WASTE REMOVAL,

BALANCE OF PROGRAM,

SYSTEMS ENGINEERING EVALUATION

REPORT (U)

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ADC / RO: Paul D. d'Entremont Date: 9/18/03

Title: Sr. Fellow Engineer

OPERATIONS ORGANIZATION: Liquid Waste Disposition Projects

PLANT OR SITE LOCATION: F and H Area

Author: D. A. Zupon

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Westinghouse Savannah River Company LLC
Savannah River Site
Aiken, SC 29808

SRS savannah river site ™

DISCLAIMER

TEAM MEMBER APPROVAL

Approved by: Neil R Davis — 9/17/03
N. R. Davis, Project Owner — Date

Approved by: Noel J. Chapman — 9/18/03
N. F, Chapman, Engineering — Date

Approved by: M E Harrell — 9/18/03
M. E. Harrell, Operations — Date

Approved by: G W Gentry — 9/17/03
G. W. Gentry, Maintenance — Date

Approved by: Stephen A. Smith — 9/17/03
S. A. Smith, WSMS — Date

Approved by: D. A. Zupon — 9.17.2003
D. A. Zupon, Systems Engineering — Date

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ABSTRACT

The Savannah River Site has 51 high-level waste storage tanks. These tanks range in capacity from 750,000 to 1,300,000 gallons. All of the waste contents in the tanks must eventually be removed and processed for final disposition. About 3,400,000 gallons of the waste is in the form of a thick sludge. Removal of this waste typically requires a project expenditure of $25,000,000 to $30,000,000 to provide the necessary waste removal equipment. There has been significant pressure to reduce the cost of waste removal as part of a DOE Complex-wide initiative to reduce costs and accelerate waste disposition schedules. With this as a driver, SRS initiated a formal Systems Engineering Evaluation (SEE) to identify new technologies to support the DOE initiatives. The report contained herein documents the results of the SEE.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ACRONYMS

AB	Authorization Basis
AHP	Analytic Hierarchy Process
ALARA	As Low As Reasonably Achievable
DCS	Distributed Control System
DOE	U. S. Department of Energy
DOE-SR	DOE-Savannah River
DWPF	Defense Waste Processing Facility
EMM	Electro Mechanical Manipulator
EPA	Environmental Protection Agency
ESP	Extended Sludge Processing
FFA	Federal Facilities Agreement
FY	Fiscal Year (October through September)
HDB	H-Area Diversion Box
HLW	High Level Waste
HLWMD	High Level Waste Management Division
HLW-SP	High Level Waste – System Plan
PE&CD	Projects, Engineering & Construction Division
SAR	Safety Analysis Report
SB2	Sludge Batch 2
SB3	Sludge Batch 3
SCDHEC	South Carolina Department of Health and Environmental Control
SE	Systems Engineering
SME	Subject Matter Expert(s)
SRS	Savannah River Site
SRTC	Savannah River Technology Center
TF	Tank Farm
VFD	Variable Frequency Drive
VHS	Vulnerability (Risk) Handling Strategy
WAC	Waste Acceptance Criteria
WCS	Waste Characterization System
WSRC	Westinghouse Savannah River Company

LIST OF DEFINITIONS

Baseline Technology	The waste removal technology is identified in project documentation (e.g., Functional Performance Requirements, Functional Design Criteria) which includes four standard slurry pumps and one telescoping transfer pump for sludge removal and three standard slurry pumps and one telescoping transfer jet for salt removal.
Bulk Waste Removal	Is defined as removing the first 99% of the original volume of waste which typically means leaving no more than 10,000 gallons of waste solids (saltcake, sludge, zeolite, other insolubles) in the tank at the completion of bulk waste removal. This operation is typically done with slurry pumps.
Decision Makers	The HLW Business Team consisting of the Level 1 and 2 Managers in the HLW Division and matrixed support managers.
Enhancement	Alternatives that were screened out because they did not perform one or more functions were reviewed to determine if the alternative could be used to improve the performance of other alternatives. If yes, then the screened out alternative was added to the enhancement list.
Heel Removal	*The purpose of heel removal is to remove as much of the remaining waste as* required to enable the tank to pass a Performance Assessment indicating that the tank is ready to close. It is assumed that the residual heel in most tanks must be between 100 and 1,000 gallons.
Idea	A concept which, if implemented, would satisfy one or more functions.
Program Expectations	The following are the team's understanding of HLW program expectations for the waste removal program: - Reduce the baseline cost of waste removal project work by at least 30%; - Ensure, to the extent possible with current knowledge, that waste removal will support known site missions such as Am/Cm, MOX, etc.; - Meet FFA and HLWSP Rev 12 schedules; - Perform all steps necessary to get tanks ready for closure including bulk waste removal, heel removal, annulus cleaning, and spray washing recognizing that some tanks may need to be cleaned to the extent that the residual sludge is less than 100 gallons.
Spray Washing	Washing the inside of a tank with water to rinse off residual waste on tank walls, cooling coils, etc. This was done in the past by pumping heated inhibited water from a 10,000 gallon spray wash skid through three rotary spray nozzles.
Stakeholders	Individuals or organizations potentially impacted by the recommended alternative(s).
Strategy	A combination of ideas which, if implemented, would satisfy all functions.

Subject Matter Experts	Individuals recognized by the team as experts in a particular field or fields.
Validation	Provides the opportunity for stakeholder input and feedback at key points during the execution of the Systems Engineering Evaluation process.
Waste Removal	The preparation and transfer of high level waste (e.g., sludge, salt, supernate, zeolite) from a waste tank to another waste tank. Waste removal may consist of "bulk waste removal" and "heel removal".

1.0 EXECUTIVE SUMMARY

1.1 History

The Savannah River Site started radioactive operations in the early 1950's with a complement of 12 high level waste tanks. The waste sent to these tanks originated from fuel assemblies dissolved in acid and then neutralized with caustic to preclude corrosion of the carbon steel fresh waste receipt tanks. Dissolved metals precipitate in the fresh waste receipt tanks as a thick sludge. The supernatant liquid is sent to an evaporator for volume reduction. The bottoms from the evaporation process are cooled in a separate waste tank where sodium salts precipitate as a saltcake. The remaining liquid is a heavy caustic solution referred to as concentrated supernate. Over time, the tanks filled with saltcake and concentrated supernate. Further volume reduction with the SRS evaporators was not possible.

Sludge was often removed from the fresh waste receipt tanks (e.g., Tanks 1, 2, 3, 9, 10, 11, etc.) during the 1960's to provide more space for saltcake from the evaporators. Sludge removal was accomplished using high pressure water lances and centrifugal transfer pumps. While this process was very effective, it used about six parts water per one part of sludge removed. A subsequent sludge removal demonstration in Tank 16 in the late 1970's using long shaft slurry pumps was equally effective and used less water (about three parts water per one part sludge removed). Long shaft slurry pumps were improved over the next 30 years and were used to remove sludge from Tanks 15, 17, 18, 21 and 22. These pumps, three or four per tank depending on the physical characteristics of the tank, were the accepted baseline technology at the start of this SEE.

Salt removal has a similar history to sludge removal with several different techniques successfully deployed since the 1960's. Some of the techniques, like density gradient, involved no agitation or other moving parts inside the tank. Other techniques such as sluicing or slurrying with pumps were more equipment intensive. In the early 1980's, a demonstration was conducted to determine the preferred technique for salt removal in two side-by-side tanks (Tanks 19 and 20). Density gradient was deployed in Tank 20 while Tank 19 used two long shaft slurry pumps originally developed for sludge removal. The slurry pumps dissolved the salt much more quickly and efficiently (in terms of water usage) than density gradient. At that time, slurry pumps were thought to be only slightly more expensive than density gradient thus slurry pumps were selected as the baseline technology for salt removal. It was also thought that there would be a great economy of scale by using similar equipment for both salt and sludge removal. Slurry pumps were used for salt removal in Tanks 19, 20 and 24.

Over time, the cost of slurry pumps has steadily increased due to a number of factors including:

- Improved shaft and column alignment to reduce vibration;
- Installation of secondary containment to prevent release of contamination;
- Use of mechanical seals to reduce unwanted water leakage through the seals into the tank;
- Addition of safety class interlocks to control hydrogen release during slurrying;
- Upgrading support platforms to mitigate seismic concerns; and
- Upgrading cable trays and support poles to resist seismic events

The original waste removal line item project included scope to install waste removal, water washing and annulus cleaning equipment on 24 tanks at an estimated cost of $88,000,000 or about $4,000,000 per tank in 1981 dollars. That cost is now over $25,000,000 per tank hence the driver for this SEE.

1.2 Team Mission Statement

Redefine the Waste Removal Project technical baseline to achieve HLW Program expectations.

1.2.1 Bases

- The projected funding for waste removal in HLW System Plan Revision 13 (Ref. 1) is less than the baseline cost for the waste removal project (Ref. 5). The projected funding shortfall is approximately 30%. The Waste Removal Program has been identified as a probable source of cost reduction that will enable the HLW division to achieve the Stretch and/or Super-Stretch Budget Case.

- Retrofitting a waste tank with the baseline waste removal equipment requires 46 months (6 months for walk-downs to establish initial conditions, 12 months for design, 27 months for construction and testing, and 1 month for a readiness review). In some cases of the HLW System Plan Revision 13, adequate funding is not available until three years before the required closure date (Ref. 1 and 6). A simpler, cheaper waste removal technology would increase the chances of the closure date being met.

- The baseline technology will not clean the tank sufficiently to enable closing (Ref. 7 and 8). Slurry pumps are assumed to remove 90% of the insoluble solids. Beyond this point, the water to solids ratio becomes excessive. Different heel removal technologies have been demonstrated on Tanks 16, 17 and 20. While the provision for conducting demonstrations is included in the project baseline, a technical baseline for heel removal has not been established for the remaining tanks.

- The project baseline does not include annulus cleaning (Ref. 7). There are several tanks that are expected to require annulus cleaning prior to closure based on Tank 16 samples and modeling (Ref. 10).

- The installation of waste removal equipment often requires the removal of contaminated large equipment. This is included in the project baseline, however, the current estimate is based on obsolete work methods and controls. Current requirements specify more decontamination, flushing, waste characterization, packaging and shipping controls that have increased the cost (Ref. 10).

- The project baseline assumes that the tank farm infrastructure is maintained sufficiently to support waste removal activities (Ref. 7). This is often not the case resulting in the need to add scope to the project to refurbish or replace steam services, instrument/plant air, breathing air, etc.

- The project baseline and cost estimate was developed per the Authorization Basis that was in effect during 1996 (Ref. 7). Since that time, the Tank Farm has instituted TSRs and is in the process of upgrading the SAR. This has resulted in the need to increase the functional classification of instruments, provide installed spare instruments and the backfitting of other instruments and equipment as was experienced on Tank 19 (Ref. 11 and 12).

1.3 Problem Definition

The current Waste Removal Project baseline does not support HLW Program expectations.

1.4 Systems Engineering Methodology

The System Engineering approach was determined to be the most appropriate method for accomplishing the assigned task. The BOP SEE Team utilized the methodology and tools per the SRS Site Program (Ref. 2). Modifications to the process and outputs were made where appropriate. (Section 4.0)

Implementation of the Systems Engineering (SE) approach resulted in three phases of activities:

- Identification
- Evaluation
- Selection

The identification phase consisted of evaluating the problem definition and identifying key missions and assumptions. Screening (Go/No Go) criteria (Appendix C) and weighted selection criteria (Appendix B) were developed and accepted. Alternative problem solutions were then solicited from Subject Matter Experts (SME), Stakeholders, and other SRS employees. The issues were further developed by the BOP SEE Team and combined to eliminate duplication.

The evaluation phase first focused on assessing the *alternatives* for key mission impacts and screening the *alternatives* against the Go/No Go screening criteria (Appendix C) and combining like alternatives. This resulted in the idea pro-forma sheets found in Appendix F. The evaluation phase then focused on assessing the the idea pro-forma sheets using the analytical hierarchy process defined in Appendix B. The best overall benefit to the facility considering risk reduction, cost, schedule, and other factors is documented in Appendix I. These recommendations are for consideration by facility management in planning further efforts for the facility to reduce overall risk. A number of the strategies are cost and manpower intensive and consideration must be given to other priorities and budgets for the facility that was not part of development of the recommendations in this report.

1.5 Dissenting Opinions

None noted.

1.6 BOP SEE Team Members and External Input

BOP SEE Team members were chosen to provide expertise in Plant Support, Engineering, Process Engineering, Operations, Programs, Maintenance, System Engineering, and HLW Engineering.

1.7 Alternative Idea Management

Subject Matter Experts and stakeholders participated at the request of the BOP SEE Team, to help identify and evaluate alternatives to support the Team's mission.

1.8 Cost and Schedule

Order of magnitude estimates were established based on previous experience, or in comparison to other facilities. More detailed cost and schedule estimates will be developed as scope is better defined for each selected alternative.

1.9 Recommendations

The Team recommends the following methods based on the analysis of 115 conceivable alternatives.

1.9.1 Bulk Sludge Preparation for Transfer

For Bulk Sludge Preparation for Transfer the Team recommends using one or more floor mounted canned submersible pumps on rotating (or oscillating) masts. The recommended vendor is Curtiss-Wright Electro-Mechanical Corporation based on their long history of manufacturing highly reliable pumps for use in the Nuclear Industry.

1.9.2 Bulk Sludge Waste Transfer

For Bulk Sludge Waste Transfer the Team recommends using a sump pump mounted to a mast. This configuration achieved demonstrated reliability for 47 transfers of 12 million gallons of waste at SRS. This method provides multi-application use for Sludge/Salt Transfer and de-watering.

1.9.3 Bulk Salt Preparation for Transfer

For Salt Preparation for Transfer the Team recommends using one or more floor mounted canned submersible pumps on rotating (or oscillating) masts. This method provides multi-application use for Sludge and Salt Preparation for Transfer.

1.9.4 Bulk Salt Waste Transfer

For Salt Waste Transfer the Team recommends using a sump pump mounted to a mast. Method provides multi-application use for Sludge/Salt Transfer and de-watering.

1.9.5 Heel Preparation for Transfer

For Heel Preparation for Transfer the Team recommends using oxalic acid cleaning at 4 to 8-wt %. This method was used in Tank 16 using three batches of heated 4-wt % oxalic acid.

1.9.6 Heel Waste Transfer

For Heel Waste Transfer the Team recommends enhancing the bulk waste transfer pump to enable it to pump the tank liquid level down to approximately one-inch. If this proves to be impractical, then the Team recommends using an air driven submersible pump. Wilden is a vendor that has been used and is inexpensive.

1.9.7 Spray Wash Tank

For Spray Washing the Tank the Team recommends using a simple directional spray nozzle. This method uses a commercial water nozzle on a mast and is under development by HLW maintenance.

1.9.8 Annulus Preparation for Transfer

For Annulus Preparation for Transfer the Team recommends sampling, then based on expected results, take no additional actions. For tanks that can't meet closure requirements without annulus cleaning, the Team recommends dissolving the waste with water that is re-circulated with small Flygt mixers. If the waste is insoluble in water, then the Team recommends acid dissolution with oxalic acid.

1.9.9 Annulus Waste Transfer

For Annulus Waste Transfer the Team recommends continuing to use the present method of transfer jets and gang valves.

1.10 Deliverables

This report satisfies the final deliverable of the BOP SEE Team.

2.0 INTRODUCTION TO AND PURPOSE OF BOP SEE

2.1 Problem

The BOP SEE Team was formed to recommend new methods that would support HLW Program expectations by preparing targeted F and H HLW Tanks for closure at a cost effective accelerated rate. DOE Environmental Management wants SRS to take a more aggressive approach to accelerate HLW Tank clean up to reduce risks and liabilities.

2.2 BOP SEE Team

Table 2-1 Lists the BOP SEE Core Team members. Some Team members did not continuously support the BOP SEE due to other assignments.

Table 2-1 BOP SEE Core Team

NAME	AREA OF CONTRIBUTION
Davis, Neil	Waste Removal Program Manager
Brown, Kenneth	Project Management
Chapman, Noel	CST Engineering
Delley, Alexcia	Systems Engineering
Donahue, Troy	Project Management
Gentry, George	Maintenance
Harrell, Mike	Waste Removal Operations
Parnell, Ron	Design Engineering
Saldivar, Eloy	Design Authority
Smith, Steve	Westinghouse Safety Management
Zupon, Donald	Systems Engineering

Table 2-2 lists the BOP SEE management overview personnel. Selected Level 2 and 3 managers in the HLW division and supporting divisions were asked to periodically review progress and provide feedback to this System Engineering Evaluation process.

Table 2-2 Management Overview

NAME	AREA OF CONTRIBUTION
Abell, Gary	PE&CD Design Engineering
Clark, Wyatt	CST Facility Manager
Davis, Will	CST Facility Manager
Dickert, Ginger	CST Area Manager
Handfinger, Harvey	HLW Maintenance
Johnson, Mike	CST Area Manager
Lex, Tom	HLW Engineering
Miller, Marshall	CST Engineering
Pair, Charles	PE&CD Construction
Schuetz, Phil	HLW Projects
Tamosaitis, Walt	SRTC

2.4 Subject Matter Experts (SME)

The BOP SEE Team utilized various SME in the process. These individuals provided technical, project management, operation, and regulatory expertise, along with suggestions for alternative identification and evaluation. The following were invited to participate in idea brainstorming sessions.

Table 2-3 Subject Matter Experts

NAME	AREA OF CONTRIBUTION
Dennis Conrad	HLW Engineering
Gene Dixon	HLW Engineering
Ivan Lewis	HLW Engineering
Dave Martin	HLW Engineering
Vince LeDonne	HLW Engineering
Steve Tibrea	HLW Engineering
Marshall Miller	HLW Engineering
Bob Leishear	HLW Engineering
Paul d'Entremont	HLW Engineering
Terry Ortner	HLW Engineering

NAME	AREA OF CONTRIBUTION
Brannen Adkins	HLW Engineering
Rahn Ross	HLW Engineering
Kim Hauer	HLW Maintenance
Danny Blair	HLW Maintenance
Robert Wilson	HLW Maintenance
John McCullogh	HLW Maintenance
Joe Cato	HLW Maintenance
Mark Mahoney	HLW Operations
Jim Herbert	HLW Operations
Mike Green	HLW Operations
Bill Dixon	HLW Operations
David Hobbs	SRTC
Walt Tamosaitis	SRTC
Mike Poirier	SRTC
Bill Van-Pelt	SRTC
Tom Nance	SRTC
Mike Augeri	SRTC
Med Allen	SRTC
Dave Stefanko	SRTC
Tom Crouse	PE&CD
Cliff Boasso	PE&CD
Jim Menghi	PE&CD
Paul Shearer	PE&CD
Ed Howard	PE&CD
Gary Abell	PE&CD
Jean Baladi	PE&CD
Lee Carey	PE&CD
P. J. Bhatt	PE&CD
John Wood	WSMS
Flygt	Vendor

NAME	AREA OF CONTRIBUTION
Carl Enderlin	Tank Focus Area
Barry Burks (Oak Ridge)	Tank Focus Area
John Fazio (West Valley)	Contractor
Curtiss-Wright EMD	Vendor
Lawrence Pumps, Inc	Vendor
Pete Gibbons	Tank Focus Area
Mike French	Citizens Advisory Board
Lee Poe	Citizens Advisory Board
Tom Gutmann	DOE
Cavanaugh Mims	DOE

2.5 Evaluation Meetings

The primary method chosen to perform the WR BOP SEE was to hold meetings focused on functions performed for tank closure. The Team brainstormed on potential alternatives for closing tanks. Alternative criteria were evaluated as delineated in Attachment D. Team member participation varied over the two year term of the project.

Table 2-4 BOP SEE Team Meeting Dates

2001		2002	
Month	**Day**	**Month**	**Day**
March	22, 28	January	9, 16, 17,23, 24, 30
April	11, 18, 25	February	6, 13, 20
May	2, 9, 16, 23, 30	March	6, 13, 27
June	6, 13, 20, 27	April	3, 10, 17, 24
July	11, 18, 25	May	8, 15, 22, 23, 29
August	1, 15	June	5, 12, 19
October	24		
November	7, 14, 28		
December	19		

2.6 Key Assumptions

2.6.1 Funding

The Waste Removal Program will receive the required funding (TEC, OPC and Operating Expense) to complete activities per the schedule in HLW System Plan, Revision 12.

Basis - The FFA Plan and Schedule for closure of old-style tanks and the Site Treatment Plan requirement to have all HLW vitrified by FY28 will be sufficient priority at the Site level to ensure adequate funding for this task.

2.6.2 Project Baseline

It is possible to revise the existing baseline to accommodate the recommended technology.

2.6.3 FFA Tank Closure Dates

The existing closure dates are non-negotiable.

Basis - numerous interactions with SCDHEC indicate that re-negotiation is unlikely.

2.6.4 Authorization Basis

The AB for waste removal and other tank farm activities will remain essentially the same throughout the performance of this Systems Engineering Evaluation.

Basis - the AB was revised in FY99, current efforts are in progress to streamline the requirements as well as to develop a new AB that is compliant with 10CFR830.

2.6.5 Regulatory Requirements

The Tank Closure EIS Record of Decision, the NRDC lawsuit, and the NRC Waste Incidental to Reprocessing rulings will allow closure of future waste tanks per the precedent set by Tanks 17 and 20.

Basis - resolution of each item is ongoing.

2.6.6 Sludge Composition

The sludge in the remaining waste tanks will be similar in physical characteristics (shear stress, particle size, etc.) to the sludge that has been removed in the past.

Basis – there is a significant quantity of sludge in twenty-three tanks, seventeen of those tanks have been sampled representing about 95% of all sludge. Also, Tank 8 contained sludge that was kept in a dry state for about 15 years. It was rewet and slurried similar to other sludge.

2.6.7 Riser Availability

All risers are assumed to be available for equipment insertion including risers that may contain other equipment.

Basis - failed or obsolete equipment has been removed on other tanks, needed equipment has been relocated when needed.

2.6.8 New Risers

New risers with a diameter greater than 12 inches cannot be installed in Type I - III tanks.

Basis – there are horizontal and vertical cooling coils underneath most of the tank, there are embedded conduits and service lines in the tank tops, and the structural integrity of the tank top could be jeopardized by cutting through the rebar.

2.6.9 Tank Access

All existing piping penetrations into and out of a tank can be used. Also, new penetrations can be installed.

Basis - existing penetrations have been reused on other tanks, new penetrations have been installed into diversion boxes which are similar in construction to waste tanks, above grade piping can be used if needed.

2.6.10 Zeolite

The zeolite present in Tanks 18, 19, 24, 27 and 42 can be prepared for removal either with slurry pumps or a high pressure spray device.

Basis- a) The zeolite in Tanks 19 and 24 was in a consolidated mound that was not disturbed by slurry pump or Flygt mixer operations, b) The zeolite in Tank 19 was broken up with a high pressure vendor supplied "hydrolance", c) An oxalic acid dissolution demonstration conducted in Tank 24 dissolved about 1/3 of the zeolite.

2.6.11 Aluminum Dissolution

Will not be part of the HLW flowsheet, aluminum in sludge will be vitrified.

Basis – HLW System Plan, Revision 12 does not acknowledge this process step due to the uncertainty that the aluminum can be dissolved with the baseline technology or that it is cost effective to do so.

2.6.12 Tank Controls

Non-compliance with existing tank controls may be acceptable during waste removal activities on tanks to be closed.

Basis – the current safety strategy being developed for Tank 18 is based upon relaxing temperature and other controls due to the short duration of the waste removal task and the fact that the tank will soon be closed.

2.6.13 Tank Cleaning

Residual sludge must be less than 100 gallons for HHW tanks and 1,000 gallons for LHW tanks.

Basis – these values were used in the F Tank Farm Performance Assessment and resulted in a beta-gamma dose of 1.9 mrem/yr at the point of compliance vs a Drinking Water Standard of 4 mrem/yr.

2.6.14 Waste Removal from Leaking Tanks

No new function will be required to remove waste from tanks with a leakage history.

Bases:

1. The leakage rate of waste from the primary tank to the secondary, or vice-versa, will be 4 gpm or less.

   Basis: the maximum leak rate observed on Tank 16 with over 350 leak sites was 4 gpm.

2. Leakage rates can be reduced by reducing the liquid level above the leak sites.

   Basis: this was observed on Tank 16. Leak rates were reduced to zero when the static head was reduced to 147 inches or less.

3. Leakage rates can be reduced by controlling the supernate chemistry.

   Basis: additional NaOH and NaNO2 can be used in the slurry media to promote self-sealing of leak sites. This has been observed on all leaking tanks.

4. Leakage rates can be reduced by operating the annulus ventilation system.

   Basis: the leaks in Tank 16 were self sealing when the annulus ventilation system was operating. Leaks became active only after a prolonged shutdown of the ventilation due to release of contamination from the annulus (the annulus was maintained at positive pressure relative to the atmosphere).

5. Small, controlled leakage to the annulus during waste removal will be acceptable to the regulators and the public.

   Basis: the potential for small leaks can be briefed to all stakeholders before waste removal starts. Mitigative actions can be developed and implemented prior to the start of waste removal including: (a) increased surveillances and procedural controls, (b) increased readiness to transfer out of the annulus (within 24 hours) and the primary including backup systems if needed, (c) the annulus ventilation system will be operating under negative pressure, and (d) recovery plans and procedures for leak response for sound tanks.

3.0 RECOMMENDED OVERALL STRATEGY

Refer to Appendix F for the selected alternative detailed Idea record. Refer to Appendix I for the detailed idea alternative ranking information.

3.1 Bulk Sludge Preparation for Transfer

The Team's review of Bulk Sludge Preparation for Transfer determined that 32 ideas passed the Team's screening process. Ten ideas were determined by the Team to rank higher than the baseline process now used for Bulk Sludge Preparation for Transfer.

Alternative 1.1.33 "One ADMP in center riser" was determined to have the highest ranking, but was only useful for Type I tanks.

Alternative 1.1.44 "Canned pump on a mast" was determined to have the next highest ranking providing flexibility in applications to all HLW tanks.

3.2 Bulk Salt Preparation for Transfer

The Team's review of Bulk Salt Preparation for Transfer determined that fourteen ideas passed the Team's screening process. Twelve ideas were determined by the Team to rank higher than the baseline process now used for Bulk Salt Preparation for Transfer.

Alternative 1.2.11 "Density Gradient" has the highest ranking.

Alternative 1.2.13 "Two Submersible Pumps" has the next highest ranking.

3.3 Bulk Sludge Waste Transfer

The Team's review of Bulk Sludge Waste Transfer determined that thirteen ideas passed the Team's screening process. Five ideas were determined by the Team to rank higher than the baseline process now used for Bulk Sludge Waste Transfer.

Alternative 2.1.9 "Transfer Pump on Mast" has the highest ranking.

Alternative 2.1.8 "Macerator Pump" has the next highest ranking.

3.4 Bulk Salt Waste Transfer

The Team's review of Bulk Salt Waste Transfer determined that 6 ideas passed the Team's screening process. Four ideas were determined by the Team to rank higher than the baseline process now used for Bulk Salt Waste Transfer.

Alternative 2.2.1 "Jets" has the highest ranking.

Alternative 2.2.6 "Sump Pump on a Mast" has the next highest ranking.

3.5 Heel Preparation for Transfer

The Team's review of Heel Preparation for Transfer determined that 27 ideas passed the Team's screening process. No baseline process for Heel Preparation for Transfer was identified.

Alternative 3.1.4 "Use tank 16 Oxalic Acid Cleaning at 8%" has the highest ranking.

Alternative 3.1.1 "Chemical dissolution" has the next highest ranking.

3.6 Heel Waste Transfer

The Team's review of Heel Waste Transfer determined that 5 ideas passed the Team's screening process. No baseline process for Heel Waste Transfer was identified. **Alternative 4.1.6** "Reuse Bulk Transfer Pump" *was viewed by the Team as very easy to implement and therefore very attractive.* There was a concern that the pump suction could not be enhanced to draw the tank level down to an acceptable level. It was determined that this alternative should be demonstrated and, if successful, then this alternative is recommended. If not successful, then Alternative 4.1.3 is recommended.

Alternative 4.1.3 "Air driven submersible pump has the highest ranking.

Alternative 4.1.2 "Macerator Pump" has the next highest ranking.

3.7 Spray Wash Tank

The Team's review of Spray Wash Tank determined that 4 ideas passed the Team's screening process. One idea was determined by the Team to rank higher than the baseline process now used for Bulk Salt Waste Transfer.

Alternative 5.1.5 "Directional Spray Nozzle" is ranked above the baseline process.

3.8 Annulus Preparation for Transfer

The Team's review of Annulus Preparation for Transfer determined that 12 ideas passed the Team's screening process. Eight ideas were determined by the Team to rank higher than the baseline process now used for Annulus Preparation for Transfer.

Alternative 6.1.10 "Sample, Evaluate, Do Nothing" has the highest ranking.

For those tanks that will require annulus cleaning, the Team viewed **Alternative 6.1.3** "Flygt Mixers in Racetrack Mode" as very attractive, however there was uncertainty about the solubility of the waste. The Team determined that additional sampling and/or evaluation should be performed to eliminate the uncertainty. If the waste is soluble, then alternative 6.1.6 is recommended.

Alternative 6.1.6 "Acid Clean, Reuse in Primary" has the next highest ranking.

3.9 Transfer Annulus Waste

The Team's review of Transfer Annulus Waste determined that 3 ideas passed the Team's screening process. No alternative ranked higher than the present baseline for Transfer Annulus Waste.

4.0 SYSTEMS ENGINEERING PROCESS

This section defines the System Engineering (SE) process used to objectively and efficiently complete the BOP SEE activities. The process provided steps to develop the relevant information and activities needed for the BOP SEE Team. The SE approach is instrumental in managing large and technically complex projects and is recognized by both the DOE and DNFSB as an effective methodology for project development.

The BOP SEE Team utilized the methodology and tools per the SRS Site Program for SE evaluations. Modifications to the process and outputs were made where appropriate to facilitate the Team activities. Only the salient points of the SE process used by the Team are presented in this report.

The SE process requires the identification of appropriate personnel and resources to perform mission definition and analysis, functions and requirements analysis, strategy evaluation, risk management, integration and planning, selection, validation, and verification.

The SE process was utilized in developing ideas and ultimately a preferred strategy for BOP SEE Team recommendations. The SE phases are Identification, Evaluation, and Selection

4.1 Identification of Alternatives

During the Identification Phase, the Team developed the SE inputs, alternative identification, and the combining of similar alternatives. These areas are further discussed below.

4.1.1 SE Input Development

During the Identification Phase, the Team developed a Planning Model (Appendix O) of tasks required to complete the scope of the charter. This model identifies the controls, inputs, support resources, and outputs obtained. The Identification Phase also focused on applying the SE process in the development of problem definition, identifying key missions and assumptions, developing Screening (Go / No Go) criteria and weighting criteria, (Appendix H), and definitions of terms. The Team's mission was accomplished by identifying alternatives, determining their impacts, and developing handling strategies using the SE Risk Analysis Process. The BOP SEE Team applied the Analytical Hierarchy Process (AHP) to prioritize the selected alternatives. Upon establishing the SE inputs, they were validated with management.

4.1.2 Alternative Identification

Alternatives were defined to improve the Waste Removal Projects technical baseline to achieve LWPD Program expectations. The overall process of identifying alternatives (ideas) for subsequent evaluation is depicted in Figure 4-1.

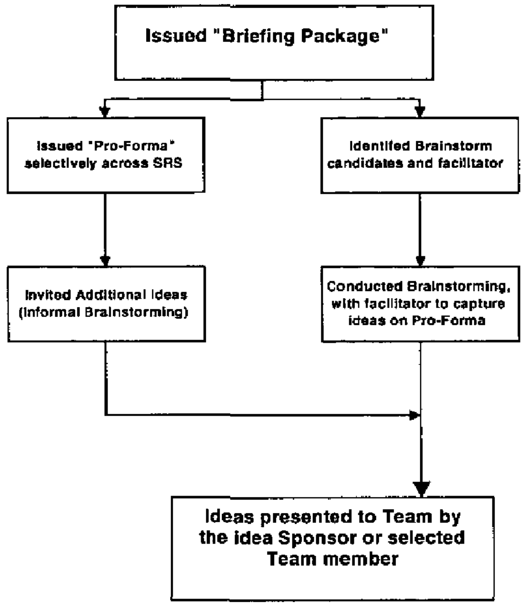

Figure 4-1 Process for Identification of Alternatives (Ideas)

The methods used to identify alternatives for waste removal from the HLW Tanks included:

- The BOP SEE Team conducted formal brainstorming sessions with subject matter experts/stakeholders to identify alternatives (ideas). A briefing package was distributed in advance of this activity in order to provide invitees with ample time to think about potential alternatives.
- The Team identified and solicited other knowledgeable SRS employees for their input.
- Team members used literature and World Wide Web searches to identify candidate ideas to augment the formal brainstorming session.
- Discussions with equipment vendors

The BOP SEE Team chose to document these alternatives using a FileMaker Pro database referred to as "Idea Pro-forma" by the Team. The results of the Identification phase culminated with 349 alternative Idea Pro-forma records. The collected 349 alternatives were assigned a unique identifier number by the Team member assigned to manage and control the data management process.

4.2 Screening of Alternatives

The Team and selected SME(s) screened each alternative (idea) per the "Screening Criteria" shown in Appendix C. The Team used the 'Idea Screening Process' shown in figure 4-2 and the 'Application of Selection Criteria' shown in figure 4-3 in order to maintain consistency during the screening process.

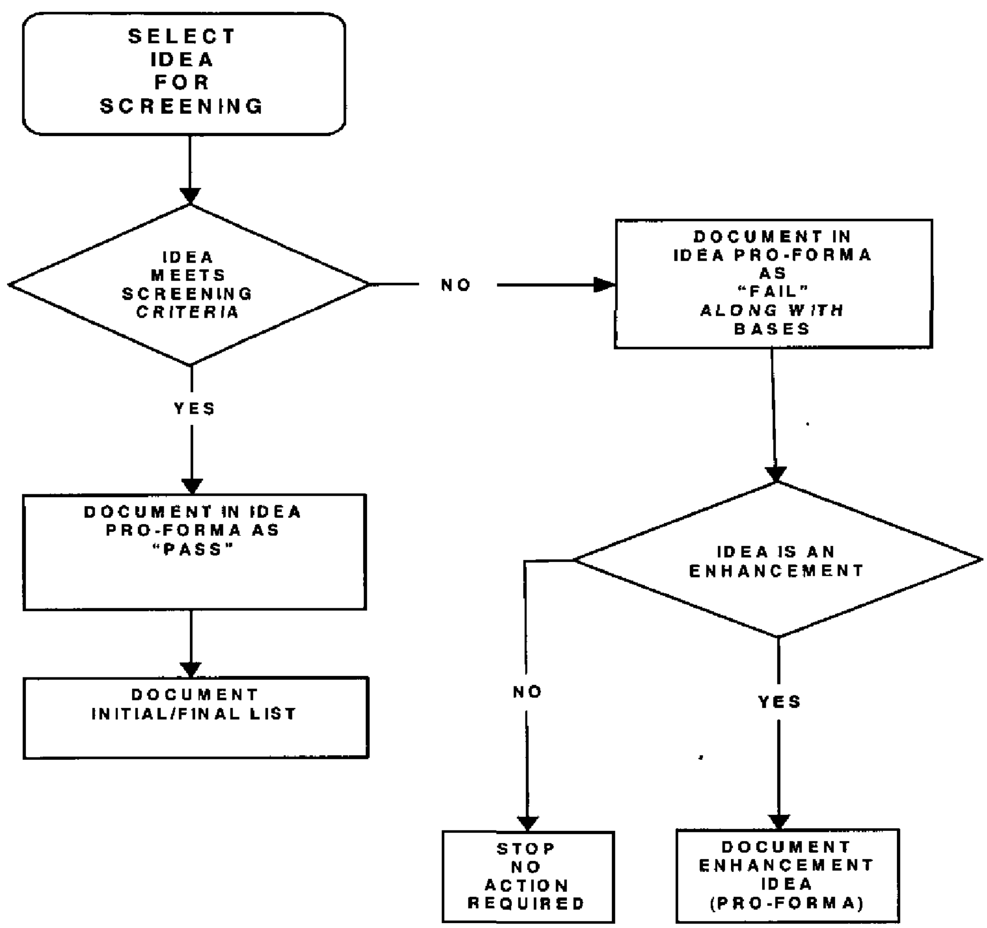

Figure 4-2 Idea Screening Process

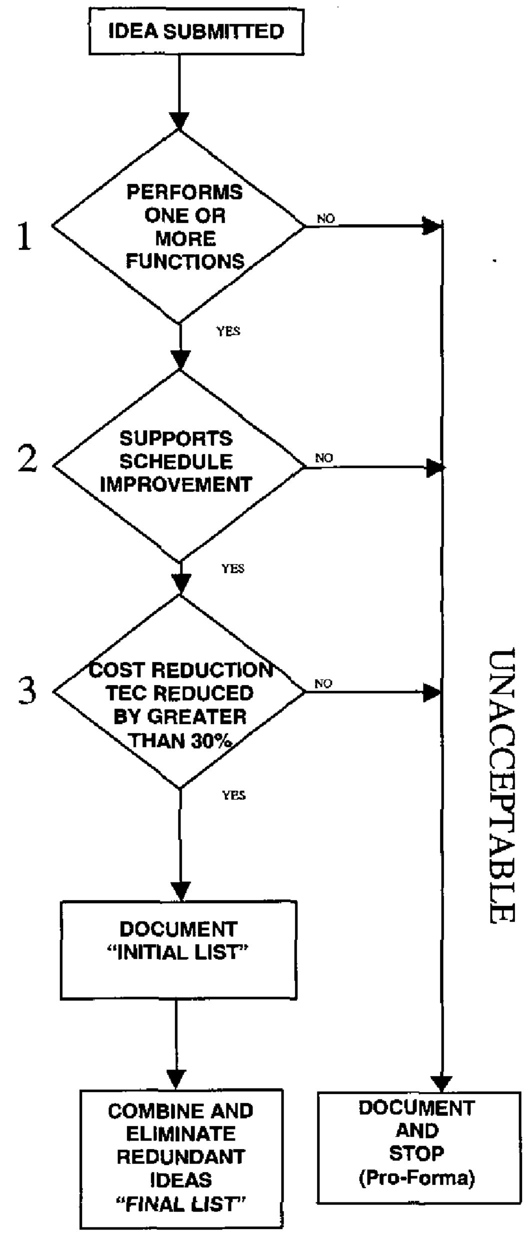

Figure 4-3 Application of Selection Criteria

4.2.1 Accepted Alternatives (Ideas)

Those ideas that satisfied the screening criteria were identified by "Pass" in the pass/fail block on the Idea Pro-Forma. If insufficient information existed to make a decision, the Team obtained the needed information or proceeded to make assumptions. The assumptions were documented and evaluated as risks.

