Page 1 of 1

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Waste Feed Delivery Strategy for Tanks 241-AN-102 and 241-AN-107

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U.S. Department of Energy Contract DE-AC06-99RL14047

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Key Words: Tank 241-AN-102, Tank 241-AN-107, AN-102, AN-107, staging tank, waste feed delivery, fitness for use, process flowsheet, engineering study methodology

Abstract: This engineering study establishes the detailed retrieval strategy, equipment requirements, and key parameters for preparing detailed process flowsheets; evaluates the technical and programmatic risks associated with processing, certifying, transferring, and delivering waste from Tanks 241-AN-102 and 241-AN-107 to BNFL; and provides a list of necessary follow-on actions so that program direction from ORP can be successfully implemented.

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Waste Feed Delivery Strategy for Tanks 241-AN-102 and 241-AN-107

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

CH2MHILL
Hanford Group, Inc.
Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC06-99RL14047

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The authors are especially appreciative of the cooperation and support provided by Ron Orme, Ed Fredenburg, and Paul Certa on this engineering study. Ron Orme addressed the substantial chemistry issues related to processing, transferring, and delivering waste feed from Tanks 241-AN-102 and 241-AN-107. Ed Fredenburg and his team focused the issues and established the information needed to show that Tank 241-AN-102 would likely be fit for use as a staging tank. Paul Certa provided extensive support during all phases of this study.

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EXECUTIVE SUMMARY

INTRODUCTION

The Waste Feed Delivery Program mission is to deliver the right feed, at the right time, in the right quantities to the Privatization Contractor (BNFL Inc. [BNFL]) for treatment. Since its inception, the Waste Feed Delivery Program has established, maintained, and controlled the programmatic and technical baseline for delivery of the waste feed. In recent (September and November 1999) refinements to the technical baseline, the U.S. Department of Energy, Office of River Protection (ORP) provided direction on the delivery of waste from Tanks 241-AN-102 and 241-AN-107 (DOE-ORP 1999a and 1999b). This direction, which was incorporated into this study, briefly states:

- *Tank 241-AN-102 will be the first feed tank.*
- *Tank 241-AN-102 also will be a staging tank, replacing Tank 241-AN-106.*
- *Supernate from Tanks 241-AN-102 and 241-AN-107 will be delivered directly to BNFL.*
- *Corrosion inhibitor (caustic) may be added to Tanks 241-AN-102 and 241-AN-107 if required.*

PURPOSE

The initial purpose of this engineering study was to provide interim guidance to Project W-521 (also referred to as Project W-211B) by October 1999 to begin the conceptual design of the equipment required to process, certify, transfer, and deliver feed from Tanks 241-AN-102 and 241-AN-107 to BNFL. After that need was satisfied by issuing the interim guidance, the scope of this engineering study was shifted to verifying that the September and November 1999 direction from ORP (DOE-ORP 1999a and 1999b) was technically feasible.

This engineering study:

- *Establishes the detailed retrieval strategy, equipment requirements, and key parameters for preparing detailed process flowsheets.*
- *Evaluates the technical and programmatic risks associated with processing, certifying, transferring, and delivering waste from Tanks 241-AN-102 and 241-AN-107 to BNFL.*
- *Provides a list of necessary follow-on actions so that ORP's direction (Case 3S5) can be successfully implemented.*

FINDINGS

The findings derived from this engineering study are detailed below.

- *The approach in ORP's direction letters is feasible.*
- *The retrieval strategy for Tank 241-AN-102 is to determine if an unacceptable corrosion condition exists in Tank 241-AN-102 before adding caustic, to decant the supernate in two batches for direct delivery to BNFL, and to clean out the tank (add enough flush to dissolve some of the residual solids and transfer the residuals to Tank 241-AP-107 or another suitable double-shell tank). After cleanout, Tank 241-AN-102 will be used as a staging tank for delivery of subsequent batches of supernate to BNFL. The technical baseline will assume that caustic will be added to Tank 241-AN-102 unless it is determined that no corrosion condition exists.*
- *The retrieval strategy for Tank 241-AN-107 is to add caustic for corrosion protection, to decant supernate in one batch for direct delivery to BNFL, and to leave the residuals in Tank 241-AN-107.*
- *The equipment functional requirements and technical details for processing, certifying, transferring, and delivering waste from Tanks 241-AN-102 and 241-AN-107 to BNFL are presented in Tables ES-1 and ES-2.*
- *The current waste in Tank 241-AN-102 may or may not require caustic addition. Either way, there is no adverse impact on the composition of this waste as delivered to BNFL.*
- *Waste in Tank 241-AN-107 requires caustic addition for corrosion protection. As a side benefit, the resulting chemistry changes in Tank 241-AN-107 would improve the likelihood of meeting Envelope C maximum limits on certain constituents, which improves the ability to deliver conforming waste.*
- *Tank 241-AN-102 is likely to be found fit for use as a staging tank even though its waste is currently caustic deficient.*

ACTIONS

A number of risks were identified in this engineering study. The resolution of these risks could further simplify processing, certifying, transferring, and delivering waste from Tanks 241-AN-102 and 241-AN-107. This study recommends the following actions be taken to mitigate these risks.

- *Establish that Tank 241-AN-102 is likely to be fit for use as a staging tank (Section 4.1.2).*
  - *Perform an adequate ultrasonic examination of the primary tank to verify that unacceptable corrosion has not yet occurred.*

- *Calculate the stresses in the primary tank to determine if sufficient stress exists to promote stress corrosion cracking.*
- *Measure the electrochemical noise of the actual waste to determine if an unacceptable corrosion condition currently exists in the tank.*

The result of these actions will determine if caustic must be added now to Tank 241-AN-102 to protect the tank from accelerated corrosion and whether current, primary tank corrosion levels are acceptable so Tank 241-AN-102 can be used as a staging tank.

- *Determine whether the solids in Tank 241-AN-102 should remain and be mixed with supernate from Tank 241-AN-105 or be transferred to Tank 241-AP-107 before addition of supernate from Tank 241-AN-105 (Section 4.2.3).*
  - *The remaining heel (solids and supernate) in Tank 241-AN-102 after second decant and decant of residual supernate to Tank 241-AP-107 will not affect envelope compliance of the Tank 241-AN-105 batch being staged in Tank 241-AN-102.*
  - *This decision needs to consider whether it is better to transfer these solids to BNFL along with the low-activity waste feed from Tank 241-AN-105 or to keep them in the double-shell tank system.*
- *Address high transuranic (TRU) levels in Tank 241-AN-107 (Section 4.3.2).*

  The TRU levels in Tank 241-AN-107 are expected to be ~115% over the Envelope C limit. Alter the TRU limit for Envelope C or make a formal request under Clause H.43 (DOE-RL 1998) for BNFL to determine the cost impacts of processing the Tank 241-AN-107 waste with slightly elevated TRU.
- *Correct caustic deficient condition in Tank 241-AN-107 (Section 4.3.3).*

  Immediately add caustic to raise the free hydroxide level from below detectable to 0.5 M (Section 4.3.3).

Although the final results of this engineering study are based on Case 3S5 all findings in Section 4.0 are directly applicable and transferable to the Readiness-to-Proceed-2 submittal case, 3S6E (also know as 2006 Hot Start). The only changes between Cases 3S5 and 3S6E affecting Tanks 241-AN-102 and 241-AN-107 are the timing of when feed is delivered from these tanks and the specific sources of supernate that are staged in Tank 241-AN-102 during its use as a staging tank. All of the equipment functional requirements in Tables ES-1 and ES-2 are still valid, and the identified actions still need to be pursued.

METHODOLOGY ENHANCEMENT

In addition to the technical elements associated with delivering conforming waste from Tanks 241-AN-102 and AN-107, program management requested that an improved methodology for performing retrieval engineering studies be developed. Program management asked that this *methodology be tested in this engineering study. In Section 3.0, that proposed methodology is described along with the results of that application.*

REFERENCES

BNFL-5193-ID-19, 1999, Interface Control Document ICD-19 Between DOE and BNFL Inc. for Low-Activity Waste Feed, Rev. 3B DRAFT, BNFL Inc., Richland Washington.

DOE-RL, 1998, TWRS Privatization Contract, No. DE-AC06-96RL13308, Mod. A006, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-ORP, 1999a, Lockheed Martin Corporation Work Authorization, (Work Authorization for Fiscal Year 2000, signed by J. C. Peschong, DOE Director Management Systems Office, and M. P. DeLozier, River Protection Project General Manager on September 30), U.S. Department of Energy, Office of River Protection, Richland, Washington.

DOE-ORP, 1999b, Response to LMHC-9957486 – HLW & Low Activity Waste Source Tank Retrieval Sequence, (Letter from J. A. Poppiti, Director, Program Development Division, to M. P. DeLozier, President and River Protection Project General Manager , dated November 1), U.S. Department of Energy, Office of River Protection, Richland, Washington.

Table ES-1. Tank 241-AN-102 Summary Functional Requirements for Equipment for Waste Feed Delivery. (2 sheets)

Processing Step	**Requirements**
Step 1 – Caustic Addition/Mixing	*Add 0.05 ML (~13 kgal) of 50 wt% caustic.* • *Heat caustic lines to above caustic freezing point.* *Mix upon addition to uniformly disperse throughout the tank.* • *Mix caustic so that it is dispersed in both the supernate (3.68 ML [971 kgal] of 1.4 sp. gr.) and sludge (0.34 ML [89 kgal] of 20 wt% solids in sludge with sludge of 1.5 sp. gr.).*
Step 2 – Solids Settling	*Provide sufficient time after any disturbance of sludge to allow complete settling.* • *Allow for up to 6 months of settling (conservative).*
Step 3- Certification	*It is premature to anticipate how the certification requirements currently in BNFL-5193-ID-19 will be modified to establish that the supernate is conforming to the envelope specifications.*
Step 4A – First Decant	*Decant the top 1.81 ML (478 kgal) of supernate to BNFL Inc.* • *Supernate consists of 1.77 ML (467 kgal) of supernate and 0.04 ML (11 kgal) of sludge (0.5 wt%) entrained in the supernate.* • *Bounding supernate specific gravity and weight percent solids after dilution in Step 4B are <1.35 sp. gr. and <2 wt% solids.** *Minimize amount of settled-sludge carryover during supernate decant.*
Step 4B – In-line Dilution for First Decant (e.g., pump intake dilution)	*Add 0.42 ML (110 kgal) to 1.04 ML (276 kgal) of dilution water to the pump intake.* • *Mixture will contain 0.23 L to 0.58 L of water per liter of supernate.* • *Dilution water will be added at approximately the supernate temperature (29 °C [85 °F]).* *Note: Piping, pumping, and dilution water metering are addressed by Projects W-211 and W-314.*
Step 4C – Second Decant	*Decant ~1.81 ML (~478 kgal) of supernate to BNFL Inc.* • *Supernate consists of 1.77 ML (467 kgal) of supernate and 0.04 ML (11 kgal) of sludge entrained in the supernate.* • *Bounding supernate specific gravity and weight percent solids after dilution in Step 4D is <1.35 sp. gr. and <2 wt% solids.** • *Leave ~25 cm (~10 in.) of supernate above the height of the remaining sludge (estimated to be ~109 cm [43 in.] above the tank bottom).*
Step 4D – In-line Dilution for Second Decant	*Add 0.42 ML (110 kgal) to 1.04 ML (276 kgal) of dilution water to the pump intake.* • *Mixture will contain 0.23 L to 0.58 L of water per liter of supernate.* • *Dilution water will be added at approximately the supernate temperature (29 °C [85 °F]).*

Table ES-1. Tank 241-AN-102 Summary Functional Requirements for Equipment for Waste Feed Delivery. (2 sheets)

Processing Step	**Requirements**
Steps 5A and 5B – Transfer to BNFL Inc.	*Transfer diluted, decanted supernate to BNFL Inc. Bounding supernate transfer conditions are <1.35 sp. gr. and <2 wt% entrained solids.** *Note: Transfer pump and piping for transferring supernate of <1.35 sp. gr. and containing <2 wt% solids are addressed in existing design requirements of Projects W-314 and W-211.*
Step 6 – Flush Water/Caustic Addition	*Add cleanout solution to Tank 241-AN-102.* • *Add ~0.76 ML (~200 kgal) of the warmest water available from the water delivery system to increase turbulence and ensure the supernate remains below saturation in major salts.* • *Add ~0.002 ML (~0.60 kgal) of 50 wt% caustic uniformly to the flush water if caustic was not added in Step 1.* *Note: Flush and caustic equipment requirements are addressed in existing design requirements for Projects W-211 and W-314.*
Step 7 – In-tank Mixing	*Mix contents of Tank 241-AN-102:* • *0.19 ML (50 kgal) of supernate (1.4 sp. gr.), 0.25 ML (67 kgal) sludge (1.5 sp. gr. sludge with 20 wt% solids in sludge), and 0.76 ML (200 kgal) of flush water.*
Step 8 – Transfer Flush to Tank 241-AP-107	*Transfer ~1.09 ML (289 kgal) of residuals to Tank 241-AP-107.* • *Leave ~25 cm (~10 in.) of waste.* • *1.01 ML (268 kgal) of supernate and 0.08 ML (21 kgal) of solids with bulk specific gravity of <1.35 and <2 wt% entrained solids will be transferred.* *Note: Equipment requirements for transferring flush are addressed by Projects W-314 and W-211.*

**Nominal supernate after dilution is <1.35 sp. gr. and ~0.5 wt% solids.*

Table ES-2. Tank 241-AN-107 Summary Functional Requirements for Equipment for Waste Feed Delivery.

Processing Step	**Requirements**
Step 1 – Caustic Addition/Mixing	*Add ~0.21 ML (55 kgal) of 50 wt% caustic.* • *Heat caustic lines to above caustic freezing point.* *Mix upon addition to uniformly disperse throughout the tank.* • *Mix caustic so that it is dispersed in both the supernate (3.02 ML [797 kgal] of 1.39 sp. gr.) and sludge (0.93 ML [247 kgal] of 8 wt% solids in sludge with sludge of 1.47 sp. gr.).*
Step 2 – Solids Settling	*Provide sufficient time after any disturbance of sludge to allow complete settling.* • *Allow for up to 6 months of settling (conservative).*
Step 3 - Certification	*It is premature to anticipate how the certification requirements currently in BNFL-5193-ID-19 will be modified to establish that the supernate is conforming to the envelope specifications.*
Step 4A – Supernate Decant	*Decant 3.59 ML (948 kgal) of supernate.* • *Supernate consists of 3.39 ML (895 kgal) of supernate and 0.02 ML (53 kgal) of sludge entrained in the supernate.* • *Leave ~25 cm (~10 in.) of supernate above the height of the remaining sludge (height of sludge estimated to be ~66 cm [26 in.] above the tank bottom).* • *Minimize amount of settled-sludge carryover during supernate decant.*
Step 4B – In-line Dilution (e.g., pump intake dilution)	*Add ~0.54 ML (~142 kgal) of dilution water to the pump intake.* • *Mixture will contain 0.15 L of water per liter of supernate.* • *Water will be added at approximately the supernate temperature (29 °C [85 °F]).* *Note: Piping, pumping, and dilution water metering are addressed by Project W-521 (W-211B).*
Step 5 – Transfer to BNFL	*Transfer diluted, decanted supernate to BNFL Inc.* • *Bounding decanted supernate is <1.35 sp. gr. and <2 wt% solids.* • *Nominal decanted supernate is <1.35 sp. gr. and ~0.5 wt% solids.* *Note: Transfer pump and piping for transferring <1.35 sp. gr. supernate containing <2 wt% solids are addressed in existing design requirements of Projects W-314 and W-521 (W-211B).*

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CONTENTS

TABLES

FIGURES

APPENDICES

LIST OF TERMS

AGA	alternatives generation and analysis
BNFL	BNFL Inc.
AN-101	Tank 241-AN-101
AN-102	Tank 241-AN-102
AN-105	Tank 241-AN-105
AN-106	Tank 241-AN-106
AN-107	Tank 241-AN-107
AP-107	Tank 241-AP-107
DOE	U.S. Department of Energy
FY	fiscal year
LAW	low-activity waste
M&I	Management and Integration (contractor)
Memorandum-I	*Memorandum-I, Problem Statement, Boundaries, Demands, and Issues Associated with Delivering Waste from Tanks 241-AN-102 and 241-AN-107* (RPP-6011)
ORP	Office of River Protection
RPP	River Protection Project
sp. gr.	specific gravity
TOC	total organic carbon
TRU	transuranic

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1.0 PURPOSE

This engineering study began as an alternatives generation and analysis (AGA) study focusing on:

- Evaluating the various reasonable approaches for processing, certifying, transferring, and delivering waste from Tanks 241-AN-102 (AN-102) and 241-AN-107 (AN-107)[1]

- Suggesting a preferred path for processing, certifying, transferring, and delivering this waste to BNFL Inc. (BNFL).

