~~XXXX~~ RMIS View/Print Document Cover Sheet ~~XXXX~~

This document was retrieved from the Boeing ISEARCH System.

Accession #: D196054903

Document #: SD-WM-TA-162

Title/Desc:

DST RETRIEVAL ALLOWABLE HEEL TRADE ANALYSIS

2. To: (Receiving Organization) Retrieval Program		3. From: (Originating Organization) Retrieval Engineering 73530		4. Related EDT No.: NA	
5. Proj./Prog./Dept./Div.: Tank Waste Remediation System		6. Cog. Engr.: W. H. Grams 73530/D2ADE		7. Purchase Order No.: NA	
8. Originator Remarks: Approval and Release				9. Equip./Component No.: NA	
				10. System/Bldg./Facility: NA	
11. Receiver Remarks:				12. Major Assm. Dwg. No.: NA	
				13. Permit/Permit Application No.: NA	
				14. Required Response Date: 9/22/95	

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	WHC-SD-WM-TA-162	N/A	0	Double-Shell Tank Retrieval Allowable Heel Trade Analysis	N/A	1	1	

16. KEY					
Approval Designator (F)		Reason for Transmittal (G)		Disposition (H) & (I)	
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)		1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)		1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged	

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)									
(G)	(H)	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN
1	1	Cog. Eng. W. H. Grams	<i>[Signature]</i>	9/21/95	H5-61	L. A. Fort	<i>[Signature]</i>	9/22/95	H5-36
1	1	Cog. Mgr. D. E. Ball	<i>[Signature]</i>	9/21/95	H5-61	D. L. Lamberd	<i>[Signature]</i>	9/21/95	H5-61

18. W. H. Grams <i>[Signature]</i> 9/21/95 Signature of EDT Originator Date	19. G. A. Meyer <i>[Signature]</i> 9/21/95 Authorized Representative for Receiving Organization Date	20. D. E. Ball <i>[Signature]</i> Cognizant Manager Date	21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
--	---	---	---

THIS PAGE INTENTIONALLY
LEFT BLANK

RELEASE AUTHORIZATION

Document Number: WHC-SD-WM-TA-162, Rev. 0

Document Title: Double-Shell Tank Retrieval Allowable Heel Trade Analysis

Release Date: September 26, 1995

**This document was reviewed following the
procedures described in WHC-CM-3-4 and is:**

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

T.L. Ontiveros

September 26, 1995

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy. Available in paper copy. Printed in the United States of America. To obtain copies of this report, contact:

Westinghouse Hanford Company - Document Control Services
P.O. Box 1970, Mailstop H6-08, Richland, WA 99352
Telephone: (509) 372-2420; Fax: (509) 376-4989

THIS PAGE INTENTIONALLY
LEFT BLANK

SUPPORTING DOCUMENT

1. Total Pages 70

2. Title

Double-Shell Tank Retrieval Allowable Heel Trade Analysis

3. Number

WHC-SD-WM-TA-162

4. Rev No.

0

5. Key Words

DST retrieval
allowable heel
tank reuse

6. Author

Name: W. H. Grams

W H Grams

Signature

Organization/Charge Code 73530/D2ADE

7. Abstract

This *Double-Shell Tank Retrieval Allowable Heel Trade Analysis* evaluates the effects a remaining heel has on subsequent waste storage requirements after initial retrieval. The information contained in this analysis will be used as a basis to identify crucial double-shell tank (DST) retrieval system design and performance requirements for continued storage of waste in DSTs. The information presented in this analysis is summarized by the DST initial retrieval and reuse strategy. The strategy is based on the waste compatibility and consolidation requirements that are governed by the remaining heel after initial retrieval.

8. RELEASE STAMP

OFFICIAL RELEASE	
BY WHC	
DATE	9/27/95
Sta. 37	35

THIS PAGE INTENTIONALLY
LEFT BLANK

**DOUBLE-SHELL TANK RETRIEVAL
ALLOWABLE HEEL
TRADE ANALYSIS**

September 1995

W. H. Grams

Westinghouse Hanford Company
Richland, Washington

This page intentionally left blank.

CONTENTS

1.0 INTRODUCTION	1
1.1 PURPOSE	1
1.2 SCOPE	1
1.3 DEFINITIONS	2
1.4 EXECUTIVE SUMMARY	4
2.0 TRADE ANALYSIS OF THE THREE STUDY CASES	7
2.1 CASE 1--NO HEEL ALLOWED	7
2.1.1 Retrieval Systems	8
2.1.2 Retrieval Operations Considerations	8
2.1.3 Characterization	8
2.1.4 Instrumentation	9
2.1.5 Summary	9
2.2 CASE 2--HARD HEEL ALLOWED	9
2.2.1 Retrieval Systems	9
2.2.2 Retrieval Operations Considerations	10
2.2.3 Characterization	10
2.2.4 Instrumentation	10
2.2.5 Summary	11
2.3 CASE 3--RESIDUAL SLUDGE ALLOWED	11
2.3.1 Retrieval Systems	11
2.3.2 Retrieval Operations Considerations	11
2.3.3 Summary	12
3.0 THE EFFECTS OF A REMAINING DOUBLE-SHELL TANK	
HEEL AFTER INITIAL RETRIEVAL	13
3.1 TANK SPACE	13
3.2 WASTE COMPATIBILITY	15
3.3 INCIDENTAL BLENDING	17
3.3.1 Segregation of PUREX and Plutonium Finishing Plant	
Transuranic Containing Solids	21
3.3.2 Segregation of Complexed Waste	21
3.3.3 Segregation of Supernate (Low-Level Waste)	21
3.3.4 Minimizing Concentration of Glass Degrading Material	22
3.4 EFFECT OF A HEEL ON DOUBLE-SHELL TANK RETRIEVAL	
SEQUENCE	22
3.4.1 Complexed Waste (CC and DC)	22
3.4.2 Transuranic Waste (DN/PD and DN/PT)	25
3.4.3 Concentrated Phosphate Waste	25
3.4.4 Aging Waste (NCAW)	25
3.4.5 Non-complexed Waste (DSS, DSSF, and DN)	25
3.5 EFFECTS OF A HEEL ON DOUBLE-SHELL TANK REUSE	26

3.5.1 Double-Shell Tank Reuse Supporting Double-Shell Tank/Single-Shell Tank Retrieval	26
3.5.2 Double-Shell Tank Reuse Supporting Low-Level Waste Immobilization	29
3.6 SUMMARY OF THE EFFECTS OF A REMAINING DOUBLE-SHELL TANK HEEL AFTER INITIAL RETRIEVAL	29
3.6.1 Tank Space	29
3.6.2 Waste Compatibility	29
3.6.3 Incidental Blending	30
3.6.4 Retrieval Sequence	31
3.6.5 Double-Shell Tank Reuse	31
4.0 CONCLUSIONS AND RECOMMENDATIONS	33
4.1 CONCLUSIONS	33
4.2 RECOMMENDATIONS	33
4.2.1 Double-Shell Tank Initial Retrieval and Reuse Strategy Based on Allowable Heel	33
4.2.2 Additional Studies and Analysis	36
5.0 REFERENCES	39

APPENDIX

A - HANFORD SITE DOUBLE-SHELL TANK WASTE CONTENTS	A-1
---	-----

LIST OF TABLES

1. Sludge Shear Strength Related to Effective Cleaning Radius and Percent Mobilized Using Two Mixer Pumps	14
2. Hanford Site Double-Shell Tank Estimated Heel Using Two Mixer Pumps.	16
3. Compatibility Matrix For Tank Wastes From Past Practice Waste Transfer Operations	17
4. Double-Shell Tank Retrieval Blending Considerations	19
5. Hanford Site Double-Shell Tank Waste Summary by Waste Type.	23
6. Double-Shell Tank Reuse Limitations: Retrieval Using Two Mixer Pumps	28
7. Key Milestones and Projects Effecting Double-Shell Tank Retrieval.	34

LIST OF TERMS

CC	Complexed concentrate
CP	Concentrated phosphate
DC	Dilute concentrate
DN	Dilute noncomplexed
DN/PD	Dilute Non-Complexed Waste Containing PUREX TRU Solids.
DN/PT	Dilute Non-Complexed Waste Containing PFP TRU Solids
DOE	U.S. Department of Energy
DSS	Double-shell slurry
DSSF	Double-shell slurry feed
DST	Double-shell tank
ECR	Effective cleaning radius
EDTA	ethylenediaminetetraacetic acid
EPA	Environmental Protection Agency
HEDTA	hydroxyethylethylenediaminetriacetic acid
HLW	High-level waste
LLW	Low-level waste
NCAW	Neutralized current acid waste
NCRW	Neutralized cladding removal waste
PFP	Plutonium Finishing Plant
PUREX	Plutonium-uranium extraction
SST	Single-shell tank
TRU	Transuranic
USQ	Unreviewed Safety Question
WHC	Westinghouse Hanford Company
WIPP	Waste Isolation Pilot Plant

This page intentionally left blank.

DOUBLE-SHELL TANK RETRIEVAL ALLOWABLE HEEL TRADE ANALYSIS

1.0 INTRODUCTION

1.1 PURPOSE

This *Double-Shell Tank Retrieval Allowable Heel Trade Analysis* evaluates the effects a remaining heel has on subsequent waste storage requirements after initial retrieval. The information contained in this analysis will be used as a basis to identify crucial double-shell tank (DST) retrieval system design and performance requirements for continued storage of waste in DSTs. The information presented in this analysis is summarized by the DST initial retrieval and reuse strategy found in Section 4.0. The strategy is based on the waste compatibility and consolidation requirements that are governed by the remaining heel after initial retrieval.

1.2 SCOPE

This trade analysis was limited to the assessment of DST retrieval preparatory to reuse of the tank for future DST storage missions. Specifically, this analysis focused upon mobilization and transfer of sludges and removal of a hard heel. No technical issues have been identified that involve retrieval and transfer of supernates. DST retrieval to meet terminal cleanout before final closure is not addressed. There were three study cases used for this analysis:

1. No heel allowed
2. A hard heel allowed
3. Residual sludge allowed.

The third case analysis included a determination of sludge quantities and residual liquid that could remain.

To define and focus the trade analysis, the following constraints and assumptions were developed:

- All waste storage activities will meet compatibility and safety requirements. (Constraint)
- Initial retrieval systems do not need to be able to meet the cleanout requirements for final closure. (Final closure requirements have not been established). (Constraint)

- Mixer pumps are the primary method for sludge mobilization and maintaining slurry uniformity. Past practice sluicing will be used in conjunction with mixer pumps for sludges that are difficult to mobilize. For this analysis, mobilization of waste will be accomplished by installation of two mixer pumps. (Constraint)
- Mixer pumps will not remove a hard heel and some sludge in all cases. (Assumption)
- Tank waste inventories will be calculated using the information in *Tank Farm Surveillance and Waste Status Summary Report for October 1994* (Hanlon 1994). (Constraint)
- Relative risk values (probability/consequence) for environmental protection and safety concerns will be approximately equal for all study cases when averaged over the overall time frame for DST/single-shell tank (SST) retrieval and disposal. (Assumption)
- All DSTs will be reused to store waste. (Assumption)
- All tank waste will be considered mixed waste. Segregation will not be required because of mixed waste issues. (Assumption)
- Key *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) milestones affecting this analysis are: M-45-03A, M-45-03-T02, M-45-03-T01, M-45-05-T01, M-45-05-T02, M-50-02, M-60-05, M-45-05-T03, M-45-05-T04, M-45-05-T05, M-50-04, and M-50-03. (See Table A-1, Appendix A.)