4.2.2 Rejected Alternatives (Ideas)

If the application of any criterion resulted in an "unacceptable" response, then that idea was rejected. Ideas screened out at this level are identified by "fail" in the pass/fail block on the Idea Pro-Forma. The causative failure was also documented on the form. If the idea failed screening criteria, it was evaluated to determine if it could be an enhancement. In other words, did the failed idea enhance one of the ideas that passed the screening. If it was an enhancement, then the "enhancement" block was checked on the Idea Pro-Forma and the bases was also documented on the form.

4.2.3 Idea List

An 'Initial List' contained the ideas that passed the screening criteria. The 'Initial List' was revised to become the 'Final List' of alternatives (ideas) that have been combined or eliminated because they were redundant. This process took 349 alternatives and screened, then combined similar ideas to a 'Final List' of 115 alternatives.

4.3 Weighted Evaluation of Alternatives

Application of the weighted evaluation criteria defined in this section resulted in alternative (idea) ratings based on numerical scores. This rating score aided the Team in alternative selections. To provide consistency in understanding and application of the weighted evaluation criteria, intensities are assigned to each evaluation criterion. This provides a basis for discussion and comparison of each alternative (idea) versus the evaluation criteria using a common standard.

The overall process of rating (prioritizing) the selected waste removal alternatives is based on a weighted evaluation process depicted in Figure 4-4. This analysis was performed using the Analytical Hierarchy Process (AHP) (See Appendix B) methodology using Expert Choice software (Ref. 4). AHP is discussed in Appendix A of the SE Methodology Manual (Ref. 2). See Appendix H for a summary showing alternative (idea) analysis results.

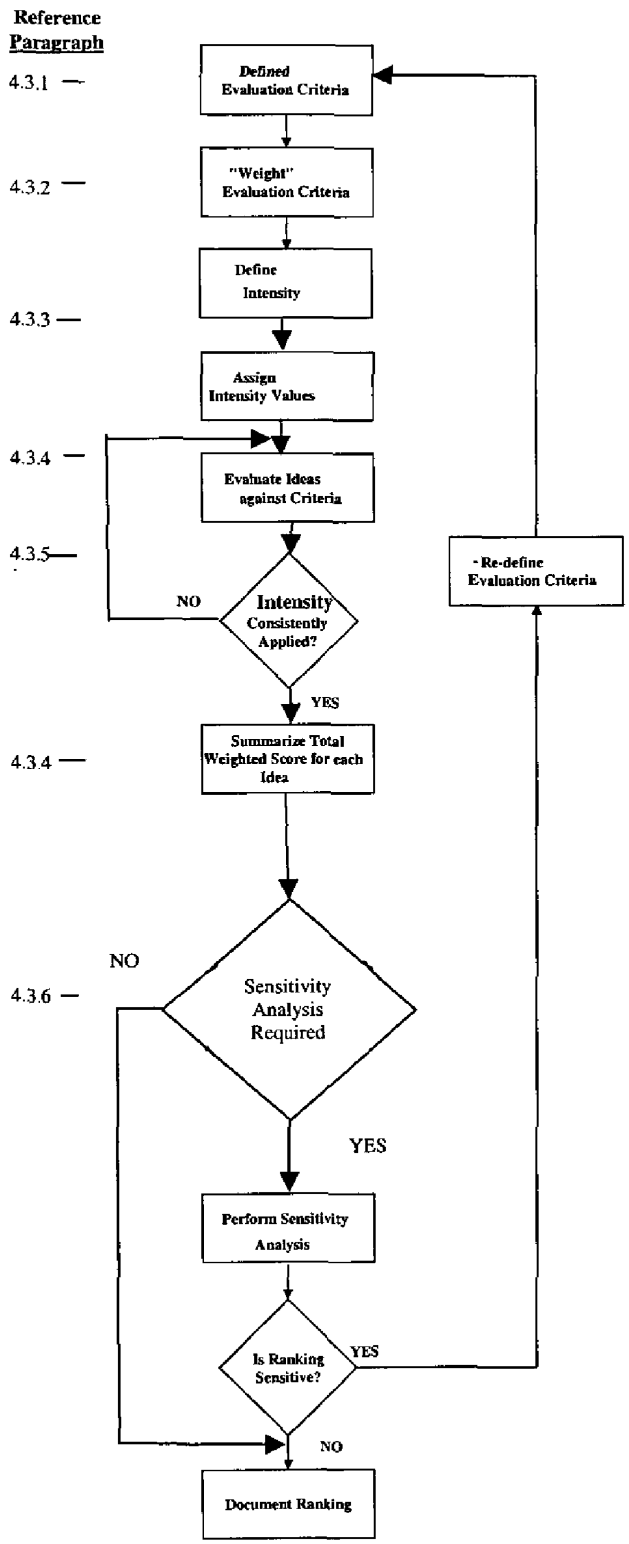

Figure 4-4 Weighted Evaluation Process

4.3.1 Defined Evaluation Criteria

The Team identified each evaluation criteria (see Table 4-1) by title (category), an identification number (1.0, 2.0, 3.0, etc.), a definition to facilitate the universal understanding of, and a basis for the criteria's selection. Each sub-criteria has the same type of information documented as the primary criterion. {Note: A sub-criteria identification number is traceable to its respective criterion (1.1, 1.2, 1.3, etc.)}. Attachment H documents the Team's identified criteria details.

4.3.2 Weighting of Evaluation Criteria

The evaluation criteria were defined, then the Team "weighted" the criteria with respect to their relative importance by using "pair-wise" comparison to each criteria. The criterion judged to be most important has the highest weight factor.

Criteria and sub-criteria weight factors are expressed as a decimal within a range of greater than or equal to zero or less than or equal to unity (0 to 1). The *sum* of all weights for the criteria shall equal 1. Sub-criteria were also used for comparison weights, but only against the other sub-criteria within the same criterion. Likewise, the *sum* of sub-criteria weights, within their assigned criterion, shall equal 1. Attachment H provides details of how this information was documented. Expert Choice software was used to determine the weight criteria. See table 4-1.

CRITERIA TITLE	WEIGHT -- STANDARD
1.0 Cost	0.257
2.0 Effectiveness	0.177
3.0 Reliability	0.165
4.0 Technical Maturity	0.116
5.0 Complexity	0.087
6.0 Reusability	0.075
7.0 Integration	0.067
8.0 Radiological Controls	0.057

Table 4-1 Criteria Weights

4.3.3 Intensities and Intensity Values

Intensities provide a means of quantifying aspects of the evaluation criteria for a more objective evaluation of the ideas or strategies to ensure a more consistent application.

Intensity levels were developed and assigned at the lowest criterion level, i.e., if sub-criteria exist then Intensity Levels are only defined for the sub-criteria and no Intensities are defined for the parent criterion. See Attachment H

Typically, three to five Intensities were defined and assigned to an evaluation criterion. Intensities are scenarios of acceptability from "most desirable" to "least desirable" for the evaluation criterion to which they are assigned. The most desirable Intensity was assigned a value of 100 % of the criteria weight and the least desirable was assigned a value of zero. The value of intermediate Intensities are assigned numerical values greater than zero and less than 100 % of the criteria weight depending on the desirability of that specific Intensity. Expert Choice software (ECPro) was used by the Team to record the Team developed Intensity values.

4.3.4 Evaluation of Alternatives (Ideas)

Each of the alternatives (Ideas) was evaluated against each evaluation criterion, sub-criteria and the respective Intensity. The Intensity value which "best describes" the idea under consideration was identified and recorded along with an explanatory note(s), if needed, to clarify the Team's decision. Inputs from SME, stakeholders, studies, etc., were used to accomplish this step. See Appendix I.

Weighted scoring of ideas was obtained by adding each Team selected evaluation criteria's Intensity Value for all alternatives (Ideas) that passed screening. Higher scores represent better compliance with the evaluation criteria than lower scores. Appendix I documents these results

4.3.5 Consistency Check

After completion of the previous steps, a "vertical slice" assessment was conducted to compare the Intensity Values assigned to each of the alternatives. Adjustments were completed to ensure consistency in the assignment of Intensity Values between alternatives.

4.3.6 Sensitivity Analysis

A sensitivity analysis seeks to determine if small changes (±10%) in criteria weighting have a significant affect on the numerical scores calculated for each alternative. Potential uncertainty and bias in assigning criteria weights can result based on the engineering judgements used to determine them.

After discussion with the Expert Choice software vendor and their consultants at the University of Pittsburgh, the Team determined that this step would not be statistically useful due to the large number of alternatives that the Team evaluated.

4.3.7 "What If" Analysis

The Team varied the criteria weights, using the Expert Choice software, to determine the impact on the alternative ratings. This "what if" analysis showed no impact on the top 5 alternatives in each ranking category.

4.4 Risk Assessment

A screening of the alternatives, using the *ratings* method defined by the analytical hierarchy process (AHP), identified the best two or three options for each process. Then, a risk assessment team analyzed these options to determine their risks and risk handling strategies needed to aid the alternatives successful implementation. The process steps and options that were assessed for risk are listed in Appendix M.

The Risk Assessment Team elected to accomplish these risk management activities by: 1. Screening the idea to determine the potential for technical risk; 2. Identification of potential sources of risk and the events causing these risks; 3. Analysis of individual risks to ascertain their impact on project performance, cost, and schedule; 4. Evaluation of risk handling strategies to mitigate, or reduce risks.

Risk analysis includes risk identification, determining the consequence, probability, risk level, and determining a risk handling strategy.

4.4.1 Risk Identification

The team conducted thorough screening of the selected alternatives for each process step. The results of the screening appear in Appendix P. Risk screening identified several areas with the potential for technical and programmatic risk to both the project and operations.

4.4.2 Probability Evaluation

Probability of occurrence is a qualitative or quantitative representation of a relative probability of realizing a risk. The Team assessed the alternative's probability based on historical experience, opinions of the SME, and the Team's knowledge and experience. A probability of Very Likely, Likely, Unlikely, and Very Unlikely was assigned based on the criteria established in the Identification/SE inputs Phase and is documented in Appendix J. Using the Systems Engineering Guidance Manual, (Ref. 2), the risk level associated with the top alternatives was then determined.

4.4.3 Consequence Evaluation

Consequence of occurrence is defined as the qualitative or quantitative representation of the potential impact of realizing a risk. The consequence evaluation was focused on identifying risks alternative that impact the schedule and/or cost of waste removal from the HLW Tanks. A consequence of Negligible, Marginal, Significant, Critical, and Crisis was assigned based on the criteria established and is documented in Appendix K.

4.4.4 Risk Level

Risk level is a qualitative evaluation of the risk associated with the occurrence of an event based on the probability that the alternative's ability to meet waste removal expectations combined with the consequences should the event occur and is documented in Appendix L.

4.4.5 Risk Handling Strategy

Risk Management is a structured, formal, and disciplined approach focused on the necessary steps and planning actions to determine and control risks to an acceptable level. The Team used the Systems Engineering Guidance Manual, (Ref. 2) to manage this process.

A Risk Handling Strategy is the action(s) or inaction(s) taken to address risk issues identified and quantified in the analysis efforts. See Appendix M. The strategies are categorized as:

- Risk reduction – Risk Handling Strategy that decreases risk by lowering the probability that a risk event will occur.
- Mitigation – a Risk Handling strategy that decreases risk either by lowering the consequence of a risk event or by a combination of reducing the probability that a risk event will occur and reducing the consequence of that event.
- Risk Transfer – Risk Handling Strategy that transfers responsibility for the risk to something (i.e., a separate activity) or someone else who has agreed to accept the risk.
- Risk Avoidance – Risk Handling Strategy that totally eliminates the threat or risk-driving event, usually by eliminating the potential cause.
- Risk Acceptance - Risk Handling Strategy that prepares for and deals with the consequences of a risk, either actively or passively. This is essentially a "no action" strategy.

4.5 Strategy Selection

A strategy is defined as a combination of ideas for each function such that all seven functions are performed. The Team considered the top scoring 5-10 ideas in each function for incorporation into strategies. Key to successful strategy development was combining individual ideas in a synergistic way that saved time or reduced cost. The list of enhancements was then reviewed and enhancements were applied where beneficial to the strategy. This process resulted in 115 strategies.

The strategies were then scored using the weighted selection criteria and in consideration of the results of the individual idea risk analysis process and the impact to infrastructure. Strategies that required less new infrastructure or less reliance on existing infrastructure tended to be lower cost and more reliable. The highest scoring strategy was:

No.	Function	Idea
1.0	Prepare bulk sludge for transfer	Submersible, high-capacity, floor-mounted, reusable mixer pumps
2.0	Transfer bulk sludge	Commercial, disposable sump pump on a mast
3.0	Prepare heel for transfer	Oxalic and/or nitric acid
4.0	Transfer heel waste	Re-use bulk transfer pump with enhancements
5.0	Water wash tank	Eliminate via evaluation or use simple portable spray tool
6.0	Prepare annulus waste for transfer	Eliminate via evaluation or use small Flygt mixers for agitation
7.0	Transfer annulus waste	Use baseline equipment

Enhancements applied to this strategy are listed below.

Enhancement	Impact
Floor mounted mixer and transfer pumps	• Eliminates tank top platforms and trusses
Engineered transfer pump suction	• Enables transfer pump to be used for bulk and heel transfer functions
Portable control room	• Eliminates costly outages to tie in new equipment
Locate portable control room at tank	• Eliminates routing instrument signal wire and power cables to central control rooms • Eliminates need for new cable trays, support columns and foundations
Portable power sub-station	• Eliminates motor control center expansions, D&R and HVAC mods
Route new cables on the ground in flex conduit	• Eliminates needs for conduit supports
Smart water addition	• Each step where water is added can be done in a way that disperses hard sludge

5.0 REFERENCES

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2. M. J. Cercy, Systems *Engineering Methodology Guidance Manual.* WSRC Manual WSRC-IM-98-00033, Revision 7, Savannah River Site, Aiken, SC 29808, (September 28, 2001).

3. Dr. Thomas L. Saaty. *Decision Making for Leaders.* RWS Publications, Pittsburgh, PA 15213, (1995).

4. *Expert* Choice 2000, *Decision Support Software.* Expert Choice, Inc., Pittsburgh, PA 15213

5. W-183 Baseline Cost

6. Federal Facilities Agreement for the Savannah River Site, Administrative Docket Number 89-05-FF, August 13, 1993

7. G-FPR-G-00019, Revision 0 and G-FDC-G-00029, Revision 2

8. GMJ doc

9. M. S. Hay, Results of Characterization and Dissolution Tests of Samples from Tank 16H, WSRC-99-00124, Rev. 0, January 18, 1999

10. Contaminated Large Equipment (CLE) Disposition Evaluation, HLW-ENG-2000-00003, February 17, 2000

11. Changes to the Authorization Basis as a result of Tank 8 waste removal are documented in WSRC-TS-96-14, Rev. 6

12. Changes to the Authorization Basis as a result of Tank 19 waste removal are documented in WSRC-TR-99-00450

6.0 APPENDIXES

Appendix A – Technology Functions and Requirements

Number	Function	Requirements
1.0	Remove HLW	• Reduce TEC Baseline by 30% • Close tanks per HLWSP 12 • Provide feed per HLWSP Rev 12 and the STP: Salt solution at 6.9 Mgal/year, Sludge at 250 cans/year • In-tank equipment must fit through available risers: 24" diameter for Type I, II and IV tanks, 36" plus two 48" diameter risers for Type III tanks

1.1	Prepare Bulk Waste For Transfer	• Prepare >99 volume % of waste, e.g., must prepare all but 10,000 gallons
		• Meet these select criteria of the ESP and SWPF WACs:
		  • corrosion chemistry
		  • temperature
		  • specific gravity
		  • wt % insoluble solids

1.2	Transfer Bulk Waste	• Maintain velocity 3 - 4.5 ft/sec to avoid solids settling • Provide ability to flush prime mover and route • Remove waste to ~3" level • Prime mover must be compatible with route

1.3	Prepare Heel for Transfer	• Prepare all non-residual waste (nominally all but last 100 gallons for HHW and 1,000 gallons for LHW tanks)
		• Meet these criteria for ESP or Tank Farm WAC:
		  • corrosion chemistry
		  • temperature
		  • specific gravity
		  • wt % insoluble solids

1.4	Transfer Heel	• Maintain velocity 3 - 4.5 ft/sec to avoid solids settling • Provide ability to flush prime mover and route • Remove solids down to <100 or <1,000 gallon residual • Enable solids verification <100 or <1,000 gallon residual • Prime mover must be compatible with route

Number	Function	Requirements
1.5	Spray Wash Tank	• Remove visible waste deposits from walls and internal structures
1.6	Prep. Annulus Waste for Transfer	• Prepare all non-residual waste (nominally all but last 100 gallons for HHW and 1,000 gallons for LHW tanks) including waste in ducts of Type I and II tanks, does not apply to Type IV tanks
1.7	Transfer Annulus Waste	• Maintain velocity 3 - 4.5 ft/sec to avoid solids settling • Provide ability to flush prime mover and route • Remove waste to enable verification (nominally all but last 100 gallons for HHW and 1,000 gallons for LHW tanks) • Waste must be removed from ducts

Appendix B – Acceptable Ideas Criteria Weighting and Priorities

Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP), which forms the basis of the Expert Choice™ decision support software (Expert Choice, version 2000, Second Edition) used in this study, enhances decision making by providing a logical, easy-to-use framework in which all elements of a decision can be defined, organized, and carefully evaluated (Ref. 4). Designed to reflect the way people actually think, the AHP is a mathematical theory for measurement and decision making that was developed by Dr. Thomas L. Saaty more than twenty years ago. Today, the AHP is one of the world's most popular approaches to multi-objective decision making, and Expert Choice, Inc., has become one of the world's leading vendors of AHP-based decision software.

As Dr. Saaty notes in his book *Decision Making for Leaders*, (Ref. 3) "In solving problems by explicit logical analysis, three principles can be distinguished: the principle of constructing hierarchies, the principle of establishing priorities, and the principle of logical consistency. These natural principles of analytic thought underlie the AHP." He goes on to say "In utilizing these three principles, the AHP incorporates both the qualitative and the quantitative aspects of human thought: the qualitative to define the problem and its hierarchy, and the quantitative to express judgments and preferences concisely. The process itself is designed to integrate these two properties."

The AHP incorporates judgments and personal values in a logical way. It depends on imagination, experience, and knowledge to structure the hierarchy of a problem and on logic, intuition, and experience to provide judgments. The AHP provides a framework for connecting elements of one part of a problem with those of another to obtain the combined outcome. It is a process for identifying, understanding, and assessing the interactions of a system as a whole.

With the AHP, objectives, criteria, and alternatives are arranged in a hierarchical structure, or model, similar to a family tree. The factors affecting the decision are organized in gradual steps, from the general in the upper levels of the hierarchy to the specific in the lower levels. The purpose of the structure is to make it possible to judge the importance of the elements in a given level with respect to some or all of the elements in the adjacent level above. The process of building this structure not only helps to identify all the elements of a decision more accurately, but also helps to recognize the interrelationships between them.

Influence in this hierarchical structure is distributed downward. The top level, or goal, has the greatest importance (or priority) and thus has a value of one. This value is apportioned among the elements in the second level, and the values of each of these in turn is apportioned among those of the third level, and so-on to the lowest-level objectives/criteria. These objective/criterion priority values are derived by the Expert Choice program based upon pair-wise comparisons of the objectives at each of the model nodes.

Finally, pair-wise comparisons of the alternative solutions with respect to each of the lowest-level criteria provide alternative preference values. These preference values are then synthesized with the objective/criterion priority values by the program to derive an overall preference value for each of the alternative solutions being considered.

Among the benefits of AHP is the fact that it accommodates hard data, such as costs, as well as personal judgment and intuition. It also permits the derivation of relative, mathematically based weights for objectives/criteria instead of simply assigning weights to variables as do some other decision analysis techniques. By reducing complex decisions to a series of simple comparisons and rankings and then synthesizing the results, the AHP not only helps in reaching the best decision, but also provides a clear rationale for that choice.

Another important feature of the AHP is that it provides a framework for group participation in decision making or problem solving. Ideas and judgments can be questioned and strengthened or weakened by evidence that other people present. And in fact, the conceptualization of any problem by the AHP requires the consideration of ideas, judgments, and facts accepted by others as essential aspects of the problem.

Criteria Weighting

Brainstorming coupled with pair wise comparison of the selected alternatives was performed to identify criteria as they relate to the vulnerability assessment. To the extent possible, criteria were kept independent of each other; i.e. - every attempt was made to avoid "double counting". The criteria selected by the Team: Cost (Project), Cost (Operating), Effectiveness, Reliability (Longevity) Reliability (Maintainability), Technical Maturity, Complexity (Construction), Complexity (Closure), Complexity (Closure), Complexity (Operation), Complexity (Design), Reusability (Multi-Functionalism), Reusability (Repeatability), Reusability (Portability), Integration (Process), Integration (AB), Integration (Infrastructure), and Radiological Controls Descriptions for each of the criterion are provided in Appendix H (1.0 to 6.0).

Pair-wise ranking of the decision criteria was performed to develop criteria weighting using the Analytical Hierarchy Process. The results of the criteria weighting process depicted in Table 4-1 below reflects the team's evaluation of the importance of each of the criteria in selecting a preferred alternative.

Weighted Criteria Intensity

The BOP SEE Team developed standards to evaluate each of the alternatives using the selected criteria in Table 4-1. A summary of the intensity (sub-criteria) is provided in Appendix H (see intensity and definition columns).

Appendix C – Screening Criteria

Screening Criteria #1

Criteria: The Idea will contribute to cost reduction, the Strategy will reduce TEC cost by >30%.

Basis: There is insufficient funding in the current contract period to execute the Stretch or Super-Stretch Cases as described in HLW System Plan, Revision 12. Waste Removal has been identified as a potential source of cost savings. HLW management has proposed 30% as a goal for the SEE team.

Screening Criteria #2

Criteria: The idea will contribute to schedule improvement, the Strategy will support closure of tanks and provision of feed for downstream processes per HLW System Plan, Rev 12.

Basis: The typical schedule for outfitting a tank with waste removal equipment is 46 months from the start of field walk-downs to the finish of readiness assessments. Often, funding is not available 46 months in advance of the required start of waste removal thus compressing the schedule,, conditions change in the Tank Farm resulting in the need to change the order of waste removal. It is therefore necessary to develop a more streamlined approach for waste removal that can be implemented more quickly to provide the required "agility" in the HLW program to adjust to changing schedules and needs.

Screening Criteria #3

Criteria: The Idea will perform at least one function, the Strategy will perform all functions per the requirements.

Basis: Ideas that cannot perform one or more of the process functions cannot contribute to waste removal. These ideas will be screened out, however, they will be considered as enhancements to other ideas if warranted. Strategies must perform all functions to be a viable solution.

Appendix D – Support Functions and Requirements

Number	Existing Function	Existing Requirement
1.0	Available Support Infrastructure	Existing infrastructure is available and meets the following requirements.
1.1	H&V	Each tank has an installed HVAC system: • maintain primary tank space at a negative pressure relative to the secondary tank • maintain secondary tank pressure negative relative to the atmosphere • Airflow through the primary tank vapor space is maintained to prevent accumulation of dangerous levels of hydrogen (150-1,000 cfm)
1.2	Inhibited Water	IW systems (tanks, pumps, make-up chemicals) are provided in each area of the tank farm to dissolve salt or suspend sludge: • pH > 7 • inhibited with 0.015 M OH and 500 ppm NaNO2 • flow cc's/min for pumps, 100 gpm for bulk addition or to flush pump column • pressure 90 psi • 10,000 gal make-up tank, satellite tanks 3,000 gal • continuous make-up capability only in FTF at the Inter Area Dilution Facility and ITP Cold Feeds, both at 100 gpm
1.3	Bearing Water	BW systems (tanks, pumps) are provided in the following areas of the tank farm as needed to pressurize pump columns to prevent inleakage of waste into the pump column: Tank 1, HDB-1, ITP Cold Feeds • pH > 7 • inhibited with OH and NaNO2 • pressure maintained at >15 psi above highest hydrostatic waste pressure
1.4	Flush Water	FW is provided throughout the tank farm to flush transfer lines and contaminated equipment and to make up IW/BW as needed • pressure 150 psi • Temperature 25 °C, can be heated on some systems to 90 °C • Minimum flow is ~10 gpm with both pumps off and head pressure only • PH typically 4-5 (well water)

Number	Existing Function	Existing Requirement
1.5	Instrument Air	IA is provided thoughout the tank farm to supply instruments as needed: • oil and debris free • pressure > 90 psi • capacity >100 cfm
1.6	Plant Air	PA is provided thoughout the tank farm to supply equipment as needed • pressure > 150 psi • capacity >500 cfm
1.7	Electrical	Electrical power is provided in each area of the tank farm as needed to powe existing and future baseline waste removal equipment • 24 v, 110 v, and 460 v • standby power is available in each area of the tank farm for baseline waste removal equipment
1.8	Steam	Steam service is routed throughout the tank farm: • 25, 150 and 325 psi steam is provided in each area of tank farm; 25 and 150 psi steam at each tank to supply baseline tank and waste removal equipment, • flow > 10,000 lbs/hr in each area
1.9	Chromate Cooling Water	CCW is provided to each Type I, II and III tank as needed for HVAC and tank cooling: • pressure >90 psi • supply temperature typically 25-30 °C • flow > 500 gpm
1.10	Tank Top Instrumentation	Instrumentation is provided at each tank to monitor key parameters: • tank temperature • liquid temperature • sludge/salt temperature • liquid level • primary HVAC flow • HEPA filter dP • secondary HVAC flow • *presence of liquid in annulus*
1.11	Control Rooms	Control rooms are provided in each area of the tank farm: • continuously occupied • emergency response capable

Number	Existing Function	Existing Requirement
1.12	Waste Transfer Systems	Transfer piping and equipment are provided at each waste tank: • jacketed • *shielded* • full leak detection

Appendix E – Alternatives Index

VW Sorted by

FUNCTION	SLUDGE = 1 SALT = 2	IDEA #	ALTERNATIVE DESCRIPTION	RANKED SCORE
			>> BULK SLUDGE PREPARATION FOR TRANSFER <<	
1	1	33	One ADMP in Center Riser	0.842
1	1	44	Canned Pump on a Mast	0.834
1	1	32	Two Modified ADMP's	0.795
1	1	16	Sluicing	0.755
1	1	3	Submersible Slurry Pumps (with magnetic coupling)	0.713
1	1	15	Mini Quad Volute Slurry Pumps	0.7
1	1	12	Chemical Cleaning for Tanks 5 and 6	0.66
1	1	10	Universal Shaft Pump	0.623
1	1	27	Bore Hole Miner	0.602
1	1	13	Dilute Nitric Acid (<1m)	0.597
1	*1*	*43*	*Bulk Sludge Prep* ***Baseline***	*0.583*
1	1	42	Sluicing with Recirc	0.576
1	1	2	Create sump in annulus, sluice sludge into sump	0.566
1	1	29	Modular Jet Mixing Pump	0.556
1	1	9	Tank in Tank	0.541
1	1	14	Single Discharge Pump With Flygt Mixer	0.535
1	1	1	Tilt Bed Trailer with Mixer	0.496
1	1	5	Russian Pulsating Mixer	0.486
1	1	6	AEA pulse tube mixer	0.486
1	1	31	Confined Sluicing	0.484
1	1	22	Dewater with Lagoon Cleaner	0.425
1	1	25	Wave Machine	0.41
1	1	40	Flygt Mixers in Racetrack with Vertical Flygt Mixer in Center	0.391
1	1	37	Pump Dry with Absorbent Material and Convey Out	0.382
1	1	7	Industrial Wet Vac	0.378
1	1	36	Easily Manipulated Mechanical Arm (EMMA)	0.36
1	1	28	Sewer Sucker	0.333
1	1	8	Industrial Pool Cleaner	0.289
1	1	20	Dewater & Vacuum	0.281
1	1	11	Pneumatic Conveying	0.278
1	1	26	Remove Large Section of Tank Top and Convey	0.206
1	*1*	*4*	*Multi-Point Suction*	*0.16*
			>> BULK SALT PREPARATION FOR TRANSFER <<	
1	2	2	Steam Recirculating Jet for Salt Removal	0.864
1	2	11	Density Gradient	0.78
1	2	13	Two Pumps	0.755
1	2	12	Modified Density Gradient	0.722
1	2	9	Two Pulse Tube Mixers	0.714

FUNCTION	SLUDGE = 1 SALT = 2	IDEA #	ALTERNATIVE DESCRIPTION	RANKED SCORE
1	2	14	Sluicing	0.694
1	2	3	Hydrolance for Salt Removal	0.689
1	2	1	Modified Density Gradient for Salt Removal Using Recycle Lines and Submersible Pump	0.688
1	2	7	Two Slurry Pumps	0.671
1	2	6	One Slurry Pump	0.669
1	2	5	Two Flygt Mixers	0.665
1	2	10	One Pulse Tube Mixer	0.653
1	*2*	*4*	*Bulk Salt Prep* ***Baseline***	*0.603*
1	2	8	Two Modified Advanced Design Slurry Pumps	0.589
			>> BULK SLUDGE WASTE TRANSFER <<	
2	1	9	Pump on Mast	0.818
2	1	8	Macerator Pump	0.796
2	1	3	Disposable Transfer Pump on a Rope	0.774
2	1	12	Screw Pump	0.718
2	1	5	Hanford SEE Pump Like Tank 19	0.663
2	*1*	*14*	*Bulk Sludge Transfer* ***Baseline***	*0.644*
2	1	10	Modify TTP with Motor at Bottom (submersible pump)	0.609
2	1	11	Diaphragm Pump	0.548
2	1	6	Wand W/Booster Pumps in Series	0.363
2	1	7	Vacuum Tank	0.363
2	1	4	Pump on a Raft	0.361
2	1	2	Truck Waste	0.344
2	1	13	Modified Deep Well Eductor Pump	0.292
			>> BULK SALT WASTE TRANSFER <<	
2	2	1	Jets	0.848
2	2	6	Sump Pump on a Mast	0.825
2	2	5	Air Operated Diaphragm Pump on Mast	0.733
2	2	3	Sump Pump on Cable	0.691
2	*2*	*2*	*Bulk Salt Transfer* ***Baseline***	*0.665*
2	2	4	Hanford SEE Pump	0.641
			>> HEEL PREPARATION FOR TRANSFER <<	
3	1	4	Use Tank 16 Oxalic Acid Cleaning at 8 wt %	0.718
3	1	1	Chemical Dissolution	0.674
3	1	11	Oxalic Acid with Oxidizer	0.632
3	1	29	Movable / Articulated Hose	0.624
3	1	5	Selective Leaching with Oxidizer and IW	0.543
3	1	6	Oxalic Acid & Citric Acid	0.527
3	1	8	Reverse Surface Charge to Defloc Sludge Particles by Well Water Addition	0.517
3	1	9	Suspend Heel Materials with Surfactants	0.512
3	1	15	Selective Leaching of Radionuclides	0.498
3	1	28	Chemical Dissolution (Russian Regime) with a Complexing Agent	0.498

FUNCTION	SLUDGE = 1 SALT = 2	IDEA #	ALTERNATIVE DESCRIPTION	RANKED SCORE
3	1	33	Partition Tank and Move Sludge with a Sluicer	0.48
3	1	12	Add Material to Increase Sp Gr of Slurry Media	0.469
3	1	7	Reverse Surface Charge to Defloc Sludge Particles by Acid Addition	0.468
3	1	20	Reuse Flygt Mixers	0.453
3	1	21	Vertical Flygt Mixers (150 hp)	0.365
3	1	16	Leach Radionuclides with Ammonium Hydroxide	0.333
3	1	19	SRS Crawler with Suction Pump	0.302
3	1	18	SRS Crawler with Water Monitor	0.299
3	1	17	ARD	0.28
3	1	26	Street Sweeper / Grinder / Pumper	0.28
3	1	13	Dissolve Heel Materials with Ionic Liquids	0.262
3	1	35	Houdini with CSEE	0.238
3	1	23	Tank in Tank with mobile Wilden pump	0.223
3	1	31	Scoop with Remote "Bobcat"	0.214
3	1	2	Ultrasonic	0.132
3	1	10	Ultrasound with Oxalic Acid Cleaning	0.092
			>> HEEL WASTE TRANSFER <<	
4	1	3	Air Driven Submersible Pump	0.734
4	1	2	Macerator Pump	0.623
4	1	7	Reuse Bulk Transfer Jet	0.619
4	1	6	Reuse Bulk Transfer Pump	0.614
4	1	4	Transport the Waste by Tank Truck	0.344
			>> SPRAY WASH TANK <<	
5	1	5	Directional Spray Nozzle	0.729
5	*1*	*3*	*Spray Wash **Baseline***	*0.718*
5	1	6	Acid Clean Heel Removal, Do Nothing	0.703
5	1	1	Vibrate Tank	0.161
			>> ANNULUS PREPARATION FOR TRANSFER <<	
6	1	10	Sample, Evaluate, Do Nothing	0.801
6	1	6	Acid Clean, Reuse in Primary	0.713
6	1	3	Flygt Mixers in Racetrack Mode	0.675
6	1	1	Mixing Eductors	0.625
6	1	9	Water Mouse	0.605
6	1	8	Air Spargers	0.602
6	1	11	Three Centrifugal Pumps	0.597
6	1	12	Russian pump (mix, transfer and sluice)	0.482
6	*1*	*4*	*Annulus Cleaning Prep **Baseline***	*0.471*
6	1	5	Confined Sluicing End Effector (CSEE).	0.411
6	1	7	Crawler with CSEE	0.364
6	1	2	Tunnel bore in duct	0.11

FUNCTION	SLUDGE = 1 SALT = 2	IDEA #	ALTERNATIVE DESCRIPTION	RANKED SCORE
			>> TRANSFER ANNULUS WASTE <<	
7	*1*	*3*	*Use Existing Jet and Gang Valve **Baseline***	*0.723*
7	1	4	Sump Pump on Cable	0.717
7	1	5	Annulus Transfer Pump on a Mast	0.717

Appendix F (1.1) – Alternatives, Bulk Sludge Preparation for Transfer

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer
Date 8/21/2001
Function 1 1 1
Phone 8-0506
Originator Gene Dixon
Dept CSTE

Title

Tilt Bed Trailer with Mixer

Criteria

This is a trailer that houses a slurry pump or other mixing device that can back up to a tank, raise the bed to a vertical position over a riser and lower the pump/mixer into the riser. When the waste removal operation is complete, the pump/mixer could be withdrawn into the tilt bed trailer containment. The containment would house decon equipment to clean the pump/mixer.

Technical Maturity

Hanford has a thermowell removal trailer similar to this but it is not big enough to handle a large pump or mixer.

Safety Issues

Tank top loading would be a major issue.

Advantages

* *could reuse pump or mixer*
* could reduce overall cost if a durable pump or mixer could be developed

Disadvantages

* high up front cost
* significant development and testing
* above grade movement of highly contaminated equipment
* tank top loading and interference issues

Pass / Fail Pass **Total Score** 0.496 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 8/29/2001

Function 1 1 2

Phone 8-2980

Originator N. R. Davis

Dept CSTO/WR

Title

Create sump in annulus, sluice sludge into sump

Criteria

create a sump in the annulus of old style tanks. Cut a hole in the primary tank to admit sludge into the sump. Install an agitator or sparger in the sump to keep the sludge pumpable. Install a transfer pump in the sump (like the Bibo pump). Sluice sludge into the sump and transfer it into another tank.

Technical Maturity

very immature

Safety Issues

unknown

Advantages

could be cheap

Disadvantages

* can only be used on tanks to be closed
* techniques to cut holes not defined
* could use a lot of water
* difficult to control rheology

Pass / Fail Pass **Total Score** 0.566 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer
Date 8/31/2001
Function 1 1 3
Phone 208-2980
Originator Neil Davis
Dept CSTO/WR

Title

Submersible Slurry Pumps (with magnetic coupling)

Criteria

Replace long-shaft, traditional, (mixer) slurry pump design with a submersible, short-shaft, sealess design.

Technical Maturity

LOW
Not aware of any off-the-shelf designs available.

Safety Issues

Electrical Hazards

Advantages

Eliminates vibration problems associated with long-shaft pumps. Improved disposal capability in tank. Lower cost.

Disadvantages

Motor size limitations (must fit in riser)
Tank Temperature limitations (heat up tank)
R&D required

Pass / Fail Pass **Total Score** 0.713 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10-1-2001

Function 1 1 4

Phone 208-0276

Originator Stephen A. Smith

Dept WRE

Title

Multi-Point Suction

Criteria

Remove bulk waste using multiple suction points throughout the waste tank instead of the single point suction point they currently employ.

Technical Maturity

Not currently utilized in waste removal, however, not very complicated.

Safety Issues

No additional safety issues.

Advantages

Would provide multiple suction points throughout the waste so the waste wouldn't have to be directed to just one point in teh tank.

Disadvantages

More complexity in pump positioning and piping.

Pass / Fail Pass

Total Score 0.16

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10/1/2001

Function 1 1 5

Phone 8-0264

Originator E. Saldivar, Jr.

Dept HLWE

Title

Russian Pulsating Mixer

Criteria

Deploy two to four Russian Pulsating Mixers into tank to perform mobilization and transfer aspects of salt/sludge waste removal. The pump utilizes a charging vessel to lift waste/liquid that is then forced back into the tank through a pulsating motion. The pump has an additional monitoring/sluicing capability that can be used above the waste surface to dislodge/erode waste mounds. Note: The pump can also be used to transfer waste.

Technical Maturity

Russians have used this technology many times to mobilize similar waste in 90' deep x 30' diameter stainless steel tanks and to transfer the waste. The pump has been tested at PNNL and demonstrated at ORNL.