Based on interim results from this AGA study, the U.S. Department of Energy (DOE) was positioned to prescribe the path for waste feed delivery from and the future uses of AN-102 and AN-107. With this direction, it was more appropriate to continue this effort as an engineering study focusing on:

- Establishing the details for processing, certifying, transferring, and delivering waste from AN-102 and AN-107

- Determining any technical and programmatic risks and handling actions associated with carrying out DOE's prescribed approach

- Defining the equipment functional requirements for processing, certifying, transferring, and delivering waste from and to support future uses of AN-102 and AN-107.

This engineering study also developed and applied an improved methodology for performing such studies.

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[1]To aid readability, specific tanks will be referred to by their formal names (e.g., Tank 241-AN-102 and Tank 241-AN-107) only the first time they are called out in the text of this study. Following their first usage, shorter, simpler designations (e.g., AN-102 and AN-107, respectively) will be provided in parentheses. The shortened alternatives of the names will be used throughout the remainder of the text.

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2.0 INTRODUCTION

In July 1999, this effort began as an AGA study. The initial purpose of this study was to provide interim guidance to Project W-521 (also referred to as Project W-211B) to begin the conceptual design of the equipment required to process, certify, transfer, and deliver feed from AN-102 and AN-107 to BNFL. Project W-521 (W-211B) needed information on equipment requirements by October 1999 to meet its schedule for having equipment ready to deliver waste from AN-107 to BNFL no later than July 2006. Project W-521's (W-211B's) schedule was based on Baseline Case 3S3 (Garfield 2000a), the baseline in effect at that time.[2] In Baseline Case 3S3, AN-107 was to be the first tank from which low-activity waste (LAW) feed would be delivered to BNFL; AN-102 was to be the third tank (DOE-RL 1998).

The first stage in the AGA was to develop a problem statement and identify and understand the issues associated with the problem. This was addressed in Memorandum-I (RPP-6011). This product led to the development of alternative approaches for processing, certifying, transferring, and delivering waste from AN-102 and AN-107.

For the AGA to be responsive to Project W-521 (W-211B), the technical and program staff had to reach agreement early in the study on which elements associated with delivering waste feed from AN-102 and AN-107 were tradable and which elements were non-tradable. This was accomplished by developing a set of enabling assumptions, constraints, and requirements (RPP-5311). The purpose was to narrow the AGA to a realistic number of alternatives. This effort helped define the scope and boundary of the study, allowing the AGA to focus on a limited number of elements affecting the delivery of waste from AN-102 and AN-107.

Based on the AGA efforts accomplished by September 1999, DOE prescribed an approach for the delivery and uses of AN-102 and AN-107 (DOE-ORP 1999a). This simplified the study, and the focus now moved to evaluating the risks associated with DOE's program direction for delivery of AN-102 and AN-107 waste and the future uses of these tanks. This report documents that the prescribed approach is feasible. Where applicable, the report describes the specific risks that arise and proposes handling actions to minimize or eliminate these risks. This report also defines the equipment functional requirements for processing, certifying, transferring, and delivering waste to BNFL and for the future uses of AN-102 and AN-107.

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[2] The Waste Feed Delivery Program has developed a number of cases (computer simulations of the Waste Feed Delivery mission) that are named after the shorthand name for the model run (e.g., 3S5). These cases reflect different sets of requirements and assumptions. Some, but not all, of these cases are used to establish new revisions of the baseline (HNF-SD-WM-SP-012). At various steps in this study, there were different established baselines.

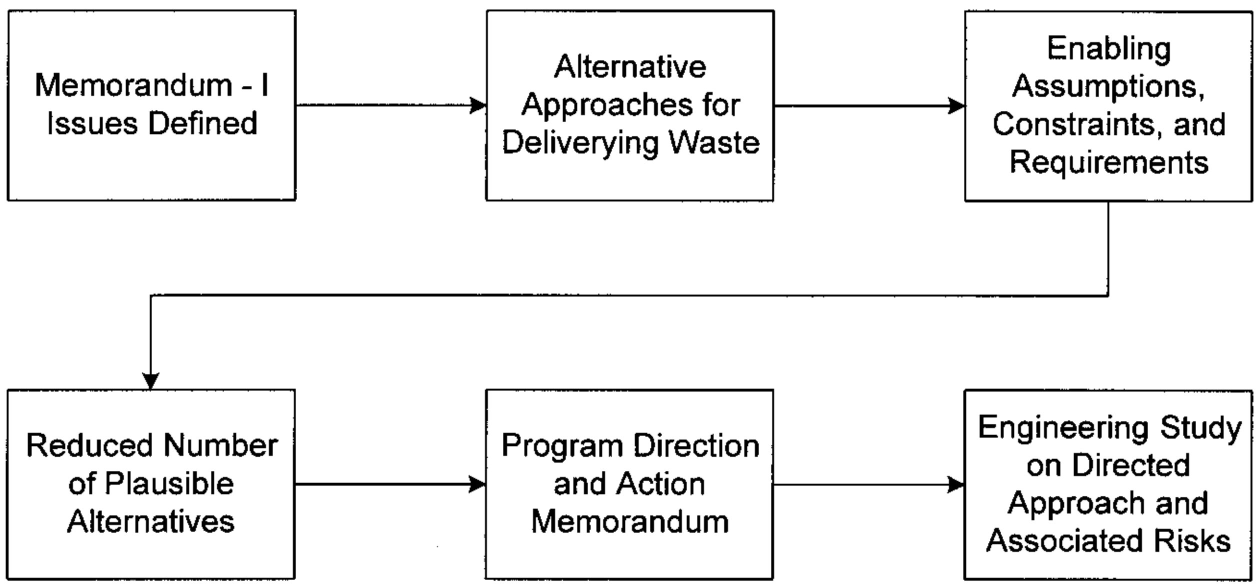
Section 3.0 describes the evolution of this study from an AGA to an engineering study. If the reader is interested in the retrieval strategy and equipment requirements and not in how this study evolved, then the reader should turn to Section 4.0.

This report was based on Baseline Case 3S5, applicable through mid-February 2000. The reported results are transferable and applicable to AN-102 and AN-107 in the now current Baseline Case 3S6E (2006 Hot Start). The only changes between Cases 3S5 and 3S6E affecting AN-102 and AN-107 are the timing of when feed is delivered from these tanks and the specific sources of supernate that are staged in AN-102 during its use as a staging tank.

3.0 EVOLUTION FROM ALTERNATIVES GENERATION AND ANALYSIS TO ENGINEERING STUDY

This study began as an AGA study with many issues and plausible alternatives that required attention. Without efforts to focus this study, an expensive and lengthy AGA would result. An approach was devised and pursued to simplify this study without compromising technical rigor and completeness. This alternative approach is presented in Figure 3-1.

Figure 3-1. Steps Used to Simplify Alternatives Generation Analysis on Tanks 241-AN-102 and 241-AN-107.



This section presents this alternative approach and documents how this approach worked in an application. At various steps in this process, there were different established baselines. To support why certain issues were pursued at the time, references are provided to the baseline that was current at the time a specific step was addressed.

In August and September 1999, the baseline was 3S3 and 3S4. In October 1999 until mid-February 2000, the baseline was 3S5. The analyses for waste feed delivery of AN-102 and AN-107, found in Section 4.0, are based on 3S5. However, all findings and actions associated with processing, certifying, transferring, and delivering of AN-102 and AN-107 waste to BNFL are transferable and applicable to the now current Baseline Case 3S6E (2006 Hot Start).

3.1 MEMORANDUM-I (AUGUST 1999)

Even with the establishment of clear boundary conditions (temporal[3] and spacial[4]) associated with Baseline Case 3S3, there were many issues that if not resolved would make this study more difficult to pursue. Delivering feed from AN-102 and AN-107 to BNFL raised a number of issues. Future uses of these tanks raised other issues. In Memorandum-I (RPP-6011), all issues believed important in the summer of 1999 were raised. The issues raised and how they might be addressed are discussed below.

- **Timing for Staging Waste from Tank 241-AN-107.** Tank AN-107 was scheduled to be the first tank from which LAW feed would be delivered to BNFL. A question was raised as to whether this feed should be retrieved early to allow more time to successfully pursue the certification process. This feed cannot be delivered until the completion of the new transfer line outside the tank farm boundary, which is not scheduled to be available until the end of fiscal year (FY) 2002.

- **Composition of Waste in Tanks 241-AN-102 and 241-AN-107.** The composition of most chemical and radiochemical analytes in AN-102 and AN-107 meets the current maximum limits required for Envelope C (HNF-SD-WM-SP-012). Issues related to total organic carbon (TOC) and transuranics (TRU) in AN-107 are being clarified, and an estimate of the probability that all other analytes will meet Envelope C requirements is being analyzed. The expectation is that only TOC and TRU in AN-107 are likely to be above the maximum limits for these analytes and remain a concern. There are not likely to be concerns with analytes in AN-102. Baseline Case 3S4 (Garfield 2000b),[5] current in August 1999, required that supernate from AN-102 and AN-107 only be used.

- **Safety Concerns with Use of Tanks 241-AN-102 and 241-AN-107.** A Project W-521 (W-211B) preliminary safety analysis plan was prepared and concluded that the existing safety authorization basis and the Project W-211 authorization basis amendment will adequately address the installation and operation of equipment associated with Project W-521 (W-211B) (i.e., the processing of waste from AN-102 and AN-107). The

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[3] The time boundary of this AGA for using AN-102 and AN-107 is Phase 1B and Phase 1B Extended waste feed delivery. During this time period, all the activities associated with AN-102 and AN-107 up to the time when these tanks become available for Phase 2 staging of waste from single-shell tanks need to be understood. Because the use of AN-102 and AN-107 in Phase 2 staging is expected to be in the time period beyond 2013, anticipating the hardware needed to deal with waste receipt, transfer, and staging beyond 2013 is premature.

[4] The spatial boundary for this AGA is AN-102 and AN-107 and the equipment needed to get the desired waste into and out of AN-102 and AN-107 during Phase 1B and Phase 1B Extended. This includes understanding all equipment required to transfer AN-102 and AN-107 waste to their downstream staging tanks (i.e., AN-101 and AN-106) and understanding the contents of the downstream staging tanks to ensure that Envelope C waste from AN-102 and AN-107 will be able to be certified in each staging tank.

[5] A shift was made from Baseline Case 3S3 to Baseline Case 3S4 in the August 1999 timeframe. The only changes between Baseline Cases 3S3 and 3S4 were that certain construction, processing, and delivery dates were moved out a couple of months to accommodate the 90% probability case.

reliance on the current authorization basis and the Project W-211 authorization basis amendments will be revisited as the study evolves.

- **Volumes of Envelope C Feed.** A major programmatic objective is to ensure there is a sufficient quantity of waste available to meet delivery order requirements. There is a sufficient volume of Envelope C to meet the contract order quantities of a minimum of 300 LAW units and a maximum of 1,200 LAW units from the first feed tank. Envelope C feed also is needed to meet the requirement for the total units of LAW used during Phase 1B (6,000 units). Tanks AN-102 and AN-107 will contribute ~2,000 units of Envelope C supernate.

- **Feed Certification.** If supernatant waste from AN-102 and AN-107 is sent to receiver Tanks 241-AN-101 (AN-101) and 241-AN-106 (AN-106), then the BNFL-5193-ID-19 procedure for certification will establish waste compliance with Envelope C requirements. If supernate from AN-102 and AN-107 is directly staged to BNFL, then establishing homogeneity of the supernate may become an issue (e.g., no mixing before waste certification).

- **Corrosion Protection Requirements.** A number of alternative approaches to addressing the tank corrosion protection concerns remain to be explored. These include demonstrating that the tanks are currently protected from unacceptable corrosion and, therefore, require no action such as addition of caustic to mitigate corrosion potential. Data evaluated since preparation of Memorandum-I (RPP-6011) suggest that hydroxide addition will be required (Reynolds 1991). All alternatives evaluated will assume that equipment for hydroxide addition, including decant pumps and mixer pumps, have been installed in AN-102 and AN-107.

- **Transfer Feed Without Staging.** Transfer of feed directly to the BNFL facility will require pumping material through as much as 2135 m (7,000 ft) of pipe. Transfer flow rates, solids settling, and transfer pressure head loss all become a concern at this distance (i.e., accumulation of solids in piping causing plugging). Transfer limits requiring flow at a Reynolds number of 20,000 may not apply to this transfer because only supernate will be transferred. The basis for establishing transfer criteria has no Reynolds number requirement (HNF-SD-WM-OCD-015).

- **Waste Compatibility.** The only waste compatibility issues (HNF-SD-WM-OCD-015) are likely to be corrosion and high phosphate waste. Restrictions on co-mingling complexed and noncomplexed waste no longer apply (HNF-SD-WM-SP-012). Current guidance is to minimize the total quantities of Envelope C feed, which translates into not contaminating Envelope A feed during staging to the point that it becomes Envelope C feed.

- **Future Uses of Tanks 241-AN-102 and 241-AN-107.** The future uses of AN-102 and AN-107 will have an impact on equipment required for each tank. The future uses of AN-102 and AN-107 will be based on Case 3S4 and the temporal boundary limitation of Phase 1B and Phase 1B Extended Order. These future uses are presented in Memorandum-I (RPP-6011), Figures 1 and 2.

- **Existing Equipment in Tanks 241-AN-102 and 241-AN-107.** To determine cost impacts of various alternatives, an inventory is required of operational equipment available in each tank. This inventory will establish which equipment has to be removed, which has to be added, and which can remain. Each of these has a cost implication. Hanford Drawing H-14-010501 indicates that the existing equipment consists primarily of safe storage monitoring devices. Caustic addition equipment (e.g., mixer pump, camera) has been installed in AN-107 and was successfully operated to complete the applicable operational test procedure at the time of installation. However, the equipment does not meet new flammable gas-deflagration mitigation requirements and cannot be operated without modification.

3.2 MEMORANDUM-I MEETING (AUGUST 1999)

In a meeting on August 18, 1999, key technical and program staff met to discuss the implications of the issues and tentative findings presented in Memorandum-I (RPP-6011). The conclusions of that meeting were presented in a meeting summary included as Appendix I to Memorandum-I (RPP-6011). Some key results of that meeting are addressed below.

- Tank AP-102 would not be substituted for AN-107 because it was not part of the current Baseline Case 3S4.

  A suggestion was made during the meeting to consider substituting AP-102 for AN-107 because of certification issues associated with AN-107. After further analyses, AP-102 was not considered further because BNFL had already expended substantial resources on understanding the processing requirements for waste in AN-107. If a shift were made, process testing of AP-102 would have to be pursued at a time when BNFL did not have the time or staff to perform these analyses. Moreover, AP-102 contains a level of phosphate that poses processing concerns (e.g., precipitation, plugging, melter foaming) to BNFL (personal communication between Russ Treat and Stan Blacker, October 13, 1999). If caustic has to be added to AN-107, the resulting chemistry changes in AN-107 would improve the likelihood of meeting Envelope C maximum limits on certain constituents (Appendix A).

  At the time, there were unwritten expectations on the part of DOE and BNFL that the current waste composition in AN-102 and AN-107 would be the actual waste that BNFL would receive (Memorandum-I [RPP-6011], Appendix I, Item 8). In December 1999, this evolved to the management and integration contractor (M&I) carrying out any corrosion protection processing of the waste required, even if that processing changes the current composition of the waste. The M&I contractor is expected to deliver envelope-conforming waste (personal communication between Russ Treat and Stan Blacker, December 6, 1999).

