summary description as evaluated
Options 4A and 4B – Clean Salt	Because the clean salt technology separates the cesium and technetium from the stream to be immobilized, evaluations are conducted for one option without a cesium ion exchange column (4A) and one option with the column (4B). For both options, the waste stream is reacted with nitric acid to convert sodium salts to sodium nitrate. The reacted solution is passed through an evaporator and cooler to crystallize out sodium nitrate. For option 4A, the crystals are washed to remove radionuclides and other species from the sodium nitrate crystals. For both options, the sodium nitrate crystals are filtered from the liquid and then immobilized in an appropriate grout. These two options send the sodium nitrate-depleted waste stream to the WTP via the DST system.
Options 5A and 5B – Clean Salt with Sulfate Removal	These two options are similar to options 4A and 4B because they react the waste stream with nitric acid to convert sodium salts to sodium nitrate, and crystallize out (through evaporation) sodium nitrate, which is filtered from the liquid, for immobilization. Option 5A involves no upstream cesium ion exchange column, but does include a sodium nitrate crystal wash step, while option 5B includes an upstream cesium ion exchange column but no washing step. In addition, options 5A and 5B include the following features, which are different from options 4A and 4B: (1) the liquid solution (which contains very little sodium nitrate) from the evaporation step is further processed to remove sulfate before being sent to the WTP via the DST system, (2) the removed sulfate is immobilized in an appropriate grout, and (3) the sodium nitrate crystals are immobilized by microencapsulation (as opposed to grout).
Option 6 – Containerized Grout	The LAW stream is passed through a cesium ion exchange column that contains crystalline silicotitanate to remove cesium. (Technetium removal was assumed when evaluating this option, but this step was not included in the flow sheet calculations done in advance of the workshop.) This results in a waste stream that is expected to require less shielding for subsequent processing steps. The waste is processed by an ambient solidification step that involves the mixing of the waste with grout formers (Portland cement, fly ash, and slag) to form a solid grout product. The resulting grout product is placed into containers for disposal. This treatment option does not send any secondary waste stream to the WTP. Again, final disposition of the ^{137}Cs-laden crystalline silicotitanate for a demonstration has not been determined but could include processing in the WTP HLW vitrification facility. The eluted technetium is returned to the DST system. All larger scale cesium and technetium ion exchange would likely take place in the WTP.
Option 7 – Sulfate Removal	The LAW stream is passed through a cesium ion exchange column that contains crystalline silicotitanate to remove cesium. This results in a waste stream that is expected to require less shielding for subsequent processing steps. The waste stream is processed through the following steps. First, the waste stream is reacted with nitric acid to change the stream from alkaline to acidic. Strontium nitrate is added in a subsequent step to precipitate sulfate. The sulfate species are filtered from the liquid and immobilized in a grout. This option sends the sulfate-depleted waste stream that contains technetium and other soluble radionuclides to the WTP via the DST system.

DST = double-shell tank.
HLW = high-level waste.
LAW = low-activity waste.
WTP = Waste Treatment Plant.

- Estimated reduction of WTP LAW processing duration compared with the current baseline for the Hanford 177 tanks if the option were to be applied to all relevant SSTs (68 tentatively identified)

- Estimated total volume of immobilized LAW (ILAW) for the Hanford 177 tanks if the option were to be applied to all relevant SSTs (68 tentatively identified) (this included both the WTP ILAW and the alternative waste forms produced by the option evaluated).

The meeting minutes and verbal presentations have been assembled in RPP-11305, *Three-Day Workshop to Evaluate Alternative Treatment Options for Hanford Site Tank Waste Meeting Minutes.*

Table 2-2 summarizes the potential impact on WTP LAW processing duration and on ILAW total volume.

The evaluators noted that the cost order of magnitude did not include the disposal cost for the immobilized waste, although it could be a significant driver, especially for higher LAW volume options. The evaluators also noted that the cost estimates were for the initial demonstration (5 gal/min basis, 1- to 2-year operation) rather than life-cycle costs for repeated deployments of the same equipment. Deployment for multiple tanks likely would result in lower costs on a per tank basis.

For option 3, steam reforming, three handouts from previous presentations were provided to the evaluators, and a verbal presentation was made by a representative of Studsvik, one of the vendors for this technology. The information provided covered most areas listed above for the other options, except for the following.

- No detailed mass balance was provided. The main process streams were qualitatively discussed, with limited quantitative data provided on some inlet process additives, off-gas streams, and waste products.

- No cost data were developed for a Hanford Site deployment of the technology that would be comparable to the other options.

- The impacts on WTP processing duration and on the total volume of ILAW were estimated by the evaluators based on the limited data provided by the vendor and by extrapolation of the calculations made for the other options.