Safety Issues

Unknown.

Advantages

Proven successful for the Russians. Does not utilize any NEW liquid additions if enough liquid exists to start mobilization and transfer. The pump can be used for mixing and transfer of waste.

Disadvantages

Potentially expensive pump that utilizes existing waste to create the pulsating action of the waste. The pump has the potential of plugging during operation.

Pass / Fail Pass **Total Score** 0.486 **Enhancement** [ ]

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10/1/2001

Function 1 1 6

Phone 8-0264

Originator E. Saldivar, Jr.

Dept HLWE

Title

AEA pulse tube mixer

Criteria

Deploy multiple AEA Pulse Tube Mixers into tank to perform mobilization aspect of salt/sludge waste removal. The pump utilizes a charging vessel to lift waste/liquid that is then forced back into the tank through a pulsating motion.

Technical Maturity

Russians have used this technology many times to mobilize similar waste in 90' deep x 30' diameter stainless steel tanks. The pump has been tested at PNNL and demonstrated at ORNL.

Safety Issues

The air vacuum eductor design utilized to lift waste into the charge vessel and then force the waste out of the charge vessel creates an aerolization issue for the area/structure that the eductor is positioned in.

Advantages

No new water is used. Minimal moving parts.

Disadvantages

The is a potential for plugging the lift and pulse waste line. Aerolization creates a worker and offsite dose issue.

Pass / Fail Pass

Total Score 0.486

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 8/13/2001

Function 1 1 7

Phone 208-2325

Originator Ron Parnell

Dept HLWE

Title

Industrial Wet Vac

Criteria

Deploy a remote control wet-vac to process and remove tank salt, sludge and supernate. Grind, size reduce,collect and pump tank content.

Technical Maturity

None at this scale

Safety Issues

??

Advantages

Eliminate the need to slurry tank contents.

Disadvantages

Cost of R&D required to develop and prove/test.

Pass / Fail Pass

Total Score 0.378

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer **Date** 8/29/2001

Function 1 1 8 **Phone** 208-1825

Originator Steve Tibrea **Dept** HLWE

Title

Industrial Pool Cleaner

Criteria

Scale up "industrialized" existing "Pool Cleaner" designs to remove heels in large tanks. Significant re-engineering and testing could be farmed out in a competitive style to university, industry, etc.

Technical Maturity

Low - Scale up issue / material compatibility issues / significant test and development challenges, along with filtering challenges.

Safety Issues

Advantages

Suction of cleaner moves to heel.

Disadvantages

Obstructed tanks will not likely be cleaned via this method.

Pass / Fail Pass **Total Score** 0.289 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category	1.1 Prepare Bulk Waste for Transfer	**Date**	8/29/2001
Function	1 1 9	**Phone**	952-2627
Originator	Mike Harrell	**Dept**	CSTO/WR

Title

Tank in Tank

Criteria

The tank in tank idea would involve the utilization of an air operated (Wilden) pump on a Crawler that could be moved on tank bottom where the sludge heel is located. Use this crawler to pump sludge into the tank in tank. The tank in a tank needs to contain a submersible combination mixer / transfer pump to remove the sludge from the waste tank.

Technical Maturity

Small (<200 gal) tank-in-tank has been used at ORNL to accumulate waste before pumping. No experience at SRS with our waste.

Safety Issues

Advantages

* will dampen fluctuations in rheology as wt % solids will be adjusted in the tank-in-tank, may help avoid line plugging if the crawler sucks up concentrated sludge with little or no water content

Disadvantages

* still have problem of poor control of the rheology of the sludge being removed from the tank
* will be difficult to install tank-in-tank

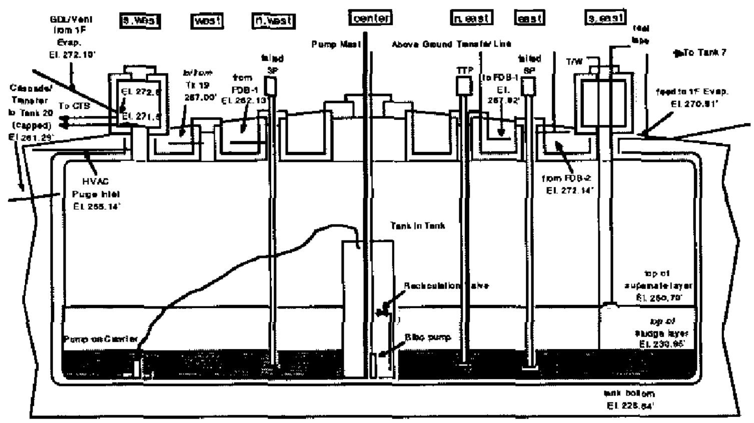
Pass / Fail Pass **Total Score** 0.541 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Process Diagram (Optional)

Tank In Tank With Pump on Crawl



The pumps could be any type sufficient to move sludge and of appropriate size. The above ground could have 4 possible tie in points as shown. Above ground transfer line should be jacketed rigid pipe supported from piers and shielded with hydroshields (poly containers of water stacked up like building blocks)

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer **Date** 10/10/2001

Function 1 1 10 **Phone** 22659

Originator G. Gentry **Dept** HLWM

Title

Universal Shaft Pump

Criteria

Use universal joint driveshafts attached to a mast connecting the motor mounted above the tank top to the pump at the bottom of the mast. The drive shafts can be assembled using the universals in up to10' lengths. This idea is based on a Tank 7 type of slurry pump but with a different shaft design that is more tolerant of misalignment and less prone to early failure as compared to standard slurry pumps.

Technical Maturity

used in industry, has not been used at SRS

Safety Issues

Advantages

* leverages standard slurry pump design
* should improve service life of standard pump

Disadvantages

* needs development and testing

Pass / Fail Pass **Total Score** 0.623 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10/23/2001

Function 1 1 11

Phone 208-2325

Originator Ron Parnell

Dept HLWE

Title

Pneumatic Conveying

Criteria

Portable / fixed pneumatic conveying system to remove sludge / supernate.
Dilute Phase, Dense Phase, Pulsed Phase or Full Vac System

Technical Maturity

No exposure in Rad related industry

Safety Issues

Personnel exposure to air release - Max with dense phase full vac. type.

Advantages

Potential reuse / cost per disposable system

Disadvantages

Managing excess air developed by blower.

Pass / Fail Pass

Total Score 0.278

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 8/29/2001

Function 1 1 12

Phone 8-2980

Originator N. R. Davis

Dept CSTO/WR

Title

Chemical Cleaning for Tanks 5 and 6

Criteria

Tanks 5 & 6 contain about 25,000 gallons of sludge each. It may be possible to dissolve this small amount of sludge with heated oxalic acid at 2-4 wt %. Some mixing would be required to remove the boundary layer of reacted sludge. Inexpensive Flygt mixers are proposed that could bear on the tank floor to reduce tank infrastructure. The dissolved sludge could be pumped to FPT-1 where the DIWF could continuously add caustic to neutralize the acid waste en route to another tank.

Technical Maturity

Fairly Mature - acid cleaning was demo'd in Tank 16. Neutralization was demo'd in HPT-3. Flygt mixers were demo'd in Tank 19. Criticality issues must be addressed.

Safety Issues

* Oxalic acid handling
* Criticality

Advantages

* should be very low cost relative to project baseline

Disadvantages

* must develop criticality control program
* must address downstream process concerns
* will generate a lot of oxalates as compared to heel removal

Pass / Fail Pass

Total Score 0.66

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 9/19/2001

Function 1 | 1 | 13

Phone 557-7751

Originator Ed Stevens

Dept SRTC

Title

Dilute Nitric Acid (<1m)

Criteria

Add dilute nitric acid to HLW tank to dissolve remaining sludge / zeolite. Would need to determine ahead of time how long and how strong to prevent excessive corrosion of tank. Some amount of corrosion could be acceptable since the tank will be closed. Acid could be dropped or sluiced. Heated nitric acid would increase dissolution rate. Once pumped from tank, the solution would need to be neutralized before sent to another HLW tank.

Technical Maturity

Fairly mature. Need to determine corrosion rates and dissolution rate vs. acid strength.

Safety Issues

Corrosion of tank. Fuming of nitric acid and fuming while neutralizing.

Advantages

would desolve the sludge and zeolite.

Disadvantages

HLW tank corrosion. Dealing with acid fumes.

Pass / Fail Pass **Total Score** 0.597 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category	1.1 Prepare Bulk Waste for Transfer	**Date**	10/25/2000
Function	1 1 14	**Phone**	208-8430
Originator	T. Caldwell	**Dept**	HLWE

Title

Single Discharge Pump With Flygt Mixer

Criteria

Single discharge slurry pumps are expected to provide superior cutting and sludge suspension capability, especially from distances greater than 1.5 times the normal two-discharge cleaning radius. However, bulk suspension of the fluid is sacrificed becaused the flowrate through the single discharge pump is greatly reduced. This allows pockets of newly suspended sludge to settle. PNNL testing has revealed that the bulk mixing imparted by FLYGT mixers is better than the standard slurry pump. Using the two units in combination will greatly improve the suspension / mixing effectiveness.

Technical Maturity

Both of these methods have been tested, however, the two techniques have not been used together.

Safety Issues

The safety issues would be the same as the baseline.

Advantages

More effective mixing.

Disadvantages

An extra opening(s) would be needed to insert one or two mixer units.

Pass / Fail Pass **Total Score** 0.535 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer **Date** 10/17/2000

Function 1 1 15 **Phone** 208-1012

Originator Glenn Beaumier **Dept**

Title

Mini Quad Volute Slurry Pumps

Criteria

Project was initiated (on hold now) to develop quad volute pumps with a small diameter volute that would fit in smaller riser openings. Plan was to replace tank 42 pumps with this design. Quads have a 40' cleaning radius, and this could be increased if only one discharge was left open. Install such a pump(s) and proceed with traditional slurry.

Technical Maturity

Very High; Vendor wanted some financial support due to unique application has no market other than SRS. Centrifical pump design well understood and is a proven waste removal technique.

Safety Issues

None

Advantages

Proven technology, existing infrastructure (steel, bearing water)

Disadvantages

New Volute design, disposition of existing pumps.

Pass / Fail Pass **Total Score** 0.7 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer
Date 10/12/2000
Function 1 1 16
Phone 208-0264
Originator Eloy Saldivar
Dept HLWE

Title

Sluicing

Criteria

Install 3 Sluicing Monitors in place of slurry pumps. Replace TTP with a combination bulk sludge removal pump and bottom /low level suction pump.

Technical Maturity

Medium; Technologies used by SRS and TFA

Safety Issues

Advantages

Low expense technology, High probability of moving sludge / zeolite

Disadvantages

Large water usage.

Pass / Fail Pass **Total Score** 0.755 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10/23/2000

Function 1 1 20

Phone 208-0264

Originator Eloy Saldivar

Dept HLWE

Title

Dewater & Vacuum

Criteria

Remove liquid from tank to expose dry material. Procure vacuum system that is deployable to all areas of tank for spot vacuuming.

Technical Maturity

Very Mature except for handling radioactive airborne particulate that must be filtered.

Safety Issues

Radioactive Airborne Particulates.

Advantages

Thorough Cleaning.

Disadvantages

Radioactive Airborne Particulates.

Pass / Fail Pass **Total Score** 0.281 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer
Date 10/24/2000

Function 1 1 22
Phone 208-2980

Originator Neil R. Davis
Dept CSTO/WR

Title

Dewater with Lagoon Cleaner

Criteria

Select a commercial hazardous waste lagoon cleaner, modify it for HLW service, and deploy it in Tank 18 to partially dewater the sludge and pump it out of the tank. I do not have a specific model or service to recommend only a memory of seeing this technology deployed on lagoons.

Technical Maturity

Very mature in non-radioactive service, probably very little experience in a HLW environment.

Safety Issues

None

Advantages

Could be a service contract
should be cheap

Disadvantages

doubtful experience in HLW service
sludge rheology could change rapidly during transfers causing pluggage

Pass / Fail Pass
Total Score 0.425
Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10/12/2000

Function 1 1 25

Phone 952-8169

Originator Gary Abell

Dept

Title

Wave Machine

Criteria

This concept uses a Wave Machine which is submersed into the tank solution and allowed to mix the content with low frequency high amplitude mechanical waves.

Technical Maturity

Comercial swimming pools use this technology.

Safety Issues

No obvious issues other than dynamic loading on tank walls.

Advantages

Technically mature and comercially available.

Disadvantages

Not used in this application before. It si not known if this type of agitation would work in preparing bulk waste. Would need to be designed / produced and tested.

Pass / Fail Pass

Total Score 0.41

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10/25/2000

Function 1 1 26

Phone 208-8430

Originator T. Caldwell

Dept HLWE

Title

Remove Large Section of Tank Top and Convey

Criteria

Shielded conveyence mechanism (as those designed by Hanford) may require a large area to access the tank interior. Cutting a new hole in tank top (say 10' x 10') would enable the deployment of the wet or dry conveyence system.

Technical Maturity

Cutting holes in Type IV tank tops have been performed on tanks 17, 19, and 20. Larger holes would require a thorough engineering analysis to determine the feasibility and size limits.

Safety Issues

A larger opening may effect the puff release amount in the current AB. Furthermore personnel safety risk are increased due too higher Rad exposure and fall potential.

Advantages

Larger access openings greatly increase the flexibility and number of options that could be considered for tank 18 waste removal.

Disadvantages

Cutting extra openings of a small size have been safely performed in the past, however large and super-large openings present new risk in the area of containment, rad levels, and fall potential.

Pass / Fail Pass

Total Score 0.206

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer
Date 10/24/2000
Function 1 1 27
Phone 208-2980
Originator Neil R. Davis
Dept CSTO/WR

Title

Bore Hole Miner

Criteria

Commercial equipment used in mining industry to mine coal and other minerals. High pressure water is used to dislodge sludge and sluice it to a transfer pump. Equipment demo'd at Oak Ridge. Clean unit available for no cost from Oak Ridge.

Technical Maturity

Demo experience, lots of experience with other sluicing methods, very low tech

Safety Issues

None

Advantages

Cheap, Quick, Easy to install, Easy to operate, available

Disadvantages

High water usage
Creates fog in the tank in seconds
Could damage other tank equipment or structures

Pass / Fail Pass
Total Score 0.602
Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10/17/2000

Function 1 1 28

Phone 208-1012

Originator Glenn Beaumier

Dept

Title

Sewer Sucker

Criteria

Purchase off the shelf "sewer sucker" and deploy in tank. Use remote arm to move suction to mounds to facilitate resuspension. Use collection tank in sewer sucker as a pump tank.

Technical Maturity

Moderate; Apparatus is basically off the shelf.

Safety Issues

Airborne activity may be very high.

Advantages

Will work

Disadvantages

Maintainability of equipment is low, Airborne activity high, Requires remote control, difficult to position suction throughout tank

Pass / Fail Pass

Total Score 0.333

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10/25/2000

Function 1 1 29

Phone 208-8430

Originator T. Caldwell

Dept HLWE

Title

Modular Jet Mixing Pump

Criteria

This option employs a standard slurry pump direct coupled to a submersible motor. The coupled unit would lower into the tank via a telescoping shaft. Reciprocating or rotating pump movement can be employed with this option. The modular pump collapses to the size of a standard shipping container for easy transport, maintenance, and burial. Hydraulic and mixing performance would be equivalent to that of a slurry pump (standard, quad-volute, or ADMP-type). The weight of the pump and shaft is less than 2 tons and could be mounted directly to a riser or new tank opening with minimal support and mounts.

Technical Maturity

The modular jet mixing pump (or ModJet) is new in concept but interest has been expressed by Tank Focus Area (TFA)

Safety Issues

Identical to the baseline

Advantages

Relative mobility and light weight allows for more rapid deployment and greater flexibility of the number of pumps that could be installed in the tank. For example, 4 or 5 pumps could be added the tank without significant tank top changes.

Disadvantages

More mechanically complex than slurry pumps but bearing water, seal design, and vibration problems would be eliminated or significantly reduced. Initial construction cost would be high.

Pass / Fail Pass **Total Score** 0.556 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10/25/2000

Function 1 1 31

Phone 208-0264

Originator Eloy Saldivar

Dept HLWE

Title

Confined Sluicing

Criteria

Utilize a low volume high pressure confined sluicing end effector (CSEE) like the one used at Oak Ridge for removing exposed sludge. A deployment arm or mast (s) is required to position the CSEE. A vacuum system is used in conjunction with the CSEE. This device would be deployed from several different risers to cover the entire tank. This would require a hose-in-hose type of above grade transfer system to enable waste to be pumped out at each riser location in which the CSEE is deployed.

Technical Maturity

Very Mature as demonstrated by Oak Ridge.

Safety Issues

Spraying analysis is required along with vacuum analysis.

Advantages

Provides hard material cleaning in a very effective manner.

Disadvantages

* Very slow process for waste removal
* requires hands-on operation
* above grade transfer system

Pass / Fail Pass

Total Score 0.484

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer
Date 10/24/2000
Function 1 1 32
Phone 208-2980
Originator Neil R. Davis
Dept CSTO/WR

Title

Two Modified ADMP's

Criteria

Develop a new wet end for the existing ADMP design that will allow insertion in a 2' diameter riser. May be single or dual discharge. Remove existing dead slurry pumps and mount in east and west risers.

Technical Maturity

Existing 39" diameter ADMP is the best slurry pump ever tested at SRS with 4000+ hours of operation before any trouble. Need new wet end.

Safety Issues

High pressure (90 psi) gas filled column.

Advantages

High equipment reliability, High probability that BCR will be enough, Only two pumps required, Good SRS experience in cold tests, Can probably use existing steel and infrastructure, Applicability to all other old-style tanks

Disadvantages

*Time and cost to develop new wet end of pump
* Rsik that the same performance cannot be obtained from a much smaller pump

Pass / Fail Pass
Total Score 0.795
Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer **Date** 10/24/2000

Function 1 1 33 **Phone** 208-2980

Originator Neil R. Davis **Dept** CSTO/WR

Title

One ADMP in Center Riser

Criteria

Install one ADMP in the 42" center riser of each Type I tank (Tanks 1-12). Maximum distance to tank wall is 37.5 ft while expected ECR in SRS sludge is 53 ft.

Technical Maturity

Existing ADMP reduced to 45' length and tested at TNX, best slurry pump ever tested with 4,200+ hours of successful operation.

Safety Issues

High pressure (90 psi) gas filled column

Advantages

High equipment reliability, High probability that ECR will be enough, Only one pump, drive, interlock, control, etc., required, Great SRS experience in cold tests, Applicability to new-style tanks

Disadvantages

* Have not actually operated an ADMP in a waste tank
* Cleaning may not be as good as expected due to numerous obstructions (support columns, cooling coils)
* Applies to Type I tanks only

Pass / Fail Pass **Total Score** 0.842 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer **Date** 10/25/2000

Function 1 1 36 **Phone** 208-8430

Originator T. Caldwell **Dept** HLWE

Title

Easily Manipulated Mechanical Arm (EMMA)

Criteria

Grey Prilgrim markets a long-reach manipulator arm which is functionally similar to an elephant trunk. The manipulator would be inserted through an existing riser to corral, mix, mobilize, and remove sludge waste from the tank. An end effector must be installed at the end of the arm to perform these operations such as the CSEE (see idea 1.1.35). To counterbalance the movement arm of the extended EMMA, a seperate structural platform must be constructed.

Technical Maturity

This technique has been demonstrated on a pilot scale using prototype arms. This technique is several million dollars away from being fully deployable.

Safety Issues

Equipment drop issues must be addressed as well as tank top loading. Mixing of the sludge is simular to that of the baseline.

Advantages

Disadvantages

The EMMA is a mechanically and electronically complex machine. Long term reliability studies have not been performed and pilot studies reveal close end sluicing (like that used by EMMA) is much less effective than global mixing using agitators and pumps. High initial capital design and operating costs would likely offset the monetary advantage of reusing the equipment.

Pass / Fail Pass **Total Score** 0.36 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category	1.1 Prepare Bulk Waste for Transfer	**Date**	10/25/2000
Function	1 1 37	**Phone**	208-8430
Originator	T. Caldwell	**Dept**	HLWE

Title

Pump Dry with Absorbent Material and Convey Out

Criteria

Large quantities of absorbent beads, simular to the type used in SWD dewatering operations, would be added to the tank. Stirring would not be needed if the material is blown into tank in a simular fashion as the dry grout in tanks 17 and 20. The water would be absorbed and the material could then be conveyed out of the tank as a dry material. This idea would be used in conjunction with the dry conveyence system proposed by others.

Technical Maturity

Absorbant beads have been used in many applications (from diapers to spill control) to dehydrate excess water. The proposed deployment mechanism was used effectively during tank 17 and 20 closure.

Safety Issues

Gas generation effects are not known.

Advantages

This technique has the advantage of getting the waste into a dry form if a dry conveyence technique is chosen.

Disadvantages

* Over long periods of time, water is released from the beads.
* dry conveyance system unknown, would probably require significant development

Pass / Fail Pass **Total Score** 0.382 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer **Date** 10/24/2000

Function 1 1 40 **Phone** 208-2980

Originator Neil R. Davis **Dept** CSTO/WR

Title

Flygt Mixers in Racetrack with Vertical Flygt Mixer in Center

Criteria

Remove dead slurry pumps from east and west risers. Deploy 50 hp Flygt mixers that can sweep 180o in each riser. Deploy 150 hp vertical Flygt mixer in center riser to keep solids from accumulating there. Applies to Type I tanks only (Tanks 1-12).

Technical Maturity

Full scale hot demo of 50 hp Flygt mixers in Tank 19 complete. It is well known that 50 hp units need more development to increase projected life. The 150 hp unit is on the drawing board.

Safety Issues

none

Advantages

low cost
could be used with no VSD's if vibration problems can be cured

Disadvantages

Equipment development needed
Must shut down mixers at tank levels below ~42"
Would probably have a high water to sludge ratio vs slurry pumps

Pass / Fail Pass **Total Score** 0.391 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10/24/2000

Function 1 1 42

Phone 208-2980

Originator Neil R. Davis

Dept CSTO/WR

Title

Sluicing with Recirc

Criteria

This idea is based on seeting up a recirc system with a nearby tank that has operable slurry pumps in it. As an example, Tank 6 could be used in concert with Tank 7. Install sluicers in Tank 6 supplied by a new above grade hose-in-hose pumping system installed in Tank 7. Supernate from Tank 7 would be pumped through the Tank 6 sluicing nozzles to push sludge towards a transfer pump in Tank 6. The sludge would be transferred out to Tank 7. The sludge would be allowed to settle and then the clarified supernate would be reused to remove more sludge from Tank 6.

Technical Maturity

Sluicing has been used successfully at many sites on many tanks

Safety Issues

It is expected that sludge particles will be aerosolized from a water jet impinging on exposed sludge. It is not known how big a safety concern this may be.

Advantages

no water addition needed to remove sludge
low cost
proven technology

Disadvantages

some equipment development needed but not major
tank will fog up during sluicing
sludge rheology will vary with sluicing, potential for transfer line pluggage
significant amount of above grade piping

Pass / Fail Pass **Total Score** 0.576 **Enhancement** [ ]

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer
Date 1/22/2002

Function 1 1 43
Phone 8-2980

Originator N. R. Davis
Dept CSTO

Title

Bulk Sludge Prep Baseline

Criteria

Use four 150 hp slurry pumps with Variable Speed Drives. Pumps are suspended from riser platforms. Pump assemblies are continuously rotated at 1/5 rpm using Rotec bearings. Internal shaft bearings are updated to tilt pad bearings as used on Tank 7. Expected cleaning radius in typical settled sludge is 25 to 30 ft as recently experienced on Tank 8 and several other tanks in the past. Required infrastructure is electrical to pump, electrical to Rotec, bearing water supply, bearing water station, and air supply to blow down column.

Technical Maturity

Very mature. The baseline has been used successfully for bulk sludge removal on 10 or more tanks.

Safety Issues

Release of hydrogen during initial startup of pumps. Potential for aerosolization.

Advantages

pump performance is well known
expected life is well known
pumps fit through 24" risers

Disadvantages

* expected life is probably limited to 2,000 hrs (tilt pad bearings may improve this)
* high cost

Pass / Fail Pass **Total Score** 0.583 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer
Date 3/12/2002
Function 1 1 44
Phone 8-2980
Originator N. R. Davis
Dept CSTO

Title

WEMD Canned Pump on a Mast

Criteria

A few vendors submitted proposals for an advanced design mixer pump. The Lawrence ADMP was awarded the contract. The WEMD pump had several merits that may not have been adequately considered. This idea combines the proposed WEMD pump with a rotating mast supported by the tank floor. Pump attributes are: 6,000 gpm, UoD of 30 ft ^{2}/sec, ECR of 53 ft. Motor attributes: canned motor, product cooled, rad hardened to withstand 1000 mega-rads of absorbed dose, good to 200°C, 1340 rpm, 350 hp. The combined assembly is 22.5" in diameter. The presumed service life of this pump is long thus this pump is expected to be reused on several tanks before it dies.

Technical Maturity

The design is very well developed however, a prototype has not been built.

Safety Issues

* none

Advantages

* WEMD produces an extremely high quality product
* expected long life lends itself to reuse
* has all advantages of floor supported pumps (no tanktop steel)
* has advantages of canned pumps (no bearing water, short shaft)

Disadvantages

* need to build, test and refine prototype
* probably expensive to build first unit

Pass / Fail Pass
Total Score 0.834
Enhancement ☐

Appendix F (1.2) – Alternatives, Bulk Salt Preparation for Transfer

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer **Date** 8/21/2001

Function 1 2 1 **Phone** 952-2324

Originator C. L. Donahue **Dept** PM

Title

Modified Density Gradient for Salt Removal Using Recycle Lines and Submersible Pump

Criteria

Add desired amount of water based on batch size required. Place Submersible Pump at desired elevation. This pump is connected to a valve box such that salt solution can be transferred out of the tank or recycled within the tank until fully saturated. Transfer solution out of tank when ready.

Technical Maturity

Very Mature - There is nothing used in this process that is not already in use in the tank farms.

Safety Issues

Above grade recycle lines will need to be adequately shielded to prevent unnecessary exposure.

Advantages

Minimizes use of water to achieve salt saturation prior to transfer out of tank.
Requires no mixing pumps.
Reusable Power Source.

Disadvantages

Needs steam sparger as heat source.
Nozzles could plug if not properly sized or improperly operated (i.e. leaving salt in lines when not circulating)

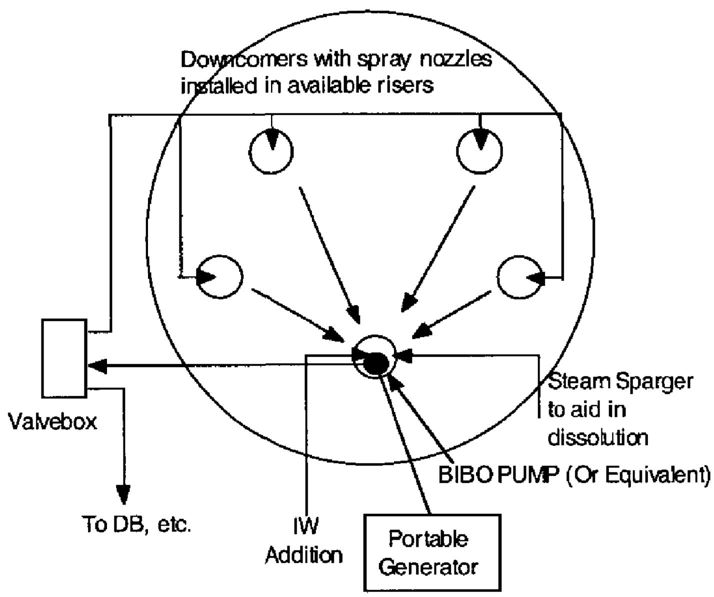
Pass / Fail Pass **Total Score** 0.688 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Process Diagram (Optional)

Modified Density Gradient (Using Pump & Sparger)



Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer
Date 8/29/2001

Function 1 2 2
Phone 8-2980

Originator N. R. Davis
Dept CSTO/WR

Title

Steam Recirculating Jet for Salt Removal

Criteria

Tank 22 received concentrate from the 1H Evaporator in the 1960's. By 1971, Tank 22 was needed for fresh waste receipt from 221-H. The salt level at that time was 60-100". RBOF waste in Tank 23 was used to dissolve the salt. Agitation was provided by a steam recirc jet. The attached info indicates that the agitation was local, i.e., it did not affect all areas of the tank. Salt removal was stopped when the salt level reached 11-17". It appeared that there was a layer of sludge blanketing the salt which hindered further dissolution. About 300 kgal of salt was dissolved. Excerpts from two technical documents are attached with salient info highlighted.

Technical Maturity

Very mature. Was done in Tank 22.

Safety Issues

* Tanks 21 and 22 were pressurized during recirc jet operation

Advantages

* cheap
*quick
* water/salt ratio = 2.4 at end of campaign (see table 5 p. 30 attached) after the process and equipment were debugged

Disadvantages

* agitation was minimal thus it was hard to reach stauration and hard to displace insolubles
* temperature and corrosion control are issues for new tanks that will be reused, less so for tanks to be closed, there were long dormant periods for the tank to cool, lots of fog
* there is a saltout concern during transfers out of the tank if the solution cools

Pass / Fail Pass **Total Score** 0.864 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 8/29/2001

Function 1 2 3

Phone 8-2980

Originator N. R. Davis

Dept CSTO/WR

Title

Hydrolance for Salt Removal

Criteria

A hydrolance was used in Tank 19 to disperse the zeolite mound. It is high pressure (>1,000 psi) and low volume (40 gpm water added). This technology could be used for salt removal if the hydrolance could be positioned throughout the tank. It could be mounted to a simple articulating arm and deployed through several different risers to cover most of the tank. This idea would work best if the transfer jet was down low in the tank and liquid levels were maintained low to promote saturation.

Technical Maturity

mature in small, open architecture tanks, not mature in large tanks with hundreds of obstructions.

Safety Issues

none

Advantages

could be cheap and quick for salt tanks, low up front cost if vendor is used

Disadvantages

must be able to position the hydrolance and suction device throughout the tank

Pass / Fail Pass **Total Score** 0.689 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer **Date** 1/22/2002

Function 1 2 4 **Phone** 8-2980

Originator Neil Davis **Dept** CSTO

Title

Bulk Salt Prep Baseline

Criteria

Use three 150 hp slurry pumps with Variable Speed Drives. Pumps are suspended from riser platforms. Pump assemblies are rotated at 1/5 rpm using Rotec bearings. Internal shaft bearings are updated to tilt pad bearings as used on Tank 7. Required infrastructure is electrical to pump, electrical to Rotec, bearing water supply, bearing water station, and air supply to blow down column.

Technical Maturity

Very mature. The baseline has been used successfully for bulk salt removal on several tanks.

Safety Issues

Hydrogen release during initial operations. Potential for aerosolization.

Advantages

* pump performance is well known
* expected life is well known
* pumps fit through 24" risers

Disadvantages

* low expected life is probably limited to 2,000 hrs (tilt pad bearings may improve this)
* high cost

Pass / Fail Pass **Total Score** 0.603 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer - Salt
Date 4/8/2002

Function 1 2 5
Phone 8-2980

Originator N. R. Davis
Dept CSTO/WR

Title

Two Flygt Mixers

Criteria

Have ITT Flygt develop the most powerful mixer that they can fit through a 24" diameter riser. This will be a Flygt design based on their engineering expertise. It is expected that the motor will be 20 to 40 horsepower. The motor should be radiation hardened. Mount the mixer on a mast that can be lowered into the tank as the salt is removed. The assembly will be supported by the tank top or tanktop steel. The assembly will be mounted on a rotec assembly set to oscillate and thus cover the entire surface of the tank.

Technical Maturity

Flygt mixers modified by SRS were used in Tank 19. This idea would be a different design that is hopefully better engineered for longer life than the Tank 19 mixers.

Safety Issues

none

Advantages

* less expensive than slurry pumps
* less supporting services than slurry pumps
* should have a longer service life than Tank 19 mixers

Disadvantages

* some development required
* this device does not lend itself to a floor supported configuration

Pass / Fail Pass
Total Score 0.665
Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category	1.1 Prepare Bulk Waste for Transfer - Salt	**Date**	4/8/2002
Function	1 2 6	**Phone**	8-2980
Originator	N. R. Davis	**Dept**	CSTO/WR

Title

One Slurry Pump

Criteria

Use one standard slurry pump for each salt tank. The pump will be of the improved design similar to Tank 7 pumps to ensure a longer service life such that the pump could be reused in another tank. This idea should be used with a water addition strategy to ensure that high spots in the salt formation beyond the range of the pump can be reduced to maintain a fairly level salt surface during dissolution. There may be areas of the tank not effected by the pump due to obstructions or too far away. Two or three variable spray nozzles could be used to add water. The nozzles could be directed manually to cut down high spots in the salt formation or used to create a broad spray pattern if needed.

Technical Maturity

It is known that significantly less agitation is needed to dissolve salt as compared to suspending sludge. Two slurry pumps mounted 5' from the east and west tank wall on Tank 19 removed the salt. One pump near the center should reach all parts of the tank.

Safety Issues

none

Advantages

* less expensive than the baseline of 3 slurry pumps
* less supporting services and infrastructure
* less D&R than baseline

Disadvantages

* slurry pump will still require a lot of infrastructure (truss, bearing water, rotec, spray chamber, etc.)
* service life <2,000 hours due to shaft and vibration problems

Pass / Fail Pass **Total Score** 0.669 **Enhancement** [ ]

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category	1.1 Prepare Bulk Waste for Transfer - Salt	**Date**	4/8/2002
Function	1 2 7	**Phone**	8-2980
Originator	N. R. Davis	**Dept**	CSTO/WR

Title

Two Slurry Pumps

Criteria

Use two standard 150 hp slurry pumps for each salt tank. The pumps will be of the improved design similar to Tank 7 pumps to ensure a longer service life such that the pumps could be reused in another tank. This idea need not be coupled with a water addition strategy; the two pumps should be able to provide some agatation over the entire surface of the tank.

Technical Maturity

It is known that significantly less agitation is needed to dissolve salt as compared to suspending sludge. Two slurry pumps mounted 5' from the east and west tank wall on Tank 19 removed the salt. Two pumps nearer to the center should easily reach all parts of the tank.

Safety Issues

none

Advantages

* less expensive than the baseline of 3 slurry pumps
* less supporting services and infrastructure
* less D&R than baseline

Disadvantages

* slurry pumps will still require a lot of infrastructure (trusses, bearing water, rotec, spray chamber, etc.)
* service life <2,000 hours due to shaft and vibration problems

Pass / Fail Pass **Total Score** 0.671 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer - Salt

Date 4/8/2002

Function 1 2 8

Phone 8-2980

Originator N. R. Davis

Dept CSTO/WR

Title

Two Modified Advanced Design Slurry Pumps

Criteria

Tank 18 will use one 10,400 gpm ADMP (Advanced Design Mixer Pump). This pump is 39" in diameter. It is proposed that a pump of similar capacity and UoD be developed that will fit in a 24" diameter riser. Two of these pumps could easily dissolve the salt in any tank.

Technical Maturity

While the ADMP is mature, getting this performance in a much smaller package will require significant design and development.

Safety Issues

none

Advantages

* less expensive than the baseline of 3 slurry pumps
* less supporting services and infrastructure
* less D&R than baseline
* ADMP is expected to have much longer service life than standard slurry pumps

Disadvantages

* slurry pumps will still require a lot of infrastructure (trusses, bearing water, rotec, spray chamber, etc.)
* significant R&D needed
* expected high discharge velocity may cause excess aerosolization

Pass / Fail Pass **Total Score** 0.589 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer - Salt

Date 4/8/2002

Function 1 2 9

Phone 8-2980

Originator N. R. Davis

Dept CSTO/WR

Title

Two Pulse Tube Mixers

Criteria

AEA Technologies is developing a large Pulse Tube Mixer (PTM) for use at Hanford for salt removal. It is proposed that two of these devices be installed in a salt tank. The device would be supported by the tank floor after mining through the salt layer. The suction is at the bottom of the well. The discharge is above the liquid level. Tests at AEA showed that the discharge distance is at least 45' with a coherent spray pattern. Each device would be rotated with a rotec assembly similar to the Flygt mixers on Tank 19. Water is added and the PTMs are operated to ensure that saturation is reached. Two PTMs should be able to reach all parts of an obstructed tank.

Technical Maturity

PTMs are mature in rad service. A small unit is being used in FPT-1. Others have been in service for years in the UK.

Safety Issues

none

Advantages

* less expensive than the baseline of 3 slurry pumps
* less supporting services and infrastructure, less D&R than baseline
* Expected to have much longer service life than standard slurry pumps
* No moving parts in rad service, could reuse all or part of the PTM and services

Disadvantages

* mining to bottom of tank could cause criticality concern
* aerosolization during PTM discharge cycle

Pass / Fail Pass **Total Score** 0.714 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer - Salt

Date 4/8/2002

Function 1 | 2 | 10

Phone 8-2980

Originator N. R. Davis

Dept CSTO/WR

Title

One Pulse Tube Mixer

Criteria

AEA Technologies is developing a large Pulse Tube Mixer (PTM) for use at Hanford for salt removal. It is proposed that one of these devices be installed in a salt tank. The device would be supported by the tank floor after mining through the salt layer. The suction is at the bottom of the well. The discharge is above the liquid level. Tests at AEA showed that the discharge distance is at least 45' with a coherent spray pattern. The device would be rotated with a rotec assembly similar to the Flygt mixers on Tank 19. A water addition strategy will be needed to ensure that all parts of the tank are reached. The PTM is operated to ensure that saturation is reached. One PTM should be able to reach most parts of an obstructed tank.

Technical Maturity

PTMs are mature in rad service. A small unit is being used in FPT-1. Others have been in service for years in the UK.