- Use of AN-102 as a staging tank was addressed by suggesting that the AGA could be expanded to include this issue.

  The intent was to address this idea only in a risk section by weighing the implications to waste feed delivery of having AN-102 as an extra staging tank (i.e., the desirability of having three staging tanks early in Phase 1B) against its future use as a nonstaging tank in the Baseline Case 3S4. Tank AN-107 has 21 airlift circulators. There are numerous other tanks in the AN Farm that would be better candidates for use as a staging tank requiring thorough mixing of tank contents.

Other items raised during the meeting (e.g., concern over Envelope C compliance, corrosion in these tanks) are addressed in Section 4.0.

3.3 GENERATION OF ALTERNATIVES (AUGUST 1999)

The issues raised and analyses performed in Memorandum-I (RPP-6011) allowed for the construction of plausible alternative approaches for delivering waste feed from AN-102 and AN-107. More than 40 alternatives were generated, which were more alternatives than could be reasonably pursued. To provide a reasonable scope for this AGA study, these alternatives were carefully analyzed to uncover common factors that, when carefully framed, allowed for the logical reduction in the number of alternatives. The analysis was based on Baseline Case 3S4, current at that time. The common factors were: (1) type of waste transferred (supernate or supernate and solids) and approach to transfer (staged or direct delivery), (2) dilution approach, (3) hydroxide addition, (4) Envelope C compliance, and (5) future uses of the tanks. These alternatives were presented using a matrix format (see Figure 3-2). Each unique combination of factors became a plausible alternative that required analysis.

3.4 DEVELOPMENT OF ENABLING ASSUMPTIONS, CONSTRAINTS, AND REQUIREMENTS (SEPTEMBER 1999)

The program staff was asked to make various decisions on which factors really needed to be carried forward in the analysis and which factors could be resolved/addressed without further analysis. This was accomplished by developing a set of enabling assumptions, constraints, and requirements to be imposed on the AGA (RPP-5311). These factors are presented in Tables 3-1, 3-2, and 3-3.

According to Baseline Case 3S4, current at the time, AN-106 was to be the second staging tank for Phase 1B Waste Feed Delivery. Program staff requested that AN-102 be considered as the second staging tank, replacing AN-106. This became an additional element in the study and required careful analysis.

Figure 3-2. Memorandum-I Alternatives Generation Matrix (from RPP-6011).

	Transfer				Water Addition			Free Hydroxide Addition								Envelop C Compliance			Future Uses	
	Type		Location					Type			Addition Method									
	Supernate Only	Supernate and Solids	To Interim Staging	Direct to BNFL	No Addition	In-Line	In-Tank	No Hydroxide	NaOH Addition	KOH Addition	In-Line	In-Tank	M&I Receiver Tank	Supernate - In-Line, Solids - In-Tank	Supernate - Receiver, Solids - In-tank	Non-Compliance	Change Requirements	Feed Blending	Case 3S3	Other Future Uses
Alternative 1	X		X			X		X								X			X	
Alternative 2	X		X			X		X									X		X	
Alternative 3	X		X			X		X										X	X	
Alternative 4	X		X			X			X		X					X			X	
Alternative 5	X		X			X			X		X						X		X	
Alternative 6	X		X			X			X		X							X	X	
Alternative 7	X		X			X			X			X				X			X	
Alternative 8	X		X			X			X			X					X		X	
Alternative 9	X		X			X			X			X						X	X	
Alternative 10	X		X			X			X				X			X			X	
Alternative 11	X		X			X			X				X				X		X	
Alternative 12	X		X			X			X				X					X	X	
Alternative 13	X		X			X				X	X					X			X	
Alternative 14	X		X			X				X	X						X		X	
Alternative 15	X		X			X				X	X							X	X	
Alternative 16	X		X			X				X		X				X			X	
Alternative 17	X		X			X				X		X					X		X	
Alternative 18	X		X			X				X		X						X	X	
Alternative 19	X		X			X				X			X			X			X	
Alternative 20	X		X			X				X			X				X		X	
Alternative 21	X		X			X				X			X					X	X	
Alternative 22	X			X		X		X								X			X	
Alternative 23	X			X		X		X									X		X	
Alternative 24	X			X		X		X										X	X	
Alternative 25	X			X		X			X			X				X			X	
Alternative 26	X			X		X			X			X					X		X	
Alternative 27	X			X		X			X			X						X	X	
Alternative 28	X			X		X				X		X				X			X	
Alternative 29	X			X		X				X		X					X		X	
Alternative 30	X			X		X				X		X						X	X	
Alternative 31	X		X			X			X			X				X				X
Alternative 32	X		X			X			X			X					X			X
Alternative 33	X		X			X			X			X						X		X
Alternative 34	X		X			X				X		X				X				X
Alternative 35	X		X			X				X		X					X			X
Alternative 36	X		X			X				X		X						X		X
Alternative 37	X			X		X			X			X				X				X
Alternative 38	X			X		X			X			X					X			X
Alternative 39	X			X		X			X			X						X		X
Alternative 40	X			X		X				X		X				X				X
Alternative 41	X			X		X				X		X					X			X
Alternative 42	X			X		X				X		X						X		X

Table 3-1. Assumptions. (2 sheets)

No.	Assumption	Basis	Type
A-1	Organic vapor discharges to the environment are controlled by the AN Farm ventilation system. The tank ventilation system is outside of the spatial boundary of this study.	This is an enabling assumption that the current ventilation system for the AN Farm is sized properly and contains components needed to prevent release to the atmosphere of organic vapors at levels higher than allowed by permit.	Non-tradable
A-2	Hydroxide addition equipment will be installed in AN-102 and AN-107 to mitigate the potential for stress corrosion cracking.	HNF-SD-WM-SP-012, Baseline Assumption 3.1, states that the requirements defined by HNF-SD-WM-OCD-015 will be followed. These assumptions were approved by the Tank Waste Remediation System Major Assumption Board. The basis for adding caustic is defined in Reynolds 1991.	Non-tradable
A-3	If hydroxide addition is found to be necessary, hydroxide will be added to the tanks soon after the decision is made in FY 2001.	This is an enabling assumption based on the assumption that if the tanks are found to be in jeopardy of stress cracking, immediate measures will be taken to protect the tank. The loss of a tank would severely impact waste feed delivery operations.	Non-tradable
A-4	The organics/energetic reactions (exothermic reactions) are within the requirements specified in HNF-SD-WM-OCD-015.	Moisture content in tanks is high, so slightly elevated energetic levels are not a safety concern (see HNF-SD-WM-ER-545 and HNF-SD-WM-ER-678).	Non-tradable
A-5	Co-mingling complexed and noncomplexed waste in AN-102 and AN-107 as defined by Baseline Case 3S4 is allowed.	DOE provided direction that allows RPP to manage wastes, to the extent practical, in a manner to minimize the processing costs (i.e., minimize conversion of Envelope A waste to Envelope C waste) (Kinzer 1998).	Non-tradable
A-6	First campaign of Envelope C waste must deliver 500 to 1,300 units.	BNFL-5193-ID-19.	Non-tradable

Table 3-1. Assumptions. (2 sheets)

No.	Assumption	Basis	Type
A-7	The quantity of Envelope C waste (between 300 and 2,100 units) to be delivered will be a **derived requirement** based on: (a) The risk of decanting supernate that has a total of >2 wt% solids (b) The percentage of contingent feed that will be allocated to accommodate reductions of Envelope C feed delivered to BNFL.	(a) 2 wt% solids requirement: DOE-RL 1998. (b) **Enabling assumption** of the number of units delivered to be provided by Waste Feed Delivery Program Management.	(a) Non-tradable (b) Tradable
A-8	Only current supernate from AN-102 and AN-107 will be used to make up Envelope C waste for delivery to BNFL (i.e., no intentional dissolution of current solids in either AN-102 or AN-107).	HNF-SD-WM-SP-012.	Tradable
A-9	Specific gravity of waste during transfer operations must be <1.35.	**Derived requirement** to ensure that major component solubility levels are below saturation limits and that viscosity and specific gravity are in the pumpable range (i.e., ensure maximum pressure requirements for the DST piping are not exceeded) (HNF-SD-WM-OCD-015).	Non-tradable
A-10	Transfer routes are available, after AN-107 supernate is transferred, to ensure that further uses of AN-107 (as required) are possible (e.g., base case valve pit configurations support transfers and receipts during future uses of AN-107 through 2018).	**Derived requirement** from HNF-SD-WM-SP-012.	Non-tradable
A-11	Transfer routes are available, after AN-102 supernate is transferred, to ensure that further uses of AN-102 (as required) are possible (e.g., base case valve pit configurations support transfers and receipts during future uses of AN-102 through 2018).	**Derived requirement** from HNF-SD-WM-SP-012.	Non-tradable
A-12	Certification of waste: Follow BNFL-5193-ID-19, Section 3.1, procedures if waste is staged. If waste is sent directly to BNFL, a modified procedure for waste certification will be developed.	**Enabling assumption** to allow assessment of feasibility of direct transfer of supernate from AN-102 and AN-107 to BNFL.	Non-tradable

Table 3-2. External Constraints. (2 sheets)

No.	Constraint	Basis	Type
C-1	All delivered LAW is assumed to be within the BNFL facility permits and safety authorization basis; therefore, no feed blending or adjustments are required.	Erickson 1999, Section 3.2.2.1, Assumption 22c.	Non-tradable
C-2	Twenty-eight sound DSTs will be available for the duration of Phase 1B Extended Order. No DSTs will develop leaks, and no new DSTs will be constructed.	Erickson 1999, Section 3.2.3, Assumption 7.	Non-tradable
C-3	If AN-107 is the first batch of waste delivered to BNFL, a minimum of 300 units of Envelope C waste must be delivered.	DOE-RL 1998, Section H.9.	Non-tradable
C-4	If AN-102 is the first batch of waste delivered to BNFL, a minimum of 300 units of Envelope C waste must be delivered.	DOE-RL 1998, Section H.9.	Non-tradable
C-5	No more than 2,100 units of Envelope C waste will be delivered to BNFL during Phase 1B.	DOE-RL 1998, Section H.9.	Non-tradable
C-6	A minimum order quantity of 6,000 units of LAW will be delivered during Phase 1B.	DOE-RL 1998, Section H.9.	Non-tradable
C-7	The supernate delivered to BNFL from AN-107 must comply with Envelope C composition requirements.	DOE-RL 1998, Section C, Specification 7.	Tradable
C-8	The supernate delivered to BNFL from AN-102 must comply with Envelope C composition requirements.	DOE-RL 1998, Section C, Specification 7.	Tradable
C-9	In accordance with Clause H.43 (DOE-RL 1998), out-of-specification feed will be processed by BNFL if it is within their technical ability to process the waste, the facility permits, and the facility authorization basis.	DOE-RL 1998; Erickson 1999, Section 3.2.3, Assumption 11.	Non-tradable
C-10	Waste from AN-102 and AN-107 will not be blended with other wastes.	Erickson 1999, Section 3.2.2, Assumption 22c.	Non-tradable

Table 3-2. External Constraints. (2 sheets)

No.	Constraint	Basis	Type
C-11	BNFL expects that current waste in AN-102 and AN-107 will be the waste that they receive.	Memorandum-I (RPP-6011), Appendix I, Item 8; personal communication between Russ Treat and Stan Blacker, August 26, 1999.	Tradable
C-12	Sodium molarity: (a) must be between 4 M and 10 M (b) must be between 3 M and 10 M. The more restrictive sodium molarity limits of between 4 M and 10 M will be used.	(a) Erickson 1999. (b) DOE-RL 1998.	Non-tradable
C-13	Each batch to be delivered will be limited to a maximum of 2.27 ML to 3.08 ML (600 kgal to 800 kgal).	Erickson 1999, Section 3.2.3, Assumption 22b.	Non-tradable
C-14	Batch delivery will be completed within 30 days of the waste transfer date. (A request is being made to DOE to extend the duration to 60 days.)	DOE-RL 1998, Clause H.9.	Non-tradable

Table 3-3. Requirements. (2 sheets)

No.	Requirement	Basis	Type
R-1	All safety and environmental requirements will be met. The only environmental factor identified to distinguish alternatives is tank fitness-for-use certification requirements of WAC 173-303.	HNF-SD-WM-TRD-007, Section 3.3.6. Factors determined to distinguish alternatives were identified in a meeting with cognizant safety and environmental personnel (see Appendix B).	Non-tradable
R-2	The materials in AN-102 and AN-107 must meet all applicable compatibility requirements (Memorandum-I [RPP-6011]).	HNF-SD-WM-SP-012, Assumption 3.1; HNF-SD-WM-OCD-015.	Non-tradable
R-3	Waste will be transferred from AN-107 to staging tank AN-106 (Case 3S4) using waste transfer piping systems (as opposed to trucking or other transfer methods).	HNF-SD-WM-SP-012, HNF-SD-WM-TRD-007.	Tradable
R-4	Waste will be transferred from AN-102 to staging tanks AN-101 and AN-106 (Case 3S4) using waste transfer piping systems (as opposed to trucking or other transfer methods).	HNF-SD-WM-SP-012, HNF-SD-WM-TRD-007.	Tradable

Table 3-3. Requirements. (2 sheets)

No.	Requirement	Basis	Type
R-5	Transfer of waste from AN-107 directly to BNFL is allowable.	Treat 1999.	Tradable
R-6	Transfer of waste from AN-102 directly to BNFL is allowable.	Treat 1999.	Tradable
R-7	Reynolds number must be >20,000 for transport of slurries with <1.35 sp. gr. and solids >5 vol%.	HNF-SD-WM-OCD-015, HNF-2728.	Non-tradable
R-8	System equipment will be capable of transferring prepared waste in 4 to 9 days.	HNF-SD-WM-TRD-007.	Tradable

3.5 REDUCTION OF ALTERNATIVES

Based on these enabling assumptions, constraints, and requirements, the scope of the AGA was reduced to addressing the following four key factors:

1. Use of AN-106 as the second staging tank
2. Use of AN-102 as the second staging tank
3. Staged transfer of compliant Envelope C waste
4. Direct transfer to BNFL of compliant Envelope C waste.

Corrosion and chemistry concerns were associated with these four factors (i.e., was there an immediate need to add hydroxide and what impact would that addition have on the chemistry of the current contents of AN-102 and AN-107). When these factors and the hydroxide chemistry issues were dissected, a set of three groups of alternative approaches for delivering waste feed from AN-102 and AN-107 resulted. One group of four alternatives was based on needing to add hydroxide to mitigate corrosion, without the hydroxide adversely altering the chemistry of the waste. The second group of four alternatives was based on not needing to add hydroxide to mitigate corrosion. The third group of two alternatives was based on needing to add hydroxide to mitigate corrosion, with the hydroxide adversely altering the chemistry of the waste.

The discussion of this reduction in the number of alternatives was documented in Section 5.1 of RPP-5311. Determining which set of alternatives actually applied was based on understanding the corrosion and chemistry issues associated with AN-102 and AN-107. The analyses of the corrosion and chemistry issues are presented in Section 4.0 of this study.

3.6 PROGRAM DIRECTION (SEPTEMBER 1999)

Based on information resulting from the above efforts, the program staff recommended to DOE the logical path for delivering waste from AN-102 and AN-107. Those discussions resulted in program direction from DOE on delivering waste from AN-102 and AN-107 (DOE-ORP 1999a and 1999b).

This program direction specified that (1) AN-102 would be the first feed tank; (2) AN-102 would also be a staging tank, replacing AN-106; (3) feed from AN-102 and AN-107 would be delivered directly to BNFL; and (4) corrosion inhibitor (caustic) could be added to AN-102 and AN-107 if required to resolve safety issues. An engineering study was determined to be more appropriate than an AGA because a formal decision was no longer required.

3.7 INTERIM GUIDANCE (OCTOBER 1999)

Because Project W-521 (W-211B) needed input by October 1999, interim guidance was provided on specific equipment functional requirements for processing, certifying, transferring, and delivering waste contained in AN-102 and AN-107 (see Appendix C). This guidance incorporated the just-issued program direction and described the risks associated with accepting each functional equipment requirement, given that there were substantial analyses to be performed beyond mid-October.