Table 2-2. Potential Impact of Each Option on Waste Treatment Plant Low-Activity Waste Processing Duration and Immobilized Low-Activity Waste Total Volume. [Note 5]

Option		Treatment of 68 SSTs						Treatment of Other 81 SSTs + 28 DSTs	ORP Mission Impact		
Path	Option Name	WTP ILAW from Selective Dissolution (m^3) [Note 1]	WTP ILAW Unique to Path (m^3) [Note 2]	Secondary Waste Stream to the Waste Treatment Plant	Total Path WTP ILAW Volume	Percent of baseline WTP ILAW	Volume Alternative Solid LAW (m^3)	WTP ILAW (m^3)	Total ILAW + Alt. Solid LAW (m^3)	Percent of baseline WTP ILAW	Years to Process ILAW in WTP [Note 3]
	Baseline [Note 1]	0	9.65E+04	N/A	9.65E+04	100.0%	0	6.18E+04	1.58E+05	100.0%	38.4
1	Bulk vitrification	1.84E+04	0	No	1.84E+04	19.1%	5.56E+04	6.18E+04	1.36E+05	85.8%	19.5
2	Active metal reduction	1.84E+04	0	No	1.84E+04	19.1%	2.27E+05	6.18E+04	3.07E+05	193.9%	19.5
3	Steam reforming	Note 4	Note 4	No	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4	Note 4
4A	Clean salt no Cs IX	1.84E+04	5.96E+04	Yes	7.80E+04	80.8%	4.46E+04	6.18E+04	1.84E+05	116.5%	33.9
4B	Clean salt with Cs IX	1.84E+04	5.96E+04	Yes	7.80E+04	80.8%	4.46E+04	6.18E+04	1.84E+05	116.5%	33.9
5A	Clean salt and sulfate removal no Cs IX	1.84E+04	9.24E+03	Yes	2.76E+04	28.6%	5.53E+04	6.18E+04	1.45E+05	91.4%	21.7
5B	Clean salt and sulfate removal, with Cs IX	1.84E+04	9.24E+03	Yes	2.76E+04	28.6%	5.53E+04	6.18E+04	1.45E+05	91.4%	21.7
6	Containerized grout	1.84E+04	0	No	1.84E+04	19.1%	2.82E+05	6.18E+04	3.62E+05	228.9%	19.5
7	Sulfate removal	1.84E+04	3.98E+04	Yes	5.82E+04	60.3%	3.42E+04	6.18E+04	1.54E+05	97.5%	29.1

[1] Baseline is volume of WTP glass produced from processing all LAW in WTP. Does not include sodium added from process operations conducted in WTP.
[2] WTP ILAW calculated volume is based on the Gimple Rule and density of 2.65 g/cm^3.
[3] WTP ILAW net glass production rate is 30 metric tons of glass per day.
[4] Information on this option was given to the evaluators in a presentation by Brad Mason, Studsvik, AB, entitled "THOR Steam Reformer Technology for Hanford Tank Waste Support," to the Cleanup Constraints and Challenges Team Mission Acceleration Subgroup on May 22, 2002.. To the extent available, this information is contained in RPP-11305, 2002, *Three-Day Workshop to Evaluate Alternative Treatment Options for Hanford Site Tank Waste Meeting Minutes*, CH2M HILL Hanford Group, Richland, Washington.
[5] The information in this table represents summary information from RPP-11131, 2002, *Mission Acceleration Initiative Demonstration Information Package*, Rev. 0, CH2M HILL Hanford Group, Richland, Washington.

Cs IX = cesium ion exchange.
DST = double-shell tank.
ILAW = immobilized low-activity waste.
LAW = low-activity waste.
ORP = Office of River Protection.
SST = single-shell tank.
WTP = Waste Treatment Plant.

3.0 EVALUATION

3.1 EVALUATION PROCESS

The 12 evaluators agreed on the evaluation criteria listed and described in Table 3-1. The criteria were grouped into five areas: compliance and safety, project utility, operability, technical risk, and programmatic risk. The criteria were not weighted.

A number of general changes and clarifications were made in the course of evaluating the options, including the following (detailed option-specific changes and clarifications are described later in this section; detailed scores are provided in Table 3-2).

- Selective dissolution, solid–liquid separation, and cesium separation are developed technologies in common to nearly all of the options. Thus, although these technologies were discussed, they were treated as non-discriminators in the evaluation.

- The cesium separation technology was based on non-regenerable crystalline silicotitanate (CST). Although acceptable for the purposes of demonstrating treatment of a cesium-depleted waste stream, the potentially significant adverse impacts of CST on the quantity of HLW glass led to the conclusion that regenerable ion exchange resins could be used in place of CST to minimize these impacts.

- Technetium removal was added to several options to improve overall scoring relative to ease of waste incidental to reprocessing (WIR) determinations and obtaining regulator acceptance of the waste form. The evaluators agreed that adequate proven technology exists for this separation. DOE's ability to make WIR determinations pursuant to DOE O 435.1 is currently in litigation. Ecology expects the WIR process to continue to get great scrutiny by the State and the public. DOE remains accountable for obtaining WIR determinations.

- Although adaptability to skid mounting is a feature that often facilitates cost-effective demonstration of a technology, it was recognized that equipment that generates or has the potential to generate hazardous off-gas streams should be enclosed within a facility designed to accommodate the hazard. Thus, the scoring process considered the use of fixed facilities that enclose process equipment where appropriate. One evaluator pointed out that for most options, temperature control and shielding would require containment of the equipment in a facility but that constructing "skid-mounted" equipment offsite could still lead to some cost savings.

- Two of the project utility evaluation criteria were deleted from the scoring process because they were considered non-discriminators: "Percent of Waste Applicable To," and "Compatibility with RPP Integrated Flow Sheet." Other criteria were clarified before scoring the options. For example, all compliance and safety criteria were noted to imply that any deployment would be safe and compliant but that different options would be more or less challenging to implement in a safe and compliant manner.

Table 3-1. Evaluation Criteria.