Safety Issues

none

Advantages

* less expensive than the baseline of 3 slurry pumps
* less supporting services and infrastructure, less D&R than baseline
* Expected to have much longer service life than standard slurry pumps
* No moving parts in rad service, could reuse all or part of the PTM and services

Disadvantages

* mining to bottom of tank could cause criticality concern
* aerosolization during PTM discharge cycle
* this idea would work best on Type I tanks with center riser, would be less effective on Type II or III tanks

Pass / Fail Pass **Total Score** 0.653 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer - Salt

Date 4/8/2002

Function 1 2 11

Phone 8-2980

Originator N. R. Davis

Dept CSTO/WR

Title

Density Gradient

Criteria

This process has been used on Tanks 10 and 20. The salt is mined under the jet riser to the tank bottom. The jet height is set at the tank bottom. The jet capacity is 10-15 gpm. Water is added at the far side of the tank from the jet. As the water washes over the top of the salt and percolates through the salt, there is enough residence time to ensure that the salt solution is saturated or nearly so. The densest salt solution will migrate to the bottom of the well. The low capacity jet is operated to remove salt solution at the same rate as water is added. The salt surface is kept covered with water. Water may be added manually via a nozzle directed at salt mounds if they are present.

Technical Maturity

Very mature, used at SRS.

Safety Issues

none

Advantages

* less expensive than the baseline of 3 slurry pumps
* less supporting services and infrastructure, less D&R than baseline
* expected to have much longer service life than standard slurry pumps
* no moving parts in rad service

Disadvantages

* mining to bottom of tank could cause criticality concern
* process is slower than slurrying
* maintaining dedicated transfer route for weeks at a time may interfere with other transfers
* may use more NaOH as NaNO3 would be preferentially dissolved

Pass / Fail Pass **Total Score** 0.78 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer - Salt **Date** 4/8/2002

Function 1 2 12 **Phone** 8-2980

Originator N. R. Davis **Dept** CSTO/WR

Title

Modified Density Gradient

Criteria

This process is similar to Density Gradient except that it is a batch vs. continuous process. In this option, water is added and allowed to "soak" for several days and thus dissolve salt. The transfer jet, usually a TTJ, is then lowered down to the salt supernate interface. Supernate is transferred out at 75 gpm. The process is repeated until the tank is empty. The water addition could be made through nozzles to cut down salt mounds if this occurs.

Technical Maturity

This alternative has been suggested several times but has not been demonstrated at full scale in a tank. Salt dissolution rates are known.

Safety Issues

none

Advantages

* less expensive than the baseline of 3 slurry pumps
* less supporting services and infrastructure, less D&R than baseline
* expected to have much longer service life than standard slurry pumps
* few moving parts in rad service

Disadvantages

* process is slower than slurrying
* requires either a TTJ (expensive) or several transfer jet lowerings (exposure)
* total lack of agitation leads to salt mounds, channeling and/or slow dissolution rates as insoluble solids accumulate on salt surface

Pass / Fail Pass **Total Score** 0.722 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer - Salt

Date 4/8/2002

Function 1 2 13

Phone 8-2980

Originator N. R. Davis

Dept CSTO/WR

Title

Two WEMD Pumps

Criteria

This idea is based on the ability to develop and deploy a short shaft submersible pump. Westinghouse EMD has proposed a design that could fit through a 24" diameter riser. One of these pumps in the center riser of Tanks 1-3 and 9-10 could get all of the salt out. Two pumps could be used for other obstructed tanks that do not have center riser (e.g., Tanks 14, 25, 27-31, 36-38, 44-46). It is proposed that the salt be mined under the center riser to the tank floor. The pump could then be installed in the well and lowered as needed as salt is removed from the top. The motor is rad hardened and product cooled. For Type I tanks, one pump in the center riser will be sufficient.

Technical Maturity

Significant R&D is needed to develop the pump. The motor design is very mature.

Safety Issues

none

Advantages

* less expensive than the baseline of 3 slurry pumps due to less supporting services, infrastructure, D&R, tanktop steel, and bearing water than baseline
* expected to have much longer service life than standard slurry pumps, thus pump could be reused for heel removal and in other tanks

Disadvantages

* significant R&D needed

Pass / Fail Pass

Total Score 0.755

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category	1.1 Prepare Bulk Waste for Transfer - Salt	**Date**	4/8/2002
Function	1 2 14	**Phone**	8-2980
Originator	N. R. Davis	**Dept**	CSTO/WR

Title

Sluicing

Criteria

This idea is based entirely on the ability to operate several nozzles installed in different parts of the tank to direct water at the exposed salt to dissolve the salt in a more or less even layers. No pumps or other form of agitation would be required. Operation of the different nozzles would presumably preclude salt mounds, channeling, etc.

Technical Maturity

This technique has not been demo'd at SRS in salt tanks. It has worked in sludge tanks.

Safety Issues

none

Advantages

* less expensive than the baseline of 3 slurry pumps
* less supporting services and infrastructure, less D&R than baseline
* expected to have much longer service life than standard slurry pumps

Disadvantages

* will be difficult to ensure salt solution is saturated; may be wasteful in this regard
* may require 5-10 nozzles to ensure all parts of the tank can be reached
* most effective on exposed salt, may drive need for many transfers
* insoluble solids will accumulate and tend to slow down dissolution rate

Pass / Fail Pass **Total Score** 0.694 **Enhancement** ☐

Appendix F (2.1) – Alternatives, Bulk Sludge Waste Transfer

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste
Date 8/21/2001

Function 2 1 2
Phone 8-0506

Originator Gene Dixon
Dept CSTE

Title

Truck Waste

Criteria

Use a shielded truck to transport waste from the waste removal tank to the ESP tank (40 or 51). The tank would need a tank truck loading facility and pump. The ESP tank would need an unloading facility. Truck capacity assumed to be 1,000 to 4,000 gal. Tank features: top pumpout to avoid leaks, agitator to keep solids suspended, hose-in-hose to provide containment during transfers, flush fittings to rinse out tank and hose after use to avoid pluggage, liquid level probes to avoid overfill.

Technical Maturity

very immature for such a high waste volume and source term, very mature for low activity waste with low wt & insoluble solids

Safety Issues

* above grade movement of liquid waste
* potential for crash or leak
* rad exposure to operate loading/unloading and truck

Advantages

* eliminates reliance on aging transfer equipment
* does not interfere with other tank farm transfers
* could be cheaper in long run

Disadvantages

* high up front cost of truck and resolution of AB issues
* high rad exposure (see attached note)
* truck design would be very difficult due to shielding, weight, crash-worthyness, etc.

Pass / Fail Pass
Total Score 0.344
Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste

Date 8/29/2001

Function 2 1 3

Phone 8-2980

Originator N. R. Davis

Dept CSTO/WR

Title

Disposable Transfer Pump on a Rope

Criteria

Use a sump pump suited to the tank environment. Attach a tether to support the pump and the power cable. Lower the pump into the tank to the desired depth and tie off the tether to secure the pump. For salt tanks with gentle or no agitation, no precautions are needed to keep the pump in position. For sludge tanks with vigorous agitation, design features will be needed to keep the pump from being buffeted about the tank such as making the pump very heavy. The pump should be free draining to promote easy flushing after use, and it should have a modified suction beel to enable the pump to draw the liquid level down to 1-2" without pulling in air.

Technical Maturity

Mature

Safety Issues

None

Advantages

cheap, easy to adjust height, easy to replace

Disadvantages

* design need to prevent buffeting
* motor resides in very high rad field

Pass / Fail Pass

Total Score 0.774

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste

Date 8/30/2001

Function 2 1 4

Phone 952-2324

Originator C. L. Donahue

Dept PM

Title

Pump on a Raft

Criteria

Float pump on a raft-like object with a bottom suction. The pump could be manually or remotely positioned. Pump could be lifted during slurry operations. This idea would work best on Type IV tanks where getting tangled in cooling coils would not be a problem. The pump should be product cooled as it will reside above the liquid. The pump can be moved about the tank with tethers.

Technical Maturity

Haven't seen this application in use.

Safety Issues

Raft would need to be bouyant and sturdy enough to resist overturning.

Advantages

Pump would not need to be in the waste. Raft would be contaminated but pump could be exchanged if needed. Pump could be positioned to apply suction where needed. Avoids need for agitation.

Disadvantages

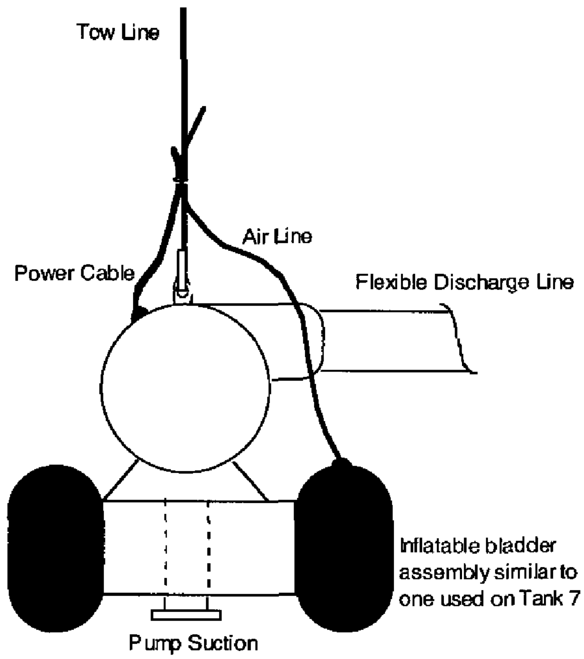
Would not work well in a tank with cooling coils.

Pass / Fail Pass **Total Score** 0.361 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Process Diagram (Optional)



Waste Removal Balance of Program SEE

Idea Pro-Forma

Category	1.2 Transfer Bulk Waste	**Date**	8/20/2001
Function	2 1 5	**Phone**	208-1448
Originator	Brannen Adkins	**Dept**	HLWE

Title

Hanford SEE Pump Like Tank 19

Criteria

Relpace TTP with short-shaft, submersible, centrifugal, transfer pump similar to Bibo pump used in tk 19. Pump will be attached to rigid mast with varible-depth capability up to 50" depending upon deployment method chosen. A coiled hose will be wrapped around the rigid mast to allow adjustment of pump on mast. This device would be supported from the tank top. Steel truss may be required depending on weight.

Technical Maturity

Pump design is mature. Coiled-hose and telescoping mast concept are new.
Medium

Safety Issues

none

Advantages

Low Cost, Easily replaced, simple, eliminates cans, eliminates vibration

Disadvantages

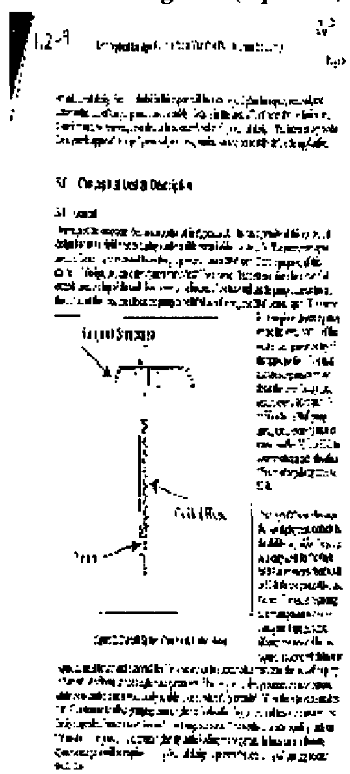
Pump heat added to tank

Pass / Fail Pass **Total Score** 0.663 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Process Diagram (Optional)



Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste

Date 8/20/2001

Function 2 1 6

Phone 208-1448

Originator Brannen Adkins

Dept HLWE

Title

Wand W/Booster Pumps in Series

Criteria

Use sluice wand with booster pumps in series instead of long-shaft pumps to transfer waste between tanks.

Technical Maturity

Low

Safety Issues

Requires above grade transfer - AB concerns

Advantages

Low cost, Simple, Can be moved from tank to tank

Disadvantages

Suction lift limitations, AB concerns

Pass / Fail Pass

Total Score 0.363

Enhancement ☐

Waste Removal Balance of Program SEE

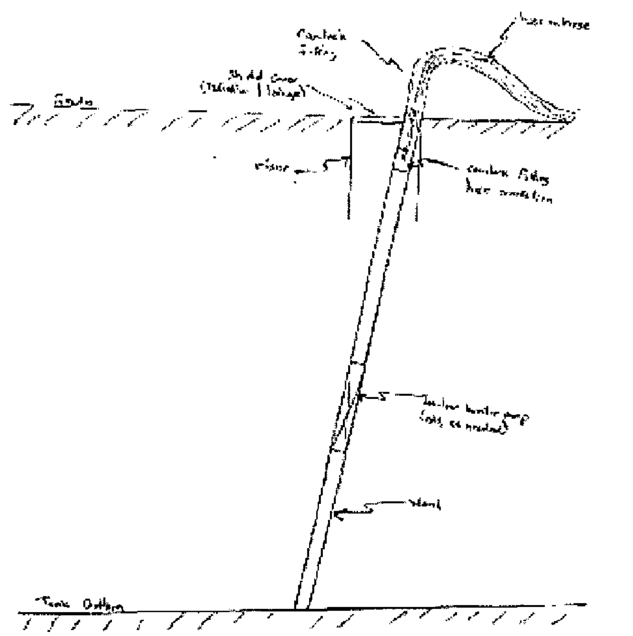
Idea Pro-Forma

Process Diagram (Optional)

High Level Waste Division

Pro-Forma Form

Process Diagram (Optional)



Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste
Date 10/1/2001
Function 2 1 7
Phone 8-0264
Originator E. Saldivar, Jr.
Dept HLWE

Title

Vacuum Tank

Criteria

Utilize a vacuum system to retrieve waste in a dry/damp form. A vaccuum would be maintained on the small tank to draw sludge into it. The tank would then be pressurized to dispell the sludge into another waste tank. The suction leg would need to be positioned throughout the tank to reach all of the sludge.

Technical Maturity

Used throughout industry. Never used at SRS to retrieve highly radioactive waste that I am aware of.

Safety Issues

Venting of exhaust that is contaminated. Shielding of receipt tank/drum for worker and meeting transportation requirements.

Advantages

Taking the suction to the waste would appear to provide very complete cleaning. This suction technology is used throughout industry and is considered very effective.

Disadvantages

Immature technology in the HLW Tank Farms. Worker protection and transportation issues will be significant. Would be very difficult to position suction on tanks with cooling coils.

Pass / Fail Pass **Total Score** 0.363 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste

Date 10/18/2000

Function 2 1 8

Phone p-12297

Originator C. L. Sharpe

Dept

Title

Macerator Pump

Criteria

There is a pump called a "chopper pump" that is advertised to reduce size of "solids". Ad refers to sewage treatment. This is not a suggestion per se. It is a response to the idea that we may need to grind up solids. One vendor is Vaughn, Crane maybe? These pumps are similar to sump pumps but are designed to reduce the size of solids as they pump. This pump would be mounted on a mast supported by the tank floor.

Technical Maturity

Weak - No Known use. Radiation resistance unknown. Method of deployment unknown. Needs considerable followup if the need to :chop or grind" persists or is thought to be necessary.

Safety Issues

TBD

Advantages

* Pump is advertised to reduce solid size.
* these pumps are typically very robust
* no bearing water service is needed, only electrical

Disadvantages

Material unknown, deployment unknown. Probably a development job.

Pass / Fail Pass

Total Score 0.796

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste **Date** 10/24/2000

Function 2 1 9 **Phone** 208-2980

Originator Neil R. Davis **Dept** CSTO/WR

Title

Bibo Pump on Mast

Criteria

Install a Bibo sump pump mounted to a mast. Raising or lowering the pump assembly along the mast will vary the suction height. A flexible discharge hose will run between the Bibo and the existing nozzle in the riser.

Technical Maturity

Bibo pump was used in tank 19 for over one year, 47 transfers, 12 million gallons.

Safety Issues

none

Advantages

low cost
could be used with no VSD
Applicability to other tanks
Short shaft pump

Disadvantages

Some equipment development needed but not major
Bibo longevity may be low due to high rad rate at motor
Must prevent hose kinking
need 45 ft long mast

Pass / Fail Pass **Total Score** 0.818 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste

Date 10/24/2000

Function 2 1 10

Phone 208-2980

Originator Neil R. Davis

Dept CSTO/WR

Title

Modify TTP with Motor at Bottom (submersible pump)

Criteria

Modify an existing TTP to make it into a short shaft pump. Keep the wet end of the pump and the telescoping discharge piping system. Select a commercially available motor that works under water similar to a Flygt motor. Product lube and product cooled is preferred. Upgrade components that would quickly fail in a high rad environment. Modify the pump column so that it serves only to support the pump and electrical/flushwater supplies. Intermediate flanges, o-rings, bearing and bearing water supply could be eliminated.

Technical Maturity

Wet end of TTP very mature, motors not normally used down in tank although experience with submerged Flygt motors on Tank 19 indicates service life of at least 1 year.

Safety Issues

none

Advantages

lower cost than TTP, Applicability to other tanks, Short shaft pump, Combines known components in cost effective way, Retains adjustable suction height feature

Disadvantages

Some equipment development needed but not major
motor longevity may be low due to high rad rate at motor

Pass / Fail Pass **Total Score** 0.609 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste

Date 10/25/2000

Function 2 | 1 | 11

Phone 952-2657

Originator J. E. Herbert

Dept CSTO / WR

Title

Diaphragm Pump

Criteria

Utilize an air driven stationary diaphragm pump to convey the slurry media. Pump can be mounted from roof or sit upon tank bottom. Air supply can be from a portable compressor.

Technical Maturity

Many diaphram pumps exist in industry for chemical and slurry transfer. Good Rad resistance demonstrated on tank 48 ITP demo.

Safety Issues

Would have to carefully review any issues regarding sludge aerosolization due to pump misoperation.

Advantages

This design good at handling a variety of solids. Pump is self priming and would not necessarily need to be placed in the waste. Possible that suction hose could be mobile w/crawler.

Disadvantages

In order to generate sufficient flowrate pump would need to be of considerible size / weight restricting adaption of this type pump to a mobile platform or crawler. Not self draining, would need valves and fittings.

Pass / Fail Pass **Total Score** 0.548 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste

Date 10/24/2000

Function 2 1 12

Phone 208-2980

Originator Neil R. Davis

Dept CSTO/WR

Title

Screw Pump

Criteria

Select a nice stainless steel screw or progressive cavity pump from some reputable manufacturer like a Moyno pump. Would be helpful to be product lubricated and cooled. Mount the pump on a mast. Pump suction height can be varied by raising/lowering entire assembly.

Technical Maturity

Moyno type pumps being used in rad industry but not at SRS

Safety Issues

none

Advantages

very robust reliable type of pump
can pump gravel and other large particles
cheap
no VSD

Disadvantages

Some equipment development needed but not major
Pump longevity may be low due to high rad rate at motor
scant experience at SRS

Pass / Fail Pass

Total Score 0.718

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste

Date 10/18/2000

Function 2 1 13

Phone p-12297

Originator C. L. Sharpe

Dept

Title

Modified Deep Well Eductor Pump

Criteria

Presented as lower cost option to Hazleton style TTP. Lower cost is actually TBD. Labor (and possibly others) build a verticle, close coupled self-priming pump.
Two Options: with eductor and without eductor
See attached sketches: CLS-4-I , CLS-4-II

Technical Maturity

Low

Safety Issues

TBD
prime system isolation

Advantages

Shelf equipment, Cost (if proven)

Disadvantages

Unproven, Probably a dvelopment job. If design gets involved, cost is going up.

Pass / Fail Pass

Total Score 0.292

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste

Date 1/22/2002

Function 2 1 14

Phone 8-2980

Originator Neil Davis

Dept CSTO

Title

Bulk Sludge Transfer Baseline

Criteria

Use one 75 hp Telescoping Transfer Pump (TTP) with Variable Speed Drive. TTP is suspended from riser platform. Internal shaft bearings are same as current design. Typical pumping rates are 100 to 300 gpm depending on line losses, head, etc. Required infrastructure is electrical to pump, bearing water supply, bearing water station, and air supply to blow down column. Suction elevation is adjusted by removing or adding containment cans. Pump discharge line telescopes to accomodate different suction elevations.

Technical Maturity

Very mature. TTPs have been used on at least 10 tanks with only minor problems.

Safety Issues

None

Advantages

* lot of experience
* acceptable service life
* wide variability of pumping rates
* easy to adjust suction height

Disadvantages

* cost about $250,000 per pump plus $1.5 to 2.0 M for support services and infrastructure

Pass / Fail Pass **Total Score** 0.644 **Enhancement**

Appendix F (2.2) – Alternatives, Bulk Salt Waste Transfer

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste

Date 11/14/2000

Function 2 2 1

Phone 557-7270

Originator R. A. Leishear

Dept CSTE

Title

Jets

Criteria

Use standard fixed length steam jets. Mine a well to the bottom of the salt tank. Install the jet with the suction at the tank floor

Technical Maturity

Mature - used in several salt removal campaigns

Safety Issues

Advantages

* Technology is well understood
* low up front cost
* no moving parts in tank
* reuses exsiting infrastructure

Disadvantages

* jets add 5% steam dilution whereas pumps do not
* may have to periodically flush jets if solids accumulate at bottom of well
* mining to bottom of tank is labot intensive and workers will get some radiation exposure

Pass / Fail Pass **Total Score** 0.848 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste

Date 1/22/2002

Function 2 2 2

Phone 8-2980

Originator Neil Davis

Dept CSTO

Title

Bulk Salt Transfer Baseline

Criteria

Use one Telescoping Transfer Jet (TTJ). The TTJ is installed in the existing jet riser of each salt tank. Typical transfer rates are 75 gpm. There is no new required infrastructure other than a new riser plug which is furnished with the TTJ. The suction elevation is adjusted by turning a handwheel to raise or lower the suction. The jet discharge line telescopes to accomodate different suction elevations.

Technical Maturity

Very mature. TTJs have been used on at least 10 tanks with only minor problems.

Safety Issues

None

Advantages

* lot of experience
* acceptable service life
* easy to adjust suction height

Disadvantages

* cost about $600,000 - 900,000 per jet and riser plug

Pass / Fail Pass

Total Score 0.665

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste - Salt

Date 3/8/2002

Function 2 2 3

Phone 8-2980

Originator N. R. Davis

Dept CSTO

Title

Sump Pump on Cable

Criteria

Commercial grade sump pump capable of transferring at least 75 gpm. Attch pump to cable and lower to desired height. Vary height with a cable and winch assembly. Make pump heavy enough to keep stationary when mixers are running. The discharge hose might be a flex hose spiraled around the cable to enable it to adjust length without kinking. The connection to the existing transfer line can be made in the riser by using a standard squeeze type connector or an expandable interior collar inside the transfer line (see diagram attached). There will be one main discharge valve and a flush fitting on either side. Could include suction bell to enable pump to draw liquid level down to 1" or so such that one pump could be used for bulk, heel and dewater.

Technical Maturity

The pump part is very mature. Used in tank 19 heel removal. The cable part has not been tried in a waste tank.

Safety Issues

Pump drop

Advantages

* cheap - no bearing water or tank top steel
* have some pertinent experience

Disadvantages

* need design for cable
* may not be able to keep mixers running during transfer until most salt is gone and pump can rest on floor of tank

Pass / Fail Pass

Total Score 0.691

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste - Salt
Date 3/8/2002

Function 2 2 4
Phone 8-2980

Originator N. R. Davis
Dept CSTO

Title

Hanford SEE Pump

Criteria

Hanford conducted an SEE that included this proposed design. A 2 piece telescoping mast is installed with an inline pump attached to the bottom section. The 2 sections telescope to adjust pump suction height. The weight is supported from above. The discharge hose is coiled around the telescoping mast to enable height adjustment without kinking the hose. This unit has not been built, it is a concept.

Technical Maturity

Sump pumps have been used in Tank 19 heel removal. Telescoping sections are used on standard TTJ's and TTP's. This idea combines pieces and parts of many existing equipment assemblies. On a 10 scale, maturity is about 6-7.

Safety Issues

Pump drop

Advantages

* could be cheaper than TTP or TTJ

Disadvantages

* needs a lot of design
* bears on tank roof or support steel

Pass / Fail Pass
Total Score 0.641
Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste - Salt
Date 3/8/2002
Function 2 2 5
Phone 8-2980
Originator N. R. Davis
Dept CSTO

Title

Air Operated Diaphragm Pump on Mast

Criteria

Attach an air operated diaprhagm pump to a mast. Mine salt down to tank floor. Insert mast to bear on tank floor. Adjust suction height by raing or lowering pump assembly as it travels on mast. Must route vent hose up to vapor space. Must have clean dry air to avoid pilot valve failure and freeze-up of vent. Use flex discharge hose spiraled around mast to enable height adjustment withyout kinking. Provide standard three valve manifold to enable flusing. Must have drain valves on diaphragm chambers as this type of pump is not free draining.

Technical Maturity

Somewhat mature. Used on tank 48 ITP demo.

Safety Issues

May be sludge aerosolization issues

Advantages

* may be cheaper than TTJ or TTP
* no tank top steel or bearing water

Disadvantages

* lots of design needed
* not free draining, need extra valves
* need high quality air supply
* service life of diaphragms in high rad environment may be an issue

Pass / Fail Pass **Total Score** 0.733 **Enhancement** [ ]

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.2 Transfer Bulk Waste - Salt **Date** 3/8/2002

Function 2 2 6 **Phone** 8-2980

Originator N. R. Davis **Dept** CSTO

Title

Sump Pump on a Mast

Criteria

Commercial grade sump pump capable of transferring at least 75 gpm. Mount it on a rigid mast that bears on the tank floor. Pump can travel up and down along the mast to adjust suction height. Vary height with a cable and winch assembly. The discharge hose might be a flex hose spiraled around the mast to enable it to adjust length without kinking. The connection to the existing transfer line can be made in the riser by using a standard squeeze type connector or an expandable interior collar inside the transfer line (see diagram attached). There will be one main discharge valve and a flush fitting on either side. Could include suction bell to enable pump to draw liquid level down to 1" or so such that one pump could be used for bulk, heel and dewater.

Technical Maturity

Very mature. Used in Tank 19 heel removal. Bibo pump lasted almost one year and pumped several million gallons of slurried sludge before failure.

Safety Issues

None.

Advantages

* cheap
* no tank top steel or bearing water
* have experience

Disadvantages

* need design to make reliable easy to install connection to transfer line with flush capability
* must mine salt down to tank bottom before installing mast

Pass / Fail Pass **Total Score** 0.825 **Enhancement** ☐

Appendix F (3.1) – Alternatives, Heel Preparation for Transfer

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 9-25-2001

Function 3 1 1

Phone 5-8199

Originator Bill Van Pelt

Dept SRTC

Title

Chemical Dissolution

Criteria

Use dilute acidic solutions (such as 1-2M nitric acid) to dissolve heels and produce an aqueous solution to transfer out of the tank. The acid stream would be neutralized in a local pump tank or in a nearby tank set up with slurry pumps. The transfer lines would be flushed when complete to avoid scattering acid around where it is not wanted. Neutralized nitric acid forms sodium nitrate which is 100% compatible with tank farm waste. A second transfer pump would need to be ready to deploy if the primary pump failed while acid was in the tank.

Technical Maturity

Shown to readily dissolve 2H evaporator deposits. Russians also use chemical cleaning,

Safety Issues

Corrosion of tank

Advantages

* Fast and effective.
* No solids to transport.
* Cheap - no new equipment.

Disadvantages

* Corrosive to tank, may only be viable if tank to be closed after heel removal.
* need to understand corrosion rate
* need to perform dissolution quickly to avoid excessive corrosion
* may reactivate leaks sites

Pass / Fail Pass **Total Score** 0.674 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 8/29/2001

Function 3 1 2

Phone 8-2980

Originator N. R. Davis

Dept CSTO/WR

Title

Ultrasonic

Criteria

Install commercially available ultrasonic probes into the tank down to the tank bottom. Use ultrasound to render the sludge easier to suspend while the slurry pumps are running. Informal telephone discussions with vendors indicate that many (>>10) probes would be needed for a tank 85 ft in diameter and that tank or equipment damage could result.

Technical Maturity

Not mature - never been used in this application. Rigid tank structure not conducive to ultrasound.

Safety Issues

Potential for tank damage.

Advantages

* could be cheap
* no moving parts added for heel removal

Disadvantages

* significant R&D needed
* could be high risk of damage

Pass / Fail Pass

Total Score 0.132

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer
Date 8/21/2001

Function 3 1 4
Phone 8-2980

Originator N. R. Davis
Dept CSTO/WR

Title

Use Tank 16 Oxalic Acid Cleaning at 8 wt %

Criteria

The residual sludge in Tank 16 was removed with 3 batches of heated 4 wt % oxalic acid. The solubility limit of oxalic acid in water is 8 wt % so this idea proposes to use a stronger acid at 8 wt %. It is assumed that 2 or 3 batches will be required to get most of the sludge out of the tank. Dissolution will not be complete, however, the undissolved sludge components will be easier to suspend and thus promote waste removal. The acid stream is neutralized on the fly in a local pump tank. Oxalic acid is known to preferentially dissolve poisons but not fissile isotopes thus there is a credible criticality mechanism. Criticality is not expected to be a problem if the residual volume of sludge is a few thousand gallons or less.

Technical Maturity

Mature - this process was successfully used on Tank 16. Some technical work will have to be performed to ensure that criticality and downstream process impacts are fully understood.

Safety Issues

* acid handling
* criticality

Advantages

* no new equipment needs to be installed to facilitate heel removal
* have some experience in Tank 16 and subsequent SRTC and TFA tests

Disadvantages

* need to set up a pump tank for neutralization in H Tank Farm (F Tank Farm can use the DIWF)
* must complete criticality evaluation/testing

Pass / Fail Pass **Total Score** 0.718 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category	1.3 Prepare Heel For Transfer	**Date**	9/30/2001
Function	3 1 6	**Phone**	5-2838
Originator	D. T. Hobbs	**Dept**	SRTC

Title

Oxalic Acid & Citric Acid

Criteria

Use a mixture of oxalic acid and citric acid to affect removal of tank and annulus heel materials. Metal oxides and hydroxides will dissolve upon contact with a solution containing 5 - 15 g/L each of oxalic and citric acids.

An additional process step could be added to decompose the the organic acids that would increase flammable gas generation and complex radionuclides. The tank must be rinsed with IW prior to grouting.

Technical Maturity

Demonstrated at the laboratory scale with simulated SRS waste sludges. Pilot scale testing ($10\ m^3$) in progress at the Mining and Chemical Combine with Russian HLW materials.

Safety Issues

Increased hydrogen and flammable organic compounds generation due to the addition of citric acid into the HLW system.

Advantages

Low corrosivity of carbon steel. Organic acids, particularly the citric acid, complex with metals and radionuclides including actinides to decrease uncontrolled accumulation of fissile isotopes.

Disadvantages

Addition of organic complexants into HLW system impacts safety by increased generation of flammable compounds (e.g., hydrogen and organic compounds). Addition of chelating compounds could adversely impact separation of radionuclides in the Salt Processing Facility. Requires additional processing to limit impacts on safety (flammable gases) and radionuclide separation.

Pass / Fail Pass **Total Score** 0.527 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer **Date** 9/30/2001

Function 3 1 7 **Phone** 5-2838

Originator D. T. Hobbs **Dept** SRTC

Title

Reverse Surface Charge to Defloc Sludge Particles by Acid Addition

Criteria

Add nitric acid solution to sludge slurry until the pH of the solution results in a reversal of the surface charge on the sludge particles. Reversing the surface charge will force the sludge particles to repel each other making the particles much easier to suspend and remain in suspension so that the solids can be pumped out of the tank.

Technical Maturity

Untested with SRS high-level wste sludges.

Safety Issues

Addition of nitric acid to the waste tank will increase corrosion of the carbon steel.

Advantages

No new chemicals introduced into the HLW system.

Disadvantages

May be difficult to control or be effective for all types of sludges. Reversal of surface charge is dependent on the specific metal oxide or metal hydroxide compound. Since sludge is comprised of many different chemical components, the quantity of acid required to affect the charge reversal could vary continously.

Pass / Fail Pass **Total Score** 0.468 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 9/30/2001

Function 3 1 8

Phone 5-2838

Originator D. T. Hobbs

Dept SRTC

Title

Reverse Surface Charge to Defloc Sludge Particles by Well Water Addition

Criteria

Add well water to sludge slurry until the pH of the solution results in a reversal of the surface charge on the sludge particles. Reversing the surface charge will force the sludge particles to repel each other making the particles much easier to suspend and remain in suspension so that the solids can be pumped out of the tank.

Technical Maturity

Untested with SRS high-level wste sludges.

Safety Issues

Addition of well water to the waste tank will increase corrosion of the carbon steel.

Advantages

No new chemicals introduced into the HLW system.

Disadvantages

May be difficult to control or be effective for all types of sludges. Reversal of surface charge is dependent on the specific metal oxide or metal hydroxide compound. Since sludge is comprised of many different chemical components, the quantity of acid required to affect the charge reversal could vary continously.

Pass / Fail Pass **Total Score** 0.517 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 9/30/2001

Function 3 1 9

Phone 5-2838

Originator D. T. Hobbs

Dept SRTC

Title

Suspend Heel Materials with Surfactants

Criteria

Add surfactants (ppm levels) to heel slurry that will result in stable suspension that does not readily settle. This could be done by spiking IW with a drum pump addition of surfactant during IW addition to the tank. The surfactant imparts the appropriate charge on the surface of the heel particles that the particles remain in suspension and can be easily pumped out of the tank.

Technical Maturity

Untested with SRS high-level waste sludges.

Safety Issues

Addition of surfactants could increase hydrogen and flammable gas generation if the surfactant is an organic compound.

Advantages

Generally the quantity of surfactant needed to produce a stable suspension is very small (typically a few ppm).

Disadvantages

May be difficult to control or be effective for all types of sludges. Surfactants that are effective in highly alkaline solutions are rare. The variety of components in SRS sludges may preclude finding a surfactant that is effective for all materials. Introduction of surfactants into the HLW system could adversely impact downstream operations including Evaporation, Salt Processing, DWPF and Saltstone.

Pass / Fail Pass

Total Score 0.512

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 8/20/2001

Function 3 1 10

Phone 8-2980

Originator N. R. Davis

Dept CSTO/WR

Title

Ultrasound with Oxalic Acid Cleaning

Criteria

Add enough 2-4 wt% OA heated to 90oC to react with the estimated sludge volume. Insert an ultrasound device and operate the device to dislodge the sludge and separate the sludge particles. Allow the dissolution reaction to go to completion. Pump the dissolved sludge to another waste tank via a stainless steel pump tank that has been outfitted for continuous inhibiter addition.
One batch should get the tank clean enough.

Technical Maturity

Low - not aware of any off-the-shelf designs for large waste tanks, vendors contacted were concerned about tank damage.

Safety Issues

oxalic acid handling
criticality concern due to preferential dissolution of poisons but not fissile isotopes

Advantages

similar to 3.1.4 except that less OA may be needed as slurry pumps are not used for mixing

Disadvantages

* ultrasound not mature in this application
* criticality concern
* cost to retrofit a pump tank for caustic addition
* cost of ultrasound device

Pass / Fail Pass **Total Score** 0.092 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer **Date** 9/30/2001

Function 3 1 11 **Phone** 5-2838

Originator D. T. Hobbs **Dept** SRTC

Title

Oxalic Acid with Oxidizer

Criteria

Use a mixture of oxalic acid and an oxidizer to increase the dissolution of radionuclides. Key radionuclides (e.g., ^{99}Tc and the actinides) may be in reduced oxidation states that limit solubility in aqueous solutions. Addition of an oxidizer (e.g., hydrogen peroxide and sodium permanganate) reacts with the reduced radionuclide to produce a higher oxidation stable that readily dissolves into the oxalic acid solution. Assume 2-3 batches will be need to remove most sludge. Tank must be rinsed with IW prior to grouting.

Technical Maturity

Limited testing in the laboratory with cooling coil from Tank 16 exhibited proof of principle.

Safety Issues

Possible increased hydrogen production. Addition of oxidizer would increase corrosivity of the oxalic acid solution to carbon steel.

Advantages

Potentially effective for a wide range of radinuclides including ^{99}Tc and the actinides.

Disadvantages

Depending on the quantity and the specific oxidizier used, increased hydrogen production (due to hydrogen peroxide) or increased number of HLW glass cannisters (sodium permanganate) may result.

Pass / Fail Pass **Total Score** 0.632 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 8/31/2001

Function 3 1 12

Phone 208-2980

Originator N. R. Davis

Dept CSTO/WR

Title

Add Material to Increase Sp Gr of Slurry Media

Criteria

Oak Ridge has added bentonite clay to increase the sp gr of the slurry media which retards the settling rate of sludge thus enabling more sludge to be removed during pumpdown of the tank. The bulk waste removal equipment, presumably some sort of slurry pumps, would be reused for this application. The non-rad slurry would be delivered via vendor trucks as needed.

Technical Maturity

mature at Oak Ridge

Safety Issues

no new safety issues

Advantages

* no new equipment needs to be added for heel removal

Disadvantages

* increased material handling to get material into waste tank
* material will likely end up in glass thus more cans will be produced
* may cause downstream process problems

Pass / Fail Pass **Total Score** 0.469 **Enhancement** [ ]

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 9/30/2001

Function 3 | 1 | 13

Phone 5-2838

Originator D. T. Hobbs

Dept SRTC

Title

Dissolve Heel Materials with Ionic Liquids

Criteria

Add ionic liquids to tank that will dissolve heel materials which can be easily pumped out of the tank. Depending on the chemical properties of the ionic liquid, a second processing step may be used to recover the ionic liquid for reuse or disposal in a low-level wasteform.

Technical Maturity

Untested with SRS high-level waste sludges. Professor Robin Rogers at University of Alabama recently awarded research grant to investigate use of ionic liquids for EM applications.

Safety Issues

Ionic liquids may be corrosive to carbon steels. Ionic liquids may undergo chemical and radiolytic decomposition to produce flammable gases.

Advantages

The solvency power of ionic liquids may be order of magnitude higher than that exhibited by aqueous solutions.

Disadvantages

The use of ionic liquids may adversely impact downstream operations. Additional processing may be required to recover or dispose the ionic liquids.

Pass / Fail Pass

Total Score 0.262

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer **Date** 9/30/2001

Function 3 | 1 | 15 **Phone** 5-2838

Originator D. T. Hobbs **Dept** SRTC

Title

Selective Leaching of Radionuclides

Criteria

Add aqueous solution containing a compound that selectively dissolves radionuclides that are important in tank closure (e.g., ^{99}Tc and actinides). The added compound would be selected from those known to form strong complexes with the radionuclide (e.g., a phosphine oxide for actinides) or that are synthesized and found to form strong complexes with selected radionuclides. This idea works in concert with oxalic acid as described in idea 3.1.4.