3.8 ACTION MEMORANDUM (NOVEMBER 1999)

On November 8, 1999, the "Action Memorandum – Simplifying Efforts on AN-102 and AN-107 Evaluations" was issued (Appendix D). Based on the prior focusing and documentation, this memorandum requested that the efforts on AN-102 and AN-107 be reduced by stopping work on the AGA and the associated formal decision. The memorandum suggested that efforts continue by performing a less formal engineering study. The engineering study was to focus on evaluating the risks associated with DOE's program direction for delivery of AN-102 and AN-107 waste and the future use of the tanks. Three uncertainties that required attention were identified:

1. Chemistry changes in the contents of AN-102 and AN-107 after addition of free hydroxide

2. Feasibility of direct delivery of supernate from AN-102 and AN-107 to BNFL

3. Fitness for use of AN-102 as a staging tank.

The remainder of this engineering study will focus on (1) verifying that DOE's program direction for delivering waste from AN-102 and AN-107 and future uses of AN-102 are technically feasible and (2) documenting any risks associated with this approach.[6]

[6] At the time of final issue of this engineering study, a new Baseline Case 3S6E (2006 Hot Start) was approved. In this baseline case, AP-101 is the first LAW waste feed source tank, with AN-102 being the second LAW waste feed source tank. AN-107 becomes the fourth LAW waste feed source tank. All elements associated with delivering waste from AN-102 and AN-107 addressed in Baseline Case 3S5 are directly transferable to waste delivery and future uses in the new Baseline Case 3S6E.

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4.0 WASTE FEED DELIVERY STRATEGY ANALYSIS

4.1 ANALYSIS OF TANK 241-AN-102 PREFERRED PATH FOR WASTE FEED DELIVERY

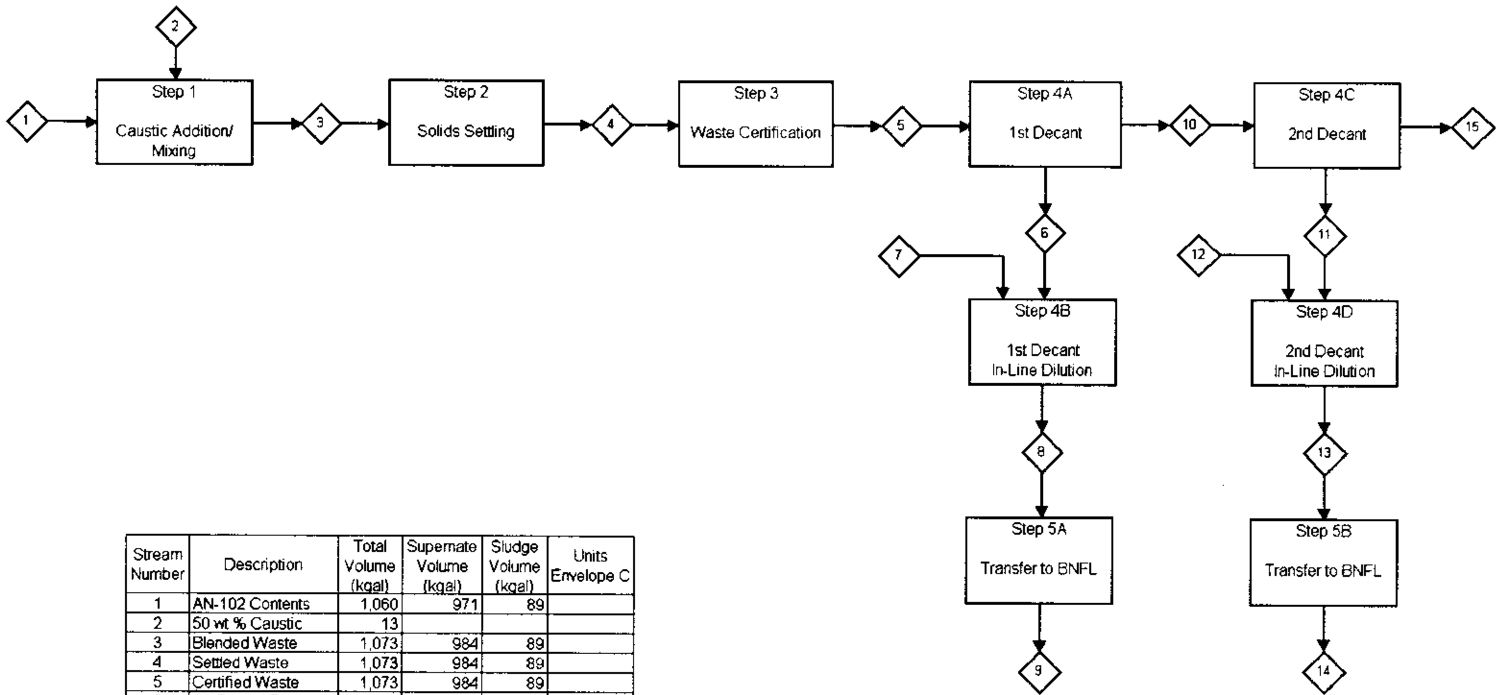
Based on the evolution of events discussed in the Section 3.0, a preferred path was prescribed for delivery of waste from AN-102 to BNFL. This path is presented as simplified a flowsheet in Figures 4-1 and 4-2. The path consists of several steps, each of which will be analyzed in this section. Appropriate contractual and programmatic requirements are stated to provide the framework for understanding this preferred path. Although this section is based on Baseline Case 3S5 (Garfield 2000c), current until mid-February 2000, all findings and actions associated with processing, certifying, transferring, and delivering of AN-102 and AN-107 waste to BNFL are transferable and applicable to the now-current Baseline Case 3S6E (2006 Hot Start) (Garfield 2000d).

4.1.1 Contractual and Programmatic Requirements

The following contractual and programmatic requirements were used as the basis for analysis of the AN-102 waste feed delivery preferred path.

- AN-102 is the first feed tank for Phase 1B waste feed delivery (DOE-ORP 1999a).
- A minimum of 300 units and a maximum of 1,200 units of LAW must be delivered to BNFL from the first tank (DOE-RL 1998).
- The first batch of AN-102 waste must be transferred to BNFL by July 2008. The second batch of AN-102 waste must be transferred to BNFL by May 2009 (Baseline Case 3S5).
- AN-102 waste must conform to Envelope C compositions, including the requirement of <2 wt% entrained solids in the delivered feed (DOE-RL 1998).
- AN-102 will be the second staging tank (AN-101 is the first one) for Phase 1B LAW feed delivery (DOE-ORP 1999a).
- AN-102 contents must conform to existing corrosion protection specifications (OSD-T-151-00007) or a waiver from strict compliance must be granted.
- Corrosion inhibitor (caustic) up to a 0.5 M concentration of free hydroxide can be added to the waste in AN-102 if required to resolve safety issues (DOE-ORP 1999b).

Figure 4-1. Tank 241-AN-102 Feed Retrieval Flowsheet.

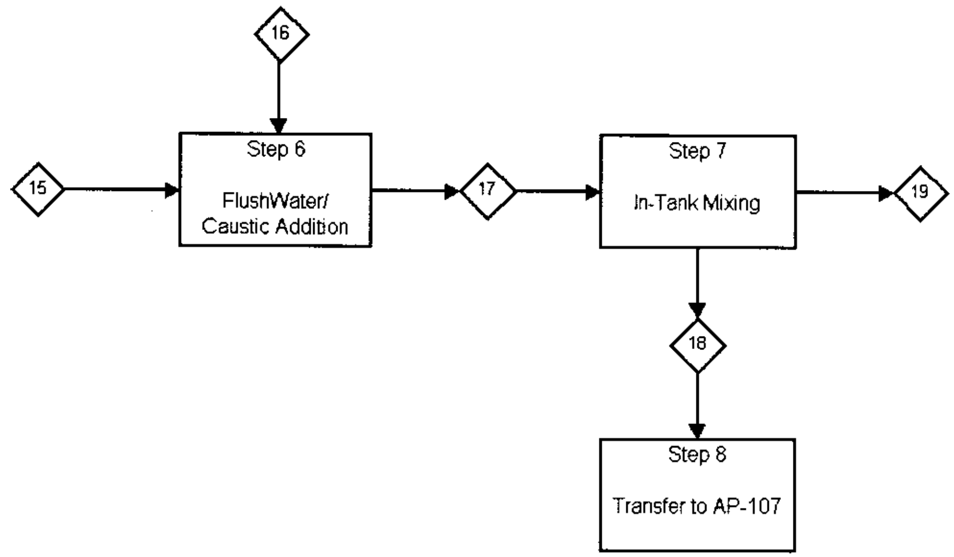


Stream Number	Description	Total Volume (kgal)	Supernate Volume (kgal)	Sludge Volume (kgal)	Units Envelope C
1	AN-102 Contents	1,060	971	89	
2	50 wt % Caustic	13			
3	Blended Waste	1,073	984	89	
4	Settled Waste	1,073	984	89	
5	Certified Waste	1,073	984	89	
6	1st Decant Batch	478	467	11	
7	Dilution Water	110 (276)			
8	Diluted Feed	588 (754)	577 (743)	11 (11)	
9	BNFL Feed	588 (754)	577 (743)	11 (11)	510
10	AN-102 Contents	595	517	78	
11	2nd Decant Batch	478	467	11	
12	Dilution Water	110 (276)			
13	Diluted Feed	588 (754)	577 (743)	11 (11)	
14	BNFL Feed				510
15	AN-102 Contents	117	50	67	

Notes

1. Numbers reflect values provided in Appendix F, "Flowsheet Input on Tank 241-AN-102 Waste."
2. Numbers in parenthesis ( ) reflect values being used in Case 3S5.
3. Flowsheet shows that caustic will be added to the waste. However, recommended testing of the waste for corrosion potential may find that caustic addition is not required.

Figure 4-2. Tank 241-AN-102 Solids Cleanout Flowsheet.



Stream Number	Description	Total Volume (kgal)	Supernate Volume (kgal)	Sludge Volume (kgal)	Units Envelope C
15	AN-102 Contents	117	50	67	
16	Flush Water	200			
17	Diluted Waste	317	50	67	
18	Heel Waste	289	268	21	
19	AN-102 Contents	28	26	2	

Notes 1. Numbers reflect values provided in Appendix F, "Flowsheet Input on Tank 241-AN-102 Waste."

4.1.2 Initial Conditions

Tank AN-102 contains 3.68 ML (971 kgal) of Envelope C supernate and 0.034 ML (89 kgal) of sludge. The composition of the supernate complies with all chemical and radiochemical analyte limits that constitute Envelope C waste (see Appendix E). The solids are believed to contain the typical metal oxides and hydroxides as well as several precipitated sodium salts. About two-thirds of the solids (most likely sulfates and carbonates) can be dissolved with extensive dilution. There are 62,900 kg of aluminum in AN-102, with most of it in the supernate (e.g., only 6,170 kg of aluminum are in the sludge). Most of the aluminum in the sludge is in solution in the interstitial liquid. There is evidence of solid phase aluminum in the sludge, but it is not washable by water nor dissolved by caustic; therefore, it is not gibbsite. It is most likely an aluminosilicate. The solids are expected to contain limited amounts of fluoride/phosphate and fluoride/sulfate double salts and sodium oxalate (Appendix F).

> **Risk.** Appendix E is based on the latest Best Basis Inventory information on the contents of AN-102.[7] The information in the Best Basis Inventory for AN-102 is based on sampling and analyses performed over several years and is documented in HNF-SD-WM-ER-545. All components are comfortably below the maximum limits for each chemical and radiochemical analyte. Data for lanthanum and mercury are available but not reported in Appendix E; their values are well below the Envelope C limits (HNF-5187). Waste from AN-102 is expected to conform to the Envelope C requirements; therefore, the risk of Envelope C noncompliance is considered to be low.

There are ~300 m^3 of freeboard in this tank (Appendix F). Temperatures of AN-102 waste generally remain near 29 °C (85 °F) (based on the Tank Waste Information Network System database).

The equipment currently in AN-102 is listed in Memorandum-I (RPP-6011), Section J. This equipment consists primarily of pressure and temperature measurement instrumentation. There is a transfer pump in Riser 005. The extent of debris existing in the tank is not fully known. It is expected that debris in this tank would be similar to that expected in other tanks (e.g., gloves, sludge weights with attached cables, rocks, tapes) and, therefore, should be part of the existing Project W-211 design criteria (HNF-SD-W211-FDC-001). An engineering study (RPP-5982) is under way to evaluate the debris issue in feed tanks.

The contents of AN-102 have not met the DST operating specification requirements for corrosion protection for at least 4 years. The current value of AN-102 is 0.21 M free hydroxide, derived from the waste nitrate and nitrite levels and waste temperature (HNF-SD-WM-ER-545), with the corrosion protection specification value being 0.3 M free hydroxide (OSD-T-151-00007). In February 1985, AN-102 was first identified as a tank not complying with corrosion protection requirements (Sloughter and Miller 1996). The waste composition of AN-102 places AN-102 in the stress corrosion cracking region (Appendix G).

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[7] Information used to construct the table in Appendix E was obtained in the January 2000 update of the Best Basis Inventory for AN-102. Appendix E is an update of Appendix I of HNF-SD-WM-SP-012.

Risk. The initial integrity assessment of AN Farm DSTs was completed in FY 1999 (HNF-4860) to satisfy requirements of WAC 173-303-640(2). Minimal consideration was given in this assessment to operating conditions and waste characteristics relevant to the planned use of AN-102 and AN-107 as staging tanks for waste feed delivery. Once those conditions are better defined, and before these tanks are used for waste feed delivery operations, the existing integrity assessment should be updated and the fitness of the tank for use should be recertified. Because AN-102 has operated outside of the DST operating specification requirements for corrosion protection (OSD-T-151-00007), there is a risk that the tank will not be certified fit for use as a staging tank or that the certification process will be so lengthy it will impact waste feed operations.

Key RPP corrosion, operations, and regulatory personnel and an independent engineer have determined that AN-102 would likely be certified as fit for use in a timeframe that would support the waste feed delivery schedule (see Appendix G). Therefore, the risks associated with the fitness-for-use determination are believed to be low if the following recommended mitigative measures are implemented:

- Performing an adequate ultrasonic examination of the primary tank to verify that unacceptable corrosion has not occurred.
- Calculating the stresses in the primary tank to determine if sufficient stress exists to promote stress corrosion cracking
- Conducting corrosion monitoring to assess corrosivity of existing waste in AN-102 to determine if an unacceptable corrosion condition currently exists in the tank.

These measures should be implemented as soon as possible (see Appendix G).

Another issue that was addressed was the retainment of gas in the tank. The level of solids in AN-102 combined with the specific gravity of the waste result in a product that is significantly below the threshold for concern over gas retainment (Memorandum-I [RPP-6011]). Therefore, concern over tank waste turnover or excess hydrogen retention is not warranted.

4.1.3 Step 1 – Caustic Addition/Mixing

Baseline Case 3S5 proposes that caustic be added to AN-102 in October 2001. This is an arbitrary date that will most likely change after results from the recommended mitigative measures are known. These results will either warrant immediate caustic addition, support delay until the mixing equipment for tank staging is installed, or eliminate the need to add caustic. Because this caustic addition will have no impact on the solids volume within the tank or the overall tank chemistry (Appendix F), this engineering study will take the conservative track and assume that caustic will be added in October 2001, as specified in Baseline Case 3S5.

If the mitigative measures establish that caustic does not need to be added, then this step in the flowsheet should be disregarded. Project W-211 staff should weigh how they wish to approach this uncertainty in the conceptual design of the equipment required for AN-102 waste feed retrieval. If caustic addition cannot be delayed, then equipment should be designed that will add caustic in the immediate vicinity of the mixing apparatus and will adequately disperse the caustic or depend on recirculation of tank contents.