1.3 DEFINITIONS

Complexant--A chemical species that is able to bond to another chemical species and thus reduce the availability of that species for further chemical reaction. A chelate is a special case of complexed chemical species; chelating agent is one kind of complexant. Organic compounds that form coordination complexes with insoluble metal ions solubilizing the metal ion.

Complexed Waste--Dilute waste material containing relatively high concentrations of chelating agents, such as ethylenediaminetetraacetic acid (EDTA), hydroxyethylethylenediaminetriacetic acid (HEDTA), etc., from B Plant waste fractionization operation. Characterized by a high content of organic carbon including organic complexants. The main sources of this waste in the DST system are saltwell liquid inventory from SSTs. (Also called dilute complexed [DC] waste).

Heel--A heel is defined as the residue remaining in a tank after its contents have been retrieved to the maximum extent practicable and before the tank is either refilled or cleaned of hazardous material before final closure and landfill disposal. A heel can consist of solid waste, free liquids, and sludges.

Hard Heel--A hard heel is defined as solid material that has consolidated and is cemented or bonded to the tank such that removal can only be accomplished by direct high pressure water jets or mechanical removal (scraping).

High-Level Waste--The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic (TRU) waste and fission products in concentrations requiring permanent isolation (DOE Order 5820.2A).

Low-Level Waste--Any gaseous, liquid, or solid waste that contains radioactivity and is not classified as high-level waste (HLW), TRU waste, or spent nuclear fuel or 11e(2) byproduct material as defined by DOE 5820.2A. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste (LLW), provided the concentration of transuranic is less than 100 nCi/g. For this analysis, the LLW is a component of the supernatant of the non-complexed waste tanks.

Sludge--At the Hanford Site, the term sludge is applied to those solids that settle and accumulate at the bottom of a storage tank; solids formed by precipitation or self-concentration, primarily insoluble metal hydroxides and oxides precipitated from neutralized waste. Sludge usually was in the form of suspended solids when the waste was originally received in the tank from the waste generator. The sludges are considered to be HLW.

Supernatants/Supernate--The liquid layer that is above the solids in the waste storage tanks. Drainable liquid remaining minus drainable interstitial. Supernate is usually derived by subtracting the solids level measurement from the liquid level measurement. In some cases, the supernatant volume includes floating solid crusts because their volume cannot be measured. (Also known as supernates.) The supernatants contain the LLW fraction that will be separated during LLW processing.

Transuranic (TRU)--Period 7 elements having an atomic number of 93 or greater (elements that are heavier than uranium in the periodic table).

Transuranic (TRU) Waste--Without regard to source or form, waste that is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay. For this analysis, TRU Waste is limited to waste that has the potential for certification for deep geologic disposal at the Waste Isolation Pilot Plant (WIPP), in Carlsbad, New Mexico.

Watch List Tanks--Tanks that have been designated as having an unreviewed safety question (USQ) surrounding it or other major safety concern. The safety issue can be related to several different items, i.e., hydrogen gas, ferrocyanide, organics, and high heat.

1.4 EXECUTIVE SUMMARY

The *Double-Shell Tank Retrieval Allowable Heel Trade Analysis* evaluates the effects a remaining heel has on subsequent waste storage requirements after initial retrieval. The information contained in this analysis will be used as a basis for the identification of DST retrieval system design and performance requirements.

This document addresses the three study cases for initial retrieval either leaving no heel, a hard heel, or residual sludge. The amount of heel was estimated for a base case using two 300 hp mixer pumps for sludge mobilization. The analysis identified that there is a distinct advantage for leaving residual sludge whenever possible. Initial retrieval allowing residual sludge results in retrieval activities that require less equipment, a lesser degree of characterization, and a less complicated operations. For those DSTs containing a sludge, it will be difficult to ensure that a high degree of cleanout is possible for the initial retrieval campaign. For this reason, retrieval plans should be based upon some residual sludge remaining.

Any limitations on tank reuse are dependent upon two elements: the compatibility of the waste added onto the heel and the need to ensure that tank operational and safety specifications have been met. As long as waste is compatible and the tank requirements and specifications are within the operational limits, there is no limit on the size of the remaining heel.

The heel, remaining after initial retrieval, affects the future storage mission of the DSTs. Available tank space, waste compatibility, incidental blending, retrieval sequence and tank reuse were considered when addressing what constitutes the effects of an allowable heel. From this analysis, two waste types will limit or restrict tank reuse, complexed waste, and sludge containing large quantities of TRU.

A complexed heel has the potential to bring the insoluble TRU materials into solution. This would complicate the LLW immobilization processes. For this reason, the amounts of a complexed heel must be very small, such that the soluble TRU content will not adversely affect the downstream processes. To avoid problems, it is recommended that complexed waste remain segregated. This involves segregation of tanks SY-101, SY-103, AN-102, AN-107, and AY-101.

Complete segregation is not necessarily required for those DSTs containing large amounts of TRU, namely AW-103, AW-105, and SY-102. Tanks AW-103 and AW-105 could be used to store supernates for LLW feed, sludge for HLW feed, and other TRU solids

and sludges. The TRU is essentially insoluble and as long as suitable settling time is allowed before transfers, this material should not appreciably contaminate the supernates. The remaining DST containing TRU (SY-102) will require a more stringent limit on a remaining heel. This tank is geographically situated such that it is the only useful DST for staging West Area SST waste for cross-site transfer to the East Area DSTs and processing facilities. Some, but not all, of the SST waste would be incompatible, either due to complexants or limitations on incidental blending of TRU, requiring initial retrieval to leave little or no heel.

Storage of treated LLW scheduled for vitrification adds stringent requirements for the allowable heel. The radionuclide content of vitrified LLW has strict limitations on the amount of certain radionuclides including TRU, Sr_{90} , and Cs_{137} . If the treated LLW were close to the low end of the allowable radionuclide content specification, e.g. containing the maximum allowable, then any incidental blending of this waste with the heel material would take the feed material out of specification. For this reason, any DST containing a heel could not be used to store treated LLW.

In summary, the amount of heel is not limited for waste that is compatible as long as tank safety and operations specifications are met. Tanks currently holding complexed waste cannot be used for future DST storage missions unless they have been completely retrieved leaving no heel. The tanks having a TRU containing heel can be reused with some restrictions with the exception of SY-102 which must be retrieved leaving little or no heel. Finally, any tank which contains a heel cannot be used to store treated LLW. These and other recommendations, based upon the analysis of the heel remaining in a DST after initial retrieval, are summarized in an initial retrieval strategy and a reuse strategy, Section 4.0.

This page intentionally left blank.

2.0 TRADE ANALYSIS OF THE THREE STUDY CASES

Selection of equipment, processes, and procedures for the initial retrieval of the DSTs is dependent upon the operations strategy. The three study cases bracket how large and what type of heel can remain:

- Case 1: No heel allowed (initial retrieval removes essentially all waste)
- Case 2: A hard heel allowed (initial retrieval removes all but solids that are cemented (fixed) to the bottom of the tank)
- Case 3: Residual sludge allowed (initial retrieval removes liquids and as much of the sludges as practical).

To enable a comparison, the following four areas were evaluated for each study case:

1. Retrieval system needed to mobilize the waste
2. Operations considerations for retrieval operations
3. Characterization requirements to support design and operation
4. Instrumentation needs to monitor retrieval.

Cost was not considered directly. Costs will be relative to the general complexity or level of effort described under the four areas of comparison.

A risk evaluation was not conducted. Risks associated with safety and environmental protection are not easily evaluated without detailed requirements, which have not been established. Risks associated with cost and schedule will be again proportional to the complexity or level of effort to achieve the desired cleanout. Until the detailed requirements have been established, a risk assessment would not provide better definition of the three study cases than a comparison of the relative costs and effects on schedule and budget.

2.1 CASE 1--NO HEEL ALLOWED

DST retrieval to the level where no heel is left is the most stringent case. For this study, the residual would contain no sludge and solids would be removed down to a point where only a thin film or coating directly bonded to the tank is left. This cleaning would remove essentially all sludge/solids, with no restriction on future storage due to waste compatibility. The characterization of the waste tanks has not progressed to the point where the physical characteristics of sludges and solids are known. Therefore, the equipment needed for this level of cleanout can be estimated only and the confidence of its adequacy is relatively low.

2.1.1 Retrieval Systems

The retrieval system to retrieve DST waste, leaving no, or very minimal, residual heel, will be directly proportional to the quantity and resistance to mobilization of the sludges in the tanks. Tanks containing only supernates (for instance the AP farm) will require only a transfer pump to remove all waste including a hard heel. Other tanks that contain deep sludges with a relatively high strength, such as tank AW-103, may be difficult to retrieve requiring both mixer pumps and sluicing systems. In general, if no heel is allowed, the retrieval system will be the most extensive and, therefore, the most costly.

2.1.2 Retrieval Operations Considerations

When initial retrieval before tank reuse requires removal of all waste including a hard heel, then operations must plan a much more painstaking campaign, especially if sluicing is required, to ensure the desired retrieval. This would take considerable time to ensure that the sludges and solids are mobilized and that the transfer operations are complete. At least one wash cycle will be required when the tank has been initially emptied to the maximum extent possible. This rinse cycle would involve backfilling with wash solution, running the mixer pumps to clean the tank. If solids are difficult to retrieve, the wash water may need to be Ph adjusted in an attempt to dissolve any solids. This would then require an additional step to then increase the Ph before transfer. If a hard heel is not removed using mixer pumps or a combination of sluicing and mixer pumps, and chemical dissolution is not possible, then a mechanical cleaning using remote vehicles or a long reach arm is required. Another major operations consideration for this initial DST retrieval is the ability to deal with sludges and solids after transfer from the tank. These materials would contain the bulk of the transuranics, uranium, and heavy metals in addition to the majority of the strontium. There would need to be either enough tank space to receive these sludges and solids or they would have to be accepted into a treatment facility that could accept and process the HLW.

Safety issues such as hydrogen or noxious gas generation, nuclear criticality, and chemical incompatibility are eliminated when DST waste is completely retrieved, insofar as adding waste to the now empty tank.

2.1.3 Characterization

Before design of retrieval systems that will leave no hard heel, the physical properties of the supernates, sludges, and the hard heel need to be determined with a high degree of confidence. A very extensive characterization program is required. This characterization would include determination of the physical, chemical, and radiological properties of any hard heels, sludges, saltcakes, and supernates.

2.1.4 Instrumentation

In addition to the instrumentation required to monitor slurry/supernate transfers, retrieval would require in-tank instruments to measure sludge mobilization over the entire tank. The instrumentation would have to be accurate enough to measure even small amounts of sludge lodged behind in-tank hardware or along the tank periphery. Instrumentation that would accomplish this task has not been proved or fully developed.

2.1.5 Summary

This is the most restrictive retrieval case. As such, retrieval to this high level of cleanout will require the most extensive retrieval system, the most complicated operations, the most extensive characterization, and the most comprehensive instrumentation and control system.