Compliance and safety	Project utility	Operability	Technical Risk	Programmatic Risk
Operational Safety – What are the operational safety impacts of the flow sheet or key process, including ALARA considerations?	**Percent of Waste Applicable To** – What percentage of the 68 targeted SSTs is the flow sheet applicable to? Are the flow sheets or key processes potentially applicable to other tank wastes?	**Ease of Operations and Process Control** – Does the flow sheet or key process create difficult operational or operations control situations including liquid, gas, and solid effluent or waste handling?	**Flow sheet Operations Maturity** – Is the flow sheet or key process based upon mature technologies, equipment, and process control approaches?	**Pathway to Deployment** – Are there any elements in the pathway to full-scale deployment that present unusual challenges or risks that will require special attention or that may not be manageable?
Regulatory Permitting – Would the flow sheet or key process create unusually difficult regulatory permitting issues due to such factors as high temperatures, difficult off-gas treatment requirements, or other flow sheet specific issues?	**Relative Effect on Waste Volume Disposed of Onsite Including Secondary Wastes** – Will the flow sheet or key process significantly increase or decrease the volume of LAW and secondary waste disposed of onsite?	**Process Stability** – Are any flow sheet elements unstable? Can process control be maintained if any flow sheet process fails? Can the flow sheet accommodate likely variations in waste feed and ambient environment conditions?	**Susceptibility to Chemistry Risks** – Is the flow sheet or key process susceptible to failure due to low concentrations or buildup of chemicals that may be present in the waste feed?	**Vendor Reliance** – Is the successful deployment of the flow sheet overly reliant on a single vendor? If so, does the vendor have a long and stable business performance history?
Waste Incidental to Reprocessing-Related – How difficult will it be to meet the waste incidental to reprocessing requirements?	**Relative Impact on Mission Completion Date** – Can the flow sheet or key process reduce the time required for mission completion?	**Ease and Frequency of Maintenance** – Does the flow sheet or key process require frequent maintenance or will anticipated maintenance require unusually lengthy shutdowns?	**Deployment History in Other Venues** – Have key flow sheet processes and control approaches been successfully deployed on a commercial scale for other wastes or chemicals that are translatable to the tank wastes?	**Equipment and Parts Availability** – Is the flow sheet dependent on special order equipment or parts such that their availability for testing, initial operations, or continued deployment would create unusually high risks?
Land Disposal Restrictions – Is the waste form likely to meet land disposal restrictions?	***Compatibility with RPP Integrated* Flow Sheet and Operations** – Will the flow sheet or key process create any significant compatibility issues with the overall tank farm–WTP flow sheet? Is the flow sheet or key process compatible with potential technetium removal requirements?	**Number and Complexity of Unit Operations** – How many unit operations are there?	**Susceptibility to Scale-up Issues** – Is the flow sheet or key process likely to encounter significant scale-up issues that could impair performance at the 5 to 10 gal/min treatment rates anticipated?	**Relative Cost Impact** – Is the flow sheet or key process likely to create significant cost issues or benefits?
Waste Form Performance, Technetium – What is the relative effectiveness of immobilizing technetium?		**Relative Likelihood of Meeting RPP Treatment Needs** – What are the RPP treatment needs? How difficult will it be to pass an operational readiness review? What is the ease of mobility?		
***Waste Form Performance*, Nitrate** – What is the relative effectiveness of immobilizing nitrate?				

ALARA = as low as reasonably achievable. LAW = low -activity waste. RPP = River Protection Project. SST = single-shell tank. WTP = Waste Treatment Plant.

Table 3-2. Detailed Scores.

	1 Bulk Vit[1]	2 Active Metal Reductn [1,2]	3 Steam Reform[1],[2]	4A Clean salt ceramic grout, no cesium removal	4B Clean salt ceramic grout without cesium removal	5A Clean salt sulfate removal, no cesium removal	5B Clean salt sulfate removal with cesium removal	6 Grout[2]	7 Sulfate removal [3]
Compliance and Safety									
Op safety	2	2	2	2	3	2	3	4	4
Reg permit	2[4]	3[4]	2	3	3	3	3	3	4
WIR	2.5	2	3.5	4	4	4	4	3[5]	4
LDR	4	3[5]	3	2	2	2	2	1.5[6]	3
Tc	4	3	3	3	3	3	3	2	3
Nitrate	4	4	4[7]	1	1	1	1	1	4
Project Utility									
Percent waste app	4	4	4	4	4	4	4	4	4
Waste vol disp onsite	3	2	2	3	3	3	3	1	3
Date mission completion	3	3	3	2	2	4	4	4	3
RPP integrated flow sheet compatibility	3	3	3	3	3	3	3	3	3
Operability									
Ease ops and process cont	2	1[8]	25	2	3	1	2	4[9]	3.5
Process stability	3	2	3	2	2	2	2	4[9]	4
Ease maintenance	2	2	2	2	3	1	2	3	4
Number, complexity unit ops	2	1.5	2	2	2	1	1	4	4
RPP treatmt needs	1[10]	1[10]	1[10]	2	2	3	3	3	3
Technical Risk									
Maturity	4	1	3.5	2	2	2	2	4	4
Chem risk	3	2	2	2	2	2	2	4	4
Deployment history	3	1	3	1	1	1	1	4	3
Scale-up	4	3	4[11]	2	2	2	2	4	4
Programmatic Risk									
Path to deployment	2[12]	1[13]	2[11,14]	1	1	1	1	1	3
Vendor rely	2	3	3	3	3	3	3	4	4
Equip avail	3[15]	3	3	3	3	3	3	4	4
Cost impact	2	2	Not rated[16]	1	1	2	2	3	2[17]