Technical Maturity

Untested with SRS high-level waste sludges. A list of known complexants or functional groups can be easily developed from a review of the chemical literature.

Safety Issues

* Addition of organic-based complexants could increase flammable gas production.
* same criticality concerns as 3.1.4.

Advantages

Selective removal of only radionuclides leaving the bulk of the waste components in the waste tank. Selective leaching would in principle reduce the quantity of waste requiring disposal in the DWPF and Saltstone.

Disadvantages

The introduction of the complexants into the HLW system could adversely impact downstream operation particularly radionuclide separation processes in the Salt Processing Facility. Long development program required to identify possible candidate compounds. Also, has same disadvantages of 3.1.4.

Pass / Fail Pass **Total Score** 0.498 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category	1.3 Prepare Heel For Transfer	**Date**	9/30/2001
Function	3 1 16	**Phone**	5-2838
Originator	D. T. Hobbs	**Dept**	SRTC

Title

Leach Radionuclides with Ammonium Hydroxide

Criteria

Add aqueous solution of ammonium hydroxide to selective leach radionuclides from the heel solids. The ammonium hydroxide solution would then be removed from the waste tank and sent to holding tank to allow ammonia to evolve and be swept out of the holding tank via the active tank ventilation system. Modifications to the H&V system are likely to safely release the ammonia.

Technical Maturity

Untested with SRS high-level waste sludges. Metallic ions known to form amine complexes upon contact with ammonium hydroxide. Amine complexes are relatively stable.

Safety Issues

Addition of ammonium hydroxide to waste tanks increases production of flammable gases (NH_3 is flammable).

Advantages

The use of ammonium hydroxide is compatible with alkaline wastes. No new chemicals added to the HLW system. Ammonia releases to the vapor phase with time so that downstream impacts of the complexant are minimized.

Disadvantages

Increased vapor phase flammability from the release of ammonia from the ammonium hydroxide. Process requires additional holding tank to affect controlled release of ammonia from the leachant.

Pass / Fail	Pass	**Total Score**	0.333	**Enhancement**	

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer **Date** 10/24/2000

Function 3 1 17 **Phone** 208-2980

Originator Neil R. Davis **Dept** CSTO/WR

Title

ARD

Criteria

ARD is a full service subcontractor specializing in the cleanout of tanks, basins and the like. They also sell their equipment and that is the basis of this idea. They have considerable experience in radioactive and hazardous waste cleanups. They have several different sizes and types of robotic devices with a variety of attachments for pressure cleaning, pumping, brushing, scarifying, etc. The preferred configuration is probably a small tracked robot that can fit in a 2 ft riser that has a "carpet cleaner" attachment that uses low volume high pressure water sprays to liquify the sludge and a powerful suction pump to move the sludge out of the tank.

Technical Maturity

Robotics are very mature in similar applications at Oak Ridge, Fernald, Hanford, etc. ARD has experience here at SRS in M-Area and in the ETF retention basins.

Safety Issues

none

Advantages

High equipment reliability, High probability that technique will work on a sludge heel, could be the answer to hard zeolite in Tank 24 , minimal equipment development by SRS required.

Disadvantages

Must have very accurate quantification of sludge properties as part of the bid proposal, Some development needed to interface ARD equipment with our tank configuration, will be very difficult to use this idea on obstructed tanks, 100% hands on operation.

Pass / Fail Pass **Total Score** 0.28 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 10/24/2000

Function 3 1 18

Phone 208-2980

Originator Neil R. Davis

Dept CSTO/WR

Title

SRS Crawler with Water Monitor

Criteria

SRTC has developed a robotic crawler with an onboard water monitor (fire nozzle). The crawler can be inserted through a 24" riser. It was developed for Tank 19. This crawler could be used in unobstructed tanks to push the sludge heel to a transfer pump. By continuing to reposition the crawler and sluicing the sludge to the transfer pump, it is believed that most of the sludge could be removed.

Technical Maturity

Sluicing is a very mature technology for sludge removal. The SRS crawler has not been used in rad service.

Safety Issues

aerosolization of sludge during operation

Advantages

Existing tested equipment, Low cost, Can be implemented quickly, Advances the SRS crawler program, Applications on other Type IV tanks

Disadvantages

Uses lots of water per unit sludge removed
Sludge rheology being pumped out not consistent
No provisions to decon and repair crawler in the event of mechanical problems
SRS crawler not well suited to sludge more than 2-3 inches deep

Pass / Fail Pass

Total Score 0.299

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 10/24/2000

Function 3 | 1 | 19

Phone 208-2980

Originator Neil R. Davis

Dept CSTO/WR

Title

SRS Crawler with Suction Pump

Criteria

The idea is to bring the transfer pump to the sludge vs pushing the sludge with water to the transfer pump. This idea would develop a combination high pressure water spray/suction head for the SRS crawler, similar to a carpet cleaner. These improvements would make the SRS crawler similar in capability to the ARD device (see 3.1.17).

Technical Maturity

ARD has perfected this technology. SRS would need to develop and debug a similar spray/suction head.

Safety Issues

none

Advantages

low volume of water per unit of sludge removed
advances SRS crawler program
Low cost

Disadvantages

1) Need to develop new equipment, 2) Sludge rheology will vary greatly, 3) could cause pluggage, 4) can be used in Type IV tanks only, 5) need high pressure water supply, 6) SRS crawler not well suited to sludge more than 2-3 inches deep

Pass / Fail Pass

Total Score 0.302

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 10/24/2000

Function 3 | 1 | 20

Phone 208-2980

Originator Neil R. Davis

Dept CSTO/WR

Title

Reuse Flygt Mixers

Criteria

If Flygt mixers are used as the bulk waste removal technology, then continue to use them for heel removal. The water to sludge ratio would decrease but no new equipment is needed, only time and water.

Technical Maturity

Full scale hot demo in Tank 19 in progress. It is well known that 50 hp units need more development to increase projected life. A 150 hp unit is on the drawing board.

Safety Issues

none

Advantages

low cost
could be used with no VSD's if vibration problems can be cured
Applicability to other Type IV tanks
May have long enough ECR; Tank 19 experience will tell

Disadvantages

Equipment development needed
Must shut down mixers at tank levels below ~42"
Would probably have a high water to sludge ratio vs slurry pumps
Unclear whether the heel could be removed down to <1,000 gal before too much water is used

Pass / Fail Pass

Total Score 0.453

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer **Date** 10/24/2000

Function 3 1 21 **Phone** 208-2980

Originator Neil R. Davis **Dept** CSTO/WR

Title

Vertical Flygt Mixers (150 hp)

Criteria

If this option is selected for bulk waste removal, then continue to use it for heel removal. Water to sludge ratio will get worse.

Technical Maturity

Flygt mixers themselves are very mature in commercial applications. Minimal experience in rad applications. The 150 hp unit is on the drawing board. None have ever been built.

Safety Issues

none

Advantages

low cost
could be used with no VSD's if vibration problems can be cured
Applicability to other Type IV tanks or spot removal in some other tanks

Disadvantages

Equipment development needed, ECR not known, Would probably have to shut down pumps at 3-4' waste level, Would probably have a high water to sludge ratio vs slurry pumps, Not certain that sludge could be removed to <1,000 gal before too much water used

Pass / Fail Pass **Total Score** 0.365 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 10/19/2000

Function 3 1 23

Phone 952-2627

Originator Mike E. Harrell

Dept CSTO/WRC

Title

Tank in Tank with mobile Wilden pump

Criteria

The tank in tank idea would involve the utilization of an air operated (Wilden) pump on the SRS Crawler that could be moved on the tank bottom where the sludge heel is located. Use this crawler to pump sludge into the tank-in-tank. The tank-in-tank needs to contain a submersible combination mixer / transfer pump to remove the sludge from the waste tank. This idea is the same as 1.1.9.

Technical Maturity

The crawler is existing design coupled with the Wilden pump that has been approved as a method to perform emergency transfer from waste tank annulus. The tank-in-tank with pump is nothing more than a mini pump tank with a submersible pump simular to the 2F evaporator feed

Safety Issues

None

Advantages

The tank in tank can be small enough to deploy through existing riser. The riser location in the tank should make the length of hose from crawler pump as short as possible, making it more maneuverable. The pumps can be small and relatively inexpensive.

Disadvantages

The small pumps may be subject to frequent failure. The tank-in-tank is small so rheology may be difficult to control. This idea is not suited for tanks with obstructions.

Pass / Fail Pass

Total Score 0.223

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 10/25/2000

Function 3 | 1 | 26

Phone 952-2657

Originator J. E. Herbert

Dept CSTO / WR

Title

Street Sweeper / Grinder / Pumper

Criteria

Deploy a crawler based platform that can simutaneously erode a mound of material using a roller brush attachment at the front of the crawler, which would convey this material into a unit that would size reduce chunks into fines like a macerator. Discharge from the macerator would then be swept into the intake of a high head / high volume pump for transport into the receipt tank. Each piece of rotating machinery would be powered from a hydraulic hose pressurized by an above-tank skid.

Technical Maturity

Machinery similar to this has been used to remove sludge materials in basins and tank in the chemical industry

Safety Issues

Cross contamination of hydraulic fluids. Possible damage to tank integrity due to equipment malfunction, misoperation

Advantages

Combines all steps into one tool. Negates need to agitate tank.

Disadvantages

Complex mechanical device, many opportunities for equipment failure. Difficult to decon for maintenance purposes. This idea is not suited for obstructed tanks.

Pass / Fail Pass **Total Score** 0.28 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 10/25/2000

Function 3 1 28

Phone 208-8430

Originator T. Caldwell

Dept HLWE

Title

Chemical Dissolution (Russian Regime) with a Complexing Agent

Criteria

Chemical dissolution will require a method of agitation such as jet mixer pumps (slurry pumps) or submersible agitators. It is presumed that the majority of the sludge has already been removed and the tank is mostly dewatered. A suite of dicarboxylic acids is then added to disolve the sludge and zeolites. The disolved sludge and zeolite is then sent to a stirred pump tank where neutralization with caustic occurs. The reconstituted sludge is then pumped to sludge reciept tank. A final rinse of weak acid will effectively decontaminate the tank.
The addition of a fluoride complexing agent would accelerate zeolite breakdown.

Technical Maturity

The former Soviet Union has used regime to completely decontaminate their stainless and carbon steel tanks sufficiently to allow personnel inspection

Safety Issues

Handling of acid streams presents personnel safety risk. Heats of neutralization and reaction must be quantified. Offgassing of hazardous vapors are possible. A flouride complexing agent may indiscriminately attack the carbon steel tank.

Advantages

A decontaminated tank simplifies closure. A clean tank may even allow reinspection and possible reuse of the tank for uses other than high level waste. The flouride complexing agent may be able to accelerate zeolite or aluminosilicate breakdown.

Disadvantages

Extra salt produced from acid/ base neutralization which would require extra tank space and more canister production.

Pass / Fail Pass **Total Score** 0.498 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 10/12/2000

Function 3 | 1 | 29

Phone 557-7270

Originator D. Stefanko

Dept HLWE

Title

Movable / Articulated Hose

Criteria

A sluicer mounted to an arm installed in a riser is the basis of this idea. The sluicer would be repositioned as needed to wash sludge towards the transfer pump. Water would be provided by the existing 10,000 gallon spray wash skids. A light and camera system would be needed to operate the sluicer.

Technical Maturity

This method was used on Tank 17. While inefficient in terms of water added per unit of sludge removed, the technique did eventually remove 7,800 of 10,000 gallons of sludge.

Safety Issues

aerosolization of sludge particles

Advantages

* cheap
* no moving parts inside tank
* only need 6 or 8 inch ports to install

Disadvantages

* very high water:sludge ratio
* 100% hands on operation
* tank will fog up thus reducing visibility
* may need to relocate sluicer several times for obstructed tanks

Pass / Fail Pass

Total Score 0.624

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category	1.3 Prepare Heel For Transfer	**Date**	10/17/2000
Function	3 1 31	**Phone**	208-1012
Originator	Glenn Beaumier	**Dept**	

Title

Scoop with Remote "Bobcat"

Criteria

Run existing slurry pumps / waste removal process to clear an area. Deploy a remote "Bobcat" and "Pig Trough" with pump. Use Bobcat to scoop up sludge / zeolite, dump in pig trough, pump to receipt tank. Trough may need agitation.

Technical Maturity

Medium. Bobcat-type front end loaders commercially available. Need to outfit with remote controls. This was done for Tank 13 cleanup in 1984.

Safety Issues

None

Advantages

* Abandon existing pumps in place (and "Bobcat" when done)

Disadvantages

* New technology
* Maintainability of Bobcat if it fails
* hard to install through 2 or 3 ft risers
* 100% hands on operation

Pass / Fail Pass **Total Score** 0.214 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.1 Prepare Bulk Waste for Transfer

Date 10/24/2000

Function 3 1 33

Phone 208-2980

Originator Neil R. Davis

Dept CSTO/WR

Title

Partition Tank and Move Sludge with a Sluicer

Criteria

Use a material like concrete or grout to partition the tank and then use a robotic device to convey the sludge into the partition that contains the transfer pump. The latter partition serves as a "tank-in-tank" where sludge can be accumulated, mixed and pumped out. The same method could also be used to push the sludge towards the transfer pump as the grout is denser than the sludge. Roof mounted sluicers could be used to clean an area of the tank floor on the far side of the tank from the transfer pump. Add grout to this area. Use sluicers to clean area between grout layer and transfer pump. Add more grout. Continue until most of tank floor is covered and sloped towards the transfer pump.

Technical Maturity

seems simple, was observed in cold tests during Tanks 17/20 CTL testing, but has not been tried in a HLW tank

Safety Issues

None

Advantages

* Reduces the area that a robotic device or sluicer would have to cover
* Provides a head start on grouting

Disadvantages

* Haven't deliberately tried to do this in a HLW tank
* Applies only to heel removal
* grout will not displace hard or unmoved sludge
* regulatory issue of adding grout to a tank that is not approved for closure

Pass / Fail Pass

Total Score 0.48

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 10/24/2000

Function 3 1 35

Phone 208-2980

Originator Neil R. Davis

Dept CSTO/WR

Title

Houdini with CSEE

Criteria

The Houdini is a 1,000 pound crawler that can fit through a 24" riser. It expands in the tank to almost 4 ' wide by 5' long. It has an onboard robotic arm that can hold and position cleaning tools. The crawler and all associated equipment is fully operational and available at no cost. Erect the support systems for the Houdini over a riser on Tank 18. The steel platform on the NW riser could be used with minimal D&R. Deploy the Houdini with the Confined Sluicing End Effector (CSEE) and use it to dislodge the sludge, liquify it, and transfer it out of the tank exactly like the process used at Oak Ridge. A subcontract group performed all tasks at Oak Ridge.

Technical Maturity

Robotics are very mature, Houdini used at Oak Ridge to clean out 9 tanks with low level radioactive sludge. Some development needed as the CSEE was mostly held by a separate robotic arm at Oak Ridge.

Safety Issues

none

Advantages

High equipment reliability, High probability that technique will work, Applicability to other Type IV tanks, Could be the answer to hard zeolite in Tank 24 as high pressure CSEE will chew up zeolite and other hard sludges

Disadvantages

Does not further the SRS robotic program
Not sure how Houdini would work in 20" of sludge

Pass / Fail Pass **Total Score** 0.238 **Enhancement** ☐

Appendix F (4.1) – Alternatives, Heel Waste Transfer

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.4 Transfer Heel

Date 10/18/2000

Function 4 1 2

Phone p-12297

Originator C. L. Sharpe

Dept

Title

Macerator Pump

Criteria

There is a pump called a "chopper pump" that is advertised to reduce size of "solids". Ad refers to sewage treatment. This is not a suggestion per se. It is a response to the idea that we may need to grinnd up solids. One vendor is Vaughn, Crane maybe?

Technical Maturity

Weak - No Known use. Radiation resistance unknown. Method of deployment unknown. Needs considerable followup if the need to :chop or grind" persists or is thought to be necessary.

Safety Issues

TBD

Advantages

Pump is advertised to reduce solid size.

Disadvantages

Material unknown, deployment unknown. Probably a development job.

Pass / Fail Pass

Total Score 0.623

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.4 Transfer Heel

Date 10/19/2000

Function 4 1 3

Phone 952-2627

Originator Mike E. Harrell

Dept CSTO/WRC

Title

Air Driven Submersible Pump (WILDEN)

Criteria

The air driven submersible pump.

Technical Maturity

This type of pump is capable of pumping heavy sludge.

Safety Issues

None

Advantages

The air driven pumps are inexpensive and small making removal and replacement possible if needed. Cheap. Will pump solids.

Disadvantages

* requires supply of clean dry air
* lots of elastomeric parts in high rad field
* not free draining, will need axtra piping and valving to allow flushing and draining

Pass / Fail Pass

Total Score 0.734

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.4 Transfer Heel

Date 10/12/2000

Function 4 1 4

Phone 952-8169

Originator Gary Abell

Dept

Title

Transport the Waste by Tank Truck

Criteria

This concept would would employ the use of a tanker truck especially designed for radioactive shipment. The contents in the tank would be pumped into the truck and then driven to the next HLW Tank for dumping.

Technical Maturity

Fairly High

Safety Issues

Shielding and accident scenarios would need to be addressed.

Advantages

Concept is well understood; very mature, and is readily available.

Disadvantages

* Shielding requirements
* Contaniment to avoid leak potential
* significant AB revisions

Pass / Fail Pass **Total Score** 0.344 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.4 Transfer Heel

Date 3/8/2002

Function 4 1 6

Phone 8-2980

Originator N. R. davis

Dept CSTO

Title

Reuse Bulk Transfer Pump

Criteria

If some simple enhancements are made to the bulk waste removal pump, then the same pump could also be used for heel removal and final dewatering. Enhancements would include: variable height adjustment, suction bell to reduce inlet velocity and thus pump the tank down lower, variable speed drive to slow pump down for heel and dewater. This idea depends on finding a pump that can operate over a wide range of transfer rates to maximize pumpdown capability.

Technical Maturity

Don't know. Should not be too bad.

Safety Issues

none

Advantages

* one pump can serve three functions
* saves on exposure due to no removal and replacement of pump to serve different functions

Disadvantages

* research is needed to identify pump
* must have VFD to enable low pumpdown

Pass / Fail Pass **Total Score** 0.614 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.4 Transfer Heel

Date 3/8/2002

Function 4 | 1 | 7

Phone 8-2980

Originator N. R. Davis

Dept CSTO

Title

Reuse Bulk Transfer Jet

Criteria

The assumptions here are: 1) the jet is installed at the tank bottom, 2) some form of acid cleaning is used to dissolve the heel. In this case, all or nearly all insoluble solids would be dissolved thus rendering them easy to jet without fear of pluggage.

Technical Maturity

Oxalic acid cleaning used on Tank 16. Demo'd transfer jet on sludge transfer from HPT-3 to HDB-6 so a jet can move some sludge.

Safety Issues

none

Advantages

* very cheap - basically a "do nothing" idea.

Disadvantages

* must be used with acid cleaning, probably would not work if insoluble solids are not dissolved.

Pass / Fail Pass

Total Score 0.619

Enhancement ☐

Appendix F (5.1) – Alternatives, Spray Wash Tank

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.5 Spray Wash Tank **Date** 8/21/2001

Function 5 1 1 **Phone** 8-0506

Originator Gene Dixon **Dept** CSTE

Title

Vibrate Tank

Criteria

Vibrate the tank using an ultrasonic or other type of device to dislodge contamination on tank internals. Add water, slurry the dislodged waste and pump it out.

Technical Maturity

* not mature for a large tank

Safety Issues

* vibration may damage tank

Advantages

* eliminates extensive water addition
* could be cheap

Disadvantages

* significant R&D needed

Pass / Fail Pass **Total Score** 0.161 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.5 Spray Wash Tank

Date 2/6/2002

Function 5 1 3

Phone 8-2980

Originator Neil Davis

Dept CSTO

Title

Spray Wash Baseline

Criteria

The project baseline provides a portable 10,000 gal spray wash tank. The tank contains a steam heater to heat the water to 90oC and two 100 gpm transfer pumps. Three rotary spray jets are installed through risers into the primary tank vapor space. The tank surfaces, including cooling coils and the tank roof are sprayed in 10,000 gal batches. After about 30,000 - 50,000 gal of spraying, there is enough water in the bottom of the tank to slurry and transfer out of the tank. The portable spray wash tank can be relocated to other tanks as needed.

Technical Maturity

Very mature - used on Tanks 16 and 20.

Safety Issues

Spraying on tank roof and underneath risers could cause above grade leaks of contaminated water. Riser plugs are designed with spray shields to prevent leaks.

Advantages

* mature technology
* have successfully used this method on 2 tanks
* residue is pumped out of the tanks

Disadvantages

* uses a lot of water
* expensive

Pass / Fail Pass

Total Score 0.718

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.3 Prepare Heel For Transfer

Date 3/11/2003

Function 5 1 5

Phone 8-2980

Originator N. R. Davis

Dept CSTO

Title

Directional Spray Nozzle

Criteria

This device is being developed by HLW Maintenance (Joe Cato) for demonstration in Tank 18. The device consists of a commercial water nozzle mounted on a mast. The azimuth can be varied by manually turning a crank. The mast can be manually rotated. Water is supplied by the existing spray wash tanks. The device is about 8 ft long and is designed to be inserted in a 6" or 8" diameter inspection port. The spray will reach the tank wall with a focused spray up to 60-70 ft away.

Technical Maturity

no new technology

Safety Issues

none

Advantages

* cheap
* demo is scheduled in tank 18

Disadvantages

* demo may drive need for rework

Pass / Fail Pass

Total Score 0.729

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.5 Spray Wash Tank

Date 3/8/2002

Function 5 1 6

Phone 8-2980

Originator N. R. Davis

Dept CSTO

Title

Acid Clean Heel Removal, Do Nothing

Criteria

If acid cleaning is used for heel prep, then the acid could be added through fixed nozzles to clean cooling coils and tank walls. This could be evaluated and then deemed adequate for spray washing. Thus, no additional step for spray washing would be required.

Technical Maturity

Acid cleaning was demo'd on Tank 16. Fixed nozzles were used to rewet Tank 8. Very mature.

Safety Issues

Must evaluate spraying dilute acid to see if there are any issues.

Advantages

* eliminates need for separate step to do spray wash

Disadvantages

* can only be used with acid cleaning

Pass / Fail Pass **Total Score** 0.703 **Enhancement** ☐

Appendix F (6.1) – Alternatives, Annulus Preparation for Transfer

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer
Date 8/29/2001

Function 6 1 1
Phone 952-2627

Originator Mike Harrell
Dept CSTO/WR

Title

Mixing Eductors

Criteria

Install water eductors through annulus risers and oriented to create flow around the annulus. Inhibited water from existing spray wash skid could be used as the motive force. Water eductors typically entrain one unit of liquid for each unit of liquid supplied. The eductors would be operated until the desired high level in the annulus is reached. The salt solution would then be jetted out of the annulus and the process repeated until most of the waste is removed. One of the eductors would need to discharge into the duct on Type I and II tanks. The duct would also have to have holes punched in the bottom to enable salt solution to drain out.

Technical Maturity

water eductors are used in the ITP filter cell sumps to remove waste

Safety Issues

no new issues

Advantages

* less equipment vs. baseline (e.g., no new gang valves)
* no moving parts in annulus

Disadvantages

* this idea only provides agitation when water is being added
* annulus transfer jet may need to be replaced with a higher capacity unit

Pass / Fail Pass
Total Score 0.625
Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer

Date 10-1-2001

Function 6 1 2

Phone 208-0276

Originator Stephen A. Smith

Dept WRE

Title

Tunnel bore in duct

Criteria

Use a tunnel boring machine the approximate diameter of the duct in the annulus and bore out all waste. May need different diameter cutting heads as the duct changes diameter (see attached sketch).

Technical Maturity

Tunnel boring machines are common devices used in tunnel projects to over 30 feet in diameter. Placing one in the annulus of a waste tank might not be the easiest.

Safety Issues

Rotating cutting surfaces within a waste tank annulus.

Advantages

Get the annulus clean of waste products. Fairly simple to deploy, and not very expensive.

Disadvantages

* Rotating equipment with cutting surfaces could damage the tank
* significant tool development is required
* tether management will be difficult

Pass / Fail Pass

Total Score 0.110

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer

Date 8/20/2001

Function 6 1 3

Phone 208-1448

Originator Brannen Adkins

Dept HLWE

Title

Flygt Mixers in Racetrack Mode

Criteria

Add water to the annulus. Place multiple Flygt mixers in annulus to mobilize and suspend sludge / salt material in preperation for transfer. Operate the mixers in the same direction to take advantage of the additive effect. One mixer must be directed inside the duct on Type I and II tanks. Holes will need to be punched in the duct to allow dissolved salt to drain to the annulus transfer jet.

Technical Maturity

Mature "off the shelf" technology

Safety Issues

may need to control hydrogen evolution in tanks with a lot of salt in the annulus

Advantages

* Low Cost
* Previous experience with Flygt mixers in tank 19

Disadvantages

* Riser size limits size of mixers
* Limited success on tank 19

Pass / Fail Pass **Total Score** 0.675 **Enhancement**

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer | **Date** 2/6/2002
Function 6 1 4 | **Phone** 8-2980
Originator Neil Davis | **Dept** CSTO

Title

Annulus Cleaning Prep Baseline

Criteria

The baseline process is to install 3 steam powered recirculating jets and one set of sp.gr. diptubes in the annulus of Tanks 1, 9, 10, 11, 12, 13, 14 and 15. Each tank will get a new gang valve, or the project will build a portable gang valve, capable of supplying the 3 jets. The gang valve will be of the new electro-pnuematic design with a containment curb, local ARM and containment building. The existing liquid level diptubes, annulus transfer jet and spray wash skid will be used. Heated inhibited water will be added from the spray wash skid, the jets will recirculate the water to dissolve annulus waste, and the transfer jet will transfer the solution into the primary tank where it can be transferred to another tank and on to be evaporated.

Technical Maturity

Not mature. The recirc jets have been built and tested in the shop. Samples taken from the Tank 16 annulus indicate that the waste cannot be dissolved in water, dilute caustic or dilute oxalic acid. It is not known if this is typical of other annuli.

Safety Issues

* none

Advantages

* this is the most mature alternative at this time (see Functional Design Criteria for better description)
* uses heated water to enhance dissolution

Disadvantages

* very expensive, particularly the gang valves
* never demonstrated in a tank

Pass / Fail Pass | **Total Score** 0.471 | **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer

Date 10/1/2001

Function 6 1 5

Phone 8-0264

Originator E. Saldivar, Jr.

Dept HLWE

Title

Confined Sluicing End Effector (CSEE).

Criteria

Utilize a manipulator or a manual articulating arm to deploy a high pressure water Confined Sluicing End Effector to dislodge and transfer waste out of the annulus space.

Technical Maturity

The CSEE has been demonstrated on numerous occasions at other sites on hard salt cake.

Safety Issues

Tether management could be very hazardous to the operation. Utilizing an articulating arm or a manipulator in a confined space would also be a challenge.

Advantages

Complete cleaning could be accomplished as long as the CSEE was extremely small or the ductwork is removed.

Disadvantages

The ductwork will limit the effectiveness of the technology if it is not removed. This is a very time laborious evolution due to the transfer rate of the CSEE.

Pass / Fail Pass **Total Score** 0.411 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer

Date 3/8/2002

Function 6 1 6

Phone 8-2980

Originator N. R. Davis

Dept CSTO

Title

Acid Clean, Reuse in Primary

Criteria

If acid cleaning is to be used in the primary tank for heel removal, then clean annulus first with acid and jet acid to the primary and reuse for heel removal. Some moderate form of agitation will be needed. Use a Flygt mixer to move dilute acid around annulus in racetrack mode to remove boundary layer of reacted acid.

Technical Maturity

Acid cleaning demo'd on Tank 16. Also, tried on Tank 24 to dissolve zeolite. Flygt mixers used on tank 19 heel removal.

Safety Issues

must establish corrosion rate of acid on carbon steel

Advantages

* less agitation is required for acid cleaning than for water dissolution
* acid may dissolve insoluble components whereas water may not

Disadvantages

* annulus may be come recontaminated during heel removal in primary
* acid may eat up refractory under tank

Pass / Fail Pass **Total Score** 0.713 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer

Date 3/8/2002

Function 6 1 7

Phone 8-2980

Originator N. R. Davis

Dept CSTO

Title

Crawler with CSEE

Criteria

Design and build a small crawler that can fit in the 30" wide annulus through a 24" diameter riser. Deploy a CSEE on the crawler (this is an end effector with high pressure water sprays to liquify solids and a suction hose to remove waste). The crawler must have an arm to position the CSEE very accurately. Cameras and light and a remote monitor/controller will be needed to operate crawler. Must have elaborate tether management for suction hose, high pressure water supply hose, electric or hydraulic hose to operate crawler.

Technical Maturity

Very mature in open tanks. Used at Oak Ridge on 9 tanks. Never used in annulus

Safety Issues

none

Advantages

* ability to position suction may help

Disadvantages

* ductowrk may interfere with crawler operation
* may not be able to clean inside ducts
* probably very expensive

Pass / Fail Pass

Total Score 0.364

Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer

Date 3/8/2002

Function 6 1 8

Phone 8-2980

Originator N. R. Davis

Dept CSTO

Title

Air Spargers

Criteria

Install several air spragers in all available risers. Use compressed air to provide agitation to promote dissolution of solids.

Technical Maturity

mature

Safety Issues

* must not over-pressurize annulus
* potential for outgassing contamination

Advantages

* low cost

Disadvantages

* agitation may not be adequate in between risers
* may need large annulus HVAC depending on air input rate

Pass / Fail Pass **Total Score** 0.602 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer

Date 3/8/2002

Function 6 1 9

Phone 8-2980

Originator N. R. Davis

Dept CSTO

Title

Water Mouse

Criteria

Commercial pipe cleaner that uses water to push device into pipe or duct. Most water discharged behind to propel device, but some water discharged from front to dissolve or dislodge solids in front of device. This was called a "water mouse" and used on tanks 17 and 20 to move sludge away from tank walls. Vendor can supply service.

Technical Maturity

very mature in industrial setting, not used in annulus ducts before

Safety Issues

none

Advantages

* may have best chance of cleaning inside ducts
* simple device, self propelled

Disadvantages

* may add a lot of water
* could get stuck in duct

Pass / Fail Pass **Total Score** 0.605 **Enhancement** [ ]

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer
Date 3/8/2002
Function 6 1 10
Phone 8-2980
Originator N. R. Davis
Dept CSTO

Title

Sample, Evaluate, Do Nothing

Criteria

Sample dried salt in all tanks with salt in annulus (1, 9-15, 16 already sampled). Analyze sample, run fate and transport model. If no significant impact to performance assessment, then do nothing.

Technical Maturity

Very mature

Safety Issues

none

Advantages

* low cost, eliminates need to do annulus cleaning

Disadvantages

* cost of evaluation
* Se-79 and Tc-99 are soluble and therefore expected to be in annulus salt in significant quantities
* salt samples from Tank 16 annulus indicated annulus cleaning was required

Pass / Fail Pass **Total Score** 0.801 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer
Date 3/8/2002
Function 6 1 11
Phone 8-2980
Originator N. R. Davis
Dept CSTO

Title

Three Centrifugal Pumps

Criteria

Install three centrifugal pumps in three risers. Mount on tank roof. Have at least one pump discharge into annulus duct. Add water (heated if available) from nearest spray wash skid to dissolve salt. Operate pumps in racetrack mode.

Technical Maturity

Equipment is mature. Procees chemistry not mature. Salt samples in tank 16 annulus were not *soluble in water, dilute caustic, dilute oxalic acid. Tank 16 may be anomoly due to sand blasting* leak sites.

Safety Issues

must maintain proper liquid level and pump speed to avoid annulus pan overflow.

Advantages

* cheaper than baseline, no new gangvalves

Disadvantages

* may be difficult to clean out ducts

Pass / Fail Pass
Total Score 0.597
Enhancement ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.7 Transfer Annulus Waste

Date 10/1/2001

Function 6 1 12

Phone 8-0264

Originator E. Saldivar, Jr.

Dept HLWE

Title

Russian pump (mix, transfer and sluice)

Criteria

Same as 1.1.5 in Bulk Waste Removal. The Russians have developed their own version of a pulse tube mixer (see attached information). This one device can agitate waste to promote dissolution and mixing and convey the waste out of the tank. Three or four units will be required to cover the whole annulus. One must be directed inside the annulus duct on Type I and II tanks. Holes must be punched in the bottom of the duct to allow dissolved salt to drain.

Technical Maturity

The device has been used in Russia in rad service but not at SRS.

Safety Issues

Potential to draw waste into air supply system

Advantages

* one device performs 2 functions
* no moving parts in annulus
* cheaper than baseline

Disadvantages

Pass / Fail Pass

Total Score 0.482

Enhancement

Appendix F (7.1) – Alternatives, Transfer Annulus Waste

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.7 Transfer Annulus Waste

Date 3/8/2002

Function 7 1 3

Phone 8-2980

Originator N. R. Davis

Dept CSTO

Title

Baseline - Use Existing Jet and Gang Valve

Criteria

All tanks with waste in the annulus (Tanks 1, 9-16) have existing transfer jets installed and new electro-pnuematic gang valves. The jets are 75 gpm with the suction mounted near the annulus floor. The discharge transfer line is an above-grade core with jacket and lead shielding. Use of this system is included in the existing Tank Farm AB.

Technical Maturity

very mature

Safety Issues

none

Advantages

* cheap - no new cost

Disadvantages

* transfer line goes to tank primary, may be an issue if a different destination is desired

Pass / Fail Pass

Total Score 0.723

Enhancement

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.7 Transfer Annulus Waste

Date 3/8/2002

Function 7 1 4

Phone 8-2980

Originator N. R. Davis

Dept CSTO

Title

Sump Pump on Cable

Criteria

Commercial sump pump lowered to tank floor via a steel cable. Make pump heavy enough so that it won't be moved by agitation. Modify suction strainer or pipe as needed to pump down to desired level. Pump must be installed in a riser where it can sit on the floor, or, if on top of duct, the suction must have a pipe extending down to the annulus floor. If no such location is available, then modify suction so that pipe goes around duct to annulus floor.

Technical Maturity

very mature in industrial setting, not used in annulus before

Safety Issues

none

Advantages

* cheap
* requires no steam or gang valve, only power
* may be more tolerant of insolubles than a jet

Disadvantages

*will be more expensive than using existing jet
* some design needed

Pass / Fail Pass **Total Score** 0.717 **Enhancement** ☐

Waste Removal Balance of Program SEE

Idea Pro-Forma

Category 1.6 Prepare Annulus for Waste Transfer

Date 2/6/2002

Function 7 | 1 | 5

Phone 8-2980

Originator Neil Davis

Dept CSTO

Title

Annulus Transfer Pump on a Mast

Criteria

Install an inexpensive electric sump pump on a mast. Design the pump suction to be very close to annulus floor. Pump can use existing transfer line to move waste into primary tank or a new above grade hose-in-hose to go to another tank. D&R of existing jet might be required.

Technical Maturity

Very mature. Use off the shelf pump.