2.2 CASE 2--HARD HEEL ALLOWED

DST retrieval to the level where a hard heel is allowed is significantly less stringent than when retrieval must leave no heel. For this study, the residual would contain no or minimal sludges but a hard heel is acceptable. Mobilization of all but a hard heel should retrieve waste in excess of 98 percent for most DSTs. Note that the DST characterization program has not identified the extent of what would be considered a hard heel. The characterization information available does not allow exact calculation volume of the hard heel. The characterization of the waste tanks has not progressed to the point where the physical characteristics of sludges and solids are known. Therefore, the equipment needed for this level of cleanout can be estimated only and the confidence of its adequacy is relatively low.

Retrieval operations may find that the amount of sludge remaining after sludge mobilization will not meet the requirements for reuse. This will require additional equipment to remove the residuals. This equipment could include a sluicing installation, deployment of remote operated cleaning/mining equipment, or installation of a long reach arm with suitable end effectors.

2.2.1 Retrieval Systems

The retrieval system to retrieve DST waste, leaving only a hard heel, is essentially equivalent to complete retrieval (Case 1). The system required to achieve this level of retrieval will be directly proportional to the amount and strength of the sludges in the tanks. Tanks containing only supernates (for instance the AP farm) will require only a transfer pump to achieve the required level of cleanout. Other tanks that contain deep sludges with a relatively high strength such as tank AW-103 may be difficult to retrieve requiring both

mixer pumps and sluicing systems. In general, if no heel is allowed, the retrieval system will be only slightly less extensive than the complete cleanout leaving no heel. Costs for this study case would be only slightly less than Case 1.

2.2.2 Retrieval Operations Considerations

When initial retrieval before tank reuse requires essentially complete sludge removal, this then requires a high degree of confidence to ensure that the sludges are mobilized and that the transfer operations are complete. Addition of wash water and a second mobilization/transfer cycle may be required to meet residual sludge requirements. If the sludge is not removed using mixer pumps, then sluicing may be required.

Another major operations consideration for this initial DST retrieval is the ability to deal with sludges after transfer from the tank. These materials would contain the bulk of the transuranics, uranium, and heavy metals in addition to the majority of the strontium. There would need to be either enough tank space to receive these sludges and solids or they would have to be accepted into a treatment facility that could accept and process the HLW.

Safety issues such as hydrogen generation, nuclear criticality, noxious gas generation, and chemical incompatibility must be addressed. These issues may prove to be inconsequential. The compatibility of wastes added on top of a hard heel should not disturb or react to any great extent. Likewise, any minor amounts of residual sludge should not be of concern. The DST waste retrieval acceptance criteria would be established to prevent any problems.

2.2.3 Characterization

An extensive characterization program is required to provide assurance that the DSTs can be retrieved such that essentially all sludge is removed, leaving only a hard heel. This characterization would include determination of the physical, chemical, and radiological properties of sludges, saltcakes, and supernates. Before design of retrieval systems, the physical properties of the sludge and supernate would need to be determined.

2.2.4 Instrumentation

In addition to the instrumentation required to monitor slurry/supernate transfers, retrieval would require in tank instruments to measure sludge mobilization over the entire tank. The instrumentation would have to be accurate enough to measure even small amounts of sludge along the tank periphery. Instrumentation that would accomplish this task has not been proved or fully developed.

2.2.5 Summary

This retrieval case is nearly as restrictive as one which allows no heel. The level of effort required to retrieve all sludge is comparable to that for removal of the sludge plus the hard heel. As such, retrieval to this level of cleanout will require an extensive retrieval system, complicated operations, the extensive characterization of the sludges, and a comprehensive instrumentation and control system.

2.3 CASE 3--RESIDUAL SLUDGE ALLOWED

DST retrieval to the level where residual sludge is allowed is the least stringent than when compared to retrieval leaving either no heel or a hard heel. For this study, the residual would contain significant amount of sludge. This cleaning would retrieve most of the sludges and virtually all of the pumpable liquids for most DSTs. The characterization of the waste tanks has progressed to the point where the physical characteristics of sludges and solids are understood well enough where a reasonable estimate of what equipment is required can be developed.

2.3.1 Retrieval Systems

The retrieval system to retrieve DST waste, leaving residual sludge, is the least extensive and thus the least costly of the three study cases. Depending on the ultimate reuse, the heel for a given tank could be quite large without adverse effects. The retrieval system would be the least complicated and least extensive, thus having the lowest relative cost. In some cases, depending upon the reuse, it may not be necessary to retrieve any sludge, thus eliminating the mobilization equipment entirely.

2.3.2 Retrieval Operations Considerations

When initial retrieval before tank reuse allows residuals to include significant amounts of sludge, the necessary degree of confidence to ensure that the sludges are mobilized and that the transfer operations are complete is greatly reduced. The major operations issue is ensuring that the wastes added to the residual waste in the DST are compatible, both from a radionuclide and chemical compatibility perspective.

Another major operations consideration for this initial DST retrieval is the ability to deal with sludges after transfer from the tank. These materials would contain the bulk of the transuranics, uranium, and heavy metals in addition to the majority of the strontium. There would need to be either enough tank space to receive these sludges and solids or they would have to be accepted into a treatment facility that could accept and process the HLW.

Safety issues such as hydrogen generation, nuclear criticality, noxious gas generation, and chemical incompatibility issues must be addressed. These issues may prove to be inconsequential. The compatibility of wastes added on top of residual sludges could cause problems if blending of those wastes is to be avoided. The DST waste retrieval acceptance criteria would be established to prevent any problems.

2.3.3 Summary

This retrieval case is the least restrictive allowing some sludge to remain after retrieval. Of the three study cases, this requires the least extensive retrieval system, simplified operations, much less characterization, and less extensive instrumentation and controls.

2.4 OVERALL SUMMARY OF THE ANALYSIS OF THE THREE STUDY CASES

In all cases, the most restrictive cleanout requirements of leaving no heel will have the most extensive retrieval system, most complex operations, require the most extensive characterization, and the highest degree of instrumentation and control. The second study case, where a hard heel is allowed, is only slightly better. The most advantageous study case is where a hard heel plus residual sludge is allowed. From a pragmatic standpoint, this may be the only reasonable option based upon tank limitations of dome loading, riser sizes, riser locations, and numbers of risers. Major modifications of DSTs to accommodate equipment required for installation of equipment which will remove essentially all waste may be impractical, thus limiting choices to leaving residual sludges after initial retrieval.

3.0 THE EFFECTS OF A REMAINING DOUBLE-SHELL TANK HEEL AFTER INITIAL RETRIEVAL

This study deals mainly with sludges and not with supernates as no technical concerns concerning supernate mobilization and transfer were identified. The current tank inventory was derived from *Tank Farm Surveillance and Waste Status Summary Report for October 1994* (Hanlon 1994). The information from this document is summarized in Appendix A.

A relatively large heel of unmobilized sludge may remain after initial retrieval before DST reuse and could have adverse effects mainly in the following five general areas. The first is the need for the retrieved DST to provide adequate tank space for the reuse mission, and the second to meet waste compatibility requirements. The third is the effect of incidental blending of newly added waste with the heel. The remaining areas of concern were the effect on a remaining heel on the retrieval sequence and the effect of the remaining heel on DST reuse. The following paragraphs document a sensitivity analysis of the effect of the remaining heel for these five topics.

3.1 TANK SPACE

Initial DST retrieval will be done primarily to provide space for the storage of waste from SST retrieval activities. As treatment and disposal facilities are made operational, DSTs will be required to support other activities requiring waste to be retrievably stored in tanks. These include storage of in-process waste from LLW pretreatment and vitrification, and HLW pretreatment and vitrification while at the same time continuing to receive and store additional waste from the SST retrieval activities. These storage requirements include both liquid (supernates and wash solutions) and solids (undissolved saltcakes and sludges). Currently, there is no estimate or calculation of waste to be stored as "in-process waste." This stored waste would come either as retrieved waste from the SSTs or as return streams from the LLW pretreatment.

The useable tank space for storing additional waste can be increased in only two ways. First, supernates can be evaporated and concentrated to reduce liquid levels. The limits to which the concentration of supernates are practical and cost effective have not been established as stored tank waste requirements. Secondly, compatible sludges can be consolidated, creating useable tank space in the emptied tank.

Tank space, as related to how much heel remains after initial retrieval, is an operational concern for a particular tank. Until there is an ability to process (vitrify) waste and permanently remove it from the tank, the total amount of initial tank space including that which can be made available through evaporation remains fixed. DST retrieval does not create more tank space. All that can be done is to move DST waste, thus making the useable space available in specific tanks which are configured for accumulating the solids/sludges or liquids. Consolidation of compatible wastes would then create useable tank

space, even though the total DST available space remains more or less unchanged. For example, the neutralized current acid waste (NCAW) wastes have not been blended in the past and may require continued segregation. Consolidation of AZ-101 and AZ-102 would free up one tank, providing 3,800 m³ (1 Mgal) of space. The allowable heel limits for unrestricted use of the "clean" tank have not been established. The allowable heel for storage of similar, compatible waste, are a function of the tank operations requirements to maintain the waste within the safety and operations limits for that particular tank.

The relationship between the effectiveness of the mixer pumps in mobilizing sludge was developed experimentally using non-radioactive sludge simulants. This relationship between the sludge shear strength and the effective cleaning radius (ECR) is expressed by the following equation:

$$\text{Equation: } \text{ECR} = K \cdot U_0 \cdot D \cdot \tau^{-n}$$

ECR - Effective Cleaning Radius (cm)

K - Constant (17.3)

$U_0 \cdot D$ - Jet Velocity Times Jet Diameter (27,314 cm²/s)

τ - Sludge Shear Strength (dy/cm²)

n - Experimental Constant (0.67).

The ECR decreases exponentially as the shear strength increases as shown in Table 1. Small increases in sludge shear strength can mean large decreases in the ECR. Experimental data of shear strength of DST sludges conducted in hot cells show a large variability. Sludge cores show that the waste varies both top to bottom as well as radially away from the waste inlet risers. Until greater experimental data are available, the shear strength data and resulting predictions in sludge mobilizations can not be considered to be precise.

Table 1. Sludge Shear Strength Related to Effective Cleaning Radius and Percent Mobilized Using Two Mixer Pumps.

Shear strength K dy/cm ² (lb/ft ²)	Effective cleaning radius cm (ft)	% Mobilized
7 (14.7)	1,250 (41)	99
14 (29.4)	793 (26)	75
28 (58.7)	488 (16)	36
70 (147.0)	274 (9)	11

Estimates of the heel (unmobilized waste) using two mixer pumps are found in Table 2. Of the 28 tanks, 10 contain only minimal amounts of sludges; therefore, the heel would be essentially 0. Of those tanks containing sludges, 9 have no shear strength data. Until sampling and laboratory or in situ testing provides shear strength data, the mobilization effectiveness can only be assumed. The remaining 9 tanks have limited shear strength data available. For those that have several samples, the shear strength values vary considerably. For these tanks, the estimated heel could vary greatly. The estimates of remaining heel show only tanks AN-103, AW-103, SY-101, and SY-103 have significant quantities of sludge that is not mobilized by two mixer pumps. Thus, these four tanks would contain almost 5,700 m³ (1.5 Mgal) of sludge after initial retrieval assuming the shear strength data and the predictive equation are correct.