[1]Skid-mounted systems are problematic. Scores assume location inside a facility.
[2]This option is not likely to work unless technetium removal occurs before treatment; ratings assume this removal.
[3]This is a WTP enhancement. It will be more cost-effective if applied to DSTs.
[4]Process unit must be housed in a facility, otherwise score drops to 1.
[5]Regulators preferred a lower score than other technical evaluators.
[6]Low because of nitrate issues.
[7]Likely to be required in monolithic form to perform well.
[8]Disagreement among evaluators on ease or difficulty – many evaluators preferred higher score.
[9]One of the easiest operationally.
[10]Based on mobility criterion only.
[11]Rated on basis of 5-10 gal/min, which requires a 4-ft-diameter reformer similar to that currently operated by Studsvik. Team had reservations about the 9-ft-diameter unit proposed for the WTP due to insufficient information.
[12]DOE administrative policy regarding alternatives to vitrification may exclude this option.
[13]May be promising technology in the long term, but schedule precludes consideration here.
[14]Voting assumed small-scale process unit.
[15]May be patent or royalty issues associated with this option.
[16]Appears to save approximately 19 operating years, but detailed demonstration cost data not were available to make a comparison.
[17]Score if only the 68 tanks are considered.

3.2 OPTION 1: BULK VITRIFICATION

This option was deemed not viable on a skid-mounted basis due to difficulties in ensuring adequate containment of off-gases even for a limited demonstration rate (5 gal/min basis). Although there is significant vendor experience with skid-mounted treatment of low dose rate wastes, regulator representatives stated that given the very high operating temperature (1,600 °C, which is higher than WTP melters), maximum achievable control technology (e.g., double containment, automatic feed cutoff) will be required, and permitting would only be possible inside a building. Therefore, this option was assumed to be inside a facility.

3.2.1 Compliance and Safety

The high temperature and possible off-gas system issues drove relatively low scores on operational safety and regulatory permitting despite the relatively low number of unit operations.

The ability to obtain a WIR determination was rated low because the amount of radionuclide separation achieved by this option is lower than that achieved by the WTP; except for cesium separation, the only radionuclide separation performed is by selective dissolution. This is a concern even though the targeted tanks have significantly lower radionuclide contents than DST waste.

The waste form (aluminosilicate glass) may perform better than the WTP ILAW glass (borosilicate) with regards to land disposal restrictions (LDRs) and leachability, especially for technetium, although no Hanford Site waste-specific data are available and a specific waste form qualification process will have to be initiated.

Additionally, this process destroys the nitrates, which eliminates a concern regarding disposal performance assessment of ability to meet drinking water standards.

3.2.2 Project Utility

Bulk vitrification potentially reduces the WTP LAW treatment duration by as much as any other option (including active metal reduction, steam reforming, and grout), does not send any waste streams back to the DST system and WTP, and should produce a slightly lower ILAW volume than the WTP because high sulfate waste can be accommodated. These factors resulted in high scores on project utility.

3.2.3 Operability

The concerns mentioned above on temperature and incompatibility with a mobile system resulted in some lower scores in operability. A minority of the reviewers did not agree with these concerns and emphasized the extensive operational experience available. Another concern noted was the use of consumable graphite electrodes in a strongly oxidizing environment (WTP uses Inconel[7]).

The option received a low score on adequacy of meeting RPP treatment needs based on its assumed inability to be skid-mounted while ensuring adequate off-gas containment.

3.2.4 Technical Risk

Based on the significant vendor experience available, no significant technical risk was identified.

3.2.5 Programmatic Risk

Since this option uses a vitrification process, evaluators expressed the concern that it may not be viewed as a true supplemental alternative to WTP. Additionally, some concerns were expressed regarding potential patent and royalty issues, which lead to a reduced score on equipment availability. Finally, the implementation cost was deemed significant despite the positive effect on WTP LAW processing duration. These resulted in relatively low scores in this area.

3.3 OPTION 2: ACTIVE METAL REDUCTION

This option was deemed not viable on a skid-mounted basis even for a limited processing rate (5 gal/min basis). The process temperature is moderately low (50 °C to 120 °C), but some off-gas compounds (H_2, H_2S, NH_3) include substances that are toxic or could be explosive if process parameters were to deviate significantly from normal. As a result, regulator representatives felt that permitting would be possible only inside a facility. Therefore, for the evaluation, this option was assumed to be inside a facility.

The option was not deemed viable without a technetium separation step upstream. As in bulk vitrification, the only technetium separation from the stream to be immobilized would be at the selective dissolution step. The leachability performance of the waste form (aluminosilicate crystalline form) is unknown but is not expected to be as good as that of glass. Therefore, this option was assumed to include technetium separation upstream.

3.3.1 Compliance and Safety

The safety concerns regarding toxic and potentially explosive off-gas compounds have been accommodated in highly radioactive environments in the past, as in the case of fuel aluminum cladding dissolution operations. However, they remain significant issues, as they will require narrow control of process parameters; therefore they lead to a relatively low score in operational safety.

[7] Inconel is a trademark of Inco Alloys International, Inc.

The *ability to obtain a WIR determination was rated low for the same reasons as bulk* vitrification with less performance expected from the waste form and even though this evaluation assumed a technetium removal step.

Ease of compliance with LDRs was a greater concern to the regulator representatives than to the rest of the evaluators, based on the uncertainties with the waste form performance. The majority scoring did not completely reflect these concerns. Based on the assumed technetium separation step and on the denitration performed by this process, this option rated relatively high on disposal performance assessment regarding technetium and nitrates.