The volume of caustic required to raise hydroxide levels from 0.21 M to 0.5 M is 0.05 ML (13 kgal) of a 50 wt% caustic solution (Appendix F).[8] The cost of adding caustic depends on when it is added. Project W-211 will incorporate caustic addition and mixing capabilities in AN-102 (HNF-SD-W211-FDC-001) by July 2005 (Baseline Case 3S5). If caustic addition can wait until these upgrades are in place, the only expense will be the caustic and the labor associated with the addition. The feasibility and merits of accelerating the placement of staging tank mixing equipment in AN-102 needs to be evaluated after the results of the mitigative measures are known. If caustic needs to be added immediately, a detailed cost estimate is required. For comparison purposes, the cost so far to prepare for the addition of caustic to Tank AN-107 (e.g., planning, design, construction, equipment, installation, associated labor) is approximately $3 million, with an estimated $1.4 million still required (personal communication between Kelly Carothers and Dean Tulberg, January 3, 2000; TBR 190.N45 and TBR 190.N52 [TWR-3988]). No increase in cost for processing and final disposal of AN-102 waste feed should result because BNFL will be raising the caustic concentration to >0.7 M to support their processing activities of this type of waste (Gasper 2000).

Risk. The chemical composition (free-hydroxide concentration) of the waste in AN-102 is currently outside the requirements defined by the DST operating specifications (OSD-T-151-00007). This noncompliance could lead to excessive corrosion and premature failure of the primary tank.

Technical staff participating in the fitness for use meeting believe that the risk of premature failure of the primary tank is sufficiently low to allow additional testing to be conducted before deciding if caustic addition is required (Appendix G). Process control personnel have stated that gathering data by measuring electrochemical noise of the actual waste[9] and ultrasonic testing of the primary tank during the next year are warranted before committing to the expense of caustic addition (Sloughter and Miller 1996)

This engineering study assesses only the technical risks and does not assess the programmatic risks of not adding caustic to AN-102. These programmatic risks (e.g., not conforming to established operating specifications) should be weighed by management.

Starting design work now on the special equipment needed for early caustic addition to AN-102 is not costly. If management expeditiously pursues the recommended mitigative measures, then decisions can be made on the need for early caustic addition before efforts beyond the design of caustic addition equipment are started.

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[8] The actual volume of caustic added will be determined by incrementally adding a portion of the caustic expected to be needed, taking a sample of waste after the caustic is mixed, measuring the free hydroxyl ion concentration by a laboratory caustic demand test, and continuing to add caustic incrementally until the desired level is reached.

[9] Measurement locations need to be representative of the actual conditions in both the supernate and sludge.

4.1.4 Step 2 – Solids Settling

After caustic is mixed in AN-102, the solids will need to settle. Envelope C waste for delivery to BNFL must have <2 wt% solids. Laboratory settling data on waste taken from AN-102 show that the solids in the tank exhibit the typical settling behavior expected--an initial rapid settling that begins to slow when the slurry volume is about twice the terminal volume, followed by an extended period of compaction. The supernate should have much less than 2 wt% solids within 6 months of settling (Appendix F).

Risk. There is little risk of solids remaining in the supernate at the time of waste delivery if caustic is added within the next couple of years. Certification of AN-102 waste does not begin until May 2007 (Baseline Case 3S5). Even if caustic is added shortly after installation of mixer equipment (August 2005), there is more than enough time for solids settling. If caustic is added and tank contents mixed just before waste certification, then there will be a risk of nonconforming waste (i.e., solids content too high in supernate).

4.1.5 Step 3 – Waste Certification

Waste certification of AN-102 is planned to begin in May 2007 (Baseline Case 3S5). The supernate from AN-102 will be divided and delivered to BNFL in two batches. Although Baseline Case 3S5 shows that a certification is performed on each batch of supernate transferred to BNFL, there will be only one certification of the entire tank supernate. Baseline Case 3S5 will be corrected to reflect this position. The current procedure for certifying that LAW waste conforms to the applicable envelope is contained in BNFL-5193-ID-19, which requires that the tank contents be mixed to ensure homogeneity and then immediately sampled for certification. Waste from AN-102 will be delivered directly to BNFL. No approved certification procedure exists at this time for direct transfer waste. Discussions have begun on how to certify direct transfer waste. When a procedure for certifying direct transfer waste is formalized, any additional equipment requirements for certification can be defined. At this time, it is premature to anticipate how the certification requirements currently in BNFL-5193-ID-19 will be modified to establish that the direct transfer supernate is conforming to the envelope specifications.

4.1.6 Steps 4A and 4B – Decant and Dilution

Baseline Case 3S5 assumes that there are two separate decants of supernate from AN-102. Step 4A represents the first decant. The first decant will take place in early May 2008 and last ~4 days. During this initial decant cycle, 1.77 ML (467 kgal) of supernate and 0.04 ML (11 kgals) of solids will be decanted. The 0.04 ML (11 kgal) of solids are part of the standard assumption in Baseline Case 3S5 that up to 0.5 wt% solids is entrained in the supernate. Data from supernate sampling show the weight percent solids in the supernate of AN-102 to be substantially less than 0.5 wt% (HNF-SD-WM-DP-310). In Step 4B, ~0.42 ML

(~110 kgal)[10] of dilution water will be added in-line at the temperature of the waste, resulting in 2.23 ML (588 kgal) of AN-102 waste being transferred. Dilution ensures that the specific gravity of the supernate is ≤1.35, allowing the supernate to be pumped without undue concern about line plugging (Appendix F and Baseline Case 3S5).

Because it is expected to be a staging tank, AN-102 will require both decant and mixer equipment. Under Project W-211 (staging tank equipment design), efforts are under way to design the appropriate combination of decant and mixer equipment (HNF-SD-W211-FDC-001). The standard equipment should easily accommodate the decant and transfer of the supernate in the timeframe allotted for transfer. The supporting equipment requirements for in-line dilution addition (or pump intake) are standard for any in-line (pump-intake) water addition and are already incorporated into Project W-314 transfer design and equipment requirements (HNF-5109).

Risk. There are no risks associated with this decant or dilution.

4.1.7 Steps 4C and 4D—Decant and Dilution

Steps 4C and 4D are associated with the second decant and dilution of supernate from AN-102. The second decant will take place in late June 2009 and last ~4 days. During this second decant cycle, 2.23 ML (467 kgal) of supernate and 0.04 ML (11 kgal) of sludge will be decanted. Approximately 0.42 ML (110 kgal) of dilution water will be added at the temperature of the waste, resulting in 2.23 ML (588 kgal) of AN-102 waste being transferred. Dilution ensures that the specific gravity of the supernate is ≤1.35, allowing the supernate to be pumped without undue concern about line plugging (Appendix F and Baseline Case 3S5).

The last 25 cm (10 in.) of supernate above the original height of the sludge layer will not be decanted from AN-102. Leaving this supernate reduces the likelihood that the decant equipment will remove any sludge (i.e., ensuring that the solids content of the decanted supernate remains substantially below 2 wt% solids [DOE-RL 1998]).

Risk. In the second decant cycle, there is a risk of decanting enough sludge to impact the solids limit of the delivered waste. Additional caution may be justified in the second decant cycle because there is some uncertainty about the amount of sludge in AN-102. (It is estimated that the weight percent solids in the entire tank could be up to 4 wt% solids if the tank were thoroughly mixed [see Appendix F]). Additional precautions could include using in-line instrumentation to detect significant changes in entrained solids and/or designing the suction of the decant pump to have limited suction range. The likelihood of incorrectly positioning the suction of the decant pump so that 1 m (3 ft) of sludge is entrained is not high. At least 1 m (3 ft) of sludge would have to be removed during decanting to cause the solids content of AN-102 supernate to approach the

[10] Baseline Case 3S5 uses 1.04 ML (276 kgal) of dilution water. Numbers used in this report are based on more careful analysis that focuses specifically on AN-102 waste feed delivery. It is expected that the amount of dilution water will be adjusted in future baseline cases to approach this lower value.

contract limit of 2 wt% solids. This contract limit is based on the solids content of both decants.

The 0.08 ML (22 kgal) of sludge (0.04 ML [11 kgal] in each of the two batches) assumed to be entrained in the supernate (Baseline Case 3S5) is not supported by the supernate characterization. Substantially fewer solids will likely be decanted, leaving up to the original 0.34 ML (89 kgal) of sludge or 101,000 kg of solids (Appendix F). This will have a more significant impact on the tank cleanout.

After decanting there will be 0.44 ML (117 kgal) remaining in AN-102, 0.19 ML (50 kgal) of liquid and 0.25 ML (67 kgal) of sludge (Baseline Case 3S5). The 0.19 ML (50 kgal) of liquid is a combination of the 0.11 ML (28 kgal) (25 cm [10-in.]) buffer of supernate left above the original solids level and 0.08 ML (22 kgal) of solids-free volume that will result if 0.5 wt% solids are transferred with the supernate.

4.1.8 Step 5 – Transfer Directly to BNFL Inc.

Supernate from AN-102 is to be directly transferred to BNFL in two equal batches (2.23 ML [588 kgal] each) without being placed into an intermediate waste feed staging tank (DOE-ORP 1999a). An estimated 510 units of Envelope C waste will be delivered in each batch. The transfer distance from AN-102 to BNFL is ~2,135 m (~7,000 ft), and each transfer is to take approximately 4 days. An engineering study on the waste feed delivery transfer system (RPP-5346) is under way to evaluate the various contracting requirements and existing pumping constraints to determine what changes, if any, are needed for successfully transferring the waste to BNFL. The requirements for transfer equipment and transfer line monitoring instruments for this low-specific-gravity supernate are easily accommodated by the existing design requirements contained in Project W-314, responsible for equipment design for waste transfer during Phase 1B waste feed delivery (HNF-5109).

Risk. There are no risks anticipated beyond those normal risks associated with transfer of any supernate in or between tank farms. The results from RPP-5346 may identify issues related to the maximum piping pressures permitted in existing AN Farm piping.

4.2 SOLIDS CLEANOUT OF TANK 241-AN-102

Tank AN-102 is likely to be fit for use as a staging tank for Phase 1B waste feed delivery. Before AN-102 could be used as a staging tank, the solids in the tank have to be cleaned out. Figure 4-2 depicts the simplified flowsheet for the solids cleanout of AN-102.

4.2.1 Step 6 – Flush Water/Caustic Addition

To prepare AN-102 as a staging tank, the residuals in the tank have to be diminished and/or removed. A flush would be required to clean out the solids. If caustic addition is not conducted in Step 1, then caustic addition will be required in conjunction with the flush water addition to ensure compliance with the DST operating specifications (OSD-T-151-00007).

If the volume of tank flush water used were 0.76 ML (200 kgal), approximately two-thirds of the residual solids would go into solution (Appendix F) upon thorough mixing. The 0.76 ML (200 kgal) of flush water represent the optimum dilution (approximately 1:1 on a weight basis) to dissolve the maximum volume of solids. This additional flush would dissolve ~67,000 kg of solids, leaving ~34,000 kg of insoluble solids. These 34,000 kg of solids could either be pumped out while still entrained or be allowed to settle. These solids would likely consist primarily of aluminosilicates, uranium, iron, lead, and chromium oxides (Appendix F).

Caustic addition will not change the chemistry of the waste or cause solids dissolution (Appendix F). The equipment required to add caustic to the residuals in AN-102 during flush addition is already built into the flush/dilution addition system design (HNF-5109). The amount of 50 wt% caustic required to bring the solids into compliance with the corrosion protection specification is estimated at 0.002 ML (0.60 kgal). Adding this small amount of caustic during this step is easy and inexpensive. If caustic was not added in Step 1, add it here. This will allow transfer of the residual waste from AN-102 to a receiver tank (i.e., AP-107) without the need for a waiver, which would be required if the waste does not meet corrosion protection specifications.

Risk. There are no risks anticipated beyond those normal risks associated with flushing and adding small amounts of caustic to any tank.

4.2.2 Step 7 – In-tank Mixing

Mixing will be accomplished easily with the mixer pump equipment that Project W-211 has planned for AN-102. The average solids content in the residual sludge is expected to be ~20 wt% with a density of 1.5 g/mL; therefore, the residual sludge is mostly water and mobilization should be easy (Appendix F). Issues related to net positive suction head requirements for mixing low volumes will be handled during the Project W-211 design, based on the mixer pump and transfer pump Level 2 Specification requirements.

Risk. A study is under way to determine which net positive suction head requirements should be included in the mixer pump and transfer pumps Level 2 Specifications. The Project W-211 design group will implement these requirements. The composition of the residual solids should not pose any mobilization problems because the sludge is mostly water.

4.2.3 Step 8 – Transfer Flush to Tank 241-AP-107

Under Baseline Case 3S5, the water flush from AN-102 will be sent to Tank 241-AP-107 (AP-107). The equipment requirements for transferring this flush are addressed by Projects W-211 (HNF-SD-W-211-FDC-001) and W-314 (HNF-5109).

Risk. The decision on whether to leave ~34,000 kg of solids (i.e., the solids that did not dissolve when flush water was added and mixed in AN-102 and allowed to settle) or to keep these solids mobilized and transfer them to AP-107 will be determined by waste feed delivery management.

One factor for management to consider will be the next contents that will be placed in AN-102 for staging to BNFL. Supernate from Tank 241-AN-105 (AN-105) (Envelope A waste) is planned next for staging in AN-102 for staging to BNFL (Baseline Case 3S5). This AN-105 supernate contains significantly less than 0.5 wt% solids (HNF-SD-WM-ER-678). Adding 2.27 ML (600 kgal) of AN-105 supernate along with 1.05 ML (277 kgal) of dilution water to AN-102 will result in feed in AN-102 having <0.5 wt% solids (i.e., 34,000 kg of the 4,228,500 kg of supernate). The entire tank contents can be mobilized and sent to BNFL and easily meet the contract specification of <2 wt% solids. The addition of 2.27 ML (600 kgal) of AN-105 supernate to the 34,000 kg of solids will result in AN-102 contents becoming Envelope A waste (see Appendix E).

Another factor for management to consider is whether BNFL can process the solids into glass or if the accumulated solids will be returned to the DST System.

4.2.4 Future Uses of Tank 241-AN-102

Based on Case 3S5, the planned future use of AN-102 is to operate as an intermediate waste feed staging tank. The projected operations are defined in Table 4-1. Staging tank operations are scheduled to begin in July 2009 with the receipt of AN-105 supernate and continue through June 2016 with the receipt of waste from three additional tanks. The waste to be added to AN-102 during this period is low-specific gravity supernate with significantly less than 2 wt% suspended solids. The equipment requirements for these future uses should be the same as required for the initial feed retrieval activities.

Risk. The details of the specific future uses of AN-102 may change. If these changes are minor, then there is little risk of serious changes in equipment requirements.

4.3 ANALYSIS OF TANK 241-AN-107 PREFERRED PATH FOR WASTE FEED DELIVERY

Based on the evolution of events discussed in Section 3.0, a preferred path can be proposed for delivery of waste from AN-107 to BNFL. This path is presented in the simplified flowsheet shown in Figure 4-3. The path consists of several steps. Each of these steps will be analyzed in this section. Appropriate contractual and programmatic requirements are stated to provide the framework for understanding this preferred path.