3.2 WASTE COMPATIBILITY

Waste compatibility associated with a DST heel after initial retrieval involves two general areas of concern, namely, meeting waste tank operations requirements and tank safety.

Tank operational limits are largely based upon safety issues. Heat generation due to radionuclide decay must be accounted for when storing waste. A high-heat generation heel may not be compatible with other similar wastes if the combination would exceed tank safety limits. The amounts of fissile material would have similar compatibility concerns.

A second area of concern from the operations standpoint is ensuring mixtures of wastes will not react or change in such a way as to form a difficult-to-retrieve or plugged transfer line.

Finally, the safety issues of the possibility for hydrogen generation, may require analysis regarding blending. Some wastes have the potential for generation of hydrogen gas with a resulting flammability concern. Other areas of concern would be blending waste that could react or otherwise form an unsafe condition.

The *Tank Farms Waste Transfer Compatibility Program*, WHC-SD-WM-OCD-015, Rev. 1 (Fowler 1995) provides a detailed listing of compatibility requirements.

Table 2. Hanford Site Double-Shell Tank Estimated Heel Using Two Mixer Pumps.

Tank	Waste ^f type	Shear Strength ^a (lb/ft ²)	Effective cleaning radius/% mobilized ^b (ft/%)	Heel (Kgal)
AN-102	CC	Not Available	25/73	24
AN-103	DSS	48	19/51	459 ^d
AN-104	DSSF	Not Available	32/90 ^c	26
AN-106	CP	Not Available	35/95 ^c	1
AN-107	CC	Not Available	32/90 ^c	13
AW-101	DSSF	Not Available	32/90 ^c	8
AW-102	DN	Not Available	32/90 ^c	> 1
AW-103	DN/PD	100	12/20	290
AW-104	DN	Not Available	32/90 ^c	18
AW-105	DN/PD	> 1	< 41/99 +	> 1
AW-106	DN	Not Available	28/80 ^c	42
AY-101	DC	Not Available	35/95 ^c	4
AY-102	DN	64	16/36	20
AZ-101	NCAW	18	37/97	1
AZ-102	NCAW	41	21/60	38
SY-101	CC	38 ^c	22/63	318 ^{d,c}
SY-102	DN/PT	81	13/24	54
SY-103	CC	67	15/32	392 ^d
Remaining 10 DSTs contain minimal sludge				0

^aShear strength values presented are from hot cell testing of core samples.

^bEffective Cleaning Radius (ECR) was computed using the equations developed from scale testing of sludge simulants. The highest shear strength values from testing were used.

$$\text{Equation: } \text{ECR} = K \cdot U_0 \cdot D \cdot \tau^{-n}$$

ECR - Effective Cleaning Radius (cm)

K - Constant (17.3)

$U_0 \cdot D$ - Jet Velocity Times Jet Diameter (27314 cm²/s)

τ - Sludge Shear Strength (dy/cm²)

n - Experimental Constant (0.67)

^cSludge removal was estimated using expected sludge properties based upon existing test data.

^dTanks AN-103, SY-101, and SY-103 do not contain sludges; however, the waste is concentrated to the extent where the shear strength is large enough to require mobilization of the waste by mixer pumps or other means.

^eShear strength for SY-101 vary from less than detectable to over 242 lb/ft².

^fWaste type:

CC = Complexed concentrate

CP = Concentrated phosphate

DC = Dilute concentrate

DN = Dilute noncomplexed

DSS = Double-shell slurry

DSSF = Double-shell slurry feed

NCAW = Neutralized Current Acid Waste

DN/PD = Dilute Non-Complexed Waste Containing PUREX TRU Solids

DN/PT = Dilute Non-Complexed Waste Containing PFP TRU Solids.

3.3 INCIDENTAL BLENDING

Incidental blending, the mixing or cross-contamination of part or all of a heel with newly added waste. Blending considerations are due to radionuclide content restrictions, chemical compatibility, and operations or treatment restrictions. A restriction on blending of waste must consider what constitutes a "*de minimis*" amount of incidental blending. In other words, what is the amount of cross-contamination that does not require safety, operations, or other blending restrictions. Table 3 provides a matrix of the past practice waste transfers which have been done without problem. Incidental blending of wastes within this transfer matrix would not be at issue, therefore, there would be no limit to incidental blending.

Table 3. Compatibility Matrix For Tank Wastes From Past Practice Waste Transfer Operations.

Source waste type	Receiver waste type							
	DN	DSS-DSSF	DC	CC	NCRW (PD)	PT	NCAW	CP
DN	X	X	X	X	X	X	X	X
DSS-DSSF	X	X						
DC			X	X*				
CC			X*	X				
NCRW	X				X	X		
PT	X				X	X		
NCAW							X	
CP								X

X Indicates waste type mixing which has occurred historically, apparently without adverse effects.

*Adding CC to DC is permissible with the understanding that the volume of combined waste requiring evaporation would be increased with a resultant increase in evaporation costs.

CC = Complexed concentrate

CP = Concentrated phosphate

DC = Dilute concentrate

DN = Dilute noncomplexed

DSS = Double-shell slurry

DSSF = Double-shell slurry feed

NCAW = Neutralized Current Acid Waste

NCRW = Neutralized Cladding Removal Waste

DN/PD = Dilute Non-Complexed Waste Containing PUREX TRU Solids

DN/PT = Dilute Non-Complexed Waste Containing PFP TRU Solids.

The operational concerns due to heat generation by radionuclide decay would need to be addressed. The heat load of the heel would affect what or how much waste from another tank could be added. Again, the mixing of the heel with the new waste would not be a problem and incidental blending is not of serious concern.

Segregation of waste to ensure waste processing (vitrification) meets the final disposal criteria is the greatest concern. Five general constraints for waste blending have been identified:

1. Segregation of TRU certifiable wastes from other waste to allow TRU waste to be shipped to the WIPP Site.
2. Segregation of complexed waste from non-complexed waste to avoid contaminating supernates with complexed heavy metals and TRU.
3. Segregation of LLW from TRU waste and HLW.
4. Minimization of concentrations of elements which degrade glass durability to ensure glass meets the HLW acceptance criteria.
5. Minimization of fissile material and TRU elements to meet HLW acceptance criteria.

Table 4 shows what waste is in each DST, waste that can be transferred into that tank according to past practice transfers, and any other materials that identify a blending issue. Blending of waste in support of HLW waste processing is described in detail in *Tank Waste Remediation System High-Level Waste Feed Processability Assessment Report* (Lambert and Kim 1994). A detailed chemical and radionuclide inventory for both SSTs and DSTs is found in *Chemical and Radionuclide Inventory For Single and Double-Shell Tanks* (Shelton 1995).

Table 4. Double-Shell Tank Retrieval Blending Considerations.

Tank	Sludge		Tank space considerations for reuse after initial retrieval due to a remaining heel
	m ³	(Kgal)	
AN-101	0	0	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.
AN-102	405	89	Contains CC waste and can receive additional DN, CC, and DC waste. Quantities of organic complexants must be addressed to identify blending issues.
AN-103	0	0	Contains DSS waste and can receive additional DSS, DSSF, and DN waste. This is a watch list tank. (Tank AN-103 has no sludge.)
AN-104	1,200	264	Contains DSSF waste and can receive additional DSS, DSSF, and DN waste. This is a watch list tank.
AN-105	0	0	Contains DSSF waste and can receive additional DSS, DSSF, and DN waste. This is a watch list tank. (AN-105 has no sludge)
AN-106	77	17	Contains CP waste and can receive additional CP and DN waste. Quantities of Phosphorus must be addressed to identify blending issues.
AN-107	609	134	Contains CC waste and can receive additional DN, CC, and DC waste. Quantities of organic complexants, aluminum and sodium must be addressed to identify blending issues.
AP-101	0	0	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.
AP-102	0	0	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.
AP-103	0	0	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.
AP-104	0	0	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.
AP-105	0	0	Contains DSSF waste and can receive additional DSS, DSSF, and DN waste.
AP-106	0	0	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.
AP-107	0	0	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.
AP-108	0	0	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.
AW-101	382	84	Contains DSSF waste and can receive additional DSS, DSSF, and DN waste. This is a watch list tank.
AW-102	5	1	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.
AW-103	1,650	363	Contains DN/PD waste and can receive additional DN/PD, NCRW, and DN waste. Quantities of TRU and zirconium must be addressed to identify blending issues.
AW-104	813	179	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.

Table 4. Double-Shell Tank Retrieval Blending Considerations.

Tank	Sludge		Tank space considerations for reuse after initial retrieval due to a remaining heel
	m ³	(Kgal)	
AW-105	1,214	267	Contains DN/PD waste and can receive additional DN/PD, NCRW, and DN waste. Quantities of TRU and zirconium must be addressed to identify blending issues.
AW-106	959	211	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.
AY-101	377	83	Contains DC waste and can receive additional DC, CC, and DN waste. Quantities of Chromium must be addressed to identify blending issues.
AY-102	145	32	Contains DN waste and can receive additional DN, DSSF, NCRW, and DN/PT waste.
AZ-101	159	35	Contains NCAW waste and can receive additional NCAW and DN waste. Quantities of Iron hydroxide, noble metals, and zirconium must be addressed to identify blending issues.
AZ-102	295	95	Contains NCAW waste and can receive additional NCAW and DN waste. Quantities of iron hydroxide, noble metals, and zirconium must be addressed to identify blending issues.
SY-101	0	0	Contains CC waste and can receive additional DN, CC, and DC waste. Quantities of organic complexants, aluminum, sodium, and chromium must be addressed to identify blending issues. This is a watch list tank.
SY-102	322	71	Contains DN/PT waste and can receive additional DN/PT, NCRW, and DN waste. Quantities of TRU, aluminum, and chromium must be addressed to identify blending issues.
SY-103	0	0	Contains CC waste and can receive additional DN, CC, and DC waste. Quantities of organic complexants, aluminum, and sodium must be addressed to identify blending issues. This is a watch list tank.

CC = Complexed concentrate
 CP = Concentrated phosphate
 DC = Dilute concentrate
 DN = Dilute noncomplexed
 DSS = Double-shell slurry
 DSSF = Double-shell slurry feed
 NCAW = Neutralized Current Acid Waste
 NCRW = Neutralized Cladding Removal Waste
 DN/PD = Dilute Non-Complexed Waste Containing PUREX TRU Solids
 DN/PT = Dilute Non-Complexed Waste Containing PFP TRU Solids.

3.3.1 Segregation of PUREX and Plutonium Finishing Plant Transuranic Containing Solids

There are three DSTs that have been identified as potential TRU wastes based upon the nominal source history. These tanks are the NCRW waste in tanks AW-103 and AW-105, plus the Plutonium Finishing Plant (PFP) waste stored in tank SY-102. For the TRU wastes, blending of TRU into other waste tanks will not designate them also as TRU. The opposite occurs as blending HLW with TRU changes the designation of the TRU to high level. Thus, incidental blending of a heel in any of the three TRU tanks is not restricted as HLW can contain TRU material. Any incidental blending of the TRU waste heel with other waste would be regulated by other criteria such as fissile limits, tank heat limits, or concentration of specific elements or chemicals.

If LLW is trans-shipped through these three tanks, very small amounts of incidental blending will change the designation from LLW to TRU. For instance, only 159 L (42 gal) of sludge from SY-102 will bring the concentration of TRU in 11 m³ (30 Kgal) of LLW solids above the 100 nCi/g limit.