3.3.2 Project Utility

Active metal reduction, like bulk vitrification, potentially reduces the WTP LAW treatment duration by as much as any other option, which resulted in a high score on mission duration impact.

The estimated waste form volumes provided to the evaluators were based on conservative assumptions and resulted in a significant increase in the total ILAW volume over the WTP-only calculation. An optimized process and waste form (aluminosilicate versus phosphate ceramic) should reduce this volume, but uncertainties are high enough that the score was relatively low on waste volume impact.

3.3.3 Operability

In general, the option scored very low on operability criteria due mainly to the generation of toxic substances (H_2S, NH_3) and potentially explosive off-gases (H_2, NH_3) and therefore the expected complexity of an off-gas system. Also of concern was the fact that H_2S, even though it could potentially be avoided by close control of the process parameters, could be a poison in catalyzed off-gas treatment reactions. Another concern was the risk of solids accumulation and plugging because the solids generated are essentially insoluble. However, a significant fraction of the evaluators did not agree with the importance given to these concerns.

The option received a low score on adequacy to meet RPP treatment needs based on its assumed inability to be skid-mounted.

3.3.4 Technical Risk

All evaluators agreed that this is the least mature option, which, when combined with the safety concerns mentioned above, resulted in low scores for most technical risk criteria. The exception to the low scores was for scale-up ability, which was viewed as not very difficult for a 5 gal/min based treatment.

3.3.5 Programmatic Risk

The path to deployment was scored very low mainly due to the immaturity of the technology. It was noted that the option appears to have promise although further development may expose challenging problems.

The implementation cost of an active metal reduction demonstration was deemed significant despite the potential reduction of WTP LAW processing duration.

3.4 OPTION 3: STEAM REFORMING

The evaluators noted that the evaluation of this option was based on a level of information inconsistent with the other options because of the limited data provided by the vendor's presentation.

This option was deemed not viable on a skid-mounted basis, even for a limited inventory (5 gal/min basis). The process temperature is relatively high (735 °C), and the fluidized bed contains a potentially explosive mixture should the steam inflow fail, which requires the vessels to be designed to resist an explosion even though the process is run under slight vacuum. As a result, regulator representatives felt that permitting would only be possible inside a facility. Therefore, this option was assumed to be inside a facility.

The option was deemed not viable without a technetium separation step upstream. As in bulk vitrification, the only technetium separation from the stream to be immobilized would be at the selective dissolution step, but unlike bulk vitrification, the leachability performance of the waste form (aluminosilicate crystalline form) is mostly unknown and is not expected to be as good as that of glass. Therefore, this option was assumed to include technetium separation upstream.

Since this option is being proposed by the WTP contractor as a potential addition to the WTP, it was assumed to be implemented downstream of WTP pretreatment. This technology has the potential to be applied elsewhere in the RPP.

3.4.1 Compliance and Safety

The safety concerns mentioned above with the relatively high temperature and potentially explosive mixture, combined with the fact that the facility will have to include oxygen and steam generation plants and that large quantities of carbon or other reducing agent need to be fed to the bed in order to react with the oxygen for heat generation, led to a relatively low score on operational safety and permitting.

The ability to obtain a WIR determination was rated high based on the assumption that this option would be implemented downstream from the WTP pretreatment.

Ease of compliance with LDR and disposal performance assessment for technetium and nitrate was deemed to be similar to that of the active metal reduction option. The vendor presentation claimed that products from treating Hanford Site waste simulants were successfully tested for compliance with LDR, but the information provided suggested that only a limited number of contaminants of concern were included in the simulant. The evaluators noted that the granular waste product from the steam reforming process might have to be incorporated in a monolithic waste form to comply with applicable policies.

3.4.2 Project Utility

Steam reforming, like active metal reduction, potentially reduces the WTP LAW treatment duration by as much as any other option, which resulted in a high score on mission duration impact.

The estimated waste form volumes are high due to the low density of the crystalline waste form. Therefore, the score was relatively low on waste volume impact.

3.4.3 Operability

In general, the option scored relatively low on operability criteria due to the complexity of the reaction phenomena involved and the need to control closely all feed rates and other process parameters in order to avoid problems such as excessive carbon residues and nozzle pluggage. Regulator representatives typically scored this attribute lower than the majority of evaluators.

The option received a low score on adequacy to meet RPP treatment needs based on its assumed inability to be skid-mounted and the fact that it would require significant support facilities for steam and oxygen generation and reactant handling.

3.4.4 Technical Risk

The maturity and deployment history were scored relatively high based on the Studsvik experience presented. Virtually no scale-up is needed for a 5 gal/min demonstration, but the evaluators expressed reservations for significantly larger scales (such as the 9-ft-diameter, 40-ft-high unit considered by the WTP project). Evaluators pointed out that the Studsvik commercial steam reforming experience with power plant ion exchange resin wastes is not directly relevant to the Hanford Site high sodium salt content waste, which can cause operational problems such as nozzle pluggage and bed agglomeration. On the other hand, steam reforming is somewhat similar to fluidized bed calcination (although operated under reducing conditions, thereby minimizing the production of NOx, which is an advantage), so it will benefit from the extensive worldwide HLW calcination experience, including experience at the Idaho National Engineering and Environmental Laboratory with high sodium wastes.

3.4.5 Programmatic Risk

The path to deployment was scored relatively low due to the uncertainties on waste form performance and WTP contractual issues. The evaluators noted that this score was based on a 5 gal/min demonstration but that the score would be even lower for a larger scale.