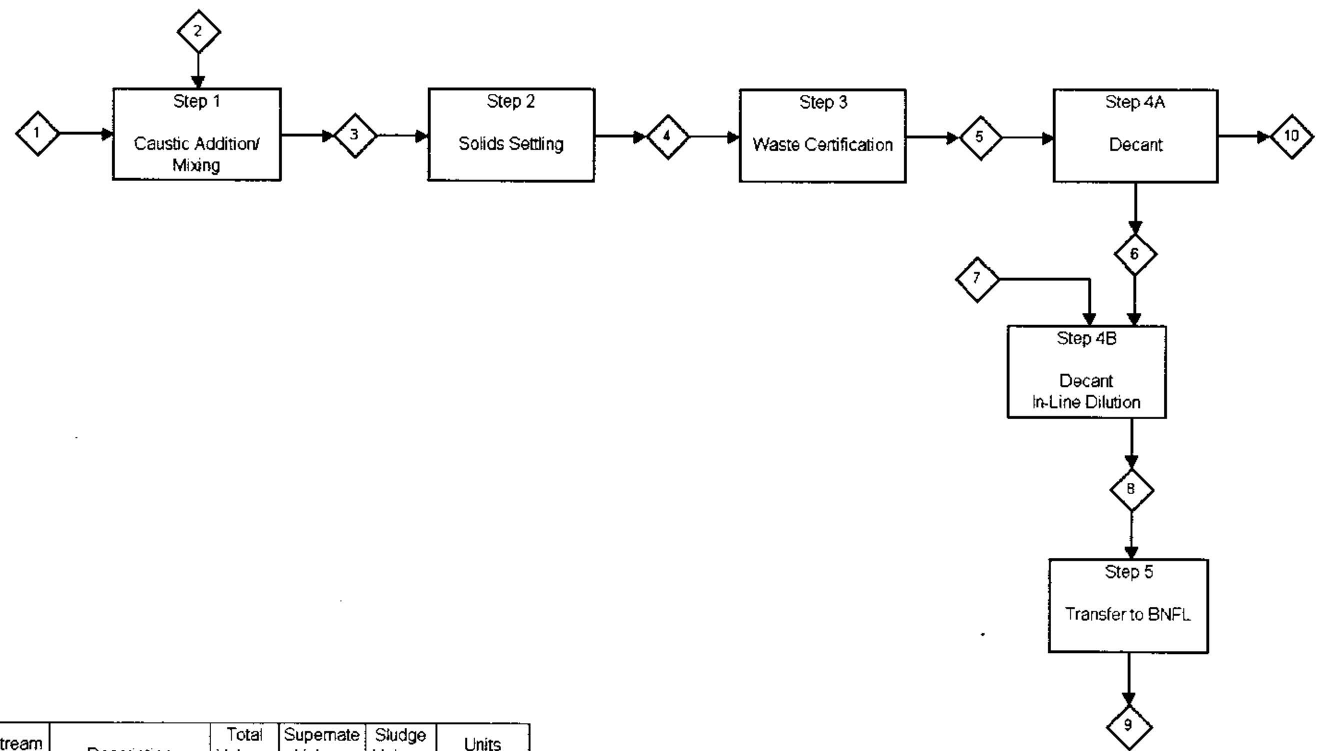
Table 4-1. Future Uses of Tank 241-AN-102 Based on Baseline Case 3S5.

From	To	Beginning Date	Ending Date	Liquid Volume (kgal)	Solid Volume (kgal)	Dilution (kgal)
Wash-Caustic	AN-102	10/01/01	10/01/01	13		
AN-102	SPARE-101*	05/02/08	05/06/08	506	1.2	293
AN-102	SPARE-101	06/27/09	07/01/09	506	1.2	292
Wash-Water	AN-102	07/02/09	07/02/09	140		
AN-102	AP-107	07/02/09	07/02/09	56	0.02	
AN-102	AP-107	07/03/09	07/03/09	84	0.03	
AN-105	AN-102	07/03/09	07/08/09	592	1.5	277
AN-102	SPARE-101	11/22/11	11/26/11	902	5.2	
AN-103	AN-102	11/27/11	11/30/11	494	1.2	287
AN-102	SPARE-101	07/13/13	07/17/13	780	1.3	
AP-106	AN-102	07/17/13	07/20/13	559		29
AN-102	SPARE-101	11/28/15	12/01/15	588	0.04	
AN-104	AN-102	01/15/16	01/19/16	716	9.4	
AN-104	AN-102	06/23/16	06/25/16	387	4.0	

NOTE: To convert kilogallons (kgal) to megaliters (ML), multiply by 0.003785.

*SPARE-101 is the designation used by BNFL Inc. for their receiver tank for AN-102 waste feed.

Figure 4-3. Tank 241-AN-107 Feed Retrieval Flowsheet.



Stream Number	Description	Total Volume (kgal)	Supernate Volume (kgal)	Sludge Volume (kgal)	Units Envelope C
1	AN-107 Contents	1,044	797	247	
2	50 wt % Caustic	55			
3	Blended Waste	1,099	976	123	
4	Settled Waste	1,099	976	123	
5	Certified Waste	1,099	976	123	
6	Supernate Decant	948	895	53	
7	Dilution Water	142 (0)			
8	Diluted Feed	1,090 (948)	1,037 (895)	53 (53)	
9	BNFL Feed	1,090 (948)	1,037 (895)	53 (53)	830
10	AN-107 Contents	151	81	70	

Notes

1. Numbers reflect values provided in Appendix A, "Flowsheet Input on Tank 241-AN-107 Waste." Supernate Decant Volume has been modified from that shown in Appendix A.
2. Numbers in parenthesis ( ) reflect dilution values being used in Case 3S5.
3. Flowsheet assumes that caustic will be added to the waste.

4.3.1 Contractual and Programmatic Requirements

The following contractual and programmatic requirements were used as the basis for analysis of the AN-107 waste feed delivery preferred path:

- AN-107 is the third LAW feed tank for Phase 1B waste feed delivery. In Phase 1B, only AN-102 and AN-107 provide Envelope C waste (DOE-ORP 1999a).
- No more than 2,100 units of Envelope C LAW can be delivered during Phase 1B (DOE-RL 1998). If the expected units of Envelope C waste from AN-102 are delivered (1,020 units, see Section 4.1.3), no more than 1,080 units of Envelope C LAW can be delivered from AN-107.
- Waste from AN-107 will be delivered in one batch and must be transferred directly to BNFL by January 2011 (Baseline Case 3S5).
- AN-107 waste must conform to Envelope C compositions, including the requirement of <2 wt% entrained solids in the delivered feed (1998).
- AN-107 remains available for single-shell tank backfill or other uses after its waste is transferred (Baseline Case 3S5).
- AN-107 will require early caustic addition to ensure tank contents conform to existing corrosion protection specifications (OSD-T-151-00007).
- Corrosion inhibitor (caustic) up to 0.5 M concentration of free hydroxide can be added to the waste in AN-107 if required to resolve safety issues (DOE-ORP 1999b).

4.3.2 Initial Conditions

Tank AN-107 contains 3.02 ML (797 kgal) of supernate and 0.93 ML (247 kgal) of sludge. The waste in AN-107 is designated as Envelope C waste. Except for TRU, the composition of the supernate complies with all chemical and radiochemical analyte limits that constitute Envelope C waste (see Appendix E). Statistical studies (HNF-5314) of the chemical characteristic of AN-107 waste indicate that TOC, ^{60}Co, and TRU have a moderate probability of exceeding Envelope C limits. The TOC concentration of the waste in AN-107 was measured at 81% to 89% of the Envelope C limits (HNF-1653). Once caustic is added to mitigate the corrosion concerns (see Section 4.3.3), the resulting increase in bulk sodium concentration is expected to reduce TOC levels to less than the 80% level of concern. The statistical studies indicated that ^{60}Co had a small probability, 5%, of exceeding the envelope limits when the feed was planned for processing in 2005. Currently, AN-107 waste is planned for transfer to BNFL in 2011. With a 5.27-year half-life, the ^{60}Co concentration will be reduced by >50% from that projected for the 2005 feed delivery. Therefore, ^{60}Co is not expected to exceed the Envelope C waste limits.

AN-107 waste temperatures generally remain near 29 °C (85 °F). AN-107 energetics measurements range from 477 to 667 J/g. This value is above the 480 J/g maximum fuel concentration limit. However, these values are not considered an issue because of the high water content of the waste, which mitigates the risk by controlling temperatures to safe levels through evaporative cooling (WHC-SD-WM-ER-600).

The AN-107 solids contain several components (e.g., aluminum, chromium, fluorine, iron, manganese, lead, PO_4, SO_4, strontium, uranium). Most of the aluminum in AN-107 is in the sludge layer (22,400 kg of a total 23,600 kg, much of it in the form of $Al(OH)_3$). The elevated concentration of chromium in the sludge results from the lack of free hydroxide in the supernate. There is a significant amount of sodium in the sludge, probably in the form of oxalate. The iron in the sludge is ~4,180 kg, with ~8,110 kg in the supernate (Appendix A).

Risk. Based on recent analysis (HNF-1653) and data from the "Best Basis Inventory Data for Case 3S5"(Appendix H), there is a high risk that the total TRU concentration in the AN-107 waste will exceed the Envelope C waste limits. Recent analysis (HNF-1653) indicates that ^{241}Am concentration in the waste is ~130% of the Envelope C limits. Based on this testing, the ^{241}Am is expected to comprise 90% of the total TRU activity in the waste. After hydroxide addition to mitigate corrosion concerns, the ^{241}Am concentration will be reduced but is still expected to be 115% of the limit. Therefore, it is recommended that either an increase be made to the TRU specification for Envelope C or a formal request be made under Clause H43 (1998) for BNFL to determine the price impacts of processing the AN-107 waste with slightly elevated TRU. Informal conversations with BNFL personnel indicate that considerable excess reagent is added for TRU separation. As a result, the process cost impacts should be negligible or zero for handling this slightly higher level of TRU. Formal discussions with BNFL would be required to confirm this information.

There are ~360 m^3 of freeboard in AN-107 (Appendix A). The equipment currently in AN-107 is listed in Memorandum-I (RPP-6011). This equipment consists of pressure and temperature measurement instrumentation. There are also 21 air lift circulators (76 cm in diameter, 5 m long [30 in. in diameter, 17 ft long]). A 56 kW (75 hp) mixer pump that does not meet current flammable gas requirements was installed in 1995. Further efforts by Project W-521 (W-211B) are needed to determine whether this mixing equipment should be made operational. A camera and assembly that do not meet current flammable gas requirements were also installed in 1995. The extent of debris existing in the tank is not fully known. It is expected that debris in this tank would be similar to that expected in other tanks (e. g., gloves, sludge weights, rocks, tapes) and, therefore, should be part of the existing Project W-521 (W-211B) design criteria (HNF-4408). An engineering study (RPP-5982) is under way to evaluate the debris issue in feed tanks.

The contents of AN-107 have not met the DST operating specification requirements for corrosion protection for at least 15 years (WHC-SD-WM-ER-600). The corrosion protection specification value is 0.3 M free hydroxide, derived from the waste nitrate and nitrite levels, waste specific gravity, and waste temperature (OSD-T-151-00007). The value of AN-107 waste has been near or below minimum detection limits (<0.02 M) for 15 years. The chemical characteristics of the waste in AN-107 place AN-107 in the stress corrosion cracking region (Reynolds 1991).

Efforts were funded to add caustic to AN-107 to bring the tank into compliance with the corrosion protection specifications. Approximately $3 million has been expended to date to install the 1995 caustic addition equipment. It is estimated that $1.4 million is still required to complete the caustic addition, assuming the existing equipment is still operable after flammable gas modification (personal communication between Kelly Carothers and Dean Tulberg, January 3, 2000; TBR 190.N45 and TBR 190.N52 [TWR-3988]).

In 1998, an ultrasonic test of AN-107's primary tank showed no excessive uniform corrosion, pitting, or stress corrosion cracking in the section of the tank that was evaluated. This test consisted of two 38 cm (15–in.) vertical sections separated by 15 cm (6 in.). The measurements were made from the upper level of the liner to the lower knuckle. The area measured represents ~1% of AN-107's interior surface. Approximately one-eighth of the tank's lower knuckle was also examined and found to be acceptable (HNF-3353).

4.3.3 Step 1 – Caustic Addition/Mixing

There is currently no indication of excessive corrosion occurring in AN-107. However, it is recommended that caustic be added as soon as possible. This recommendation is based on the following observations.

- From a programmatic perspective, AN-107 is substantially out of compliance with the corrosion-prevention specification. If AN-107 were to fail because of this noncompliance, the outcome would be hard to defend.

- Adding caustic will dissolve about half of the solids currently in AN-107, allowing an additional 123 ML (123 kgal) of free tank space for future waste storage after decanting (Appendix A). Adding caustic will also provide more Envelope C waste (830 units versus 652 units if caustic were not added) (Baseline Case 3S5) and reduce the probability of requiring contingent feed to meet the contract requirement for a minimum of 6,000 units of LAW feed during Phase 1B (DOE-RL 1998).

- A rule was developed to determine if a tank with supernate and sludge is likely to retain gases in the sludge. The rule (HNF-SD-WM-OCD-015) is to multiply the specific gravity (relative to water at 25 °C) by the height of solids in inches. The result (no units specified in HNF-SD-WM-OCD-015) is compared to threshold values to determine when a tank may be prone to retaining gases in the sludge. The contents of AN-107 has a 1.39 sp. gr. (WHC-SD-WM-ER-600) and sludge level of 229 cm [90 in.] (Appendix A). Given these values, the current tank condition in AN-107 results in a value of 126, which is near, but below the threshold of 148 for concern with designation as a flammable gas watch list tank (HNF-SD-WM-OCD-015). Adding the caustic will reduce the solids level in AN-107 by half. The new product will be far below the criteria for gas-retention concerns. Thus, concerns with tank waste turnover or excess hydrogen retention are minimal.

- Adding caustic should not increase the cost for processing and final disposition of AN-107 waste feed because BNFL will be raising the caustic concentration to >0.7 M to support their processing activities of this type of waste (Gasper 2000).

The target level for free hydroxide in AN-107 after caustic addition is 0.5 M. This will be accomplished with the addition of ~0.21 ML (~55 kgal) of 50 wt% caustic, which takes into consideration the buffering capacity of the supernate and sludge (Appendix A). In Baseline Case 3S5, caustic will be added in October 2001. There is sufficient merit to accelerate this addition.

Mixing of the caustic throughout the solids is not expected to be difficult. The solids are expected to be ~8 wt% in the sludge, and the solids density is likely to be 1.47 g/mL. This sludge, therefore, is mostly liquid.

The caustic addition equipment requirement is a mixer that adequately disperses the caustic throughout the tank and ensures that there are no local areas of high concentrations. Because AN-107 will not be a staging tank, the mixing equipment design supporting the 1995 installation should be the starting point for equipment design.

When caustic is added, most of the precipitated $Al(OH)_3$ should go back into solution. A substantial portion of the precipitated chromium should also go back into solution. (This will not cause an envelope-compliance problem.) Sodium salt dissolution is not promoted by the caustic addition. The current 0.93 ML (247 kgal) of sludge will reduce to 0.47 ML (123 kgal) of sludge or 55,000 kg of solids. This sludge contains 4,180 kg of iron, but there are 8,110 kg of iron in solution. If this iron in solution precipitates as $Fe(OH)_3$, the solids will increase by 16,000 kg to 71,000 kg.

Risk. If the mechanism that caused reduced hydroxide levels in AN-107 continues (no clearly understood mechanism has been established), then more caustic may need to be added at some point in the next 10 years before AN-107 supernate is delivered. Adding more caustic will increase the units of LAW waste delivered and could pose a problem with the maximum level of 2,100 units of LAW permitted or could limit cleanout of AN-107. Currently, 1,860 units of LAW Envelope C waste are planned for delivery during Phase IB from AN-102 and AN-107. Bringing AN-107 to a level of 0.5 M requires ~0.21 ML (~55 kgal) of 50 wt% caustic. If this volume of caustic were required again, ~100 additional units of LAW Envelope C waste would result; this is still less than the 2,100 units permitted. If there were inadequate freeboard, then the necessary small volume of supernate could be removed and placed into a DST containing salt cake liquor. At this point, no reliable data exist on the rate at which hydroxide will be consumed; therefore, the frequency at which caustic will need to be added to maintain compliance with corrosion protection specifications is not known. The current level of Envelope C waste is sufficiently below the 2,100-unit limit that two caustic additions could take place in the next 10 years. Therefore, the impact of adding caustic more than once is negligible. The cost of the further addition is small because the equipment needed to add caustic and mix the solution is available and assumed to be maintained.

After caustic is added (by October 2001 or sooner), the future need for additional caustic to protect the primary tank from excessive corrosion could be determined by the placement of a stressed coupon in AN-107 and continued measurement of electrochemical noises in AN-107. Process Engineering and Operations personnel are considering performing such measurements.

The piping, pumping, and caustic-metering equipment needed to deliver caustic to AN-107 are being addressed by Project W-521 (W-211B) (HNF-4408).