3.3.2 Segregation of Complexed Waste

Complexed wastes contain organic chemicals which combine with the normally insoluble heavy metals including the TRU, to bring them into solution. The complexed metals would cause problems during waste treatment as these complexed materials would be considered HLW and the supernatant is considered feed for the LLW stream. The complexants can be considered to reside in the supernate and interstitial fluids in the sludge. Removal of the supernates will remove most of the complexants. Non-complexed waste added to a tank containing a complexed heel will ultimately blend the complexants into the new waste through liquid diffusion. The limit for the allowable heel must be established by determining the amount of complexed waste that would be mixed and what effect that would have on waste processing.

3.3.3 Segregation of Supernate (Low-Level Waste)

Currently, certain SST tank wastes and the decanted supernates from the DSTs are considered to be feed stock for LLW processing. As the supernates will be compatible with most wastes, and that incidental blending with a sludges will not occur except for complexed waste, where the TRU and other heavy metals remain in solution will freely mix with the supernate. Except for segregating supernates from a tank containing a complexed heel, they can be added to any other tank.

3.3.4 Minimizing Concentration of Glass Degrading Material

Certain elements such as chromium, phosphorus, and zirconium detract from the durability of the vitrified waste (glass). If these elements are in solution, they will diffuse into the new waste through liquid diffusion. Insoluble material will only be mixed with the new waste when sludges are mobilized for sludge washing or waste transfer. The amount of incidental blending through sludge mobilization should be minor as a heel that was not initially mobilized will probably not be mobilized through subsequent mobilization operations using the same mobilization process. As all of these elements that affect glass durability must eventually be vitrified, the process of manufacturing high quality glass requires waste blending to minimize the concentrations of these elements. For this reason, even a large heel may not pose an incidental blending problem.

3.3.5 Fissile and TRU Minimization to Meet High-Level Waste Acceptance

The HLW acceptance criteria for permanent geologic disposal at Yucca Mountain, Nevada, may limit the amount of fissile material and TRU concentrations. As with minimizing material that affects glass durability, the concentration of fissile and TRU materials would be accomplished by blending. Thus, any incidental blending because of a heel may not pose a problem.

3.4 EFFECT OF A HEEL ON DOUBLE-SHELL TANK RETRIEVAL SEQUENCE

The retrieval sequence should address DST reuse in support of SST retrieval in the near term. Retrieval specifically to support treatment activities will follow those providing tank space for retrieved SST waste. Depending on the final schedule for initiating LLW treatment, retrieved SST waste may take up all available DST storage capability. Using the estimates for retrieval from Table 2, a summary of the sludges, estimated heel, and mobilized (waste that could be transferred) is shown in Table 5. The following paragraphs discuss what effect a heel will have upon the DST retrieval sequence.

3.4.1 Complexed Waste (CC and DC)

There are 4 DSTs that contain complexed concentrate (CC) waste including SY-101 and SY-103 in the West Area and AN-102 and AN-107 in the East Area. A fifth DST, AY-101, in the East Area, contains dilute complexed (DC) waste. As a heel of complexed waste will commingle with newly added waste, it may be inadvisable to retrieve any tank with CC or DC waste. For this reason, the retrieval sequence for these five tanks should be delayed until a facility or in-tank process is available to destroy the organic complexants.

Table 5. Hanford Site Double-Shell Tank Waste Summary by Waste Type.

Tank	Waste type	Sludge		Heel		Waste mobilized	
		m ³	Kgal	m ³	Kgal	m ³	Kgal
AN-101	DN	0	0	0	0	0	0
AP-101	DN	0	0	0	0	0	0
AP-102	DN	0	0	0	0	0	0
AP-103	DN	0	0	0	0	0	0
AP-104	DN	0	0	0	0	0	0
AP-106	DN	0	0	0	0	0	0
AP-107	DN	0	0	0	0	0	0
AP-108	DN	0	0	0	0	0	0
AW-102	DN	5	1	>5	>1	>5	>1
AW-104	DN	813	179	82	18	732	161
AW-106	DN	959	211	191	42	768	169
AY-102	DN	145	32	91	20	55	12
Total DN waste		1,923	423	368	81	1,555	342
AN-104	DSSF	1,200	264	118	26	1,082	238
AN-105	DSSF	0	0	0	0	0	0
AP-105	DSSF	0	0	0	0	0	0
AW-101	DSSF	382	84	36	8	346	76
Total DSSF waste		1,582	348	155	34	1,427	314
AN-103	DSS	0	0	2,087	459	2,173	478
Total DSS waste		0	0	2,087	459	2,173	478
AW-103	DN/PD	1,650	363	1,318	290	332	73
AW-105	DN/PD	1,219	267	>5	>1	1,209	266
Total DN/PD waste		2,864	630	1,323	291	1,541	339
SY-102	DN/PT	323	71	296	65	27	6
Total DN/PT waste		323	71	296	65	27	6

Table 5. Hanford Site Double-Shell Tank Waste Summary by Waste Type.

Tank	Waste type	Sludge		Heel		Waste mobilized	
		m ³	Kgal	m ³	Kgal	m ³	Kgal
AZ-101	NCAW	159	35	5	1	155	34
AZ-102	NCAW	432	95	173	38	259	57
Total NCAW waste		590	130	177	39	414	91
AN-106	CP	77	17	5	1	73	16
Total CP waste		77	17	5	1	73	16
AN-102	CC	405	89	109	24	296	65
AN-107	CC	609	134	59	13	550	121
SY-101	CC	0	0	1,446	318	2,337	541
SY-103	CC	0	0	1,782	392	841	185
AY-101	DC	377	83	18	4	359	79
Total CC/DC waste		1,391	306	23,414	751	4,505	991

CC = Complexed concentrate

CP = Concentrated phosphate

DC = Dilute concentrate

DN = Dilute noncomplexed

DSS = Double-shell slurry

DSSF = Double-shell slurry feed

NCAW = Neutralized Current Acid Waste

NCRW = Neutralized Cladding Removal Waste

DN/PD = Dilute Non-Complexed Waste Containing PUREX TRU Solids

DN/PT = Dilute Non-Complexed Waste Containing PFP TRU Solids.

3.4.2 Transuranic Waste (DN/PD and DN/PT)

Dilute Non-Complexed Waste Containing PUREX TRU Solids (DN/PD) is stored in the East Area in tanks AW-103 and AW-105. The Dilute Non-Complexed Waste Containing PFP TRU Solids (DN/PT) is stored in the West Area in tank SY-102. As these are potential TRU wastes, they should be consolidated and held separate from other waste until a determination is made that they can be certified as remote handled TRU waste. From a sequence standpoint, SY-102 must be retrieved for reuse as a receiver tank for West Area SST retrieved waste. Of the remaining two, based upon the remaining heel, AW-105 should also be retrieved as it would have the least heel. The sludges from SY-102 and AW-105 consolidated into AW-103. This would leave AW-103 with approximately 2,400 m³ (635,000 gal) of sludge which would be stored until it was either processed as TRU or blended with other HLW.

3.4.3 Concentrated Phosphate Waste

The concentrated phosphate (CP) waste is stored in tank AN-106. The phosphate, which adversely affects the durability of the glass, is found in both the sludge and supernate. The heel should be very small and since the means for dealing with phosphate is dilution by mixing with low-phosphate waste, then the heel should not be an issue. Therefore, the heel should not be a consideration for retrieval sequence.

3.4.4 Aging Waste (NCAW)

NCAW is stored in tanks AZ-101 and AZ-102. This waste has a relatively high concentration of radioactive material with a high-heat generation due to radioactive decay. Project W-151 will install mixer pumps, instrumentation, and controls in tank AZ-101. Current plans show that AZ-101 will be moved to tank AZ-102 freeing up AZ-101 for other uses. The heel in AZ-101 will be relatively small even if mobilization is less effective than anticipated. As the heel is insoluble and incidental blending will not be large, then the sequence for when AZ-101 is retrieved should not be closely linked to any retrieval sequence.

3.4.5 Non-complexed Waste (DSS, DSSF, and DN)

The remaining 17 DSTs contain double-shell slurry (DSS), double-shell slurry feed (DSSF), and dilute noncomplexed (DN) waste. Of these 17, only 6 tanks would contain a significant heel. The waste in these tanks are compatible and the heel would need to be considered only for those tanks which contained materials which would cause glass durability issues. Since blending is the means to deal with materials that affect glass durability, then the heel should not be related to retrieval sequence. There would be no limitations based upon a heel that would affect the retrieval sequence with the possible exception of tank

AN-103, which could have a 1,740 m³ (459,000 gal) heel. This would limit the useable tank space for reuse and may be more useful for storage of sludges.

3.5 EFFECTS OF A HEEL ON DOUBLE-SHELL TANK REUSE

3.5.1 Double-Shell Tank Reuse Supporting Double-Shell Tank/Single-Shell Tank Retrieval

The effects of a heel on DST reuse is dependent upon the following constraints which were identified in the previous paragraphs:

- CC waste is to be segregated from all other waste.
- A CC heel will limit a DST reuse to only CC waste if the complexed radionuclides, TRU and Fissile, contained in the sludge will migrate via fluid diffusion into the new, added, waste in enough quantities to cause problems with LLW processes.
- TRU designated waste (WIPP) is to be segregated from all other waste to maintain the requirement for certification.
- A TRU designated waste heel will limit reuse to HLW or TRU waste.
- A heel containing materials which may reduce the durability of the glass will not limit reuse with the qualification that those detrimental materials must be accounted for to ensure proper blending to minimize the amount of frit needed to prepare glass that meets durability requirements.
- A heel containing TRU, fissile, and heat generating radioisotopes will not limit reuse; however, they must be accounted for to ensure tank operating specifications are met.
- A heel containing TRU and fissile material will not limit reuse, however, they must be accounted for and/or blended with other waste to ensure vitrified HLW does not exceed limits on these materials.
- A heel will not limit reuse within the context of past practice compatibility (Table 4).

The reuse restrictions for the DSTs, using the above constraints are presented in Table 6. This table assumes a retrieval based upon sludge mobilization using two mixer pumps for those tanks containing any sludge. Four areas of waste acceptance are evaluated against the expected heel for each DST. The four areas are (1) noncomplexed supernates for LLW processing, (2) noncomplexed sludges for HLW processing, (3) PUREX, and PFP solids that are candidate TRU waste, and (4) complexed waste (CC). The PUREX and PFP solids are the sludges from the three DSTs that have the potential to be certified as TRU waste, namely, AW-103, AW-105, and SY-102. Finally, the complexed waste is that waste found in tanks AN-102, AN-107, AY-101, SY-101, and SY-103.

Reuse of DSTs based upon the allowable heel show that those tanks which have no appreciable heel have unlimited reuse upon retrieval of any liquid waste. These tanks could be used as storage of any of the four types of wastes.

Supernates as feed for LLW processing can be transferred to any tank other than one containing complexed waste. The only condition would be that if the heel material were to be incorporated into the supernate, the solids would have to settle out before transfer for processing.

As with the supernates, the sludges for HLW processing can be transferred to any tank but one containing complexed waste.