Vendor and equipment reliability were not viewed as significant issues, as several steam reforming vendors are available.

The cost impact was not evaluated due to lack of data comparable to the other options.

3.5 OPTIONS 4A AND 4B: CLEAN SALT

3.5.1 Compliance and Safety

The evaluators discussed the use of clean salt as the cesium separation step for dose rate reduction (option 4A), as opposed to including an ion exchange step upstream (option 4B). One evaluator felt that the implementation of clean salt without prior cesium removal, especially skid mounted, would be "anti-ALARA" and recommended the lowest rating possible for option 4A. Others felt that the loaded cesium ion exchangers from the cesium step also would be a significant source term. Based on this discussion, the majority scored option 4A lower than option 4B but not the lowest score possible.

Based on the fact that this evaporation-based process is not considered a high temperature process, these two options were scored relatively high on permitting.

The ability to obtain a WIR determination was rated very high due to the proven selectivity of the sodium nitrate crystallization, which ensures that nearly all of the radionuclides are immobilized in glass in the WTP processes (supplementing 60 tons per day ILAW glass production).

Ease of compliance with LDR was rated relatively low due to uncertainties regarding the ability of the waste form to effectively treat or immobilize constituents such as nitrates. Disposal performance assessment was rated relatively high since technetium is excluded from the sodium nitrate salt but very low for nitrate since nitrate leachability performance for grout waste forms is generally poor.

3.5.2 Project Utility

Clean salt slightly increases total LAW volume (as the separated sodium nitrate is assumed not to be delisted and, therefore, needs to be disposed of as a mixed waste) and only slightly reduces the WTP LAW treatment duration. Although clean salt removes the bulk of the salt inventory (sodium nitrate) from the stream to be vitrified, sulfates are not separated, and relatively small quantities of sulfates in this stream require the same level of dilution in glass as in the presence of high sodium quantities. These factors resulted in intermediate scores on mission duration and waste volume impact.

3.5.3 Operability

In general, these two options scored relatively low on operability criteria due to the complexity of the process for a skid-mounted operation and the difficulty of operating at the very low temperatures required for crystallization. Option 4A, which will be operated at higher dose rates, was scored lower than option 4B.

The two options received relatively low scores on likelihood of meeting RPP needs due to the difficulty in skid-mounting these options and to the relative complexity of the process.

3.5.4 Technical Risk

Although this technology is commonly used in commercial applications, and on the relative complexity of the process (acidification, evaporation, cooling, washing), evaluators scored these two options relatively low on technical risk criteria based on the limited experience with Hanford Site waste (only laboratory tests).

3.5.5 Programmatic Risk

The path to deployment was scored very low due to the predicted waste form qualification issues.

Vendor reliance and equipment availability were not found to be issues, but the cost impact was deemed very unfavorable due to high deployment costs for very little acceleration benefit.

3.6 OPTIONS 5A AND 5B: CLEAN SALT WITH SULFATE REMOVAL

3.6.1 Compliance and Safety

The dose rate concerns for the option without cesium ion exchange (option 5A) are identical to those for option 4A, resulting in the same low operational safety score. Additionally, the organic waste form used to immobilize the sodium nitrate could be a safety concern.

The same issues on permitting and WIR determination were identified for these options as for options 4A and 4B.

Ease of compliance with LDRs was rated relatively low due to uncertainties regarding the waste form performance; polyethylene is not expected to perform better than ceramic grout and is known to swell over time when used to immobilize hygroscopic salts. As for options 4A and 4B, disposal performance assessment was rated relatively high since technetium is separated but very low for nitrate due to expected poor nitrate leachability results.

3.6.2 Project Utility

Clean salt with sulfate separation results in a small decrease in total LAW volume (as the separated sodium nitrate is assumed not to be delisted and, therefore, needs to be disposed of as a mixed waste) resulting in an intermediate score on waste volume impact. These options reduce significantly the WTP LAW treatment duration, which resulted in a very high score on mission duration.

3.6.3 Operability

In general, options 5A and 5B scored as low or lower than options 4A and 4B on operability criteria. The issues as for options 4A and 4B apply, with the additional concern of a heat-processed waste form (polyethylene) and of an even higher process complexity (more unit operations).

The two options received relatively low scores on likelihood of meeting RPP needs because of the difficulty in skid-mount these options and the relative complexity of the process.

3.6.4 Technical Risk

The same technical risk issues as for options 4A and 4B apply to these two options.

3.6.5 Programmatic Risk

The same considerations and scores for options 4A and 4B apply to these two options except for the cost impact, which was scored higher for these two options due to their significantly higher acceleration benefit despite high implementation costs.

3.7 OPTION 6: CONTAINERIZED GROUT

The option was not deemed viable without a technetium separation step upstream due to the expected high leachability of technetium from grout. As in bulk vitrification, the only technetium separation from the stream to be immobilized would occur during selective dissolution, but in this case, the leachability performance of the waste form is expected to be low. Therefore, this option was changed to include technetium separation downstream of selective dissolution.

3.7.1 Compliance and Safety

No significant issue was identified regarding operational safety and permitting of this low temperature process with relatively few unit operations.

The ability to obtain a WIR determination received a relatively high score due to the separation of cesium and technetium. The regulator representatives rated this option slightly lower than other evaluators due to the expected continued stakeholders concerns with grout. These concerns include poor durability, high leachability, and increase in waste volume compared to vitrified waste.