Safety Issues

* if desire is to transfer to another tank, then hose-in-hose presents a moderate safety risk

Advantages

* enables transfer to another tank rather than back into the primary vessel which leaks

Disadvantages

* cost os higher than using existing jet
* may need AB, procedure and training revision
* eliminates reliance on complicated gang valve

Pass / Fail Pass

Total Score 0.717

Enhancement ☐

Appendix G - Key Words

Key Words		
AB	HVAC	SAMPLE
AGITATOR	IMPACT	SPARE PARTS
BUDGET	IMPROVEMENT	STEAM
CHEMISTRY	JUMPER	STORAGE
COILS	LAB	TANK
CONTAMINATED	LARGE EQUIPMENT	TANK FARM
COOLING	OBSOLETE	TRANSFER
CORROSION	OFF-GAS	TURNTABLE
DISPOSAL	PARTS	VENTILATION
ELECTRICAL	PIPE	VFD
EQUIPMENT	PROCESS	VOLUME
FAILED PARTS	PUMP	WAC
FAN	RETRIEVAL	WASTE HANDLING
FILTER	RHEOLOGY	
FLAMMABILITY	ROOF	

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Appendix H – Evaluation Criteria Weighting Factors

Criteria Number	Criteria Title	Sub-Criteria Title	Ratings Acronym	Weight -- Standard	Criterion Definition
1.0	***Cost***			**0.257**	**Life cycle cost.**
1.1		Project		*0.206*	The up front cost to design, build, test and turn over the waste removal equipment or process.
			1 S_>30%	0.206	Save > 30% vs baseline
			2 S_<30%	0.154	Save < 30% vs baseline
			3BASELIN	0.103	Baseline
			4 H_<30%	0.051	Higher < 30% vs baseline
			5 H_>30%	0.000	Higher > 30% vs baseline
1.2		Operating		*0.051*	The long term cost to operate and maintain the waste removal equipment or process including the cost of operating materials.
			1 LOCOST	0.051	Lower vs baseline
			2 OP_BL	0.026	Baseline
			3 HICOST	0.000	Higher vs baseline

Criteria Number	Criteria Title	Sub-Criteria Title	Ratings Acronym	Weight -- Standard	Criterion Definition
2.0	***Effectiveness***			**0.177**	**The *degree of confidence* that the *idea can* successfully perform its intended function.**
			1HIGCONF	0.177	High confidence
			2MODCONF	0.088	Moderate confidence
			3LOWCONF	0.000	Low confidence
3.0	***Reliability***			**0.165**	**The degree of confidence that the equipment or process can continue to perform the needed function(s).**
3.1		Longevity		*0.124*	Expected frequency of repair.
			1LREPAIR	0.124	Low repair vs baseline
			2AREPAIR	0.062	Average repair vs baseline
			3HREPAIR	0.000	High repair vs baseline
3.2		Maintainability		*0.041*	Expected ease of repair or replacement.
			1L MAINT	0.041	Easy maintenance vs baseline
			2A MAINT	0.021	Average maintenance vs baseline
			3H MAINT	0.000	Difficult maintenance vs baseline

Criteria Number	Criteria Title	Sub-Criteria Title	Ratings Acronym	Weight -- Standard	Criterion Definition
4.0	***Technical Maturity***			**0.116**	**The degree to which the idea has been developed and used in a radioactive HLW or similar environment.**
			1 RADAPP	0.116	Used in radioactive applications
			2 INDAPP	0.058	Used in industrial and limited radioactive applications
			3 PILOT	0.029	Pilot / Prototype
			4 R&D	0.000	Research and Development
5.0	***Complexity***			**0.087**	**The degree of complexity with regard to design, construction and operation.**
5.1		Construction		*0.043*	The time required and the degree of complexity with regard to fabrication, installation, D&R of obsolete equipment, testing and excavations.
			1LO COMP	0.043	Low complexity/time
			2MO COMP	0.021	Moderate complexity/time
			3HI COMP	0.000	High complexity/time

Criteria Number	Criteria Title	Sub-Criteria Title	Ratings Acronym	Weight -- Standard	Criterion Definition
5.2		Closure		*0.020*	The time required and the degree of complexity with regard to the tank ready for grouting including removal of equipment as needed and waste minimization.
			1LO.COMP	0.020	Low complexity/time
			2MO.COMP	0.010	Moderate complexity/time
			3HI.COMP	0.000	High complexity/time
5.3		Operation		*0.014*	The time required and the degree of complexity with regard to training and procedures, close-coupled operations, and impact on resources.
			1LO_COMP	0.014	Low complexity/time
			2MO_COMP	0.007	Moderate complexity/time
			3HI_COMP	0.000	High complexity/time
5.4		Design		*0.010*	The time required and the degree of complexity with regard to Title I design, Title II design and the procurement of engineered equipment. Note – it is assumed that R&D is complete.
			1LOWCOMP	0.010	Low complexity/time
			2MODCOMP	0.005	Moderate complexity/time
			3HIGCOMP	0.000	High complexity/time

Criteria Number	Criteria Title	Sub-Criteria Title	Ratings Acronym	Weight -- Standard	Criterion Definition
6.0	***Reusability***			**0.075**	**The degree to which a process or set of equipment can be reused on other tanks.**
6.1		Multi-functionalism		*0.030*	A measure of different functions one idea can perform.
			1 P>2FUN	0.030	Performs more than 2 functions
			2 P_2FUN	0.015	Performs 2 functions
			3 P_1FUN	0.000	Performs 1 function
6.2		Repeatability		*0.030*	The degree to which the equipment or process can be exactly duplicated on other tanks to reduce new design, procedures and training.
			1 HI-RPT	0.030	High repeatability
			2 M-RPT	0.015	Moderate repeatability
			3 NO-RPT	0.000	No repeatability
6.3		Portability		*0.015*	A measure of the ease with which equipment can be relocated and re-deployed on other tanks to reduce procurement and fabrication.
			1 EASPOR	0.015	Easy portability
			2 MODPOR	0.008	Moderate efforts to relocate
			3 DIFPOR	0.000	Difficult to relocate

Criteria Number	Criteria Title	Sub-Criteria Title	Ratings Acronym	Weight -- Standard	Criterion Definition
7.0	***Integration***			**0.067**	**A measure of the ease with which the idea integrates with existing conditions.**
7.1		Process		*0.033*	The impact of integrating the idea into the existing HLW process from a chemistry, schedule (e.g., outage) and tank space perspective.
			1L IMPAC	0.033	Low or no impact
			2M IMPAC	0.016	Moderate impact
			3H IMPAC	0.000	High impact
7.2		AB		*0.021*	The ease of developing and implementing changes to the existing AB to accommodate the idea.
			1 MIN AB	0.021	*Minimum or no change*
			2 SIG AB	0.010	Significant change
			3 ACC AB	0.000	New accident scenerio
7.3		Infrastructure		*0.013*	The degree to which the idea utilizes existing infrastructure and minimizes new infrastructure.
			1HUTILIZ	0.013	High utilization
			2MUTILIZ	0.007	Moderate utilization
			3LUTILIZ	0.000	Low utilizatition

Criteria Number	Criteria Title	Sub-Criteria Title	Ratings Acronym	Weight -- Standard	Criterion Definition
8.0	***Radiological Controls***			**0.057**	**Expected exposure to install, operate and maintain the equipment or process**
			1LESSEXP	0.057	Less exposure vs baseline
			2 BL_EXP	0.028	Baseline exposure
			3 MOREXP	0.000	More exposure vs baseline

Appendix I (1.1) – BOP Alternative Ranking, Bulk Sludge Preparation for Transfer

BULK SLUDGE PREPARATION FOR TRANSFER ALTERNATIVES	1.1.33 ONE ADMP IN CENTER RISER (ONLY TYPE I TANKS)	1.1.44 WEMD CANNED PUMP ON A MAST	1.1.32 TWO MODIFIED ADMPS	1.1.16 SLUICING	1.1.3 SUBMERSIBLE SLURRY PUMPS (WITH MAGNETIC COUPLING)
RAD/CONT 0.0566	1LESSEXP	1LESSEXP	1LESSEXP	2 BL_EXP	2 BL_EXP
REUSABLE-REPEATABLE 0.0302	2M-RPT	1 HI-RPT	1HI-RPT	1HI-RPT	1 HI-RPT
REUSABLE-PORTABLE 0.0151	2 MODPOR	2 MODPOR	3 DIFPOR	1EASPOR	3 DIFPOR
REUSABLE-MULT/FUN 0.0302	2 P_2FUN	2 P_2FUN	2 P_2FUN	3 P_1FUN	3 P_1FUN
TECH/MAT 0.1158	2 INDAPP	3 PILOT	3 PILOT	1 RADAPP	3PILOT
INTEGRAT-AB 0.0207	1MINAB	1 MIN AB	1 MINAB	1 MIN AB	1MIN AB
INTEGRAT-INFRASTR 0.0131	2MUTILIZ	1HUTILIZ	2MUTILIZ	1HUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	1LIMPAC	1LIMPAC	1L IMPAC	3H IMPAC	1L IMPAC
LIFE COST-OPERTING 0.0514	1 LOCOST	1 LOCOST	2 OP_BL	3 HICOST	1LOCOST
LIFE COST-PROJECT 0.2056	1S_>30%	1S_>30%	1S_>30%	1 S_>30%	1 S_>30%
RELIAB - MAINTAIN 0.0412	3HMAINT	3HMAINT	3HMAINT	1LMAINT	3HMAINT
RELIAB - LONGEVITY 0.1237	1LREPAIR	1LREPAIR	1LREPAIR	1LREPAIR	2AREPAIR
COMPLEX – CLOSURE 0.0201	2MO.COMP	2MO.COMP	2MO.COMP	1LO.COMP	2MO.COMP
COMPLEX – OPERATION 0.0142	1LO_COMP	1LO_COMP	1LO_COMP	3HI_COMP	2MO_COMP
COMPLEX – CONST 0.0425	1LO COMP	1LO COMP	1LO COMP	1LO COMP	1LO COMP
COMPLEX – DESIGN 0.01	2MODCOMP	2MODCOMP	2MODCOMP	1LOWCOMP	1LOWCOMP
EFFECTIVE 0.1768	1HIGCONF	1HIGCONF	1HIGCONF	2MODCONF	1HIGCONF
RANKED	0.842	0.834	0.795	0.755	0.713

RAD/CONT 0.0566	1LESSEXP	2 BL_EXP	2 BL_EXP	3 MOREXP	2 BL_EXP
REUSABLE-REPEATABLE 0.0302	2 M-RPT	3 NO-RPT	2 M-RPT	2 M-RPT	1 HI-RPT
REUSABLE-PORTABLE 0.0151	3 DIFPOR	3 DIFPOR	3 DIFPOR	2 MODPOR	2 MODPOR
REUSABLE-MULT/FUN 0.0302	2 P_2FUN	3 P_1FUN	3 P_1FUN	3 P_1FUN	3 P_1FUN
TECH/MAT 0.1158	3 PILOT	1RADAPP	2 INDAPP	2 INDAPP	4 R&D
INTEGRAT-AB 0.0207	1MIN AB	3 ACC AB	1 MIN AB	3ACC AB	3ACC AB
INTEGRAT-INFRASTR 0.0131	2MUTILIZ	3LUTILIZ	2MUTILIZ	3LUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	1L IMPAC	3H IMPAC	1LIMPAC	3H IMPAC	3H IMPAC
LIFE COST-OPERTING 0.0514	2 OP_BL	2 OP_BL	2 OP_BL	3 HICOST	3HICOST
LIFE COST-PROJECT 0.2056	2 S_<30%	1 S_>30%	2 S_<30%	2 S_<30%	1 S_>30%
RELIAB - MAINTAIN 0.0412	3HMAINT	3H MAINT	3H MAINT	2A MAINT	3H MAINT
RELIAB - LONGEVITY 0.1237	1LREPAIR	1LREPAIR	2AREPAIR	1LREPAIR	2AREPAIR
COMPLEX – CLOSURE 0.0201	2MO.COMP	1LO.COMP	2MO.COMP	1LO.COMP	1LO.COMP
COMPLEX – OPERATION 0.0142	2MO_COMP	3HI_COMP	2MO_COMP	3HI_COMP	2MO_COMP
COMPLEX – CONST 0.0425	2MO COMP	1LO COMP	2MO COMP	2MO COMP	1LO COMP
COMPLEX – DESIGN 0.01	2MODCOMP	1LOWCOMP	2MODCOMP	2MODCOMP	1LOWCOMP
EFFECTIVE 0.1768	1HIGCONF	2MODCONF	1HIGCONF	1HIGCONF	1HIGCONF
RANKED	0.7	0.66	0.623	0.602	0.597
BULK SLUDGE PREPARATION FOR TRANSFER ALTERNATIVES	1.1.15 MINI QUAD VOLUTE SLURRY PUMPS	1.1.12 CHEMICAL CLEANING FOR TANK 5 AND 6	1.1.10 UNIVERSAL SHAFT PUMP	1.1.27 BORE HOLE MINER	1.1.13 DILUTE NITRIC ACID (<1M)

RAD/CONT 0.0566	**2 BL_EXP**	3 MOREXP	2 BL_EXP	2 BL_EXP	2 BL_EXP
REUSABLE-REPEATABLE 0.0302	**2 M-RPT**	2 M-RPT	1 HI-RPT	2 M-RPT	2 M-RPT
REUSABLE-PORTABLE 0.0151	**3 DIFPOR**	3 DIFPOR	2 MODPOR	2 MODPOR	3 DIFPOR
REUSABLE-MULT/FUN 0.0302	**3 P_1FUN**	2 P_2FUN	1 P>2FUN	3 P_1FUN	1 P>2FUN
TECH/MAT 0.1158	**1 RADAPP**	2 INDAPP	3 PILOT	3 PILOT	3 PILOT
INTEGRAT-AB 0.0207	**1 MIN AB**	3 ACC AB	3 ACC AB	1 MIN AB	2 SIG AB
INTEGRAT-INFRASTR 0.0131	**3LUTILIZ**	3LUTILIZ	1HUTILIZ	2MUTILIZ	1HUTILIZ
INTEGRAT-PROCESS 0.0329	**2M IMPAC**	1L IMPAC	3H IMPAC	1L IMPAC	1L IMPAC
LIFE COST-OPERTING 0.0514	**2OP_BL**	3 HICOST	3 HICOST	2 OP_BL	3 HICOST
LIFE COST-PROJECT 0.2056	**3BASELIN**	2 S_<30%	1 S_>30%	3BASELIN	1 S_>30%
RELIAB - MAINTAIN 0.0412	**3H MAINT**	2A MAINT	1L MAINT	3H MAINT	2A MAINT
RELIAB - LONGEVITY 0.1237	**2AREPAIR**	1LREPAIR	1LREPAIR	2AREPAIR	3HREPAIR
COMPLEX – CLOSURE 0.0201	**3HI.COMP**	1LO.COMP	2MO.COMP	1LO.COMP	1LO.COMP
COMPLEX – OPERATION 0.0142	**1LOCOMP**	3HI_COMP	3HI_COMP	2MO_COMP	3HI_COMP
COMPLEX – CONST 0.0425	**3HI COMP**	1LO COMP	1LO COMP	2MO COMP	1LO COMP
COMPLEX – DESIGN 0.01	**2MODCOMP**	2MODCOMP	2MODCOMP	3HIGCOMP	2MODCOMP
EFFECTIVE 0.1768	**1HIGCONF**	2MODCONF	3LOWCONF	1HIGCONF	2MODCONF
RANKED	**0.583**	0.576	0.566	0.556	0.541
BULK SLUDGE PREPARATION FOR TRANSFER ALTERNATIVES	**1.1.43 BULK SLUDGE PREPARATION BASELINE (4 SP & 1 TTP)**	1.1.42 SLUICING WITH RECIRC	1.1.2 CREATE SUMP IN ANNULUS, SLUICE SLUDGE INTO SUMP	1.1.29 MODULAR JET MIXING PUMP	1.1.9 TANK IN TANK

RAD/CONT 0.0566	2 BL_EXP	3 MOREXP	2 BL_EXP	2 BL_EXP	3 MOREXP	2 BL_EXP
REUSABLE-REPEATABLE 0.0302	2 M-RPT	1 HI-RPT	2 M-RPT	2 M-RPT	2 M-RPT	2 M-RPT
REUSABLE-PORTABLE 0.0151	3 DIFPOR	2 MODPOR	2 MODPOR	2 MODPOR	1 EASPOR	2 MODPOR
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	3 P_1FUN	2 P_2FUN	2 P_2FUN	1 P>2FUN	2 P_2FUN
TECH/MAT 0.1158	2 INDAPP	4 R&D	3 PILOT	3 PILOT	3 PILOT	3 PILOT
INTEGRAT-AB 0.0207	1 MIN AB	3 ACC AB	3 ACC AB	3 ACC AB	2 SIG AB	2 SIG AB
INTEGRAT-INFRASTR 0.0131	2MUTILIZ	3LUTILIZ	3LUTILIZ	3LUTILIZ	2MUTILIZ	1HUTILIZ
INTEGRAT-PROCESS 0.0329	1L IMPAC	1L IMPAC	2M IMPAC	2M IMPAC	2M IMPAC	1L IMPAC
LIFE COST-OPERTING 0.0514	2 OP_BL	2 OP_BL	2 OP_BL	2 OP_BL	3 HICOST	3 HICOST
LIFE COST-PROJECT 0.2056	2 S_<30%	2 S_<30%	2 S_<30%	2 S_<30%	3BASELIN	2 S_<30%
RELIAB - MAINTAIN 0.0412	3H MAINT	2A MAINT	2A MAINT	2A MAINT	3H MAINT	3H MAINT
RELIAB - LONGEVITY 0.1237	2AREPAIR	3HREPAIR	1LREPAIR	1LREPAIR	2AREPAIR	3HREPAIR
COMPLEX – CLOSURE 0.0201	2MO.COMP	1LO.COMP	2MO.COMP	2MO.COMP	1LO.COMP	2MO.COMP
COMPLEX – OPERATION 0.0142	2MO_COMP	2MO_COMP	1LO_COMP	1LO_COMP	3HI_COMP	3HI_COMP
COMPLEX – CONST 0.0425	2MO COMP	2MO COMP	2MO COMP	2MO COMP	3HI COMP	2MO COMP
COMPLEX – DESIGN 0.01	2MODCOMP	3HIGCOMP	2MODCOMP	2MODCOMP	3HIGCOMP	3HIGCOMP
EFFECTIVE 0.1768	2MODCONF	1HIGCONF	3LOWCONF	3LOWCONF	1HIGCONF	2MODCONF
RANKED	0.535	0.496	0.486	0.486	0.484	0.425
BULK SLUDGE PREPARATION FOR TRANSFER ALTERNATIVES	1.1.14 SINGLE DISCHARGE PUMP WITH FLYGT MIXER	1.1.1 TILT BED TRAILER WITH MIXER	1.1.5 RUSSIAN PULSATING MIXER	1.1.6 AEA PULSE TUBE MIXER	1.1.31 CONFINED SLUICING	1.1.22 DEWATER WITH LAGOON CLEANER

RAD/CONT 0.0566	2 BL_EXP	2 BL_EXP	2 BL_EXP	3 MOREXP	3 MOREXP
REUSABLE-REPEATABLE 0.0302	2 M-RPT	2 M-RPT	1 HI-RPT	3 NO-RPT	2 M-RPT
REUSABLE-PORTABLE 0.0151	3 DIFPOR	3 DIFPOR	1 EASPOR	3 DIFPOR	3 DIFPOR
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	3 P_1FUN	2 P_2FUN	2 P_2FUN	1 P>2FUN
TECH/MAT 0.1158	4 R&D	3 PILOT	4 R&D	4 R&D	3 PILOT
INTEGRAT-AB 0.0207	2 SIG AB	1 MIN AB	3 ACC AB	2 SIG AB	2 SIG AB
INTEGRAT-INFRASTR 0.0131	3LUTILIZ	1HUTILIZ	3LUTILIZ	3LUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	1L IMPAC	3H IMPAC	3H IMPAC	2M IMPAC	2M IMPAC
LIFE COST-OPERTING 0.0514	2 OP_BL	2 OP_BL	2 OP_BL	3 HICOST	3 HICOST
LIFE COST-PROJECT 0.2056	3BASELIN	2 S_<30%	2 S_<30%	2 S_<30%	2 S_<30%
RELIAB - MAINTAIN 0.0412	2A MAINT	3H MAINT	2A MAINT	3H MAINT	3H MAINT
RELIAB - LONGEVITY 0.1237	2AREPAIR	2AREPAIR	2AREPAIR	2AREPAIR	3HREPAIR
COMPLEX – CLOSURE 0.0201	2MO.COMP	2MO.COMP	2MO.COMP	2MO.COMP	2MO.COMP
COMPLEX – OPERATION 0.0142	1LO_COMP	2MO_COMP	3HI_COMP	3HI_COMP	3HI_COMP
COMPLEX – CONST 0.0425	3HI COMP	2MO COMP	2MO COMP	2MO COMP	3HI COMP
COMPLEX – DESIGN 0.01	3HIGCOMP	2MODCOMP	3HIGCOMP	3HIGCOMP	3HIGCOMP
EFFECTIVE 0.1768	2MODCONF	3LOWCONF	3LOWCONF	2MODCONF	2MODCONF
RANKED	0.41	0.391	0.382	0.378	0.36
BULK SLUDGE PREPARATION FOR TRANSFER ALTERNATIVES	1.1.25 WAVE MACHINE	1.1.40 FLYGT MIXERS IN RACETRACK WITH VERTICAL FLYGT MIXER IN CENTER	1.1.37 PUMP DRY WITH ABSORBANT MATERIAL & CONVEY OUT	1.1.7 INDUSTRIAL WET VAC	1.1.36 EASILY MANIPULATED MECHANICAL ARM (EMMA)

RAD/CONT 0.0566	3 MOREXP	3 MOREXP	3 MOREXP	3 MOREXP	3 MOREXP	3 MOREXP
REUSABLE-REPEATABLE 0.0302	2 M-RPT	3 NO-RPT	1 HI-RPT	2 M-RPT	3 NO-RPT	3 NO-RPT
REUSABLE-PORTABLE 0.0151	3 DIFPOR	3 DIFPOR	3 DIFPOR	3 DIFPOR	3 DIFPOR	3 DIFPOR
REUSABLE-MULT/FUN 0.0302	2 P_2FUN	2 P_2FUN	2 P_2FUN	1 P>2FUN	2 P_2FUN	2P_2FUN
TECH/MAT 0.1158	4 R&D	4 R&D	4 R&D	4 R&D	4R&D	4R&D
INTEGRAT-AB 0.0207	2 SIG AB	2 SIG AB	3 ACC AB	3 ACC AB	3 ACC AB	3ACC AB
INTEGRAT-INFRASTR 0.0131	2MUTILIZ	3LUTILIZ	3LUTILIZ	2MUTILIZ	3LUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	1L IMPAC	2M IMPAC	3H IMPAC	3H IMPAC	3H IMPAC	3H IMPAC
LIFE COST-OPERTING 0.0514	3 HICOST	3 HICOST	3 HICOST	3 HICOST	3HICOST	2 OP_BL
LIFE COST-PROJECT 0.2056	2 S_<30%	2 S_<30%	2 S_<30%	2 S_<30%	3BASELIN	3BASELIN
RELIAB - MAINTAIN 0.0412	3H MAINT	3H MAINT	3H MAINT	3H MAINT	3H MAINT	3H MAINT
RELIAB - LONGEVITY 0.1237	3HREPAIR	2AREPAIR	2AREPAIR	2AREPAIR	3HREPAIR	3HREPAIR
COMPLEX – CLOSURE 0.0201	2MO.COMP	2MO.COMP	1LO.COMP	2MO.COMP	3HI.COMP	2MO.COMP
COMPLEX – OPERATION 0.0142	3HI_COMP	3HI_COMP	3HI_COMP	3HI_COMP	3HI_COMP	3HI_COMP
COMPLEX – CONST 0.0425	3HI COMP	2MO COMP	3HI COMP	3HI COMP	3HI COMP	3HI COMP
COMPLEX – DESIGN 0.01	3HIGCOMP	3HIGCOMP	3HIGCOMP	3HIGCOMP	3HIGCOMP	3HIGCOMP
EFFECTIVE 0.1768	2MODCONF	3LOWCONF	3LOWCONF	3LOWCONF	2MODCONF	3LOWCONF
RANKED	0.333	0.289	0.281	0.278	0.206	0.16
BULK SLUDGE PREPARATION FOR TRANSFER ALTERNATIVES	1.1.28 SEWER SUCKER	1.1.8 INDUSTRIAL POOL CLEANER	1.1.20 DEWATER AND VACUUM	1.1.11 PNEUMATIC CONVEYING	1.1.26 REMOVE LARGE SECTION OF TANK TOP AND CONVEY	1.1.4 MULTI-POINT SUCTION

Appendix I (1.2) – BOP Alternative Ranking, Bulk Salt Preparation for Transfer

BULK SALT PREPARATION FOR TRANSFER ALTERNATIVES	1.2.11 DENSITY GRADIENT	1.2.13 TWO WEMD SUBMERSIBLE PUMPS	1.2.12 MODIFIED DENSITY GRADIENT	1.2.9 TWO PULSE TUBE MIXERS
RAD/CONT 0.0566	2 BL_EXP	2 BL_EXP	2 BL_EXP	2 BL_EXP
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	1 HI-RPT	1 HI-RPT	1 HI-RPT
REUSABLE-PORTABLE 0.0151	3 DIFPOR	2 MODPOR	3 DIFPOR	1 EASPOR
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	2 P_2FUN	3 P_1FUN	3 P_1FUN
TECH/MAT 0.1158	1 RADAPP	3 PILOT	2 INDAPP	2 INDAPP
INTEGRAT-AB 0.0207	1 MIN AB	1 MIN AB	1 MIN AB	3 ACC AB
INTEGRAT-INFRASTR 0.0131	1HUTILIZ	2MUTILIZ	1HUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	3H IMPAC	1L IMPAC	3H IMPAC	2M IMPAC
LIFECOST-OPERTING 0.0514	2 OP_BL	2 OP_BL	2 OP_BL	2 OP_BL
LIFECOST-PROJECT 0.2056	1 S_>30%	1 S_>30%	1 S_>30%	1 S_>30%
RELIAB - MAINTAIN 0.0412	1L MAINT	3H MAINT	1L MAINT	1L MAINT
RELIAB - LONGEVITY 0.1237	1LREPAIR	1LREPAIR	1LREPAIR	2AREPAIR
COMPLEX – CLOSURE 0.0201	1LO.COMP	1LO.COMP	1LO.COMP	2MO.COMP
COMPLEX – OPERATION 0.0142	1LO_COMP	2MO_COMP	1LO_COMP	2MO_COMP
COMPLEX – CONST. 0.0425	1LO COMP	2MO COMP	1LO COMP	2MO COMP
COMPLEX – DESIGN 0.01	1LOWCOMP	2MODCOMP	1LOWCOMP	1LOWCOMP
EFFECTIVE 0.1768	2MODCONF	1HIGCONF	2MODCONF	1HIGCONF
RANKED	0.78	0.755	0.722	0.714

RAD/CONT 0.0566	2 BL_EXP	2 BL_EXP	2 BL_EXP	2 BL_EXP	2 BL_EXP
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	1 HI-RPT	1 HI-RPT	2 M-RPT	1 HI-RPT
REUSABLE-PORTABLE 0.0151	1 EASPOR	1 EASPOR	3 DIFPOR	3 DIFPOR	3 DIFPOR
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	3 P_1FUN	3 P_1FUN	3 P_1FUN	3 P_1FUN
TECH/MAT 0.1158	2 INDAPP	2 INDAPP	2 INDAPP	1 RADAPP	1 RADAPP
INTEGRAT-AB 0.0207	2 SIG AB	2 SIG AB	2 SIG AB	1 MIN AB	1 MIN AB
INTEGRAT-INFRASTR 0.0131	1HUTILIZ	1HUTILIZ	3LUTILIZ	3LUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	3H IMPAC	2M IMPAC	2M IMPAC	1L IMPAC	2M IMPAC
LIFECOST-OPERTING 0.0514	3 HICOST	3 HICOST	2 OP_BL	2 OP_BL	2 OP_BL
LIFECOST-PROJECT 0.2056	1 S_>30%	1 S_>30%	1 S_>30%	2 S_<30%	1 S_>30%
RELIAB - MAINTAIN 0.0412	1L MAINT	2A MAINT	1L MAINT	2A MAINT	2A MAINT
RELIAB - LONGEVITY 0.1237	1LREPAIR	1LREPAIR	2AREPAIR	2AREPAIR	2AREPAIR
COMPLEX – CLOSURE 0.0201	1LO.COMP	1LO.COMP	3HI.COMP	3HI.COMP	2MO.COMP
COMPLEX – OPERATION 0.0142	2MO_COMP	2MO_COMP	2MO_COMP	1LO_COMP	2MO_COMP
COMPLEX – CONST. 0.0425	1LO COMP	1LO COMP	2MO COMP	3HI COMP	2MO COMP
COMPLEX – DESIGN 0.01	1LOWCOMP	1LOWCOMP	2MODCOMP	2MODCOMP	1LOWCOMP
EFFECTIVE 0.1768	2MODCONF	2MODCONF	1HIGCONF	1HIGCONF	2MODCONF
RANKED	0.694	0.689	0.688	0.671	0.669
BULK SALT PREPARATION FOR TRANSFER ALTERNATIVES	1.2.14 SLUICING	1.2.3 HYDROLANCE FOR SALT REMOVAL	1.2.1 MODIFIED DENSITY GRADIENT FOR SALT REMOVAL USING RECYCLED LINES	1.2.7 TWO SLURRY PUMPS	1.2.6 ONE SLURRY PUMP

RAD/CONT 0.0566	2 BL_EXP	2 BL_EXP	2 BL_EXP	2 BL_EXP	2 BL_EXP
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	1 HI-RPT	1 HI-RPT	2 M-RPT	2 M-RPT
REUSABLE-PORTABLE 0.0151	3 DIFPOR	3 DIFPOR	1 EASPOR	3 DIFPOR	3 DIFPOR
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	3 P_1FUN	3 P_1FUN	3 P_1FUN	2 P_2FUN
TECH/MAT 0.1158	2 INDAPP	2 INDAPP	2 INDAPP	1 RADAPP	3 PILOT
INTEGRAT-AB 0.0207	1 MIN AB	2 SIG AB	3 ACC AB	1 MIN AB	3 ACC AB
INTEGRAT-INFRASTR 0.0131	2MUTILIZ	1HUTILIZ	1HUTILIZ	3LUTILIZ	3LUTILIZ
INTEGRAT-PROCESS 0.0329	2M IMPAC	3H IMPAC	2M IMPAC	2M IMPAC	1L IMPAC
LIFECOST-OPERTING 0.0514	2 OP_BL	3 HICOST	2 OP_BL	2 OP_BL	2 OP_BL
LIFECOST-PROJECT 0.2056	2 S_<30%	1 S_>30%	1 S_>30%	3BASELIN	3BASELIN
RELIAB - MAINTAIN 0.0412	2A MAINT	2A MAINT	1L MAINT	2A MAINT	2A MAINT
RELIAB - LONGEVITY 0.1237	2AREPAIR	1LREPAIR	2AREPAIR	2AREPAIR	1LREPAIR
COMPLEX – CLOSURE 0.0201	1LO.COMP	1LO.COMP	2MO.COMP	3HI.COMP	3HI.COMP
COMPLEX – OPERATION 0.0142	1LO_COMP	2MO_COMP	2MO_COMP	1LO_COMP	1LO_COMP
COMPLEX – CONST. 0.0425	2MO COMP	1LO COMP	1LO COMP	3HI COMP	3HI COMP
COMPLEX – DESIGN 0.01	1LOWCOMP	1LOWCOMP	1LOWCOMP	2MODCOMP	2MODCOMP
EFFECTIVE 0.1768	1HIGCONF	2MODCONF	2MODCONF	1HIGCONF	1HIGCONF
RANKED	0.665	0.658	0.653	0.603	0.589
BULK SALT PREPARATION FOR TRANSFER ALTERNATIVES	1.2.5 TWO FLYGT MIXERS	1.2.2 STEAM RECIRCULATING JET FOR SALT REMOVAL	1.2.10 ONE PULSE TUBE MIXER	1.2.4 BULK SALT PREPARATION BASELINE (3 SP & 1 TTJ)	1.2.8 TWO MODIFIED ADVANCED DESIGN SLURRY PUMPS

Appendix I (2.1) – BOP Alternative Ranking, Bulk Sludge Waste Transfer

RAD/CONT 0.0566	2 BL_EXP	2 BL_EXP	1LESSEXP	2 BL_EXP	2 BL_EXP
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	1 HI-RPT	1 HI-RPT	1 HI-RPT	1 HI-RPT
REUSABLE-PORTABLE 0.0151	3 DIFPOR	3 DIFPOR	2 MODPOR	3 DIFPOR	2 MODPOR
REUSABLE-MULT/FUN 0.0302	2 P_2FUN	3 P_1FUN	3 P_1FUN	3 P_1FUN	2 P_2FUN
TECH/MAT 0.1158	1 RADAPP	1 RADAPP	2 INDAPP	2 INDAPP	2 INDAPP
INTEGRAT-AB 0.0207	1 MIN AB	1 MIN AB	1 MIN AB	1 MIN AB	1 MIN AB
INTEGRAT-INFRASTR 0.0131	1HUTILIZ	2MUTILIZ	2MUTILIZ	2MUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	1L IMPAC	1L IMPAC	1L IMPAC	1L IMPAC	1L IMPAC
LIFECOST-OPERTING 0.0514	1 LOCOST	1 LOCOST	1 LOCOST	1 LOCOST	1 LOCOST
LIFECOST-PROJECT 0.2056	1 S_>30%	1 S_>30%	1 S_>30%	1 S_>30%	2 S_<30%
RELIAB - MAINTAIN 0.0412	1L MAINT	1L MAINT	1L MAINT	2A MAINT	2A MAINT
RELIAB - LONGEVITY 0.1237	3HREPAIR	3HREPAIR	3HREPAIR	3HREPAIR	3HREPAIR
COMPLEX – CLOSURE 0.0201	1LO.COMP	1LO.COMP	1LO.COMP	1LO.COMP	1LO.COMP
COMPLEX – OPERATION 0.0142	1LO_COMP	1LO_COMP	1LO_COMP	1LO_COMP	1LO_COMP
COMPLEX – CONST. 0.0425	1LO COMP	1LO COMP	1LO COMP	1LO COMP	2MO COMP
COMPLEX – DESIGN 0.01	1LOWCOMP	1LOWCOMP	1LOWCOMP	1LOWCOMP	2MODCOMP
EFFECTIVE 0.1768	1HIGCONF	1HIGCONF	1HIGCONF	1HIGCONF	1HIGCONF
RANKED	0.818	0.796	0.774	0.718	0.663
BULK SLUDGE WASTE TRANSFER ALTERNATIVES	2.1.9 BIBO PUMP ON MAST	2.1.8 MACERATOR PUMP	2.1.3 DISPOSABLE TRANSFER PUMP ON A ROPE	2.1.12 SCREW PUMP	2.1.5 HANFORD SEE PUMP LIKE TANK 19

RAD/CONT 0.0566	**2 BL_EXP**	2 BL_EXP	3 MOREXP	3 MOREXP	3 MOREXP
REUSABLE-REPEATABLE 0.0302	**1 HI-RPT**	1 HI-RPT	2 M-RPT	1 HI-RPT	1 HI-RPT
REUSABLE-PORTABLE 0.0151	**3 DIFPOR**	3 DIFPOR	3 DIFPOR	2 MODPOR	2 MODPOR
REUSABLE-MULT/FUN 0.0302	**2 P_2FUN**	2 P_2FUN	2 P_2FUN	1 P>2FUN	1 P>2FUN
TECH/MAT 0.1158	**1 RADAPP**	2 INDAPP	2 INDAPP	4 R&D	4 R&D
INTEGRAT-AB 0.0207	**1 MIN AB**	1 MIN AB	2 SIG AB	3 ACC AB	3 ACC AB
INTEGRAT-INFRASTR 0.0131	**3LUTILIZ**	2MUTILIZ	2MUTILIZ	3LUTILIZ	3LUTILIZ
INTEGRAT-PROCESS 0.0329	**2M IMPAC**	1L IMPAC	1L IMPAC	2M IMPAC	2M IMPAC
LIFECOST-OPERTING 0.0514	**2 OP_BL**	2 OP_BL	2 OP_BL	3 HICOST	3 HICOST
LIFECOST-PROJECT 0.2056	**3BASELIN**	2 S_<30%	2 S_<30%	1 S_>30%	1 S_>30%
RELIAB - MAINTAIN 0.0412	**2A MAINT**	3H MAINT	3H MAINT	3H MAINT	3H MAINT
RELIAB - LONGEVITY 0.1237	**2AREPAIR**	3HREPAIR	3HREPAIR	3HREPAIR	3HREPAIR
COMPLEX – CLOSURE 0.0201	**2MO.COMP**	1LO.COMP	1LO.COMP	1LO.COMP	1LO.COMP
COMPLEX – OPERATION 0.0142	**1LO_COMP**	1LO_COMP	2MO_COMP	3HI_COMP	3HI_COMP
COMPLEX – CONST. 0.0425	**3HI COMP**	2MO COMP	2MO COMP	1LO COMP	1LO COMP
COMPLEX – DESIGN 0.01	**2MODCOMP**	2MODCOMP	2MODCOMP	1LOWCOMP	1LOWCOMP
EFFECTIVE 0.1768	**1HIGCONF**	1HIGCONF	1HIGCONF	3LOWCONF	3LOWCONF
RANKED	**0.644**	0.609	0.548	0.363	0.363
BULK SLUDGE WASTE TRANSFER ALTERNATIVES	**2.1.14 BULK SLUDGE TRANSFER BASELINE (1.25 HP TTP)**	2.1.10 MODIFY TTP WITH MOTOR AT BOTTOM (SUBMERSIBLE PUMP)	2.1.11 DIAPHRAM PUMP	2.1.6 WAND W/BOOSTER PUMPS IN SERIES	2.1.7 VACUUM TANK

BULK SLUDGE WASTE TRANSFER ALTERNATIVES	2.1.4 PUMP ON A RAFT	2.1.2 TRUCK WASTE	2.1.13 MODIFIED DEEP WELL EDUCTOR PUMP
RAD/CONT 0.0566	2 BL_EXP	3 MOREXP	3 MOREXP
REUSABLE-REPEATABLE 0.0302	2 M-RPT	1 HI-RPT	2 M-RPT
REUSABLE-PORTABLE 0.0151	3 DIFPOR	2 MODPOR	3 DIFPOR
REUSABLE-MULT/FUN 0.0302	1 P>2FUN	3 P_1FUN	3 P_1FUN
TECH/MAT 0.1158	4 R&D	4 R&D	4 R&D
INTEGRAT-AB 0.0207	1 MIN AB	3 ACC AB	2 SIG AB
INTEGRAT-INFRASTR 0.0131	1HUTILIZ	2MUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	2M IMPAC	3H IMPAC	1L IMPAC
LIFECOST-OPERTING 0.0514	3 HICOST	3 HICOST	2 OP_BL
LIFECOST-PROJECT 0.2056	3BASELIN	4 H_<30%	3BASELIN
RELIAB - MAINTAIN 0.0412	3H MAINT	3H MAINT	3H MAINT
RELIAB - LONGEVITY 0.1237	3HREPAIR	2AREPAIR	3HREPAIR
COMPLEX – CLOSURE 0.0201	1LO.COMP	2MO.COMP	2MO.COMP
COMPLEX – OPERATION 0.0142	3HI_COMP	3HI_COMP	3HI_COMP
COMPLEX – CONST. 0.0425	2MO COMP	3HI COMP	3HI COMP
COMPLEX – DESIGN 0.01	2MODCOMP	3HIGCOMP	3HIGCOMP
EFFECTIVE 0.1768	2MODCONF	1HIGCONF	2MODCONF
RANKED	0.361	0.344	0.292