The PUREX and PFP solids could be transferred to any tank where there is no heel or to a tank also containing TRU waste. This should preserve the ability to certify the waste for shipment to WIPP. If a decision is made to handle this waste as HLW or if the certification process were to approve storing this waste in a tank containing a HLW heel, then, the waste could be stored in any DST except those containing complexed waste. The heel in the TRU containing tanks will prevent reuse if the those wastes stored or trans-shipped through the tank must remain below the 100 nCi of TRU per gram of waste limit for LLW. For instance, only 159 L (42 gal) of SY-102 sludge contains enough TRU to contaminate a 38 m³ (100 Kgal) transfer of 30 percent solids slurry above the 100 nCi/g limit. For this reason, use of SY-102 to receive West Area waste before cross-site transfer would require essentially complete retrieval (no sludge) before reuse. The other TRU tanks, AW-103 and AW-105 would also require complete cleanout for the same reason.

The CC waste must be segregated until such time that either the complexing chemicals have been removed or destroyed. A DST with a complexed heel could be used to store other waste if it is shown that the amount of the heel which would be blended would not cause problems with waste processing. The limits for how much of a complexed heel can remain without limiting the reuse to only complexed waste have not been determined.

Table 6. Double-Shell Tank Reuse Limitations: Retrieval Using Two Mixer Pumps.

Tank	Heel type	Waste acceptance				
		Low-level waste vit. feed	Supernate low-level waste feed	Sludge high-level waste feed	PUREX/PFP ^a TRU solids	Complexed waste
AN-101 ^b	DN	Yes	Yes	Yes	Yes	Yes
AN-102	CC	No	No	No	No	Yes
AN-103	DSS	No	Yes	Yes	No	No
AN-104	DSSF	No	Yes	Yes	No	No
AN-105 ^b	DSSF	Yes	Yes	Yes	Yes	Yes
AN-106	CP	No	Yes	Yes	No	No
AN-107	CC	No	No	No	No	Yes
AP-101 ^b	DN	Yes	Yes	Yes	Yes	Yes
AP-102 ^b	DN	Yes	Yes	Yes	Yes	Yes
AP-103 ^b	DN	Yes	Yes	Yes	Yes	Yes
AP-104 ^b	DN	Yes	Yes	Yes	Yes	Yes
AP-105 ^b	DSSF	Yes	Yes	Yes	Yes	Yes
AP-106 ^b	DN	Yes	Yes	Yes	Yes	Yes
AP-107 ^b	DN	Yes	Yes	Yes	Yes	Yes
AP-108 ^b	DN	Yes	Yes	Yes	Yes	Yes
AW-101	DSSF	No	Yes	Yes	No	No
AW-102	DN	No	Yes	Yes	No	No
AW-103	DN/PD ^a	No	Yes	Yes	Yes	No
AW-104	DN	No	Yes	Yes	No	No
AW-105	DN/PD ^a	No	Yes	Yes	Yes	No
AW-106	DN	No	Yes	Yes	No	No
AY-101	DC	No	No	No	No	Yes
AY-102	DN	No	Yes	Yes	No	No
AZ-101	NCAW	No	Yes	Yes	No	No
AZ-102	NCAW	No	Yes	Yes	No	No
SY-101	CC	No	No	No	No	Yes
SY-102	DN/PT ^a	No	Yes	Yes	Yes	No
SY-103	CC	No	No	No	No	Yes

^aTRU waste for WIPP certification^bInitial status, tank contained no sludge.

CC = Complexed concentrate

CP = Concentrated phosphate

DC = Dilute concentrate

DN = Dilute noncomplexed

DSS = Double-shell slurry

DSSF = Double-shell slurry feed

NCAW = Neutralized Current Acid Waste

NCRW = Neutralized Cladding Removal Waste

DN/PD = Dilute Non-Complexed Waste Containing PUREX TRU Solids

DN/PT = Dilute Non-Complexed Waste Containing PFP TRU Solids.

3.5.2 Double-Shell Tank Reuse Supporting Low-Level Waste Immobilization

Those tanks selected for use in support of LLW immobilization (vitrification) will have more stringent standards for reuse as storage for treated LLW ready for vitrification. This waste must have 97 ± 1 percent ^{137}Cs , 96 to 99.8 percent of the ^{90}Sr , and 96 to 99 percent of the TRU removed before vitrification. To be conservative, it should be assumed that the LLW treatment process for removing these radionuclides operates at the low end of the acceptable range some if not all the time. For this reason, the tanks that are used to store the treated LLW must contain essentially none of these radionuclides. Even insoluble solids could cause a problem as the transfer process could entrain them requiring a long settling time or a filtration process.

Several of the tanks in the AP farm contain no sludge or solids and only dilute, non-complexed (DN), supernates. Transfer of the supernates and a simple rinse should make these tanks acceptable for the LLW vitrification feed storage. Other tanks which would have any heel may not be acceptable, depending upon how well the treatment facility operates.

3.6 SUMMARY OF THE EFFECTS OF A REMAINING DOUBLE-SHELL TANK HEEL AFTER INITIAL RETRIEVAL

3.6.1 Tank Space

Of the 28 DSTs, 18 have the potential for limiting the useable space if sludges and solids are not effectively mobilized and transferred. The waste retrieval effectiveness was calculated using available sludge shear strength data along with estimating the sludge mobilization efficiency of mixer pumps for those tanks where data are unavailable as shown in Table 2. There are 16 tanks which will have 99 percent useable tank space ($>0.38 \text{ m}^3$ [1 Kgal] heel) including the 10 tanks which have no or very little sludge. Eight DSTs should have greater than 90 percent useable tank space ($>40 \text{ m}^3$ [100 Kgal] heel). The final four tanks may have a very large heel based upon existing sludge shear strength data. Tanks AN-103 would have 54 percent useable tank space (174 m^3 [459 Kgal] heel), AW-103 would have 71 percent useable tank space (110 m^3 [290 Kgal] heel), SY-101 would have 68 percent useable tanks space (120 m^3 [318 Kgal] heel), and SY-103 would have 61 percent useable tank space (148 m^3 [392 Kgal] heel). From a tank space perspective, 90 percent is probably an acceptable limit, which means that only these 4 tanks would have limitations.

3.6.2 Waste Compatibility

Waste compatibility is associated with two major issues, tank safety and tank operations. Tank safety involves insuring that a tank heel will not react or otherwise cause an unsafe condition when the tank is reused. This includes ensuring that heat generation limits are met and addressing hydrogen generation of waste mixtures. Operations concerns

would address reactions between waste types which would form difficult to mobilize sludges or which would gell or precipitate during waste transfers plugging transfer lines.

3.6.3 Incidental Blending

Incidental blending of tank wastes have a potential for causing adverse conditions during retrieval and subsequent reuse of the DSTs. Eleven DSTs have been identified as containing waste that may require segregation. Complexing agents are contained in Tanks AN-102, AN-106, AN-107, AY-101, SY-101, and SY-103. Depending on the concentration of the organic complexing agents, these wastes may need to be kept segregated until such time as the complexants can be removed. Care must be taken to ensure that criticality limits are not exceeded. Wastes with high quantities of zircon and chromium may require segregation. These elements have adverse effects on glass durability and will require blending with other wastes to control concentrations. Transuranics in tanks AW-103, AW-105, and SY-102 may need to be segregated to maximize the amount of TRU waste. The total amount of treated (vitrified) waste would remain more or less constant but segregation of TRU would make that fraction a greater percentage with a potential cost savings provided by sending more waste to WIPP as opposed to the HLW Repository (Yucca Mountain). Finally, tanks with high amounts of noble metals, aluminum, and sodium may require segregation to minimize glass production or to ensure efficient operation of the melters. The characterization process, from historical records and waste sampling plus the requirements and limitation of the waste treatment will provide input to the waste segregation requirements to avoid blending problems. Lacking specific segregation requirements, prudence demands that tanks with organics/complexants, zircon/chrome, and TRU be segregated. The allowable heel for specific waste tank retrieval to consolidate specific waste types need to be based upon the potential for contamination of waste stored or processed in the emptied tank. This may not be a serious problem as mobilization testing has shown that a heel left after initial mobilization with mixer pumps does not generally become mobilized upon subsequent mobilization efforts unless the mixer pump power is increased. Therefore, contamination from a remaining heel of sludge/solids can be minimized by running mixer pumps at reduced power for re-mobilization of stored wastes.

The incidental blending issues are also associated with safety based issues including hydrogen generation and the associated flammability issues, nuclear criticality, noxious gas generation, and chemical incompatibility. There are 6 DSTs currently on the safety watch list all for hydrogen generation and flammability issues. They are AN-103, AN-104, AN-105, AW-101, SY-101, and SY-103. Of these, AW-101 and the SY tanks probably pose the greatest potential for problems. The SY tanks are also the only tanks with safety concerns that also have blending limitations due mainly to organic complexants.

A safety assessment, mainly concerning criticality and chemical incompatibility, will be required to determine the allowable heel for all DSTs.

3.6.4 Retrieval Sequence

The heel affects the retrieval sequence by limiting the types or amount of waste that can be stored when the tank is reused. The overall sequence of retrieval must take into account the compatibility of the added waste with the remaining heel. In addition, the problems caused with blending complexed waste with non-complexed waste heel, or adversely a non-complexed waste with a complexed heel, will be a governing factor in the retrieval sequence. Segregation of waste that could be certified for disposal as TRU waste will also be a consideration for retrieval sequence. Two tanks can be selected immediately for initial DST retrieval. Tank SY-102 is the only useable West Area tank for support of SST retrieval, and therefor must be among the first tanks retrieved. AZ-101 should be in the initial retrieval sequence to take full advantage of equipment installed by project W-151.

3.6.5 Double-Shell Tank Reuse

The heel remaining after initial DST retrieval will limit reuse; however, the incidental blending of the heel and waste compatibility issues will generally not be a problem except complexed waste. The complexing agents bring radionuclides into solution, freely mixing with the supernates, adversely affecting the LLW processing. Thus, tanks with complexed heels could only be reused for storing other complexed waste.

Another restriction is maintaining the ability to certify waste as TRU Waste for disposal at WIPP. This means that waste from AW-103, AW-105, and SY-102 could only be transferred to tanks with no or minimal heel or between those three tanks only.

Finally, reuse of a tank for storage of treated LLW before vitrification must be restricted to those tanks containing no heel.

This page intentionally left blank.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

Analysis of the three study cases, as presented in Table 8, shows that wherever possible, the least restrictive requirements for the allowable heel should be applied. Costs are substantially lower, retrieval operations are greatly simplified, characterization activities are less extensive, and the instrumentation and controls are simplified.

The analysis of the effects of the remaining heel cause to subsequent activities shows that blending and safety issues are of paramount importance. The extent that a tank must be initially cleaned (the allowable heel) is largely dependent on if the heel would cause blending or safety concerns. Where waste blending and safety issues are not a problem, then the allowable heel can be large. Retrieval of liquids and supernates without moving the sludges is acceptable for many DSTs. Additional effort is necessary to understand the mixing potential when waste is added to a tank with a heel.