Ease of compliance with LDRs was rated very low due to uncertainties regarding the waste form performance, especially in meeting State-only toxicity criteria. Disposal performance assessment was rated slightly higher since technetium is separated but very low for nitrate since nitrate leachability performance for grout waste forms is generally poor.

3.7.2 Project Utility

Containerized grout, like bulk vitrification, potentially reduces the WTP LAW treatment duration by as much as any other option, which resulted in a very high score on mission duration impact.

The estimated waste form volumes are very high, which resulted in the lowest score possible in waste volume impact.

3.7.3 Operability

Containerized grout received high scores on all operability criteria because it is a low temperature, well known-process, with a small number of unit operations.

3.7.4 Technical Risk

Technical risk scores were also high for the same reasons as in operability and because extensive experience with LLW grouting exists worldwide.

3.7.5 Programmatic Risk

The path to deployment was scored very low due to stakeholder concerns and waste form performance uncertainties.

This well-proven technology received high scores on all other programmatic risk criteria with one caveat on cost impact; the evaluation did not take into consideration the immobilized waste disposal cost, which could be more significant for this options than for others due to the high waste volume.

3.8 OPTION 7: SULFATE REMOVAL

3.8.1 Compliance and Safety

No significant issue was identified regarding operational safety, permitting, and WIR determination for this low temperature, simple process.

Ease of compliance with LDR was rated relatively high, as were performance assessments for technetium and nitrates (not precipitated with sulfate to be grouted).

3.8.2 Project Utility

Sulfate separation slightly reduces the total ILAW volume and reduces significantly the mission duration, which resulted in relatively high ratings on waste volume and mission duration impacts.

3.8.3 Operability

This simple process scored high on all operability criteria. No issue was identified; the sulfate precipitate is not expected to be gelatinous or difficult to handle as it is formed under acidic conditions.

3.8.4 Technical Risk

High to very high scores were given for technical risk criteria. This process is very similar to the strontium recovery operations conducted in the past at B Plant where strontium sulfate precipitation was performed under acidic conditions. The added tank waste volume caused by the need to reneutralize the acidified sulfate-depleted solution prior to storage in the DST system is estimated to be 30 percent of the initial waste volume.

3.8.5 Programmatic Risk

This option rated high to very high on programmatic criteria, except for cost impact, since the acceleration benefit is limited and the implementation cost is significant (although among the lowest). A much higher acceleration benefit could be obtained if the option were applied not only to SST salt waste but also to high sulfate DSTs. Overall, this option is viewed as best suited within the WTP flow sheet where the sulfate-depleted acidified waste stream could be sent to the melter without neutralizing the waste.

This page intentionally left blank.

4.0 CONCLUSIONS AND RECOMMENDATION

Based on the evaluation of the nine separate flow sheets, four are recommended for additional study based on consideration of the scores shown in Table 3-2. Ranking of the options was done by totaling the raw scores. The four options according to rank (highest to lowest) that are recommended for further study are the following:

- Sulfate removal (sulfate separation)
- Containerized grout
- Bulk vitrification
- Steam reforming.

The objective of the evaluators was to assess potential technology options to determine those that warranted further investigation. Further study will be aligned with the needs of each specific option. Both radioactive and non-radioactive tests will be designed for the processes and equipment as required.

These selected options represent a range of trade-offs between process difficulty and performance, ease of achieving regulatory compliance, and benefit to the RPP in accelerating the mission. For example, the sulfate removal option is considered a comparatively simple process with less complicated regulatory issues, but the acceleration benefit of removing and disposing of sulfate alone is less than the benefit provided by other options with more challenges that do not send any fraction of the treated stream to the WTP.

The grout option also is comparatively simple but has the most difficult regulatory issues, particularly disposal issues for nitrates and technetium. Primary advantages of this option are its ability to accelerate the mission by disposing of a LAW fraction including the bulk salts and the comparatively simple and well-proven status of the technology. However, the disposal cost for the large immobilized waste volume generated is likely to offset some of these benefits.

Steam reforming represents a different set of tradeoffs. The process is more complex than the other options and has more complex off-gas permitting issues since it is considered a thermal treatment process. Two key advantages are that the steam reforming process denitrates the waste and accommodates high sulfate waste. Technetium removal requirements may be less stringent with this waste form than for grout. Some of the evaluators were uncomfortable with the lack of data regarding steam reforming.

Bulk vitrification represents yet a different mix of trade-offs. It is a relatively mature process that will denitrate the waste, will provide a comparatively robust waste form, and is capable of accelerating the mission by treating bulk LAW waste salts and sulfate. However, as within the WTP, the off-gas treatment will be technically challenging and will have complex permitting issues.

This recommendation is made recognizing open issues associated with waste acceptance criteria and disposal cost.

Additionally, active metal reduction is recommended for further evaluation by DOE Office of Science and Technology because it is a low temperature process that destroys nitrates and would likely produce a waste form that is superior to grout.

All options involving clean salt are recommended for removal from further consideration as they involve significant deployment challenges for very little acceleration benefit.

Nuclear safety and regulatory requirements may require most or all processing equipment to be placed inside suitable facilities.

Regulator participation in the workshops and in the development of this report was useful and appreciated. However, the participation is not construed as an endorsement by Ecology of any supplemental waste treatment options other than vitrification as identified in the Tri-Party Agreement, TPA M-62-00, for the treatment of the tank waste.

5.0 REFERENCES

DOE M 435.1-1, 2001, *Radioactive Waste Management Manual*, Change 1, U.S. Department of Energy, Washington, D.C.