4.3.4 Step 2 – Solids Settling

After caustic is mixed in AN-107, the remaining solids need to settle. Envelope C waste delivered to BNFL must have <2 wt% solids. No data are available for solids settling in AN-107. However, AN-107 waste should have settling characteristics similar to AN-102 waste. Based on results from AN-102, the solids settling in AN-107 should be nearly completed in less than 6 months. Certification of AN-107 would occur approximately 10 years after mixing, so settling should not be a problem (Appendix A).

Risk. Settling could be a problem if caustic had to be added in the 2009 time period to address the corrosion protection specification.

4.3.5 Step 3 – Waste Certification

Waste certification of AN-107 is planned to begin in November 2009 (Baseline Case 3S5). The current procedure for certifying that LAW waste conforms to the applicable envelope is contained in BNFL-5193-ID-19, which requires that the tank contents be mixed to ensure homogeneity and then immediately sampled for certification. Waste from AN-107 will be delivered directly to BNFL. No approved certification procedure exists at this time for direct-transfer waste. Discussions have begun on how to certify direct transfer waste. When a procedure for certifying direct transfer waste is formalized, any additional equipment requirements for certification can be defined. At this time, it is premature to anticipate any equipment requirements beyond those already available as part of the standard procedures for sampling and analyzing tank supernate.

4.3.6 Steps 4A and 4B – Decant and Dilution

Baseline Case 3S5 assumes that the supernate in AN-107 is decanted to a level 25 cm (10 in.) above the solids layer. This will provide 830 units of LAW Envelope C waste (after the hydroxide level is adjusted to 0.5 M) in one batch. For pumping, a minimum of 0.15 L of water per liter of supernate (0.54 ML [142 kgal]) will be required by way of in-line dilution. The dilution water temperature should be the same as the waste temperature. These actions will ensure that the specific gravity of the supernate is ≤1.35 (Appendix A and HNF-SD-WM-OCD-015). The equipment requirements (e.g., piping, pumping dilution, metering) for in-line dilution addition are being addressed by Project W-314 efforts (transfer design and equipment requirements) (HNF-5109). The decant is planned to take ~5 days (Baseline Case 3S5). After decanting, there will be ~0.31 ML (81 kgal) of liquid and 0.26 ML (70 kgal) of sludge remaining in AN-107.

To ensure that the contract limit of <2 wt% solids are delivered, steps to prevent decanting of solids are required. One approach is to decant down to some safe level; 25 cm (10 in.) above the sludge height after caustic addition is assumed safe. Other approaches are to deploy, if available, in-line instrumentation to detect significant changes in entrained solids or to design the suction of the decant pump to have limited suction range.

Because AN-107 will not be a staging tank, the requirements for decant equipment will not be linked with the requirements for mixing equipment. The supernate in AN-107 is easily pumpable; therefore, the decant equipment should be the standard equipment routinely employed by Operations (e.g., multiple-stage, vertical, turbine pump (stick pump) or submersible pump with capability for multiple-level deployment) to remove supernate from DSTs.

After caustic addition and mixing, there will be ~55,000 kg of solids in AN-107. This results in substantially less than 2 wt% solids in the total tank contents when the tank is mixed (i.e., 55,000 kg solids and 5,134,900 kg of supernate) (Appendix A). If the iron precipitation issue discussed in Section 4.3.3 arises, the solids would be increased to 71,000 kg, which is still below the trigger level of ~102,700 kg that corresponds to 2 wt% solids if AN-107 were thoroughly mixed. This would allow for the decant and transfer of the entire contents of AN-107 to BNFL. The advantage is that AN-107 would have no significant residual solids content.

Risk. The estimates of remaining solids in AN-107 after caustic addition are believed to be accurate. However, concern still exists that noncompliant waste (i.e., >2 wt% solids) could be delivered if the tank were decanted without allowing for solids settling. The preferred path is to allow AN-107 contents to settle after caustic addition and decant only the supernate. In addition, 25 cm (10 in.) of supernate above the maximum measured solids height should be left in AN-107 for added insurance.

4.3.7 Step 5 – Transfer Directly to BNFL Inc.

Supernate from AN-107 is to be transferred directly to BNFL in one batch (4.12 ML [1,090 kgal]) without first being placed in a staging tank (DOE-ORP 1999a). An estimated 830 units of Envelope C waste will be delivered in one transfer. The transfer distance from AN-107 to BNFL is ~2135 m (7,000 ft), and the transfer should take approximately 5 days. An engineering study on the waste feed delivery transfer system is under way to evaluate the various contracting requirements and existing pumping constraints to determine what changes, if any, are needed for successfully transferring the waste to BNFL (RPP-5346). The requirements for transfer equipment and transfer line monitoring instrumentation for this low specific gravity supernate are easily accommodated by the existing design requirements contained in Project W-521 (W-211B), responsible for equipment design for waste transfer during Phase 1B waste feed delivery (HNF-4408).

Risk. There are no risks anticipated beyond those normal risks associated with transfer of any supernate in or between tank farms. The results from RPP-5346 may identify issues related to the maximum piping pressures permitted in existing AN Farm piping.

The maximum amount of waste that BNFL can accept in one batch is being defined. The nominal maximum volume of transferred LAW feed is expected to be 3.79 ML (1 million gal) (RPP-5993). It is not clear at this point whether there will be an issue in transferring 4.13 ML (1,090 kgal) of waste from AN-107 to BNFL in one batch. The BNFL contract is expected to contain a "top off" provision that allows for delivery of batches larger than

3.79 ML (1 million gal) where only a small amount of waste beyond 3.79 ML (1 million gal) remains in the source/staging tank. As soon as BNFL has room, the small amount of waste that could not be delivered as part of the main batch is delivered as a separate "top-off" transfer and considered as part of the same batch. Approximately the same total volume of waste will be delivered from AN-102 (divided into two batches) as will be delivered in one batch from AN-107.

4.3.8 Future Uses of Tank 241-AN-107

Based on Baseline Case 3S5, AN-107 will be available for storage of waste returned from BNFL, for backfill of single-shell tanks, and for other uses during the remainder of Phase IB. In Baseline Case 3S5, AN-107 completes waste feed delivery activities in March 2011. In the now current Baseline Case 3S6E, AN-107 will be used for backfill of single-shell retrieved tanks shortly after the waste currently in AN-107 is delivered to BNFL.

5.0 EQUIPMENT FUNCTIONAL REQUIREMENTS

This section defines the functional requirements to be used in design or selection of equipment for waste feed delivery operations in AN-102 and AN-107. Table 5-1 provides the summary of the functional requirements for equipment for waste feed delivery for AN-102. Table 5-2 provides the summary of the functional requirements for equipment for waste feed delivery from AN-107. These tables list the nominal operating requirements for these two tanks based on all the analyses summarized in Section 4.0.

Table 5-1. Tank 241-AN-102 Summary Functional Requirements for Equipment for Waste Feed Delivery. (2 sheets)

Processing Step	Requirements
Step 1 – Caustic Addition/Mixing	Add 0.05 ML (~13 kgal) of 50 wt% caustic. • Heat caustic lines to above caustic freezing point. Mix upon addition to uniformly disperse throughout the tank. • Mix caustic so that it is dispersed in both the supernate (3.68 ML [971 kgal] of 1.4 sp. gr.) and sludge (0.34 ML [89 kgal] of 20 wt% solids in sludge with sludge of 1.5 sp. gr.).
Step 2 – Solids Settling	Provide sufficient time after any disturbance of sludge to allow complete settling. • Allow for up to 6 months of settling (conservative).
Step 3-Certification	It is premature to anticipate how the certification requirements currently in BNFL-5193-ID-19 will be modified to establish that the supernate is conforming to the envelope specifications.
Step 4A – First Decant	Decant the top 1.81 ML (478 kgal) of supernate to BNFL Inc. • Supernate consists of 1.77 ML (467 kgal) of supernate and 0.04 ML (11 kgal) of sludge (0.5 wt%) entrained in the supernate. • Bounding supernate specific gravity and weight percent solids after dilution in Step 4B are <1.35 sp. gr. and <2 wt% solids.* Minimize amount of settled–sludge carryover during supernate decant.
Step 4B – In-line Dilution for First Decant (e.g., pump intake dilution)	Add 0.42 ML (110 kgal) to 1.04 ML (276 kgal) of dilution water to the pump intake. • Mixture will contain 0.23 L to 0.58 L of water per liter of supernate. • Dilution water will be added at approximately the supernate temperature (29 °C [85 °F]). Note: Piping, pumping, and dilution water metering are addressed by Projects W-211 and W-314.

Table 5-1. Tank 241-AN-102 Summary Functional Requirements for Equipment for Waste Feed Delivery. (2 sheets)

Processing Step	Requirements
Step 4C – Second Decant	Decant ~1.81 ML (~478 kgal) of supernate to BNFL Inc. • Supernate consists of 1.77 ML (467 kgal) of supernate and 0.04 ML (11 kgal) of sludge entrained in the supernate. • Bounding supernate specific gravity and weight percent solids after dilution in Step 4D is <1.35 sp. gr. and <2 wt% solids.* • Leave ~25 cm (~10 in.) of supernate above the height of the remaining sludge (estimated to be ~109 cm [43 in.] above the tank bottom).
Step 4D – In-line Dilution for Second Decant	Add 0.42 ML (110 kgal) to 1.04 ML (276 kgal) of dilution water to the pump intake. • Mixture will contain 0.23 L to 0.58 L of water per liter of supernate. • Dilution water will be added at approximately the supernate temperature (29 °C [85 °F]).
Steps 5A and 5B – Transfer to BNFL Inc.	Transfer diluted, decanted supernate to BNFL Inc. Bounding supernate transfer *conditions are <1.35 sp. gr. and <2 wt% entrained solids.** Note: Transfer pump and piping for transferring supernate of <1.35 sp. gr. and containing <2 wt% solids are addressed in existing design requirements of Projects W-314 and W-211.
Step 6 – Flush Water/Caustic Addition	Add cleanout solution to AN-102. • Add ~0.76 ML (~200 kgal) of the warmest water available from the water delivery system to increase turbulence and ensure the supernate remains below saturation in major salts. • Add ~0.002 ML (~0.60 kgal) of 50 wt% caustic uniformly to the flush water if caustic was not added in Step 1. Note: Flush and caustic equipment requirements are addressed in existing design requirements for Projects W-211 and W-314.
Step 7 – In-tank Mixing	Mix contents of AN-102: • 0.19 ML (50 kgal) of supernate (1.4 sp. gr.), 0.25 ML (67 kgal) sludge (1.5 sp. gr. sludge with 20 wt% solids in sludge), and 0.76 ML (200 kgal) of flush water.
Step 8 – Transfer Flush to AP-107	Transfer ~1.09 ML (289 kgal) of residuals to AP-107. • Leave ~25 cm (~10 in.) of waste. • 1.01 ML (268 kgal) of supernate and 0.08 ML (21 kgal) of solids with bulk specific gravity of <1.35 and <2 wt% entrained solids will be transferred. Note: Equipment requirements for transferring flush are addressed by Projects W-314 and W-211.

*Nominal supernate after dilution is <1.35 sp. gr. and ~0.5 wt% solids.

Table 5-2. Tank 241-AN-107 Summary Functional Requirements for Equipment for Waste Feed Delivery.

Processing Step	Requirements
Step 1 – Caustic Addition/Mixing	Add ~0.21 ML (55 kgal) of 50 wt% caustic. • Heat caustic lines to above caustic freezing point. Mix upon addition to uniformly disperse throughout the tank. • Mix caustic so that it is dispersed in both the supernate (3.02 ML [797 kgal] of 1.39 sp. gr.) and sludge (0.93 ML [247 kgal] of 8 wt% solids in sludge with sludge of 1.47 sp. gr.).
Step 2 – Solids Settling	Provide sufficient time after any disturbance of sludge to allow complete settling. • Allow for up to 6 months of settling (conservative).
Step 3 – Certification	It is premature to anticipate how the certification requirements currently in BNFL-5193-ID-19 will be modified to establish that the supernate is conforming to the envelope specifications.
Step 4A – Supernate Decant	Decant 3.59 ML (948 kgal) of supernate. • Supernate consists of 3.39 ML (895 kgal) of supernate and 0.02 ML (53 kgal) of sludge entrained in the supernate. • Leave ~25 cm (~10 in.) of supernate above the height of the remaining sludge (height of sludge estimated to be ~66 cm [26 in.] above the tank bottom). • Minimize amount of settled-sludge carryover during supernate decant.
Step 4B – In-line Dilution (e.g., pump intake dilution)	Add ~0.54 ML (~142 kgal) of dilution water to the pump intake. • Mixture will contain 0.15 L of water per liter of supernate. • Water will be added at approximately the supernate temperature (29 °C [85 °F]). Note: Piping, pumping, and dilution water metering are addressed by Project W-521 (W-211B).
Step 5 – Transfer to BNFL	Transfer diluted, decanted supernate to BNFL Inc. • Bounding decanted supernate is <1.35 sp. gr. and <2 wt% solids. • Nominal decanted supernate is <1.35 sp. gr. and ~0.5 wt% solids. Note: Transfer pump and piping for transferring <1.35 sp. gr. supernate containing <2 wt% solids are addressed in existing design requirements of Projects W-314 and W-521 (W-211B).

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APPENDIX A

FLOWSHEET INPUT ON TANK 241-AN-107 WASTE

(PROVIDED BY R. M. ORME)

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DON'T SAY IT — *Write It!*

DATE: December 20, 1999

TO: Paul Certa

FROM: Ron Orme

cc: Stan Blacker

John Garfield

Dean Tulberg

Telephone:

SUBJECT: FLOWSHEET INPUT TO AN-102/AN-107 AGA

A considerable amount of time has been spent on framing and honing the issues and identifying the precise technical information needed to complete the AN-102 and AN-107 Alternative Generation and Analysis (AGA) effort. We are now at a point where additional specific information is needed.

Since you are the key technical person in this area of knowledge, I request that you provide the answers to the specific questions listed below. This information should be provided in written form and will be referenced in the AN-102 and AN-107 AGA.

Please provide this written information to Dean Tulberg by November 15, 1999.

To complete the evaluation of alternatives, mini-flowsheets of the process variants are required. The discussion below identifies the flowsheets required and the information the flowsheets should contain as a minimum.

Note: The following response applies to AN-107. To avoid confusion, a separate response was prepared for AN-102. Responses to the second round of questions are underlined.

Flowsheet #1

An enabling assumption is that hydroxide will be added to the waste in AN-102 and AN-107 to make it comply with the applicable tank corrosion protection requirements. One alternative is to add hydroxide to directly to AN-102 and AN-107 and thoroughly mix the waste, both solids and liquids. After caustic addition, the supernate will be decanted from AN-102 and AN-107 and transferred either directly to BNFL or to a staging tank. The mini-flowsheet for this alternative should identify the following:

1-A. What are the caustic needs for the entire contents of AN-102 and AN-107 to meet corrosion specification requirements in their respective tanks:

- What is the target [OH^-] concentration for the waste?

Lambert (1998) establishes concentrations in AN-107 (p. C-7). Nitrate, free hydroxide, and nitrite are 3.69 *M*, less than detection limit, and 1.33 *M*, respectively. For this nitrate level, free hydroxide should be at least 0.3 *M*, and [OH]+[NO_2] at least 1.2 *M*. **The target concentration for the planned flowsheet revision is 0.5 *M* OH.**

- What is the nominal concentration and volume of the caustic supply to meet the target [OH^-] concentration?

Caustic is normally supplied in bulk as a 50 wt% (or 19 *M*) solution. If caustic is to be added to this tank to satisfy the corrosion specification, **the volume of the addition is 208 m^3.** The final free hydroxide will be 0.5 *M*, and [OH]+[NO_2] will be 1.8 *M*.

Caustic requirement based on a lab study that determined AN-107 waste has buffering capacity (Herting 1995). Caustic demand is 0.039 L per L of supernate and 0.096 L per L of sludge to adjust free hydroxide to 0.5 *M*.

- What is the maximum concentration of the caustic supply allowed (i.e., can 19 M caustic be used without damaging the tank)?

The components of the caustic delivery system must be compatible with 50 wt% caustic. I would make caustic adds with mixer pumps operating to dissipate high concentration and local hot spots. Full-strength caustic would never come in contact with the tank.