Appendix I (2.2) – BOP Alternative Ranking, Bulk Salt Waste Transfer

RAD/CONT 0.0566	2 BL_EXP	2 BL_EXP	2 BL_EXP	2 BL_EXP	**2 BL EXP**
REUSABLE-REPEATABLE 0.0302	2 M-RPT	1 HI-RPT	1 HI-RPT	1 HI-RPT	**2 M-RPT**
REUSABLE-PORTABLE 0.0151	3 DIFPOR	2 MODPOR	2 MODPOR	2 MODPOR	**2 MODPOR**
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	2 P_2FUN	2 P_2FUN	3 P_1FUN	**3 P 1FUN**
TECH/MAT 0.1158	1 RADAPP	1 RADAPP	2 INDAPP	2 INDAPP	**1 RADAPP**
INTEGRAT-AB 0.0207	1 MIN AB	1 MIN AB	1 MIN AB	1 MIN AB	**1 MIN AB**
INTEGRAT-INFRASTR 0.0131	1HUTILIZ	1HUTILIZ	2MUTILIZ	1HUTILIZ	**1HUTILIZ**
INTEGRAT-PROCESS 0.0329	2M IMPAC	1L IMPAC	1L IMPAC	1L IMPAC	**2M IMPAC**
LIFECOST-OPERTING 0.0514	2 OP_BL	1 LOCOST	2 OP_BL	2 OP_BL	**2 OP BL**
LIFECOST-PROJECT 0.2056	1 S_>30%	1 S_>30%	2 S_<30%	2 S_<30%	**3BASELIN**
RELIAB - MAINTAIN 0.0412	1L MAINT	3H MAINT	3H MAINT	3H MAINT	**2A MAINT**
RELIAB - LONGEVITY 0.1237	1LREPAIR	2AREPAIR	1LREPAIR	2AREPAIR	**2AREPAIR**
COMPLEX – CLOSURE 0.0201	1LO.COMP	1LO.COMP	1LO.COMP	1LO.COMP	**1LO.COMP**
COMPLEX – OPERATION 0.0142	1LO_COMP	1LO_COMP	2MO_COMP	1LO_COMP	**1LO COMP**
COMPLEX – CONST. 0.0425	2MO COMP	2MO COMP	2MO COMP	1LO COMP	**2MO COMP**
COMPLEX – DESIGN 0.01	1LOWCOMP	1LOWCOMP	2MODCOMP	2MODCOMP	**2MODCOMP**
EFFECTIVE 0.1768	1HIGCONF	1HIGCONF	1HIGCONF	1HIGCONF	**1HIGCONF**
RANKED	0.848	0.825	0.733	0.691	**0.665**
BULK SALT WASTE TRANSFER ALTERNATIVES	2.2.1 JETS	2.2.6 SUMP PUMP ON A MAST	2.2.5 AIR OPERATED DIAPHRAGM PUMP ON MAST	2.2.3 SUMP PUMP ON CABLE	**2.2.2 BULK SALT TRANSFER BASELINE (1 TTJ)**

BULK SALT WASTE TRANSFER ALTERNATIVES	2.2.4 HANFORD SEE PUMP
RANKED	0.641
EFFECTIVE 0.1768	1HIGCONF
COMPLEX – DESIGN 0.01	2MODCOMP
COMPLEX – CONST. 0.0425	2MO COMP
COMPLEX – OPERATION 0.0142	1LO_COMP
COMPLEX – CLOSURE 0.0201	1LO.COMP
RELIAB - LONGEVITY 0.1237	2AREPAIR
RELIAB - MAINTAIN 0.0412	3H MAINT
LIFECOST-PROJECT 0.2056	2 S_<30%
LIFECOST-OPERTING 0.0514	2 OP_BL
INTEGRAT-PROCESS 0.0329	1L IMPAC
INTEGRAT-INFRASTR 0.0131	1HUTILIZ
INTEGRAT-AB 0.0207	1 MIN AB
TECH/MAT 0.1158	3 PILOT
REUSABLE-MULT/FUN 0.0302	3 P_1FUN
REUSABLE-PORTABLE 0.0151	2 MODPOR
REUSABLE-REPEATABLE 0.0302	1 HI-RPT
RAD/CONT 0.0566	2 BL_EXP

Appendix I (3.1) – BOP Alternative Ranking, Heel Preparation for Transfer

HEEL PREPARATION FOR TRANSFER ALTERNATIVES	3.1.4 USE TANK 16 OXALIC ACID CLEANING AT 8 WT%	3.1.1 CHEMICAL DISSOLUTION	3.1.11 OXALIC ACID WITH OXADIZER	3.1.29 MOVABLE / ARTICULATE D HOSE	3.1.5 SELECTIVE LEACHING WITH OXIDIZER AND INHIBITED WATER
RANKED	0.718	0.674	0.632	0.624	0.543
EFFECTIVE 0.1768	1HIGCONF	1HIGCONF	1HIGCONF	2MODCONF	2MODCONF
COMPLEX – DESIGN 0.01	2MODCOMP	2MODCOMP	2MODCOMP	1LOWCOMP	2MODCOMP
COMPLEX – CONST. 0.0425	2MO COMP	2MO COMP	2MO COMP	2MO COMP	2MO COMP
COMPLEX – OPERATION 0.0142	2MO_COMP	2MO_COMP	2MO_COMP	3HI_COMP	2MO_COMP
COMPLEX – CLOSURE 0.0201	2MO.COMP	2MO.COMP	2MO.COMP	1LO.COMP	2MO.COMP
RELIAB - LONGEVITY 0.1237	1LREPAIR	1LREPAIR	1LREPAIR	1LREPAIR	1LREPAIR
RELIAB - MAINTAIN 0.0412	2A MAINT	2A MAINT	2A MAINT	1L MAINT	2A MAINT
LIFECOST-PROJECT 0.2056	3BASELIN	3BASELIN	3BASELIN	3BASELIN	3BASELIN
LIFECOST-OPERTING 0.0514	3 HICOST	2 OP_BL	3 HICOST	2 OP_BL	3 HICOST
INTEGRAT-PROCESS 0.0329	2M IMPAC	1L IMPAC	2M IMPAC	3H IMPAC	2M IMPAC
INTEGRAT-INFRASTR 0.0131	2MUTILIZ	2MUTILIZ	2MUTILIZ	2MUTILIZ	2MUTILIZ
INTEGRAT-AB 0.0207	2 SIG AB	2 SIG AB	2 SIG AB	2 SIG AB	2 SIG AB
TECH/MAT 0.1158	1 RADAPP	3 PILOT	3 PILOT	1 RADAPP	3 PILOT
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	3 P_1FUN	3 P_1FUN	3 P_1FUN	3 P_1FUN
REUSABLE-PORTABLE 0.0151	1 EASPOR	1 EASPOR	1 EASPOR	1 EASPOR	1 EASPOR
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	1 HI-RPT	1 HI-RPT	2 M-RPT	1 HI-RPT
RAD/CONT 0.0566	1LESSEXP	1LESSEXP	1LESSEXP	2 BL_EXP	1LESSEXP

RAD/CONT 0.0566	1LESSEXP	1LESSEXP	1LESSEXP	1LESSEXP	1LESSEXP
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	1 HI-RPT	1 HI-RPT	1 HI-RPT	1 HI-RPT
REUSABLE-PORTABLE 0.0151	1 EASPOR	1 EASPOR	1 EASPOR	1 EASPOR	1 EASPOR
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	3 P_1FUN	2 P_2FUN	3 P_1FUN	3 P_1FUN
TECH/MAT 0.1158	3 PILOT	4 R&D	4 R&D	4 R&D	4 R&D
INTEGRAT-AB 0.0207	2 SIG AB	1 MIN AB	2 SIG AB	2 SIG AB	2 SIG AB
INTEGRAT-INFRASTR 0.0131	2MUTILIZ	1HUTILIZ	1HUTILIZ	2MUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	3H IMPAC	2M IMPAC	2M IMPAC	3H IMPAC	3H IMPAC
LIFECOST-OPERTING 0.0514	3 HICOST	1 LOCOST	1 LOCOST	3 HICOST	3 HICOST
LIFECOST-PROJECT 0.2056	3BASELIN	3BASELIN	3BASELIN	3BASELIN	3BASELIN
RELIAB - MAINTAIN 0.0412	2A MAINT	3H MAINT	3H MAINT	2A MAINT	2A MAINT
RELIAB - LONGEVITY 0.1237	1LREPAIR	1LREPAIR	1LREPAIR	1LREPAIR	1LREPAIR
COMPLEX – CLOSURE 0.0201	2MO.COMP	1LO.COMP	2MO.COMP	2MO.COMP	2MO.COMP
COMPLEX – OPERATION 0.0142	2MO_COMP	1LO_COMP	1LO_COMP	2MO_COMP	2MO_COMP
COMPLEX – CONST. 0.0425	2MO COMP	1LO COMP	1LO COMP	2MO COMP	2MO COMP
COMPLEX – DESIGN 0.01	2MODCOMP	1LOWCOMP	1LOWCOMP	2MODCOMP	2MODCOMP
EFFECTIVE 0.1768	2MODCONF	3LOWCONF	3LOWCONF	2MODCONF	2MODCONF
RANKED	0.527	0.517	0.512	0.498	0.498
HEEL PREPARATION FOR TRANSFER ALTERNATIVES	3.1.6 OXALIC ACID AND CITRIC ACID	3.1.8 REVERSE SURFACE CHARGE TO DEFLOC SLUDGE PARTICLE BY WELL WATER	3.1.9 SUSPEND HEEL MATERIALS WITH SURFACTANT	3.1.15 SELECTIVE LEACHING OF RADIONUCLIDES	3.1.28 CHEMICAL DISSOLUTION (RUSSIAN REGIME) WITH A COMPLEXING AGENT

HEEL PREPARATION FOR TRANSFER ALTERNATIVES	3.1.33 PARTITION TANK AND MOVE SLUDGE WITH A SLUICER	3.1.12 ADD MATERIAL TO INCREASE SP GR OF SLURRY MEDIA	3.1.7 REVEERSE SURFACE CHARGE TO DEFLOC SLUDGE PARTICLE BY ACID ADDITION	3.1.20 FLYGT MIXERS	3.1.21 VERTICAL FLYGT MIXERS (150 HP)
RAD/CONT 0.0566	2 BL_EXP	2 BL_EXP	1LESSEXP	2 BL_EXP	2 BL_EXP
REUSABLE-REPEATABLE 0.0302	2 M-RPT	1 HI-RPT	1 HI-RPT	2 M-RPT	2 M-RPT
REUSABLE-PORTABLE 0.0151	1 EASPOR	1 EASPOR	1 EASPOR	3 DIFPOR	3 DIFPOR
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	3 P_1FUN	3 P_1FUN	2 P_2FUN	2 P_2FUN
TECH/MAT 0.1158	2 INDAPP	3 PILOT	4 R&D	3 PILOT	3 PILOT
INTEGRAT-AB 0.0207	2 SIG AB	1 MIN AB	2 SIG AB	1 MIN AB	1 MIN AB
INTEGRAT-INFRASTR 0.0131	2MUTILIZ	1HUTILIZ	2MUTILIZ	1HUTILIZ	1HUTILIZ
INTEGRAT-PROCESS 0.0329	2M IMPAC	3H IMPAC	1L IMPAC	3H IMPAC	3H IMPAC
LIFECOST-OPERTING 0.0514	3 HICOST	3 HICOST	2 OP_BL	2 OP_BL	2 OP_BL
LIFECOST-PROJECT 0.2056	4 H_<30%	3BASELIN	3BASELIN	3BASELIN	3BASELIN
RELIAB - MAINTAIN 0.0412	1L MAINT	3H MAINT	2A MAINT	3H MAINT	3H MAINT
RELIAB - LONGEVITY 0.1237	1LREPAIR	2AREPAIR	1LREPAIR	2AREPAIR	2AREPAIR
COMPLEX – CLOSURE 0.0201	1LO.COMP	1LO.COMP	2MO.COMP	1LO.COMP	1LO.COMP
COMPLEX – OPERATION 0.0142	3HI_COMP	2MO_COMP	2MO_COMP	2MO_COMP	2MO_COMP
COMPLEX – CONST. 0.0425	3HI COMP	1LO COMP	2MO COMP	2MO COMP	2MO COMP
COMPLEX – DESIGN 0.01	2MODCOMP	1LOWCOMP	2MODCOMP	2MODCOMP	2MODCOMP
EFFECTIVE 0.1768	2MODCONF	2MODCONF	3LOWCONF	2MODCONF	3LOWCONF
RANKED	0.48	0.469	0.468	0.453	0.365

RAD/CONT 0.0566	1LESSEXP	3 MOREXP	3 MOREXP	3 MOREXP	3 MOREXP
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	2 M-RPT	2 M-RPT	2 M-RPT	2 M-RPT
REUSABLE-PORTABLE 0.0151	2 MODPOR	2 MODPOR	2 MODPOR	2 MODPOR	2 MODPOR
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	2 P_2FUN	3 P_1FUN	2 P_2FUN	2 P_2FUN
TECH/MAT 0.1158	4 R&D	3 PILOT	2 INDAPP	2 INDAPP	2 INDAPP
INTEGRAT-AB 0.0207	3 ACC AB	1 MIN AB	2 SIG AB	1 MIN AB	1 MIN AB
INTEGRAT-INFRASTR 0.0131	3LUTILIZ	2MUTILIZ	2MUTILIZ	2MUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	1L IMPAC	1L IMPAC	3H IMPAC	1L IMPAC	1L IMPAC
LIFECOST-OPERTING 0.0514	3 HICOST	2 OP_BL	2 OP_BL	2 OP_BL	2 OP_BL
LIFECOST-PROJECT 0.2056	4 H_<30%	4 H_<30%	4 H_<30%	5 H_>30%	5 H_>30%
RELIAB - MAINTAIN 0.0412	2A MAINT	3H MAINT	3H MAINT	3H MAINT	3H MAINT
RELIAB - LONGEVITY 0.1237	1LREPAIR	3HREPAIR	3HREPAIR	3HREPAIR	3HREPAIR
COMPLEX – CLOSURE 0.0201	2MO.COMP	2MO.COMP	2MO.COMP	2MO.COMP	2MO.COMP
COMPLEX – OPERATION 0.0142	3HI_COMP	3HI_COMP	3HI_COMP	3HI_COMP	3HI_COMP
COMPLEX – CONST. . 0.0425	3HI COMP	3HI COMP	2MO COMP	3HI COMP	3HI COMP
COMPLEX – DESIGN 0.01	3HIGCOMP	3HIGCOMP	2MODCOMP	3HIGCOMP	3HIGCOMP
EFFECTIVE 0.1768	3LOWCONF	2MODCONF	2MODCONF	2MODCONF	2MODCONF
RANKED	0.333	0.302	0.299	0.28	0.28
HEEL PREPARATION FOR TRANSFER ALTERNATIVES	3.1.16 LEACH RADIONUCLIDES WITH AMMONIUM HYDROXIDE	3.1.19 SRS CRAWLER WITH SUCTION PUMP (TYPE 4)	3.1.18 SRS CRAWLER WITH WATER MONITOR (TYPE 4)	3.1.17 ARD (TYPE 4)	3.1.26 STREET SWEEPER / GRINDER / PUMPER

RAD/CONT 0.0566	2 BL_EXP	3 MOREXP	3 MOREXP	3 MOREXP	3 MOREXP
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	2 M-RPT	2 M-RPT	2 M-RPT	2 M-RPT
REUSABLE-PORTABLE 0.0151	2 MODPOR	3 DIFPOR	2 MODPOR	3 DIFPOR	3 DIFPOR
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	2 P_2FUN	2 P_2FUN	2 P_2FUN	2 P_2FUN
TECH/MAT 0.1158	4 R&D	2 INDAPP	2 INDAPP	3 PILOT	4 R&D
INTEGRAT-AB 0.0207	3 ACC AB	2 SIG AB	1 MIN AB	2 SIG AB	2 SIG AB
INTEGRAT-INFRASTR 0.0131	3LUTILIZ	2MUTILIZ	3LUTILIZ	2MUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	3H IMPAC	1L IMPAC	1L IMPAC	1L IMPAC	1L IMPAC
LIFECOST-OPERTING 0.0514	3 HICOST	2 OP_BL	3 HICOST	2 OP_BL	2 OP_BL
LIFECOST-PROJECT 0.2056	4 H_<30%	5 H_>30%	5 H_>30%	5 H_>30%	5 H_>30%
RELIAB - MAINTAIN 0.0412	3H MAINT	3H MAINT	3H MAINT	3H MAINT	3H MAINT
RELIAB - LONGEVITY 0.1237	1LREPAIR	3HREPAIR	3HREPAIR	3HREPAIR	3HREPAIR
COMPLEX – CLOSURE 0.0201	3HI.COMP	2MO.COMP	3HI.COMP	3HI.COMP	1LO.COMP
COMPLEX – OPERATION 0.0142	3HI_COMP	3HI_COMP	3HI_COMP	3HI_COMP	3HI_COMP
COMPLEX – CONST. 0.0425	2MO COMP	3HI COMP	3HI COMP	3HI COMP	3HI COMP
COMPLEX – DESIGN 0.01	3HIGCOMP	3HIGCOMP	3HIGCOMP	3HIGCOMP	3HIGCOMP
EFFECTIVE 0.1768	3LOWCONF	2MODCONF	2MODCONF	2MODCONF	2MODCONF
RANKED	0.262	0.262	0.238	0.223	0.214
HEEL PREPARATION FOR TRANSFER ALTERNATIVES	3.1.13 DISSOLVE HEEL MATERIAL WITH IONIC LIQUIDS	3.1.34 ARD ROBOTICS	3.1.35 HOUDINI WITH CSEE	3.1.23 TANK IN TANK WITH MOBILE WILDEN PUMP	3.1.31 SCOOP WITH REMOTE "BOBCAT"

HEEL PREPARATION FOR TRANSFER ALTERNATIVES	3.1.2 ULTRASONIC	3.1.10 ULTRASOUND WITH OXALIC ACID CLEANING
RANKED	0.132	0.092
EFFECTIVE 0.1768	3LOWCONF	3LOWCONF
COMPLEX – DESIGN 0.01	3HIGCOMP	3HIGCOMP
COMPLEX – CONST. 0.0425	3HI COMP	3HI COMP
COMPLEX – OPERATION 0.0142	3HI_COMP	3HI_COMP
COMPLEX – CLOSURE 0.0201	3HI.COMP	3HI.COMP
RELIAB - LONGEVITY 0.1237	2AREPAIR	2AREPAIR
RELIAB - MAINTAIN 0.0412	3H MAINT	3H MAINT
LIFECOST-PROJECT 0.2056	5 H_>30%	5 H_>30%
LIFECOST-OPERTING 0.0514	3 HICOST	3 HICOST
INTEGRAT-PROCESS 0.0329	1L IMPAC	3H IMPAC
INTEGRAT-INFRASTR 0.0131	2MUTILIZ	3LUTILIZ
INTEGRAT-AB 0.0207	3 ACC AB	3 ACC AB
TECH/MAT 0.1158	4 R&D	4 R&D
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	3 P_1FUN
REUSABLE-PORTABLE 0.0151	3 DIFPOR	3 DIFPOR
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	1 HI-RPT
RAD/CONT 0.0566	3 MOREXP	3 MOREXP

Appendix I (4.1) – BOP Alternative Ranking, Heel Waste Transfer

HEEL WASTE TRANSFER ALTERNATIVES	4.1.3 Air driven submersible pump (WILDEN)	4.1.2 Macerator Pump	4.1.7 Reuse Bulk Transfer Jet	4.1.6 Reuse Bulk Transfer Pump	4.1.4 Transport the waste by Tank truck (Refer to idea 1.2-5 Tk 18)
RANKED	0.734	0.623	0.619	0.614	0.344
EFFECTIVE 0.1768	1HIGCONF	2MODCONF	3LOWCONF	2MODCONF	1HIGCONF
COMPLEX – DESIGN 0.01	2MODCOMP	1LOWCOMP	1LOWCOMP	2MODCOMP	3HIGCOMP
COMPLEX – CONST. 0.0425	1LO COMP	1LO COMP	1LO COMP	1LO COMP	3HI COMP
COMPLEX – OPERATION 0.0142	1LO_COMP	1LO_COMP	1LO_COMP	1LO_COMP	3HI_COMP
COMPLEX – CLOSURE 0.0201	1LO.COMP	1LO.COMP	1LO.COMP	1LO.COMP	2MO.COMP
RELIAB - LONGEVITY 0.1237	2AREPAIR	2AREPAIR	1LREPAIR	2AREPAIR	2AREPAIR
RELIAB - MAINTAIN 0.0412	3H MAINT	2A MAINT	2A MAINT	3H MAINT	3H MAINT
LIFECOST-PROJECT 0.2056	3BASELIN	3BASELIN	3BASELIN	3BASELIN	4 H_<30%
LIFECOST-OPERTING 0.0514	1 LOCOST	1 LOCOST	1 LOCOST	1 LOCOST	3 HICOST
INTEGRAT-PROCESS 0.0329	1L IMPAC	1L IMPAC	1L IMPAC	1L IMPAC	3H IMPAC
INTEGRAT-INFRASTR 0.0131	1HUTILIZ	1HUTILIZ	1HUTILIZ	2MUTILIZ	2MUTILIZ
INTEGRAT-AB 0.0207	2 SIG AB	1 MIN AB	1 MIN AB	1 MIN AB	3 ACC AB
TECH/MAT 0.1158	1 RADAPP	2 INDAPP	2 INDAPP	2 INDAPP	4 R&D
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	3 P_1FUN	2 P_2FUN	2 P_2FUN	3 P_1FUN
REUSABLE-PORTABLE 0.0151	3 DIFPOR	3 DIFPOR	2 MODPOR	2 MODPOR	2 MODPOR
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	1 HI-RPT	1 HI-RPT	1 HI-RPT	1 HI-RPT
RAD/CONT 0.0566	1LESSEXP	1LESSEXP	1LESSEXP	1LESSEXP	3 MOREXP

Appendix I (5.1) – BOP Alternative Ranking, Spray Wash Tank

RAD/CONT 0.0566	2 BL_EXP	**2 BL_EXP**	2 BL_EXP	2 BL_EXP
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	**1 HI-RPT**	1 HI-RPT	1 HI-RPT
REUSABLE-PORTABLE 0.0151	1 EASPOR	**2 MODPOR**	1 EASPOR	2 MODPOR
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	**3 P_1FUN**	2 P_2FUN	3 P_1FUN
TECH/MAT 0.1158	2 INDAPP	**1 RADAPP**	3 PILOT	4 R&D
INTEGRAT-AB 0.0207	2 SIG AB	**2 SIG AB**	2 SIG AB	3 ACC AB
INTEGRAT-INFRASTR 0.0131	2MUTILIZ	**2MUTILIZ**	3LUTILIZ	3LUTILIZ
INTEGRAT-PROCESS 0.0329	2M IMPAC	**2M IMPAC**	3H IMPAC	1L IMPAC
LIFECOST-OPERTING 0.0514	2 OP_BL	**2 OP_BL**	2 OP_BL	3 HICOST
LIFECOST-PROJECT 0.2056	1 S_>30%	**3BASELIN**	2 S_<30%	5 H_>30%
RELIAB - MAINTAIN 0.0412	1L MAINT	**1L MAINT**	1L MAINT	3H MAINT
RELIAB - LONGEVITY 0.1237	1LREPAIR	**1LREPAIR**	1LREPAIR	2AREPAIR
COMPLEX – CLOSURE 0.0201	1LO.COMP	**1LO.COMP**	1LO.COMP	3HI.COMP
COMPLEX – OPERATION 0.0142	2MO_COMP	**2MO_COMP**	2MO_COMP	3HI_COMP
COMPLEX – CONST. 0.0425	1LO COMP	**3HI COMP**	2MO COMP	3HI COMP
COMPLEX – DESIGN 0.01	1LOWCOMP	**2MODCOMP**	2MODCOMP	3HIGCOMP
EFFECTIVE 0.1768	2MODCONF	**1HIGCONF**	1HIGCONF	3LOWCONF
RANKED	0.729	**0.718**	0.703	0.161
SPRAY WASH TANK ALTERNATIVES	5.1.5 Directional Spray Nozzle	**5.1.3 SPRAY WASH BASELINE (3 SPRAY JETS)**	5.1.6 Acid Clean Heel Removal, Do Nothing	5.1.1 Vibrate tank

Appendix I (6.1) – BOP Alternative Ranking, Annulus Preparation for Transfer

ANNULUS PREPARATION FOR TRANSFER ALTERNATIVES	RANKED	EFFECTIVE 0.1768	COMPLEX – DESIGN 0.01	COMPLEX – CONST. 0.0425	COMPLEX – OPERATION 0.0142	COMPLEX – CLOSURE 0.0201	RELIAB - LONGEVITY 0.1237	RELIAB - MAINTAIN 0.0412	LIFECOST-PROJECT 0.2056	LIFECOST-OPERTING 0.0514	INTEGRAT-PROCESS 0.0329	INTEGRAT-INFRASTR 0.0131	INTEGRAT-AB 0.0207	TECH/MAT 0.1158	REUSABLE-MULT/FUN 0.0302	REUSABLE-PORTABLE 0.0151	REUSABLE-REPEATABLE 0.0302	RAD/CONT 0.0566
6.1.10 Sample, Evaluate, Do Nothing	0.801	2MODCONF	1LOWCOMP	1LO COMP	2MO_COMP	3HI.COMP	1LREPAIR	1L MAINT	1 S_>30%	1 LOCOST	1L IMPAC	1HUTILIZ	2 SIG AB	2 INDAPP	2 P_2FUN	1 EASPOR	1 HI-RPT	1LESSEXP
6.1.6 Acid Clean, Reuse in Primary	0.713	1HIGCONF	1LOWCOMP	2MO COMP	2MO_COMP	1LO.COMP	1LREPAIR	2A MAINT	2 S_<30%	2 OP_BL	2M IMPAC	1HUTILIZ	3 ACC AB	2 INDAPP	3 P_1FUN	2 MODPOR	1 HI-RPT	2 BL_EXP
6.1.3 Flygt Mixers in Racetrack mode	0.675	2MODCONF	1LOWCOMP	2MO COMP	2MO_COMP	2MO.COMP	1LREPAIR	2A MAINT	2 S_<30%	2 OP_BL	2M IMPAC	1HUTILIZ	2 SIG AB	1 RADAPP	3 P_1FUN	3 DIFPOR	1 HI-RPT	2 BL_EXP
6.1.1 Mixing Eductors	0.625	2MODCONF	1LOWCOMP	2MO COMP	2MO_COMP	2MO.COMP	1LREPAIR	2A MAINT	2 S_<30%	2 OP_BL	2M IMPAC	1HUTILIZ	2 SIG AB	2 INDAPP	3 P_1FUN	2 MODPOR	1 HI-RPT	2 BL_EXP
6.1.9 Water Mouse	0.605	2MODCONF	2MODCOMP	2MO COMP	3HI_COMP	1LO.COMP	1LREPAIR	2A MAINT	2 S_<30%	3 HICOST	2M IMPAC	1HUTILIZ	2 SIG AB	2 INDAPP	3 P_1FUN	1 EASPOR	1 HI-RPT	2 BL_EXP

RAD/CONT 0.0566	3 MOREXP	2 BL_EXP	2 BL_EXP	**2 BL EXP**	2 BL_EXP	3 MOREXP
REUSABLE-REPEATABLE 0.0302	1 HI-RPT	1 HI-RPT	1 HI-RPT	**1 HI-RPT**	1 HI-RPT	1 HI-RPT
REUSABLE-PORTABLE 0.0151	1 EASPOR	3 DIFPOR	2 MODPOR	**2 MODPOR**	2 MODPOR	2 MODPOR
REUSABLE-MULT/FUN 0.0302	3 P_1FUN	3 P_1FUN	2 P_2FUN	**3 P 1FUN**	2 P_2FUN	2 P_2FUN
TECH/MAT 0.1158	3 PILOT	2 INDAPP	3 PILOT	**3 PILOT**	2 INDAPP	3 PILOT
INTEGRAT-AB 0.0207	3 ACC AB	2 SIG AB	3 ACC AB	**2 SIG AB**	2 SIG AB	2 SIG AB
INTEGRAT-INFRASTR 0.0131	1HUTILIZ	1HUTILIZ	2MUTILIZ	**2MUTILIZ**	2MUTILIZ	2MUTILIZ
INTEGRAT-PROCESS 0.0329	2M IMPAC	2M IMPAC	1L IMPAC	**2M IMPAC**	1L IMPAC	1L IMPAC
LIFECOST-OPERTING 0.0514	1 LOCOST	2 OP_BL	2 OP_BL	**2 OP BL**	3 HICOST	3 HICOST
LIFECOST-PROJECT 0.2056	1 S_>30%	2 S_<30%	3BASELIN	**3BASELIN**	3BASELIN	3BASELIN
RELIAB - MAINTAIN 0.0412	1L MAINT	3H MAINT	2A MAINT	**2A MAINT**	3H MAINT	3H MAINT
RELIAB - LONGEVITY 0.1237	1LREPAIR	1LREPAIR	2AREPAIR	**2AREPAIR**	3HREPAIR	3HREPAIR
COMPLEX – CLOSURE 0.0201	2MO.COMP	2MO.COMP	3HI.COMP	**2MO.COMP**	2MO.COMP	1LO.COMP
COMPLEX – OPERATION 0.0142	1LO_COMP	2MO_COMP	2MO_COMP	**2MO COMP**	3HI_COMP	3HI_COMP
COMPLEX – CONST. 0.0425	1LO COMP	2MO COMP	2MO COMP	**2MO COMP**	2MO COMP	2MO COMP
COMPLEX – DESIGN 0.01	1LOWCOMP	1LOWCOMP	2MODCOMP	**2MODCOMP**	3HIGCOMP	3HIGCOMP
EFFECTIVE 0.1768	3LOWCONF	2MODCONF	2MODCONF	**2MODCONF**	2MODCONF	2MODCONF
RANKED	0.602	0.597	0.482	**0.471**	0.411	0.364
ANNULUS PREPARATION FOR TRANSFER ALTERNATIVES	6.1.8 Air Spargers	6.1.11 Three Centrfugal Pumps	6.1.12 Russian pump (mix, transfer and sluice)	**6.1.4 ANNULUS CLEANING BASELINE (3 RECIR. JETS)**	6.1.5 Confined Sluicing End Effector (CSEE)	6.1.7 Crawler with CSEE

ANNULUS PREPARATION FOR TRANSFER ALTERNATIVES	RANKED	EFFECTIVE 0.1768	COMPLEX – DESIGN 0.01	COMPLEX – CONST. 0.0425	COMPLEX – OPERATION 0.0142	COMPLEX – CLOSURE 0.0201	RELIAB - LONGEVITY 0.1237	RELIAB - MAINTAIN 0.0412	LIFECOST-PROJECT 0.2056	LIFECOST-OPERTING 0.0514	INTEGRAT-PROCESS 0.0329	INTEGRAT-INFRASTR 0.0131	INTEGRAT-AB 0.0207	TECH/MAT 0.1158	REUSABLE-MULT/FUN 0.0302	REUSABLE-PORTABLE 0.0151	REUSABLE-REPEATABLE 0.0302	RAD/CONT 0.0566
6.1.2 Tunnel bore in duct	0.11	3LOWCONF	3HIGCOMP	3HI COMP	3HI_COMP	2MO.COMP	3HREPAIR	3H MAINT	4 H_<30%	3 HICOST	1L IMPAC	3LUTILIZ	3 ACC AB	4 R&D	3 P_1FUN	3 DIFPOR	2 M-RPT	3 MOREXP

Appendix I (7.1) – BOP Alternative Ranking, Transfer Annulus Waste

TRANSFER ANNULUS WASTE ALTERNATIVES	RANKED	EFFECTIVE 0.1768	COMPLEX – DESIGN 0.01	COMPLEX – CONST. 0.0425	COMPLEX – OPERATION 0.0142	COMPLEX – CLOSURE 0.0201	RELIAB - LONGEVITY 0.1237	RELIAB - MAINTAIN 0.0412	LIFECOST-PROJECT 0.2056	LIFECOST-OPERTING 0.0514	INTEGRAT-PROCESS 0.0329	INTEGRAT-INFRASTR 0.0131	INTEGRAT-AB 0.0207	TECH/MAT 0.1158	REUSABLE-MULT/FUN 0.0302	REUSABLE-PORTABLE 0.0151	REUSABLE-REPEATABLE 0.0302	RAD/CONT 0.0566
<u>7.1.3</u> <u>USE EXISTING JET AND GANG VALVE BASELINE</u>	<u>0.723</u>	<u>1HIGCONF</u>	<u>1LOWCOMP</u>	<u>1LO COMP</u>	<u>1LO_COMP</u>	<u>1LO.COMP</u>	<u>2AREPAIR</u>	<u>2A MAINT</u>	<u>3BASELIN</u>	<u>2 OP_BL</u>	<u>1L IMPAC</u>	<u>1HUTILIZ</u>	<u>1 MIN AB</u>	<u>1 RADAPP</u>	<u>3 P_1FUN</u>	<u>2 MODPOR</u>	<u>1 HI-RPT</u>	<u>2 BL_EXP</u>
7.1.4 Sump Pump on Cable	0.717	1HIGCONF	1LOWCOMP	2MO COMP	1LO_COMP	1LO.COMP	1LREPAIR	2A MAINT	3BASELIN	2 OP_BL	1L IMPAC	2MUTILIZ	2 SIG AB	2 INDAPP	3 P_1FUN	2 MODPOR	1 HI-RPT	1LESSEXP
7.1.5 Annulus Transfer Pump on a Stick	0.717	1HIGCONF	1LOWCOMP	2MO COMP	1LO_COMP	1LO.COMP	1LREPAIR	2A MAINT	3BASELIN	2 OP_BL	1L IMPAC	2MUTILIZ	2 SIG AB	2 INDAPP	3 P_1FUN	2 MODPOR	1 HI-RPT	1LESSEXP

Appendix J - Risk Probabilities

Probability of Occurrence		
Qualitative	**Quantitative**	**Criteria (probability)**
Very Unlikely	≤ 0.1	A single event occurs, less than 10%
Unlikely	> 0.1 but ≤ 0.4	A single event occurs, 10% to 40%
Likely	> 0.4 but < 0.8	A single event occurs, 40% to 80%
Very Likely	≥ 0.8	A single event occurs, greater than 80%

Appendix K - Consequence Criteria

	Negligible	Marginal	Significant	Critical	Crisis	Units
Project Cost Threshold	< $2M	$2M to $4M	$4M to $6M	$6M to $8M	> $8M	**Dollars**
Schedule Delay (years)	< 1	1 to 2	2 to 3	3 to 4	> 5	**Years**

Appendix L – Qualitative Risk Level Matrix

PROBABILITY OF RISK VVVV					
VERY LIKELY	LOW	MODERATE	HIGH	HIGH	HIGH
LIKELY	LOW	MODERATE	HIGH	HIGH	HIGH
UNLIKELY	LOW	LOW	MODERATE	MODERATE	HIGH
VERY UNLIKELY	LOW	LOW	LOW	LOW	HIGH
CONSEQUENCE >>>	**NEGLIGIBLE**	**MARGINAL**	**SIGNIFICANT**	**CRITICAL**	**CRISIS**

Appendix M – Risk Summary Table

Risk ID	Title	Risk Level	Risk Handling Strategy	Approach	RHS Estimate	RHS Total
					TOTAL	$8,635,500
					CONTINGENCY @ ~27%	$2,364,500
					GRAND TOTAL	$11,000,000
Prog00-001	Other programs interfere with Waste Removal Activities	L	Use established division priority process and review regularly	Accept	none	
Prog00-002	Normal operations interfere with Waste Removal Activities	L	Program Management will make funding available to build facilities slightly earlier than the latest possible date needed. Doing so will account for inevitable unforeseen events.	Reduce	none	
Prog00-003	High visibility program	M	Clearly identify risk and assumptions up front; set expectations that initial deployment is a full-scale demonstration; and expect the need for refinements.	Reduce	none	
Stp100-004	1.1.32 (2) Modified ADMPs – Technology	M	Develop pump specification and award contract to develop and test prototype pump (ASAP)	Reduce and mitigate	Develop pump specification 250 mhrs = $17,500 develop and test prototype pump (contract cost) = $1,000,000	$1,017,500
Mult00-005	Effect of aerosols on AB	L	1) Bound the problem in advance. Develop one set of AB controls that will apply to all tanks with little or no subsequent revision. 2) For each new or modified design, develop analysis of aerosol formation in support of the new SAR.	Reduce and mitigate	Develop data = $250,000 Analyze data and report 1000 mhrs = $70,000	$320,000

Risk ID	Title	Risk Level	Risk Handling Strategy	Approach	RHS Estimate	RHS Total
Stp100-006	1.1.32 Disposal of (2) modified ADMPs	L	Write pump specification to include the ability to flood column with grout (e.g. put a bigger hole in the top bearing support)	Reduce	Included in 004	
Mult00-008	Moving equipment from location to location	L	Develop and test improved containers to enable safe handling of contaminated equipment	Reduce and mitigate	Develop 500 mhrs = $35,000 Build prototype = $500,000 Test 500 mhrs = $35,000	$570,000
Stp100-009	1.1.33 (1) ADMP – type I tanks only	H	1) Complete "one-pump" demonstration in Tank 18 2) Perform fluid dynamics modeling for Type I tanks	Reduce and mitigate	Complete "one-pump" demonstration in Tank 18 2 = no additional cost Perform fluid dynamics modeling for Type I tanks 700 mhrs = $49,000	$49,000
Stp100-010	1.1.33 Disposal of (1) ADMP	L	1) Evaluate analysis performed for Tank 19 for application to this risk 2) Revise design to enable pump column to be grouted	Reduce	Evaluate analysis performed for tank 19 200 Mhrs = $14,000	$14,000
Stp100-011	1.1.44 WEMD canned pump performance	M	Develop pump specification and award contract to develop and test prototype pump (ASAP)	Reduce	Develop pump specification 250 mhrs = $17,500 develop and test prototype pump (contract cost) = $1,000,000	$1,017,500
Stp100-012	Handling heavy spray with ventilation system	H	1) Bound the problem in advance. Develop one set of AB controls that will apply to all tanks with little or no subsequent revision. 2) For each new or modified design, develop analysis of equipment needs	Reduce	Develop data = $250,000 Analyze data and report 1000 mhrs = $70,000	$320,000

Risk ID	Title	Risk Level	Risk Handling Strategy	Approach	RHS Estimate	RHS Total
Mult00-013	Waste water volume	L	1) Continue ongoing evaporator improvement program 2) Select waste preparation ideas that are not water intensive	Reduce and mitigate	none	
Mult00-014	Mining a Well	L	1) Leverage recent work with high-pressure water sprays (Augusta Industrial on Tank 41 and 2H, Evaporator GDL) and improvement to mining tools (Tank 7) to develop a safer, more robust design. 2) Test/demonstrate improved tools and techniques	Reduce and mitigate	Develop a safer, more robust design 1000 mhrs = $70,000 Build prototype of robust design = $150,000 Test/demonstrate improved tools and techniques labor and materials = $100,000	$320,000
Mult00-015	Criticality potential in Salt Well	H	Continue ongoing evaluations to render probability of criticality "incredible" for as many tanks as possible.	Reduce	WSMS evaluation $150,000	$150,000
Stp200-016	1.2.13 (2) Submersible Slurry Pumps	M	Develop pump specification and award contract to develop and test prototype pump (ASAP)	Reduce	Develop pump specification 250 mhrs = $17,500 develop and test prototype pump (contract cost) = $1,000,000	$1,017,500
Stp200-017	1.12.12 Modified Density Gradient	H	Continue ongoing (as of 6/2/02) demonstration in Tank 37, evaluate performance If technique doesn't work in tank 37, this alternative will be abandoned.	Avoid	No additional cost	
Stp200-018	1.2.9 (2) pulse tube mixers	L	Conduct full-scale demonstration utilizing the Hanford facility early enough to 1) resolve unknowns 2) allow for equipment refinements without impacting key tank closure milestones.	Reduce and mitigate	Conduct full-scale demonstration 2000 mhrs = $140,000 Materials = $100,000 Note: cost to SRS could decrease based on findings from Hanford testing	$240,000