From these results the allowable heel can include most or all of the sludges and solids in AN-101, all AP tanks, AW-104, AW-106, and AY-102. The cleanout requirements for any of the remaining tanks could also leave a large heel, depending on if the tank were to be a receiver tank for compatible solids or if it needed to accept an incompatible or otherwise unacceptable (from a blending standpoint) waste. For instance, if the solids from AZ-101 are to be consolidated into AZ-102, then the cleanout for AZ-102 requires only to pump supernates and the sludge from AZ-101 needs to be transferred to the maximum extent that is practical. The allowable heel in AZ-101 would be dependent on subsequent reuse. For compatible waste, the heel could be quite large, but if the heel mixed freely with incompatible waste, then the cleanout limits would be stringent with little or no heel allowed.

4.2 RECOMMENDATIONS

4.2.1 Double-Shell Tank Initial Retrieval and Reuse Strategy Based on Allowable Heel

The recommended approach for initial DST retrieval and subsequent reuse based on the allowable heel is to deploy retrieval equipment in only those tanks where sludges/solids are to be transferred to consolidate waste. Table 7 lists some key milestones and projects that affect DST retrieval. These milestones in large part dictate what should be done. Actual removal of waste, other than evaporating water, will not be possible until the LLW pretreatment and LLW vitrification facilities are on line in the year 2005. Until then, DST operations will be mainly consolidation of solids and evaporation of water. This consolidation effort and creation of tank space will be done to meet the various milestones for SST retrieval.

**Table 7. Key Milestones and Projects
Affecting Double-Shell Tank Retrieval.**

Milestone	Date	Description	Inferred double-shell tank requirement
	09/30/1996	Project W-151, AZ-101 upgrade system.	This provides a DST with a proven set of 300 HP mixer pumps and a retrieval pump plus instrumentation and controls.
M-43-01	12/31/1996	Project W-030, Tank Farm Ventilation Upgrade	Provides upgraded ventilation for the AZ and AY farms.
M-43-07B	02/28/1998	Project W-028/058 Upgrade to the cross-site transfer line	Can retrieve the SY farm only if the cross-site upgrade is completed.
M-45-03A	10/31/1997	Initiate sluicing retrieval of C-106.	One or more DSTs must be ready to receive limited amounts of C-106 Waste.
M-45-03-T02	06/30/2002	Initiate final retrieval demonstration of C-106.	One or more DSTs must be ready to receive the all waste from C-106.
M-45-05-T01	12/31/2003	Initiate tank waste retrieval from <u>one</u> (not C-106) SST.	Additional DSTs must be available to receive SST waste.
M-45-05-T02	09/30/2004	Initiate tank waste retrieval from <u>two</u> additional SSTs.	Additional DSTs must be available to receive SST waste.
M-50-02	12/31/2004	Start hot operations of LLW Pretreatment facility to remove cesium and strontium.	Transfer of supernates begins. One or more DSTs must be available to receive Cs and Sr concentrates.
M-60-05	06/30/2005	Initiate hot operations of the LLW vitrification facility.	Begin full scale transfers of supernates to LLW pretreatment.
M-45-05-T03	12/30/2005	Initiate tank waste retrieval from <u>three</u> additional SSTs.	DSTs must be available to accept essentially full scale SST retrieval.
M-45-05-T04	12/30/2006	Initiate tank waste retrieval from <u>four</u> additional SSTs.	Full Scale operations of DSTs in support of SST retrieval.
M-45-05-T05	12/30/2007	Initiate tank waste retrieval from <u>five</u> additional SSTs.	Full Scale operations of DSTs in support of SST retrieval.
M-50-04	06/30/2008	Start Hot operations of HLW pretreatment facility.	Begin transfers of slurries to HLW pretreatment facility or perform enhanced sludge washing in select DSTs.
M-50-03	06/31/2009	Initiate Hot operations of the HLW Vitrification facility	Ramp up to full scale sludge retrieval from DSTs.

Because of the inability to transport solids from 200 West, initial solids retrieval operations will only be done in the east areas. Project W-151 and the related process test will provide a functional retrieval system in tank AZ-101. Therefore, the first activity should be to transfer sludges into Tank AZ-102. This consolidates the NCAW aging waste. The supernates from both tanks would be transferred to AY-102. Evaporation would then provide additional tank space in AY-102 for support of the retrieval of C-106. As the retrieval of C-106 progressed, then solids would be transferred to AZ-102 from the AY-102 receiver tank. A single mixer pump should be installed in AY-102 to support this activity if there is a time lag long enough for the C-106 solids to settle out. It may be possible to use a slurry transfer pump with a recirculation loop to keep the solids in suspension, thus eliminating the need for a mixer pump to mobilize the solids.

The new cross-site transfer line, project W-058, should be completed and fully operational early in 1998. The retrieval of west area tanks cannot be accomplished until the new transfer line is in place. The only tank requiring initial retrieval in west area is SY-102. The other DSTs, SY-101 and 103, should not be retrieved early as they contain difficult to retrieve complexed waste which is incompatible with other waste types and consolidation or retrieval of these tanks would result in a large net loss in available tank space. Retrieval equipment should be deployed in SY-102 with the solids transferred to AW-103 which is a compatible transfer. SY-102 would be then available for use as a receiver for the saltwell pumping and other west area SST retrieval activities. The sludge in SY-102 must be removed to the maximum extent possible to avoid contamination of other waste with TRU.

4.2.1.1 Initial Retrieval Strategy. The initial DST retrieval strategy based upon the heel after initial retrieval is as follows:

- Equipment for sludge mobilization preparatory to initial retrieval should be limited to a maximum of two mixer pumps, with no limits established for the allowable heel.
- Tanks containing complexed waste should not be retrieved until such time as the complexing agents have been destroyed or removed, or unless sampling and analysis have shown that a remaining heel contained only limited amount of complexed waste and would allow reuse for other than storing other complexed waste.
- Tanks containing aging waste should be consolidated, freeing up tank space for limited reuse.
- AW-103, AW-105, and SY-102 should be consolidated until a determination that the material is certifiable as TRU Waste.

- SY-102 sludges must be removed to the maximum extent possible, to avoid contamination of trans-shipped waste with TRU.
- When consolidating tanks, the waste from tanks with the least calculated or expected least heel should be the one mobilized and transferred.

4.2.1.2 Reuse Strategy. The DST reuse strategy based upon a remaining heel after initial retrieval is as follows:

- A tank containing a complexed waste heel can only be used to store other complexed waste until sampling and analysis shows that the amount of complexant in the heel will not adversely affect waste processing.
- A tank containing a TRU Waste heel (AW-103, AW-105, and SY-102) can be used for storage of any other waste except complexed waste.
- A tank containing a heel with materials that would affect the durability of the glass, e.g., a phosphate waste heel in AN-106, can be used for storage of any other waste except TRU waste and complexed waste.
- A tank containing an ageing waste heel can be used for storage of any other waste except TRU waste and complexed waste.
- A tank heel containing significant amounts of heat generating or fissile radionuclides will limit tank reuse only to the extent that the heel inventory could limit what or how much waste is added to the tank due to tank operational limits.
- A tank heel will not limit tank reuse within the context of past practice waste compatibility and safety.

4.2.2 Additional Studies and Analysis

The following paragraphs discuss technical issues that require resolution before final determination of allowable heel requirements for a specific tank. To resolve these issues, trade analysis, testing, and technical studies are required.

4.2.2.1 Transuranic Blending. Will blending of waste with remaining heels in tanks containing appreciable amounts of TRU waste (SY-102, AZ-101, AZ-102) cause problems. Historically these wastes have been segregated, however consolidation into one tank, probably AZ-102, will leave the remaining two available for reuse. Transfer of other waste into SY-102 and AZ-101 will mix the waste with the remaining heel.

4.2.2.2 Contamination of Waste by a Remaining Heel. Waste transferred into a tank containing a heel for subsequent re-mobilization and transfer to a third tank will be contaminated to some extent with the heel. The extent of this contamination is unknown. The expected extent of contamination needs to be known to determine the requirements for an allowable heel (e.g., if retrieval of AZ-101 leaves a heel that will not contaminate subsequent wastes, then the allowable heel limit could be quite liberal). Adversely, if this heel would freely mix, and this mixing is not acceptable, then the initial retrieval limits for the allowable heel would be much more conservative.

4.2.2.3 Segregation Requirements. The past practice segregation of tank wastes, Table 4, may no longer be valid. The actual segregation requirements must be addressed in line with consolidation of waste [separation of LLW (supernates and saltcake) and HLW and TRU (sludges)] for subsequent transfer into the LLW and HLW treatment facilities. This would address safety issues (criticality and chemical compatibility and chemical stability) and the requirements for LLW and HLW treatment.

This page intentionally left blank.

5.0 REFERENCES

- DOE Order 5820.2A, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C.
- Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and the U.S. Department of Energy, Olympia, Washington.
- Fowler, K. D., 1995, *Tank Farms Waste Transfer Compatibility Program*, WHC-SD-WM-OCD-015, Rev. 1, Westinghouse Hanford Company, Richland, Washington.
- Hanlon, B. M., 1994, *Tank Farm Surveillance and Waste Status Summary Report for October 1994*, WHC-EP-0182-79, Westinghouse Hanford Company, Richland, Washington.
- Lambert, S. L., and D. S. Kim, 1994, *Tank Waste Remediation System High-Level Waste Feed Processability Assessment Report*, WHC-SP-1143, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Shelton, L. W., 1995, *Chemical and Radionuclide Inventory For Single and Double-Shell Tanks*, Internal Memo to R. M. Orme, 75520-95-007 (August 8), Westinghouse Hanford Company, Richland, Washington.

This page intentionally left blank.

APPENDIX A

HANFORD SITE DOUBLE-SHELL TANK WASTE CONTENTS

The information presented in this appendix is derived from *Tank Farm Surveillance and Waste Status Summary Report for October 1994*, WHC-EP-0182-79 (Hanlon 1994). The data presented have not been independently verified for accuracy; however, they are appropriate for use in preliminary planning and analysis.

Table A-1. Hanford Site Double-Shell Tanks

Tank	Waste description
AN-102	CC - Concentrated Complexant Concentrated product from the evaporation of dilute complexed waste.
AN-107	
SY-101	
SY-103	
AY-101	DC - Dilute Complexed Waste Characterized by a high content of organic carbon including organic complexants: Ethylenetiaminetetra-acetic acid (ETDA), citric acid, and hydroxyethyl-ethylenediaminetriacetic acid (HEDTA), being the major complexants used. Main sources of DC waste in the DST system are saltwell liquid inventory (from SSTs).
AW-103	DN/PD - Dilute Non-Complexed Waste Containing PUREX TRU Solids. (DN/PD is also referred to as neutralized cladding removal waste [NCRW].)
AW-105	
SY-102	DN/PT - Dilute Non-Complexed Waste Containing PFP TRU Solids
AZ-101	NCAW (Aging) - Neutralized Current Acid Waste High Level, first cycle solvent extraction waste from the PUREX plant.
AZ-102	

Table A-2. Hanford Site Double-Shell Tank.

	Waste description
AN-106	<p>CP - Concentrated Phosphate Waste</p> <p>Waste originating from the decontamination of the N Reactor in the 100N area. Concentration of this waste produces concentrated phosphate waste.</p>
AN-103	<p>DSS - Double Shell Slurry</p> <p>Waste that exceeds the sodium aluminate saturation boundary in the evaporator without exceeding receiver tank composition limits. For reporting purposes, DSS is considered a solid.</p>
AN-104	<p>DSSF- Double Shell Slurry Feed</p> <p>Waste concentrated just before reaching the sodium aluminate saturation boundary (of 6.5 molar hydroxide) in the evaporator without exceeding receiver tank composition limits. This form is not as concentrated as DSS.</p>
AN-105	
AP-105	
AW-101	

WHC-SD-WM-TA-162
Revision 0

Table A-3. Hanford Site Double-Shell Tank.