DOE O 435.1, 2001, *Radioactive Waste Management*, Change 1, U.S. Department of Energy, Washington, D.C.

DOE/EIS-0189, 1996, *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement*, Washington State Department of Ecology, Olympia, Washington, and U.S. Department of Energy, Washington, D.C.

RCRA, *Resource Conservation and Recovery Act of 1976,* Pub. L. 94-580, 90 Stat. 2795, 42 USC 6901 et seq.

RPP-11131, 2002, *Mission Acceleration Initiative Demonstration Information Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-11305, 2002, *Three-Day Workshop to Evaluate Alternative Treatment Options for Hanford Site Tank Waste Meeting Minutes*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Tri-Party Agreement, 1989, *Hanford Federal Facility Agreement and Consent Order*, Washington State Department of Ecology, Olympia, Washington; U.S. Environmental Protection Agency, Washington, D.C.; and U.S. Department of Energy, Washington, D.C.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

This page intentionally left blank.

APPENDIX A

PROCESS USED TO IDENTIFY TREATMENT OPTIONS EVALUATED AT THE WORKSHOP

This page intentionally left blank.

APPENDIX A

PROCESS USED TO IDENTIFY TREATMENT OPTIONS EVALUATED AT THE WORKSHOP

Technologies for treating the Hanford Site tank wastes, including the salt fraction, have been researched and evaluated for a number of years. A systematic review of all possible technologies was conducted in the early 1990's and resulted in the issuance of DOE/EIS-0189, *Tank Waste Remediation System Hanford Site, Richland, Washington, Final Environmental Impact Statement*, and subsequent Record of Decision (62 FR 8693). These studies were reviewed in January and February of 2002, and vendors, national laboratories, and universities were consulted for additional technologies, as time allowed, in order to establish a list of all possible technologies for treating the low-activity waste.

During the month of March 2002, the technologies were grouped into families that employed the same basic principles but differed only in their implementation (e.g., all calcination technologies were grouped together, all polymer-based microencapsulations were grouped together). Single-shell tank 241-S-112 was selected as a good representative for the targeted low-activity waste source single-shell tanks. Technology experts were asked to prepare short briefings on their technologies and how they could be applied to tank 241-S-112-type waste with the objective of a tank-scale demonstration with real waste between 2005 and 2006. Additionally, separation technologies were combined with immobilization technologies to constitute complete treatment options.

This relatively high-level information was presented to a group of 35 technical and programmatic experts from the DOE complex during a two-day workshop on April 2 and 3, 2002. The group discussed the feasibility of the proposed treatment options and added a few options, leading to a total of 25 options to be considered. They used the nominal group rating technique to screen out treatment options or technologies that were unlikely to provide adequate treatment or to be deployable in the desired time frame.

The results of the April 2 and 3 workshop are documented as an appendix in RPP-11131, *Mission Acceleration Initiative Demonstration Information Package*. They were reviewed by Office of River Protection representatives, who selected six treatment options for a more detailed evaluation, with the purpose of submitting these for evaluation by the Cleanup Constraints and Challenges Mission Acceleration Initiative Subgroup by the end of May 2002. The options selected were either those with the highest scores in the workshop or options built around technologies that had received the highest scores when scores from all options, including the particular technology, were added. Two technologies were included in selected options despite relatively low scores: active metal reduction and micro-encapsulation with polymers because there was a concern that they may have been scored low because most workshop participants were very unfamiliar with them.

During April and early May 2002, mass balances and other technical and programmatic data were developed for the six selected treatment options and two variants. A seventh option — sulfate separation by strontium precipitation in acidic conditions —was added during that period. Sulfate separation had not been considered during the previous months, mainly because a relevant production reference had not been identified.

REFERENCES

RPP-11131, 2002, *Mission Acceleration Initiative Demonstration Information Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

DISTRIBUTION

Author	Addressee	
A. F. Choho, 372-8280	See list below	Date:

Subject: RPP-11306, EVALUATION OF LOW-ACTIVITY WASTE FEED SUPPLEMENTAL TREATMENT OPTIONS BY THE C3T MISSION ACCELERATION INITIATIVE TEAM FOR THE OFFICE OF RIVER PROTECTION

DISTRIBUTION

Approval	Date	Name	Location	w/att
		<u>CH2M HILL Hanford Group, Inc.</u>		
		J. W. Badden	H6-22	
		R. V. Bang	H6-16	
		K. D. Boomer	L4-07	
		K. A. Gasper	L4-07	
		M. E. Johnson	L4-07	
		R. E. Raymond	H6-22	
		G. W. Reddick	L4-07	
		R. D. Williamson	H6-22	
		R. A. Dodd	H6-22	
		R. W. Powell	H6-64	
		<u>Numatec Hanford Corporation</u>		
		A. F. Choho	H6-64	
		J. S. Garfield	L4-07	
		<u>Pacific Northwest National Laboratory</u>		
		J. W. Brothers	K7-15	
		R. A. Brouns	K9-64	
		T. M. Brouns	K9-69	
		J. L. Bryant	K7-94	
		B. A. Carteret	K9-91	
		P. A. Gauglitz	K6-28	
		M. E. Lerchen	H6-61	
		U.S. Department of Energy *<u>Office of River Protection</u>*		
		B. M. Mauss	H6-60	
		S. A. Wiegman	H6-60	
		U.S. Department of Energy <u>Richland Operations Office</u>		
		T. P. Pietrok	K8-50	
		<u>YAHSGS LLC</u>		
		W. Hewitt	H6-60	
		Central Files	B1-07	