Risk ID	Title	Risk Level	Risk Handling Strategy	Approach	RHS Estimate	RHS Total
Stp200-019	1.2.14 Sluicing	L	1) Select and try out nozzles that can aim up and down and side to side with a variable spray pattern, and can provide access to all areas of the tank	Reduce and mitigate	Design and build prototype 1000 mhrs = $140,000 Material = $20,000 Test 500 mhrs = $35,000	$195,000
Mult00-020	Pump-on-a-stick	L	1) Perform riser probing to establish key dimensions before design 2) Develop feature to make minor adjustments easily at the time of installation (as needed) to the length established by probing	Mitigate	Probe 1000 mhrs = $70,000 Design 500 mhrs = $35,000 Build prototype and test 1000 mhrs = $70,000 Material $50,000	$225,000
Stp300-021	Pump-on-a-rope	L	Use this idea only with salt or sludge preparation ideas that have little or no agitation	Avoid	Build prototype and test 1000 mhrs = $70,000 Material $50,000	$120,000
Stp400-022	2.1.5 Pump-on-a-telescoping-mast	L	1) Develop design feature to enable movable parts to remain mobile 2) Test designs to ensure high reliability	Reduce	Design 1000 mhrs $70,000 Build prototype and test 1000 mhrs = $70,000 Material $100,000	$205,000
Stp400-023	2.2.5 Air operated diaphragm pump on a stick (mast)	L	Develop and demonstrate design features to drain and flush pump, before deploying pump	Reduce	Design 200 mhrs = $14,000 Build prototype and test 2000 mhrs = $140,000 Material $50,000	$204,000

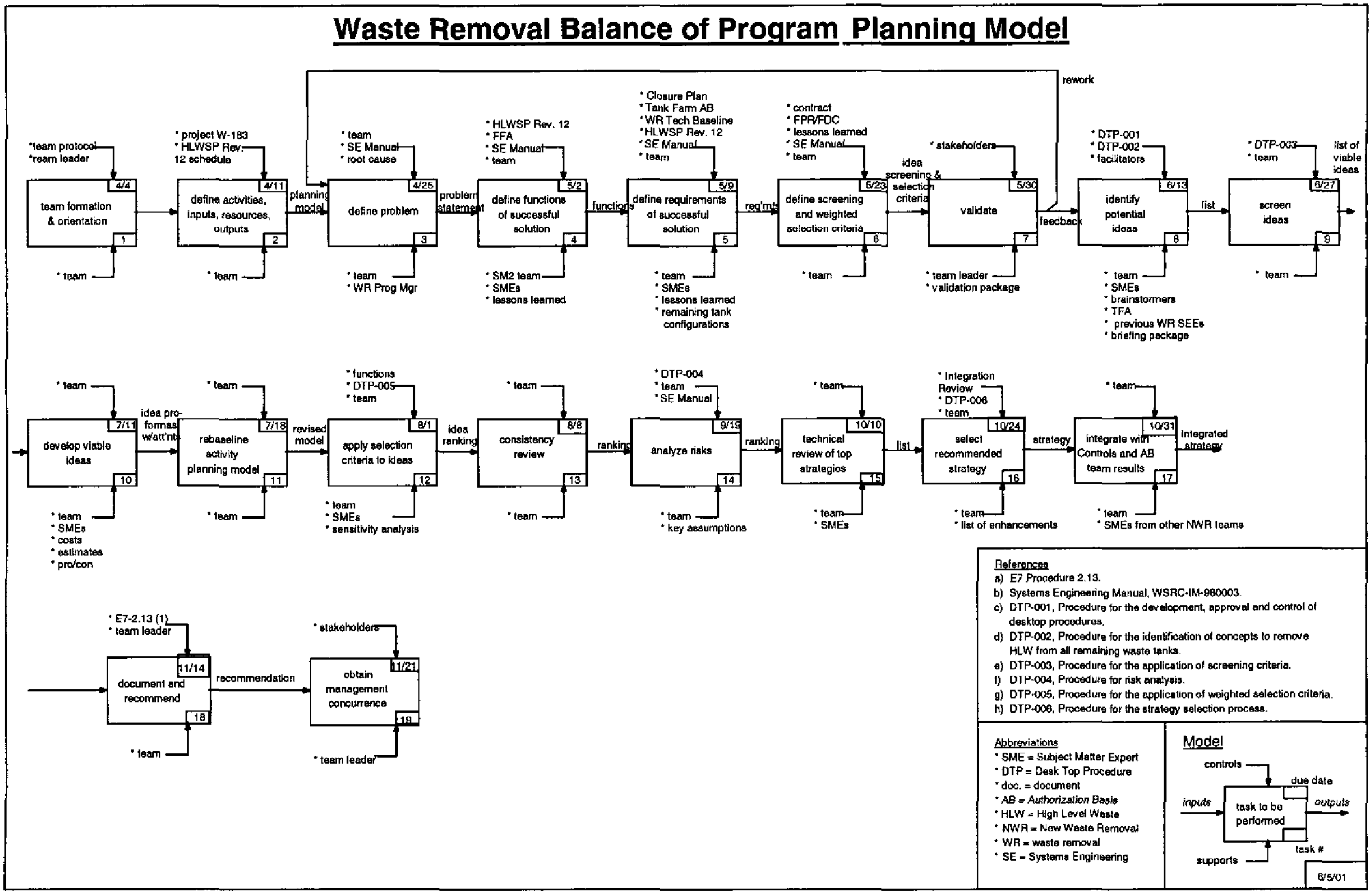
Risk ID	Title	Risk Level	Risk Handling Strategy	Approach	RHS Estimate	RHS Total
Stp500-024	3.1.4 Oxalic acid cleaning	L	Conduct thorough evaluation of acid cleaning well before the process must be deployed, such that time remains to develop alternatives or refine the process without missing key milestones.	Reduce	Evaluate 2000 mhrs = $140,000 Test 1000 mhrs = $70,000	$210,000
Stp500-025	3.1.4 Oxalic acid cleaning – neutralization	L	Develop safety strategy and controls early enough to avoid last minute changes.	Reduce	1500 mhrs = $105,000	$105,000
Stp500-026	3.1.4 Oxalic acid cleaning – criticality	L	Conduct thorough evaluation of acid cleaning well before the process must be deployed, such that time remains to develop alternatives or refine the process without missing key milestones.	Reduce	Included with 027	
Stp500-027	3.1.4 Oxalic acid cleaning – AB	L	Develop safety strategy and controls early enough to avoid last minute changes.	Reduce	Develop data = $250,000 Analyze data and report 1000 mhrs = $70,000	$320,000
Stp500-028	3.1.4 Oxalic acid cleaning – toxic material	L	Ensure design is appropriate for acid service, using a) peer reviews of design and b) procedural controls by others in the acid cleaning business.	Reduce	Included with 024, 025	$70,000
Stp500-029	3.1.4 Oxalic acid cleaning – interfaces	H	Conduct thorough evaluation of acid cleaning well before the process must be deployed, such that time remains to develop alternatives or refine the process without missing key milestones.	Reduce and mitigate	Included with 024, 025	
Stp500-030	3.1.1 Nitric acid cleaning	L	Conduct thorough evaluation of acid cleaning well before the process must be deployed, such that time remains to develop alternatives or refine the process without missing key milestones.	Reduce	Evaluate 2000 mhrs = $140,000 Test 1000 mhrs = $70,000	$210,000

Risk ID	Title	Risk Level	Risk Handling Strategy	Approach	RHS Estimate	RHS Total
Stp500-031	3.1.1 Nitric acid cleaning – neutralization	M	Develop safety strategy and controls early enough to avoid last minute changes.	Reduce	1500 mhrs = $105,000	$105,000
Stp500-032	3.1.1 Nitric acid cleaning – AB	L	Develop safety strategy and controls early enough to avoid last minute changes.	Reduce	Develop data = $200,000 Analyze data and report 1000 mhrs = $70,000	$270,000
Stp500-033	3.1.1 Nitric acid cleaning – hazardous material	L	Ensure design is appropriate for acid service, using a) peer reviews of design and b) procedural controls by others in the acid cleaning business.	Reduce	Included with 030, 031	
Stp500-034	3.1.1 Nitric acid cleaning – administrative interfaces	M	Conduct thorough evaluation of acid cleaning well before the process must be deployed, such that time remains to develop alternatives or refine the process without missing key milestones.	Reduce	Included with 030, 031	
Stp500-047	3.1.1 Nitric acid cleaning – process interfaces	M	Conduct thorough evaluation of acid cleaning well before the process must be deployed, such that time remains to develop alternatives or refine the process without missing key milestones.	Reduce	Included with 030, 031	
Stp700-035	5.1.5 Directional spray nozzle	L	Review design of other functions of waste removal to ensure accesses for spray washing are sufficient. Develop high power, directional nozzle with variable focus to maximize ability to reach all parts of the tank.	Reduce	Develop high power, directional nozzle – same as 019. Note: if risk 019 is avoided by selecting another option, the nozzle development costs will become a part of this RHS. Review design of other functions 100 mhrs = $7000	$7000

Risk ID	Title	Risk Level	Risk Handling Strategy	Approach	RHS Estimate	RHS Total
Stp800-036	6.1.10 Sample, evaluate, do nothing	M	Sample, analyze and model the remaining 8 tanks with suspected waste in the annulus (1, 9-15) to determine which annuli will need to be cleaned and avoid last minute surprises.	Reduce	sample, = $35,000/tk analyze = $50,000/tk model = $10,000/tk report = $10,000/tk $105,000tank * (8 tanks) = $840,000	$840,000
Stp800-038	6.1.6 Acid clean, reuse in primary – refractory damage	L	Conduct tests early so that time is available to develop an alternative process without missing key tank closure milestones	Reduce	Included with 024, 030	
Stp800-039	Recontamination of annulus after cleaning	M	1) Operate at low liquid level in the tank to minimize hydraulic head 2) Grout annulus or primary (whichever is cleaned first) to avoid recontamination	Reduce and mitigate	No additional cost	
Stp800-040	6.1.6 Acid clean, reuse in primary – tank wall damage	L	1) Obtain samples of annulus waste 2)Develop and implement a test program 3) Conduct tests with real waste	Reduce	Included with 024, 030	
Stp800-042	Duct rinsing	L	* develop design or use existing design for duct hole punching tool * build and test duct tool * have tool ready to deploy at start of annulus removal	Mitigate	Design 500 mhrs = $35,000 Build prototype and test 500 mhrs = $135,000 Material $50,000	$220,000
Stp800-044	Liquid circulation in annulus -- technique demonstration	L	* obtain samples * determine best solvent * determine amount of agitation required * ensure downstream impacts are acceptable	Mitigate	2000 mhrs = $70,000	$140,000

Risk ID	Title	Risk Level	Risk Handling Strategy	Approach	RHS Estimate	RHS Total
Stp100-045	1.1.33 (1) ADMP – type I tanks only	M	* use only on Type I and II tanks * isolate coils before slurrying * accept coil damage * perform heat balance assuming less coils * expand temperature range	Mitigate	Perform heat balance 500 mhrs = $35,000	$35,000
00-046	Tank in which Solids Cannot be Mined	M	1) Conduct technical exchange with other DOE sites and international sites who have experience with dried waste tanks to ascertain the methods they have used to mine in their tanks. 2) Develop mining techniques and equipment 3) Demonstrate mining techniques and equipment in a simulated environment	Reduce and mitigate	Technical exchange 200 mhrs =$14,000 Develop mining techniques 1000 mhrs = $70,000 Demonstrate mining techniques 500 mhrs = $35,000	$119,000

Appendix O – Activity Planning Model



Appendix P – Risk Data Sheets

Each complete screening sheet is followed by the identical screening sheet showing only the "yes" risk potentials with added information for the basis of the identified risk.

Process Step 1: BULK SLUDGE PREPARATION FOR TRANSFER 1.1.32 Two Modified ADMPs* **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?**		
	No	**Low**	**Yes**
1. New technology?			X
2. Unknown or unclear technology?			X
3. New application of existing technology?			X
4. Modernized/advanced technology in existing application?	x		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?	X		
2. Multiple technical agencies?	X		
3. Interface with operating structures, systems, or components during installation?	x		
SAFETY			
1. Criticality potential?	X		
2. Significant exposure/contamination potential?	X		
3. Any impact to the Facility's Authorization Basis?			X
4. Hazardous material involved?	X		
5. Process hazard potential?	X		
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?	X		
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?	X		
2. Additional releases?	X		
3. Undefined disposal methods?			X
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?			X
4. Difficult to perform functional test?	X		
5. Numerous or unclear assumptions?	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?			X
2. Specialty resources required?	X		
Part B: *Project* Risk Screening Criteria	**Potential for Risk?**		

	No	Low	Yes
COST			
1. Is the modification TPC greater than $4M?			X
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?			X
PROCUREMENT			
1. Long lead items that may affect critical path?			X
2. Potential unavailable qualified vendors or contractors?			X
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?			X
2. Multiple project interface?			*
3. Multiple contractor interface?	X		
4. Significant interface with operational facility?			*
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 1: BULK SLUDGE PREPARATION FOR TRANSFER 1.1.32 Two Modified ADMPs **Part A:** ***Technical*** **Risk Screening Criteria**	**Potential for Risk?**		
	No	**Low**	**Yes**
1. New technology?			X
2. Unknown or unclear technology?			X
3. New application of existing technology?			X
SAFETY All sludge preparation techniques have an impact on the AB.			
3. *Any impact to the Facility's Authorization Basis?* Note: need explanation of why technique impacts AB			X
REGULATORY/ENVIRONMENTAL			
3. Undefined disposal methods? The equipment has a column that may not be able to be grouted for disposal.			X
DESIGN			
3. Complex design features? Modified ADMPs are half-sized. They have not been designed, built, or tested.			X
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available? Vendor may not have the design capability to produce a pump that meets requirements.			X
Part B: ***Project*** **Risk Screening Criteria**	**Potential for Risk?**		
	No	**Low**	**Yes**
COST			
1. Is the modification TPC greater than $4M?			X
SCHEDULE			
1. *Project Schedule uncertainties or restraints that may impact project completion or milestone dates?* Potential for schedule risk, owing to the uncertain capabilities of the vendor.			X
PROCUREMENT *Potential for impact to the critical path, owing to the uncertain capabilities of the vendor.*			
1. Long lead items that may affect critical path?			X

2. Potential unavailable qualified vendors or contractors?			X
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts? Equipment will have to be moved from tank to tank.			X

Process Step 1: BULK SLUDGE PREPARATION FOR TRANSFER 1.1.33 One ADMP in center riser (only type I tanks) **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?** No	**Low**	**Yes**
1. New technology?			X
2. Unknown or unclear technology?	X		
3. New application of existing technology?			X
4. Modernized/advanced technology in existing application?	x		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?	X		
2. Multiple technical agencies?	X		
3. Interface with operating structures, systems, or components during installation?	X		
SAFETY			
1. Criticality potential?	X		
2. Significant exposure/contamination potential?	X		
3. Any impact to the Facility's Authorization Basis?			X
4. Hazardous material involved?	X		
5. Process hazard potential?	X		
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?	X		
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?	X		
2. Additional releases?	X		
3. Undefined disposal methods?			X
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?	X		
4. Difficult to perform functional test?	X		
5. Numerous or unclear assumptions?	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?	X		
2. Specialty resources required?	X		

Part B: *Project* Risk Screening Criteria	Potential for Risk?		
	No	Low	Yes
COST			
1. Is the modification TPC greater than $4M?			X
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?	X		
PROCUREMENT			
1. Long lead items that may affect critical path?			X
2. Potential unavailable qualified vendors or contractors?	X		
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?			X
2. Multiple project interface?			*
3. Multiple contractor interface?	X		
4. Significant interface with operational facility?			*
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 1: BULK SLUDGE PREPARATION FOR TRANSFER 1.1.33 One ADMP in center riser (only type I tanks) Part A: *Technical* Risk Screening Criteria	Potential for Risk? No	Low	Yes
ADMPs have not been used in this exact application			
1. New technology?			X
3. New application of existing technology?			X
SAFETY All sludge preparation techniques have an impact on the AB.			
3. Any impact to the Facility's Authorization Basis? Note: need explanation of why technique impacts AB			X
REGULATORY/ENVIRONMENTAL			
3. Undefined disposal methods? The equipment has a column that may not be able to be grouted for disposal.			X
Part B: *Project* Risk Screening Criteria	**Potential for Risk? No**	**Low**	**Yes**
COST			
1. Is the modification TPC greater than $4M?			X
PROCUREMENT			
1. Long lead items that may affect critical path? Team note: need explanation			X
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts? Equipment will have to be moved from tank to tank.			X

Process Step 1: BULK SLUDGE PREPARATION FOR TRANSFER 1.1.44 WEMD canned pump on a mast **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?** No	**Low**	**Yes**
1. New technology?			X
2. Unknown or unclear technology?			X
3. New application of existing technology?			X
4. Modernized/advanced technology in existing application?	x		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?	X		
2. Multiple technical agencies?	X		
3. Interface with operating structures, systems, or components during installation?	x		
SAFETY			
1. Criticality potential?	X		
2. Significant exposure/contamination potential?	X		
3. Any impact to the Facility's Authorization Basis?			X
4. Hazardous material involved?	X		
5. Process hazard potential?	X		
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?	X		
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?	X		
2. Additional releases?	X		
3. Undefined disposal methods?	X		
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?			X
4. Difficult to perform functional test?	X		
5. Numerous or unclear assumptions?	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?	X		
2. Specialty resources required?	X		

Part B: *Project* Risk Screening Criteria	Potential for Risk?		
	No	Low	Yes
COST			
1. Is the modification TPC greater than $4M?			X
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?			X
PROCUREMENT			
1. Long lead items that may affect critical path?			X
2. Potential unavailable qualified vendors or contractors?	X		
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?			X
2. Multiple project interface?			*
3. Multiple contractor interface?	X		
4. Significant interface with operational facility?			*
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 1: BULK SLUDGE PREPARATION FOR TRANSFER 1.1.44 WEMD canned pump on a mast Part A: *Technical* Risk Screening Criteria	Potential for Risk? No	 Low	 Yes
Pump requires a 21 ft. NPSH			
1. *New technology?*			X
2. Unknown or unclear technology?			X
3. New application of existing technology?			X
SAFETY All sludge preparation techniques have an impact on the AB.			
3. Any impact to the Facility's Authorization Basis? Note: need explanation of why technique impacts AB			X
DESIGN			
3. Complex design features? Pump requires a 21 ft. NPSH			X
Part B: *Project* Risk Screening Criteria	**Potential for Risk?** **No**	 **Low**	 **Yes**
COST			
1. Is the modification TPC greater than $4M?			X
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates? Pump has not been designed, built, or tested			X
PROCUREMENT			
1. Long lead items that may affect critical path? Pump has not been designed, built, or tested			X
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts? Equipment will have to be moved from tank to tank.			X

Process Step 1: BULK SLUDGE PREPARATION FOR TRANSFER 1.1.16 Sluicing **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?** No	**Low**	**Yes**
1. New technology?	X		
2. Unknown or unclear technology?	X		
3. New application of existing technology?	X		
4. Modernized/advanced technology in existing application?	X		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?			X
2. Multiple technical agencies?	X		
3. Interface with operating structures, systems, or components during installation?	X		
SAFETY			
1. Criticality potential?	X		
2. Significant exposure/contamination potential?			X
3. Any impact to the Facility's Authorization Basis?			X
4. Hazardous material involved?	X		
5. Process hazard potential?	X		
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?	X		
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?	X		
2. Additional releases?	X		
3. Undefined disposal methods?	X		
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?	X		
4. Difficult to perform functional test?	X		
5. Numerous or unclear assumptions?	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?	X		
2. Specialty resources required?	X		

Part B: *Project* Risk Screening Criteria	Potential for Risk?		
	No	Low	Yes
COST			
1. Is the modification TPC greater than $4M?	X		
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?	X		
PROCUREMENT			
1. Long lead items that may affect critical path?	X		
2. Potential unavailable qualified vendors or contractors?	X		
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?	X		
2. Multiple project interface?			*
3. Multiple contractor interface?	X		
4. Significant interface with operational facility?			*
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 1: BULK SLUDGE PREPARATION FOR TRANSFER 1.1.16 Sluicing **Part A:** ***Technical*** **Risk Screening Criteria**	***Potential for Risk?***		
	No	**Low**	**Yes**
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces? Technique generates large amount of water, which has to be handled, treated by other facilities, and provided by the process water system.			X
SAFETY			
2. Significant exposure/contamination potential? Technique involves spraying high-pressure water, which generates aerosol spray. Spray will have to be handled by ventilation system.			X
3. Any impact to the Facility's Authorization Basis? *All sludge preparation techniques have an impact on the AB Note: need* explanation of why technique impacts AB			X
Part B: ***Project*** **Risk Screening Criteria**	**Potential for Risk?**		
	No	**Low**	**Yes**
PROGRAMMATIC INTERFACES			
4. Significant interface with operational facility? *Technique generates large amount of water, which has to be handled, treated* by other facilities, and provided by the process water system.			X

Process Step 2: BULK SALT PREPARATION FOR TRANSFER 1.2.11 Density Gradient **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?** No	**Low**	**Yes**
1. New technology?	X		
2. *Unknown or unclear technology?*	X		
3. New application of existing technology?	X		
4. Modernized/advanced technology in existing application?	X		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?	X		
2. Multiple technical agencies?	X		
3. *Interface with operating structures, systems, or components during installation?*			X
SAFETY			
1. Criticality potential?			X
2. Significant exposure/contamination potential?	X		
3. Any impact to the Facility's Authorization Basis?	X		
4. Hazardous material involved?	X		
5. *Process hazard potential?*	X		
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?	X		
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?	X		
2. Additional releases?	X		
3. Undefined disposal methods?	X		
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?	X		
4. Difficult to perform functional test?	X		
5. Numerous or unclear assumptions?	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?	X		
2. Specialty resources required?	X		

Part B: *Project* Risk Screening Criteria	Potential for Risk?		
	No	Low	Yes
COST			
1. Is the modification TPC greater than $4M?	X		
2. Operations Schedule uncertainties or restraints that may impact program completion dates?	X		
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?	X		
2. Operations Schedule uncertainties or restraints that may impact program completion dates?			X
PROCUREMENT			
1. Long lead items that may affect critical path?	X		
2. Potential unavailable qualified vendors or contractors?	X		
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?	X		
2. Multiple project interface?			*
3. Multiple contractor interface?	X		
4. Significant interface with operational facility?			X
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 2: BULK SALT PREPARATION FOR TRANSFER 1.2.11 Density Gradient **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?**		
	No	**Low**	**Yes**
PHYSICAL INTERFACES / INTERFACE CONTROL			
3. Interface with operating structures, systems, or components during installation? *Technique requires mining a well in the salt accumulated in the bottom of the* tank. This operation has not consistently met with success on previous attempts.			X
SAFETY			
1. Criticality potential? Note: need explanation of criticality potential			X
Part B: *Project* Risk Screening Criteria	**Potential for Risk?**		
	No	**Low**	**Yes**
SCHEDULE			
2. Operations Schedule uncertainties or restraints that may impact program completion dates? Experience has shown this method to be very time-consuming.			X
PROGRAMMATIC INTERFACES			
4. Significant interface with operational facility? Technique requires a large volume of water, which may overwhelm the transfer piping.			X

Process Step 2: BULK SALT PREPARATION FOR TRANSFER 1.2.13 Two WEMD Submersible Pumps **Part A:** ***Technical*** **Risk Screening Criteria**	**Potential for Risk?** No	**Low**	**Yes**
1. New technology?			X
2. Unknown or unclear technology?			X
3. New application of existing technology?			X
4. Modernized/advanced technology in existing application?	x		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?	X		
2. Multiple technical agencies?	X		
3. Interface with operating structures, systems, or components during installation?			X
SAFETY			
1. *Criticality potential?*			X
2. Significant exposure/contamination potential?	X		
3. Any impact to the Facility's Authorization Basis?	X		
4. Hazardous material involved?	X		
5. Process hazard potential?	X		
6. *Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?*	X		
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?	X		
2. Additional releases?	X		
3. Undefined disposal methods?	X		
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?			X
4. Difficult to perform functional test?	X		
5. Numerous or unclear assumptions?	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?	X		

2. Specialty resources required?	X		
Part B: *Project* Risk Screening Criteria	**Potential for Risk?**		
	No	**Low**	**Yes**
COST			
1. Is the modification TPC greater than $4M?			X
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?			X
PROCUREMENT			
1. Long lead items that may affect critical path?			X
2. Potential unavailable qualified vendors or contractors?	X		
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?			X
2. Multiple project interface?			*
3. Multiple contractor interface?	X		
4. Significant interface with operational facility?			*
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 2: BULK SALT PREPARATION FOR TRANSFER 1.2.13 Two WEMD Submersible Pumps **Part A:** ***Technical*** **Risk Screening Criteria**	**Potential for Risk?**		
	No	**Low**	**Yes**
Pump requires a 21 ft. NPSH			
1. New technology?			X
2. Unknown or unclear technology?			X
3. New application of existing technology?			X
PHYSICAL INTERFACES / INTERFACE CONTROL			
3. Interface with operating structures, systems, or components during installation?			X
SAFETY			
1. Criticality potential? Note: need explanation of criticality potential			X
DESIGN			
3. Complex design features? Pump requires a 21 ft. NPSH			X
Part B: ***Project*** **Risk Screening Criteria**	**Potential for Risk?**		
	No	**Low**	**Yes**
COST			
1. Is the modification TPC greater than $4M?			X
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates? Pump has not been designed, built, or tested			X
PROCUREMENT			
1. Long lead items that may affect critical path? Pump has not been designed, built, or tested			X
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts? Equipment will have to be moved from tank to tank			X

Process Step 2: BULK SALT PREPARATION FOR TRANSFER 1.2.12 Modified Density Gradient **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?**		
	No	**Low**	**Yes**
1. New technology?			X
2. Unknown or unclear technology?	X		
3. New application of existing technology?	X		
4. Modernized/advanced technology in existing application?	X		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?	X		
2. Multiple technical agencies?	X		
3. Interface with operating structures, systems, or components during installation?			X
SAFETY			
1. Criticality potential?			X
2. Significant exposure/contamination potential?	X		
3. Any impact to the Facility's Authorization Basis?	X		
4. Hazardous material involved?	X		
5. Process hazard potential?	X		
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?	X		
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?	X		
2. Additional releases?	X		
3. Undefined disposal methods?	X		
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?	X		
4. Difficult to perform functional test?	X		
5. Numerous or unclear assumptions?	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?	X		
2. Specialty resources required?	X		

Part B: *Project* Risk Screening Criteria	Potential for Risk?		
	No	Low	Yes
COST			
1. Is the modification TPC greater than $4M?	x		
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?	X		
2. Operations Schedule uncertainties or restraints that may impact program completion dates?			X
PROCUREMENT			
1. Long lead items that may affect critical path?	X		
2. Potential unavailable qualified vendors or contractors?	X		
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?	X		
2. *Multiple project interface?*			*
3. Multiple contractor interface?	X		
4. Significant interface with operational facility?			X
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 2: BULK SALT PREPARATION FOR TRANSFER 1.2.12 Modified Density Gradient **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?** No	Low	Yes
1. New technology? Technique has not been demonstrated			X
PHYSICAL INTERFACES / INTERFACE CONTROL			
3. Interface with operating structures, systems, or components during installation? Technique requires large amounts of water			X
SAFETY			
1. Criticality potential? Note: need explanation of criticality potential			X
Part B: *Project* Risk Screening Criteria	**Potential for Risk?** No	**Low**	**Yes**
SCHEDULE			
2. Operations Schedule uncertainties or restraints that may impact program completion dates? This method is expected to be very time-consuming			X
PROGRAMMATIC INTERFACES			
4. Significant interface with operational facility? Technique requires a large volume of water			X

Process Step 2: BULK SALT PREPARATION FOR TRANSFER 1.2.9 Two Pulse Tube Mixers **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?**		
	No	**Low**	**Yes**
1. New technology?	X		
2. Unknown or unclear technology?	X		
3. New application of existing technology?			X
4. Modernized/advanced technology in existing application?	X		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?	X		
2. Multiple technical agencies?	X		
3. Interface with operating structures, systems, or components during installation?			X
SAFETY			
1. Criticality potential?			X
2. Significant exposure/contamination potential?			X
3. Any impact to the Facility's Authorization Basis?			X
4. Hazardous material involved?	X		
5. Process hazard potential?	X		
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?	X		
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?	X		
2. Additional releases?	X		
3. Undefined disposal methods?	X		
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?	X		
4. Difficult to perform functional test?	X		
5. *Numerous or unclear assumptions?*	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?	X		
2. Specialty resources required?	X		

Part B: *Project* Risk Screening Criteria	Potential for Risk?		
	No	Low	Yes
COST			
1. Is the modification TPC greater than $4M?	X		
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?	X		
PROCUREMENT			
1. Long lead items that may affect critical path?	X		
2. Potential unavailable qualified vendors or contractors?	X		
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?	X		
2. Multiple project interface?			*
3. Multiple contractor interface?	X		
4. Significant interface with operational facility?			*
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 2: BULK SALT PREPARATION FOR TRANSFER 1.2.9 Two Pulse Tube Mixers Part A: *Technical* Risk Screening Criteria	Potential for Risk? No	Low	Yes
3. New application of existing technology? Techniques has not been demonstrated			X
PHYSICAL INTERFACES / INTERFACE CONTROL			
3. Interface with operating structures, systems, or components during installation? Technique requires mining a well in the salt accumulated in the bottom of the tank. This operation has not consistently met with success on previous attempts			X
SAFETY			
1. Criticality potential? Note: need explanation of criticality potential			X
2. Significant exposure/contamination potential? Technique involves spraying high-pressure water, which generates aerosol spray. Spray will have to be handled by ventilation system.			X
3. Any impact to the Facility's Authorization Basis? Note: need explanation of why technique impacts AB			X

Process Step 2: BULK SALT PREPARATION FOR TRANSFER 1.2.14 Sluicing **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?** No	**Low**	**Yes**
1. New technology?	X		
2. Unknown or unclear technology?	X		
3. New application of existing technology?			X
4. Modernized/advanced technology in existing application?	X		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?	X		
2. Multiple technical agencies?	X		
3. Interface with operating structures, systems, or components during installation?			X
SAFETY			
1. Criticality potential?			X
2. Significant exposure/contamination potential?			X
3. Any impact to the Facility's Authorization Basis?			X
4. Hazardous material involved?	X		
5. Process hazard potential?	X		
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?	X		
REGULATORY/ENVIRONMENTAL			
1. *Environmental assessment/impact statement required?*	X		
2. Additional releases?	X		
3. Undefined disposal methods?	X		
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?	X		
4. Difficult to perform functional test?	X		
5. Numerous or unclear assumptions?	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?	X		
2. Specialty resources required?	X		

Part B: *Project* Risk Screening Criteria	Potential for Risk?		
	No	Low	Yes
COST			
1. Is the modification TPC greater than $4M?	X		
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?	X		
PROCUREMENT			
1. Long lead items that may affect critical path?	X		
2. Potential unavailable qualified vendors or contractors?	X		
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?	X		
2. Multiple project interface?			*
3. Multiple contractor interface?			
4. Significant interface with operational facility?			X
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 2: BULK SALT PREPARATION FOR TRANSFER 1.2.14 Sluicing **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?** No	Low	Yes
3. New application of existing technology? Technique not demonstrated in salt.			X
PHYSICAL INTERFACES / INTERFACE CONTROL			
3. Interface with operating structures, systems, or components during installation? Technique requires mining a well in the salt accumulated in the bottom of the tank. This operation has not consistently met with success on previous attempts			X
SAFETY			
1. Criticality potential? Note: need explanation of criticality potential			X
2. Significant exposure/contamination potential? Technique involves spraying high-pressure water, which generates aerosol spray. Spray will have to be handled by ventilation system.			X
3. Any impact to the Facility's Authorization Basis? Note: need explanation of why technique impacts AB			X
Part B: *Project* Risk Screening Criteria	**Potential for Risk?** No	Low	Yes
COST **PROGRAMMATIC INTERFACES**			
4. Significant interface with operational facility? Technique uses a large volume of water. Techniques will generate a large volume of dilute solution, which will have to be handled by other facilities.			X

Process Step 3: BULK SLUDGE WASTE TRANSFER 2.1.9 Bibo Pump on Mast 2.1.8 Macerator Pump 2.1.12 Screw pump "Pump-on-a-stick" techniques **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?** No	**Low**	**Yes**
1. New technology?	X		
2. Unknown or unclear technology?	X		
3. New application of existing technology?	X		
4. Modernized/advanced technology in existing application?	X		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?	X		
2. Multiple technical agencies?	X		
3. Interface with operating structures, systems, or components during installation?	X		
SAFETY			
1. Criticality potential?	X		
2. Significant exposure/contamination potential?	X		
3. Any impact to the Facility's Authorization Basis?	X		
4. Hazardous material involved?	X		
5. Process hazard potential?	X		
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?	X		
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?	X		
2. Additional releases?	X		
3. Undefined disposal methods?	X		
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?			X
4. Difficult to perform functional test?	X		
5. Numerous or unclear assumptions?	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?	X		

2. Specialty resources required?	X		
Part B: *Project* Risk Screening Criteria	**Potential for Risk?**		
	No	**Low**	**Yes**
COST			
1. Is the modification TPC greater than $4M?	X		
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?	X		
PROCUREMENT			
1. Long lead items that may affect critical path?	X		
2. Potential unavailable qualified vendors or contractors?	X		
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?	X		
2. Multiple project interface?			*
3. Multiple contractor interface?	x		
4. Significant interface with operational facility?			*
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 3: BULK SLUDGE WASTE TRANSFER *2.1.9 Bibo Pump on Mast 2.1.8 Macerator Pump 2.1.12 Screw pump* "Pump-on-a-stick" techniques **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?**		
	No	**Low**	**Yes**
DESIGN			
3. Complex design features? Technique requires a fixed-length stick. The length may vary among the tanks and the exact length is unknown.			X

Process Step 3: BULK SLUDGE WASTE TRANSFER 2.1.3 Disposable pump on a rope **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?** No	**Low**	**Yes**
1. New technology?	X		
2. Unknown or unclear technology?	X		
3. New application of existing technology?	X		
4. Modernized/advanced technology in existing application?	X		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?	X		
2. Multiple technical agencies?	X		
3. Interface with operating structures, systems, or components during installation?	X		
SAFETY			
1. Criticality potential?	X		
2. Significant exposure/contamination potential?	X		
3. Any impact to the Facility's Authorization Basis?	X		
4. Hazardous material involved?	X		
5. Process hazard potential?	X		
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?	X		
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?	X		
2. Additional releases?	X		
3. Undefined disposal methods?	X		
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?			X
4. Difficult to perform functional test?	X		
5. Numerous or unclear assumptions?	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?	X		
2. Specialty resources required?	X		

Part B: *Project* Risk Screening Criteria	Potential for Risk?		
	No	Low	Yes
COST			
1. Is the modification TPC greater than $4M?	X		
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?	X		
PROCUREMENT			
1. Long lead items that may affect critical path?	X		
2. *Potential unavailable qualified vendors or contractors?*	X		
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?	X		
2. Multiple project interface?			*
3. Multiple contractor interface?	x		
4. Significant interface with operational facility?			*
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 3: BULK SLUDGE WASTE TRANSFER 2.1.3 Disposable pump on a rope **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?** No	**Low**	**Yes**
DESIGN			
3. Complex design features? Technique requires a pump heavy enough to avoid being buffeted by the water forces inside the tank.			X

Process Step 3: BULK SLUDGE WASTE TRANSFER 2.1.5 Hanford SEE Pump like Tank 19 "Pump-on-a-mast" **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?**		
	No	**Low**	**Yes**
1. New technology?	X		
2. *Unknown or unclear technology?*	X		
3. New application of existing technology?			X
4. Modernized/advanced technology in existing application?	X		
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?	X		
2. Multiple technical agencies?	X		
3. Interface with operating structures, systems, or components during installation?	X		
SAFETY			
1. *Criticality potential?*	X		
2. Significant exposure/contamination potential?	X		
3. Any impact to the Facility's Authorization Basis?	X		
4. Hazardous material involved?	X		
5. Process hazard potential?	X		
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?	X		
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?	X		
2. *Additional releases?*	X		
3. Undefined disposal methods?	X		
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)	X		
2. Classified process / information? (DOE Orders require Security Risk Assessment)	X		
DESIGN			
1. Undefined, incomplete or unclear functional requirements?	X		
2. Undefined, incomplete or unclear design criteria?	X		
3. Complex design features?	X		
4. Difficult to perform functional test?	X		
5. Numerous or unclear assumptions?	X		
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?	X		
2. Specialty resources required?	X		

Part B: *Project* Risk Screening Criteria	**Potential for Risk?**		
	No	**Low**	**Yes**
COST			
1. Is the modification TPC greater than $4M?	X		
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?	X		
PROCUREMENT			
1. Long lead items that may affect critical path?	X		
2. Potential unavailable qualified vendors or contractors?	X		
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?	X		
2. Multiple project interface?			*
3. Multiple contractor interface?	x		
4. Significant interface with operational facility?			*
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			*

* Potential program risk, irrespective of the equipment options selected

Process Step 3: BULK SLUDGE WASTE TRANSFER 2.1.5 Hanford SEE Pump like Tank 19 "Pump-on-a-mast" **Part A: *Technical* Risk Screening Criteria**	**Potential for Risk?** No	**Low**	**Yes**
3. New application of existing technology? Telescoping mast has not been tried at SRS.			X