Tank	Waste description
AN-101	DN - Dilute Non-Complexed Waste Low activity liquid waste originating from T and S Plants, the 300 and 400 areas, PUREX facility (declading supernatant and miscellaneous wastes), 100N Area (sulfate waste), B Plant, saltwells, and PFP (supernate).
AP-101	
AP-102	
AP-103	
AP-104	
AP-106	
AP-107	
AP-108	
AW-102	
AW-104	
AW-106	
AY-102	

Table A-4. Hanford Site Double-Shell Tank Pumpable Liquids

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)
AN-101	DN	843	297	843
AN-102	CC	1084	56	995
AN-103	DSS	955	185	18
AN-104	DSSF	1063	77	802
AN-105	DSSF	1128	12	1128
AN-106	CP	422	718	405
AN-107	CC	1060	80	926
AP-101	DN	149	991	149
AP-102	DN	1102	38	1102
AP-103	DN	27	1113	27
AP-104	DN	20	1120	20
AP-105	DSSF	820	320	820
AP-106	DN	1127	13	1127
AP-107	DN	163	977	163
AP-108	DN	29	1111	29
AW-101	DSSF	1125	15	1041
AW-102	DN	882	258	881
AW-103	DN/PD	514	626	166
AW-104	DN	1123	17	860
AW-105	DN/PD	1075	65	785
AW-106	DN	604	536	328
AY-101	DC	863	117	780
AY-102	DN	789	191	757
AZ-101	NCAW	960	20	925
AZ-102	NCAW	950	30	855
SY-101	CC	1098	42	239

WHC-SD-WM-TA-162
Revision 0

Table A-4. Hanford Site Double-Shell Tank Pumpable Liquids

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)
SY-102	DN/PT	762	378	691
SY-103	CC	749	391	172

Table A-5. Hanford Site Double-Shell Tank Sludge.

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Sludge (Kgal)
AN-101	DN	843	297	0
AN-102	CC	1084	56	89
AN-103	DSS	955	185	0
AN-104	DSSF	1063	77	264
AN-105	DSSF	1128	12	0
AN-106	CP	422	718	17
AN-107	CC	1060	80	134
AP-101	DN	149	991	0
AP-102	DN	1102	38	0
AP-103	DN	27	1113	0
AP-104	DN	20	1120	0
AP-105	DSSF	820	320	0
AP-106	DN	1127	13	0
AP-107	DN	163	977	0
AP-108	DN	29	1111	0
AW-101	DSSF	1125	15	84
AW-102	DN	882	258	1
AW-103	DN/PD	514	626	363
AW-104	DN	1123	17	179
AW-105	DN/PD	1075	65	267
AW-106	DN	604	536	211
AY-101	DC	863	117	83
AY-102	DN	789	191	32
AZ-101	NCAW	960	20	35
AZ-102	NCAW	950	30	95
SY-101	CC	1098	42	0

WHC-SD-WM-TA-162
Revision 0

Table A-5. Hanford Site Double-Shell Tank Sludge.

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Sludge (Kgal)
SY-102	DN/PT	762	378	71
SY-103	CC	749	391	0

Table A-6. Hanford Site Double-Shell Tank Saltcake.

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Saltcake (Kgal)
AN-101	DN	843	297	0
AN-102	CC	1084	56	0
AN-103	DSS	955	185	0
AN-104	DSSF	1063	77	0
AN-105	DSSF	1128	12	0
AN-106	CP	422	718	0
AN-107	CC	1060	80	0
AP-101	DN	149	991	0
AP-102	DN	1102	38	0
AP-103	DN	27	1113	0
AP-104	DN	20	1120	0
AP-105	DSSF	820	320	0
AP-106	DN	1127	13	0
AP-107	DN	163	977	0
AP-108	DN	29	1111	0
AW-101	DSSF	1125	15	0
AW-102	DN	882	258	0
AW-103	DN/PD	514	626	0
AW-104	DN	1123	17	111
AW-105	DN/PD	1075	65	0
AW-106	DN	604	536	85
AY-101	DC	863	117	0
AY-102	DN	789	191	0
AZ-101	NCAW	960	20	0
AZ-102	NCAW	950	30	0
SY-101	CC	1098	42	560

Table A-6. Hanford Site Double-Shell Tank Saltcake.

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Saltcake (Kgal)
SY-102	DN/PT	762	378	0
SY-103	CC	749	391	4

Table A-7. Hanford Site Double-Shell Tank Watchlist Tanks.

Tank	Waste type	Watchlist
AN-103	DSS	Flammable/H2
AN-104	DSSF	Flammable/H2
AN-105	DSSF	Flammable/H2
AW-101	DSSF	Flammable/H2
SY-101	CC	Flammable/H2
SY-103	CC	Flammable/H2

Table A-8. Hanford Site Double-Shell Tank Waste Summary.

AN TANK FARM

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
AN-101	DN	843	297	843	0
AN-102	CC	1084	56	995	89
AN-103	DSS	955	185	18	0
AN-104	DSSF	1063	77	802	264
AN-105	DSSF	1128	12	1128	0
AN-106	CP	422	718	405	17
AN-107	CC	1060	80	926	134

Table A-9. Hanford Site Double-Shell Tank Waste Summary.

AP TANK FARM

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
AP-101	DN	149	991	149	0
AP-102	DN	1102	38	1102	0
AP-103	DN	27	1113	27	0
AP-104	DN	20	1120	20	0
AP-105	DSSF	820	320	820	0
AP-106	DN	1127	13	1127	0
AP-107	DN	163	977	163	0
AP-108	DN	29	1111	29	0

Table A-10. Hanford Site Double-Shell Tank Waste Summary.

AW TANK FARM

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
AW-101	DSSF	1125	15	1041	84
AW-102	DN	882	258	881	1
AW-103	DN/PD	514	626	166	363
AW-104	DN	1123	17	860	179
AW-105	DN/PD	1075	65	785	267
AW-106	DN	604	536	328	211

Table A-11. Hanford Site Double-Shell Tank Waste Summary.

AY TANK FARM

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
AY-101	DC	863	117	780	83
AY-102	DN	789	191	757	32

Table A-12. Hanford Site Double-Shell Tank Waste Summary.

AZ TANK FARM

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
AZ-101	NCAW	960	20	925	35
AZ-102	NCAW	950	30	855	95

Table A-13. Hanford Site Double-Shell Tank Waste Summary.

SY Tank Farm

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
SY-101	CC	1098	42	239	0
SY-102	DN/PT	762	378	691	71
SY-103	CC	749	391	172	0

Table A-14. Hanford Site Double-Shell Tank Waste Summary - Easiest to Hardest to Retrieve.

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
AN-101	DN	843	297	843	0
AP-101	DN	149	991	149	0
AP-102	DN	1102	38	1102	0
AP-103	DN	27	1113	27	0
AP-104	DN	20	1120	20	0
AP-105	DSSF	820	320	820	0
AP-106	DN	1127	13	1127	0
AP-107	DN	163	977	163	0
AP-108	DN	29	1111	29	0
AN-107	CC	1060	80	926	134
AN-105	DSSF	1128	12	1128	0
AN-106	CP	422	718	405	17
AZ-101	NCAW	960	20	925	35
AY-101	DC	863	117	780	83
SY-102	DN/PT	762	378	691	71
AZ-102	NCAW	950	30	855	95
AW-102	DN	882	258	881	1
AW-101	DSSF	1125	15	1041	84
AN-102	CC	1084	56	995	89
AY-102	DN	789	191	757	32
AN-104	DSSF	1063	77	802	264
SY-101	CC	1098	42	239	0
SY-103	CC	749	391	172	0
AW-104	DN	1123	17	860	179
AN-103	DSS	955	185	18	0

Table A-14. Hanford Site Double-Shell Tank Waste Summary - Easiest to Hardest to Retrieve.

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
AW-105	DN/PD	1075	65	785	267
AW-103	DN/PD	514	626	166	363
AW-106	DN	604	536	328	211

WHC-SD-WM-TA-162
Revision 0

Table A-15. Hanford Site Double-Shell Tank Waste Summary by Waste Type.

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
AN-101	DN	843	297	843	0
AP-101	DN	149	991	149	0
AP-102	DN	1102	38	1102	0
AP-103	DN	27	1113	27	0
AP-104	DN	20	1120	20	0
AP-106	DN	1127	13	1127	0
AP-107	DN	163	977	163	0
AP-108	DN	29	1111	29	0
AW-102	DN	882	258	881	1
AW-104	DN	1123	17	860	179
AW-106	DN	604	536	328	211
AY-102	DN	789	191	757	32
AN-104	DSSF	1063	77	802	264
AN-105	DSSF	1128	12	1128	0
AP-105	DSSF	820	320	820	0
AW-101	DSSF	1125	15	1041	84
AN-103	DSS	955	185	18	0
AW-103	DN/PD	514	626	166	363
AW-105	DN/PD	1075	65	785	267
SY-102	DN/PT	762	378	691	71
AZ-101	NCAW	960	20	925	35
AZ-102	NCAW	950	30	855	95
AN-102	CC	1084	56	995	89
AN-107	CC	1060	80	926	134
SY-101	CC	1098	42	239	0
SY-103	CC	749	391	172	0

Table A-15. Hanford Site Double-Shell Tank Waste Summary by Waste Type.

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
AN-106	CP	422	718	405	17
AY-101	DC	863	117	780	83

WHC-SD-WM-TA-162
Revision 0

Table A-16. Hanford Site Double-Shell Tank Waste Summary.

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
AN-101	DN	843	297	843	0
AN-102	CC	1084	56	995	89
AN-103	DSS	955	185	18	0
AN-104	DSSF	1063	77	802	264
AN-105	DSSF	1128	12	1128	0
AN-106	CP	422	718	405	17
AN-107	CC	1060	80	926	134
AP-101	DN	149	991	149	0
AP-102	DN	1102	38	1102	0
AP-103	DN	27	1113	27	0
AP-104	DN	20	1120	20	0
AP-105	DSSF	820	320	820	0
AP-106	DN	1127	13	1127	0
AP-107	DN	163	977	163	0
AP-108	DN	29	1111	29	0
AW-101	DSSF	1125	15	1041	84
AW-102	DN	882	258	881	1
AW-103	DN/PD	514	626	166	363
AW-104	DN	1123	17	860	179
AW-105	DN/PD	1075	65	785	267
AW-106	DN	604	536	328	211
AY-101	DC	863	117	780	83
AY-102	DN	789	191	757	32
AZ-101	NCAW	960	20	925	35
AZ-102	NCAW	950	30	855	95
SY-101	CC	1098	42	239	0

Table A-16. Hanford Site Double-Shell Tank Waste Summary.

Tank	Waste type	Total waste (Kgal)	Available space (Kgal)	Pumpable liquid (Kgal)	Sludge (Kgal)
SY-102	DN/PT	762	378	691	71
SY-103	CC	749	391	172	

THIS PAGE INTENTIONALLY
LEFT BLANK