1-B. How much room is currently available in each tank to add the caustic?

Available freeboard is about 360 m^3 in AN-107.

Is there sufficient room to add all the caustic needed and not have a problem mixing the "full" tank?

Yes.

If there is not enough room, how much current supernate should be removed to assure that there will be no problem with the addition (heating, expansion from gas generation and chemical reaction, etc). If there is not sufficient room, what would be the resulting free hydroxide level if caustic was added utilizing only the existing space available in the tank.

1-C. If the necessary amount of caustic is added, what will be the compositional changes in the current contents of AN-102 and AN-107?

By inspection of AN-107 composition information, the sludge layer is enriched in several components (Al, Cr, F, Fe, Mn, Pb, PO4, SO4, Sr, U), indicative of solid phases that are likely to be present. There is not nearly as much Al in AN-107 as in AN-102 (23,600 kg vs. 62,900 kg), but unlike AN-102, most of the Al appears to be in the sludge layer (22,400 kg vs 6,170 kg). This is consistent with the virtual absence of free hydroxide in AN-107. Herting (1994) has shown that the high caustic consumption of sludge is primarily from dissolution of $Al(OH)_3$. The high concentration of Cr in the sludge is likewise a consequence of no free hydroxide. One would not expect to see any salts dissolving from an adjustment that increases [Na], so metal/Na for most other things is likely to go down.

(Response to Item 2. We only know composition on an elemental basis, not the molecular species. I have included Table 2 from Herting 1994a so you can see composition of the sludge and how it compares to the supernate. The three elements most enriched in the sludge are Al, iron, and phosphorus. I also included Table 1 where Herting calculates the composition of the solid phase and the wt% solids in sludge. Note that Na also figures prominently in the composition of the solid phase. Herting accounted for the oxalate (Herting 1994c) in a later report and I amended Table 1 with some hand calculations. Sample R4047 had 6.97 wt% solids and R4048 had 8.8 wt% solids after this adjustment. Incidentally, the solids content of the sludge using the water content method -- (1 - 45.64wt%/49.5wt%) x 100 = 7.8 wt% -- is in remarkable agreement with the chemical analysis sum of the components method – (6.97 + 8.8)/2 = 7.9 wt%.

When Herting (1994b See his Table 3) added 19 M caustic to sludge samples, he got order of magnitude changes in dissolved Al. Refering to Herting's Table 1, about 45% of the solid phase is metals and 55% is oxalate/O/OH/CO_3 . If the Al is all $Al(OH)_3$, then caustic would redissolve 59% of the solids. It seems reasonable to say that about half of the solids could be dissolved by the caustic addition and that the only significant change in the solid phase composition is the loss of Al. He also precipitated some Mn and Pb, and a little P and Cr dissolved, but these are small changes compared to Al.)

Will the resulting composition of the supernate meet Envelope C limits?

The caustic adjustment could change Al/Na appreciably as this Al goes back into solution. Some Cr might also dissolve, but the inventory of neither Al or Cr is high enough to put the metal/Na ratio out of feed specification.

(Response to Item 3. We can say that TOC/Na would go down. The caustic leaching data we have on AN-107 doesn't address radionuclides, but I can offer an opinion. In AN-107, as we showed above, the sludge is 92 wt% liquid (only 8 wt% solids) and overall the tank is 98 wt% liquids. The supernate has about the same TRU concentration as the sludge (See Table 2). Some actinides exhibit amphoteric behavior, but there isn't enough solid phase TRU to change the TRU in solution even if TRU leaches out of the solids. TRU/Na is likely to go down. By the same reasoning, Co-60/Na is likely to go down.)

What will be the estimated volume and weight of solids remaining?

Although the sludge layer in AN-107 is larger than AN-102, Herting (1994) determined that the sludge layer is only about 8 wt% solid phase. The estimate of initial solids content based on empirical data is 110,000 kg, about 2 wt% relative to the total inventory, or slightly higher than AN-102. Most of the solids are either Al (expected to dissolve) or sodium salts (not expected to dissolve). After the caustic adjustment, the total solids content is expected to be less than 2 wt%, but with caveats.

What happens to AN-107 Fe over the ten years prior to feed certification? The liquid phase Fe concentration is 33x the concentration in AN-102; total Fe in AN-107 is considerably more (12,290 kg vs. 1,040 kg). One cannot state categorically that this will stay in solution because the complexing power of this supernate could change. If the iron drops out, it would affect the solids content of the tank.

(Response to Item 4. That's not what I said. I said that AN-107 is about 2 wt% solids. The sludge layer is about 8 wt% solids. After the adjustment, the whole tank will be less than 2 wt% solids.

Calculations

Sludge 935,000 L x 1.47 kg/L = 1,374,450 kg x 8 wt% = 110,000 kg solids

Supernate 3,060,000 L x 1,39 kg/L = 4,253,400 kg

So on a whole tank basis, about 2 wt% solids.

After the caustic adjustment, it will be less than 2 wt% solids.)

What will be the new estimate of units of LAW delivered, assuming that we will decant to 10 inches above the solids? Create a new Appendix I (TWRSO&UP) table factoring in the new supernate compositions.

The caustic adjustment adds 208 m^3 and converts part of the sludge layer to supernate, so the total volume available for decanting is 3,636 m^3. The Na delivered is 730 MT or 840 units.

(Response to Item 5. I discussed above that about 50% of the solids might dissolve, which would leave a sludge layer of 468,000 L (123 kgal). The supernate volume after adjustment is 468,000 L (recovered from the initial sludge layer) + 3,060,000 L + 208,000 L (added volume) = 3,736,000 L. Leaving 100,000-L supernate on top of the sludge, 3,636,000 L is available to decant. At 0.2 kg Na/L that's 730 MT Na.

If the total solids content of the tank truly is less than 2 wt%, then the tank could be retrieved while being stirred. In this event, the required heel is 100,000 L, that is, an additional 468,000 L could be retrieved, 94 MT Na. The total in this event is 820 MT or 945 units.)

(Response to Item 6. I was trying to make two points. First, there is a lot more Fe in AN-107 than in AN-102. Two, the iron in AN-107 tends to be more in solution. If the 8,110 kg Fe in solution precipitates, it could triple the 4,180 kg Fe currently in the solids. So instead of having 55,000 kgs of solids left, there could be 71,000 kgs.

The above is based on 3.8% Fe in solids, then 3.8% x 110,000 kgs = 4,180 kg of solid Fe.

Also, 8,110 kgs of Fe makes 16,000 kgs of $Fe(OH)_3$ if it all precipitates).

1-D. Since the addition of the caustic to AN-102 and AN-107 will require the thorough mixing of the tank contents, provide information on the settling of the remaining solids after addition and mixing. Discuss what fraction of the stirred tank can be recovered as supernate and how certain your information is, after allowing 6 months for settling.

There is no settling data on AN-107. However, after the caustic adjustment is made, the nature of the residual solids should be similar to those observed in AN-102. Persons observed the settling of AN -102 solids in nine sample bottles that contained solids (Esch 1998, p. 106). See the plots of dimensionless volume vs. time in the AN-102 writeup. The samples differed only in the centrifuged solids content, that ranged from 13.5 to 28.7 wt%. These settling curves exhibit typical behavior – an initial rapid settling period that is long enough to determine a free settling velocity, settling rate begins to slow down when the slurry volume is about twice the terminal volume, and an extended period of compaction. At the supernate recovery rates exhibited in these curves, the supernate would be mostly recovered in under 6 months. The feed delivery schedule begins certification of this tank 9 years after the adjustment, so there is every reason to believe that the tank will have settled.

1-E. What will be the temperature rise in the tank that results from heat of mixing, shaft work, etc.?

Temperature rise from dilution of caustic into the waste is a few degrees, but mostly from mixer pump input. The projected temperature rise in a tank from mixer pump operation is about 11°C every 5 days (two pumps, full tank, 114 scfm primary flow, 1053 scfm annulus flow).

1-F. What is the volume (ratio water to supernate) of dilution required to meet safe transfer requirements for supernate transfers to either staging tanks or direct to BNFL? What is the viscosity and density of the supernate after dilution?

We are targeting diluted streams to have a density of 1.35 or less. For AN-107, the minimum water addition is 0.15 L of water per L of supernate. Viscosity of full-strength supernate is between 6.9 and 16.5 cP over the temperature range 30 °C to 7 °C. After dilution, supernate should be less than 10 cP based on experience with other liquids that have been diluted and measured.

References:

Herting 1994a, Characterization of Sludge Samples from Tank 241-AN-107, Internal Memo 8E110-PCL94-064, August 10, 1994.

Herting 1994b, Results of Caustic Demand Tests on Tank 107-AN, Internal Memo 8E110-PCL94-092, November 30, 1994.

Herting 1994c, Acetate, Formate, and Oxalate in Tank 107-AN, Internal Memo 8E110-PCL94-067, December 21, 1994.

Herting 1995, Refinement of Caustic Demand for Tank 241-AN-107 Sludge Samples, Internal Memo 75764-PCS95-088, Oct. 5, 1995.

Lambert 1998, TCR for DST 241-AN-107, WHC-SD-WM-ER-600 Rev. 0B, COGEMA.

Persons 1998, Solubility Screening Tests for Tank 241-AN-102, Internal Memo 8C510-98-026, August 31, 1998.

K. G. Carothers
Page 2
August 10, 1994

8E110-PCL94-064

Table 1. Composition of Solid Phase in Tank 107-AN Sludge Samples

Tank Farm ID:	R4047		R4048	
Component	Wt % in Sludge	Wt % in Solid Phase	Wt % in Sludge	Wt % in Solid Phase
Al	1.44	23.0	1.78	22.5
Na	1.28	20.4	1.71	21.6
Fe	0.24	3.8	0.36	4.5
P	0.10	1.7	0.09	1.2
Cr	0.03	0.5	0.04	0.5
Mn	0.01	0.2	0.02	0.2
$O/OH/CO_3$	3.16	50.5	3.93	49.6
Total	6.26	100.0	7.93	100.0

The total amount of actual solid phase in the sludge samples (6.26% and 7.93% by weight) is small, but is consistent with typical Hanford waste tank sludges.

Knowledge of the bulk composition of the sludge is also desirable, especially for evaluating how easy or difficult it will be to mix the caustic with the sludge layer in the tank. Table 2 shows a summary of the bulk composition for each of the sludge samples that was analyzed. The data are derived from calculations shown later (see Tables 11a and 11b). Analyses of earlier supernatant liquid samples (Reference 2) are shown in the table for comparison. Mass balance calculations are explained in depth in the "Calculations" section of this report.

The two sludge samples are virtually indistinguishable from each other. Major differences between sludge and supernate samples show up in the aluminum, phosphate, and iron analyses. All three elements figure prominently in the solid phase, along with sodium, as shown above. However, on the whole, the sludge samples show much stronger similarities to the supernatant liquid samples than differences from them.

One final study described in the original test plan (Reference 1) remains to be done. The same two sludge samples as those described here will be used in a soon-to-be-started study to test whether the solids in the sludge have an effect on the caustic demand of the 107-AN waste. If the aluminum solids were to re-dissolve upon addition of NaOH, then there would be an increase in the amount of caustic that needs to be added to bring the free hydroxide content of the waste up to 0.5 M. These sludge caustic demand studies will be reported in a later internal memo.

Table 2. Composition of Sludge and Supernate Samples from Tank 107-AN
(values in weight percent, except as noted)

Analysis	Supernate Samples (Ref. 2)			Sludge Samples	
	R2686	R3154	R3155	R4047	R4048
SpG	1.~~047~~ 407	1.392	1.384	1.464	1.473
DSC, J/g	694	650	704	442	462
TGA % H_2O	49.7	49.55	49.25	45.45	45.83
TOC	2.99	2.99	3.24	2.63	2.79
TIC	1.22	1.12	0.88	1.00	0.96
Al	0.084	0.085	0.089	1.463	1.806
Ni	0.032	0.032	0.033	0.033	0.033
Fe	0.105	0.107	0.110	0.320	0.466
Ca	0.038	0.038	0.041	0.041	0.046
Cr	0.012	0.012	0.013	0.038	0.053
P	0.029	0.028	0.029	0.139	0.129
Pb	0.023	0.024	0.024	0.031	0.035
K	0.123	0.146	0.188	0.108	0.112
Mn	0.035	0.035	0.036	0.048	0.054
Na	14.431	14.108	14.275	14.030	14.070
S	0.185	0.189	0.218	0.177	0.178
F^-	0.00	0.00	0.00	0.12	0.11
Cl^-	0.25	0.23	0.19	0.13	0.14
NO_2^-	2.95	3.35	4.32	3.86	4.58
NO_3^-	17.88	16.67	16.41	13.40	16.04
PO_4^{3-}	0.03	0.04	0.04	0.41	0.40
SO_4^{2-}	0.79	1.16	1.00	0.83	0.85
MassBal$^{(1)}$	101.6	100.3	100.3	96.2	101.7
AT$^{(2)}$	1.07	1.09	1.01	0.75	0.96
$^{239/240}Pu^{(2)}$	0.035	0.033	0.034	0.08	0.09
$^{241}Am^{(2)}$	0.66	0.58	0.66	0.60	0.79
$^{137}Cs^{(2)}$	302	259	197	334	276
$^{90}Sr^{(2)}$	92	89	99	108	121

(1) see "Calculations - Mass Balance" section
(2) µCi per gram sludge

reported before (References 3 and 4). Although Cr, P, and Mn reactions all contribute to the observed caustic demand of the sludge, their contributions are minor compared to the Al reaction. In order to account for all of the discrepancy noted earlier, it would appear that some other reactant must be invoked, such as an organic weak acid.

Table 3. Concentrations (in mg/L) in Supernatant Liquid Determined by ICP.

	Ref. 2	Cones A/E	Cones B/F	Cones C/G	Cones D/H
[NaOH] Added-->	0.00	0.41	0.63	0.82	0.82
Al	420	3,920	7,120	8,240	8,320
Ca	560	540	600	520	540
Cr	160	200	230	210	230
Fe	1,750	1,720	1,920	1,640	1,760
K	1,750	1,510	1,570	710	1,260
Mn	580	110	150	130	100
Na	200,000	208,000	234,000	206,000	212,000
Ni	560	530	560	480	490
P	570	1,140	1,390	1,260	1,250
Pb	420	330	340	280	290
S	2,920	2,730	2,940	2,480	2,570

OVERALL CAUSTIC DEMAND

The actual caustic demand for the sludge cannot be determined from the tests that were run, because the desired level of free hydroxide concentration (0.50 M) was not reached. The three levels of added hydroxide selected for this study were based on the results from the earlier caustic demand study on the supernate samples. In retrospect (clear hindsight), the levels chosen for the sludge samples should have been higher.

A rough estimate of the sludge caustic demand can be made by extrapolating the data that is available. From the chemical characterization of the sludge (Reference 2), the maximum possible concentration of Al in the liquid phase can be calculated, assuming that all of the Al in the solid phase dissolves.

Your response of November 30, 1999 to the DSI entitled Flowsheet Input to AN-102/AN-107. AGA is appreciated. After review of the information you provided on AN-107, the following questions and requests for clarifications have been developed.

1. When you responded back to the questions sent for Flowsheet Input to AN-102/AN-107, you used the original electronic version of my previous DSI to you without revising it to show that the information was now coming from you and being sent to Paul Certa. Can you please revise this to show the DSI is "From" you, "To" Paul, so that the source of the data can be properly referenced.

   Am-41 7.1E-1 2.75E-1

2. In Item I-C (sludge compositional changes), identifies several cations and one anion (SO_4) in the sludge. Can you identify the compounds that are expected to be in the sludge and the relative wt and vol% of the major compounds in the sludge after hydroxide addition.

   Co-60 8.84E-4 2.55E-4

3. In Item I-C (Envelope C limits), can you provide a composition estimate, after hydroxide addition, (in moles/mole Na or Bq/mole Na) for those constituents previously suspected of being close to or exceeding the Envelope C limits; Co^{60}, TRU, and TOC.

4. In Item I-C (Envelope C limits), you indicate that the wt% solids will go from 8 wt % to 2 wt % solids in Tank AN-107. Please provide the basis for these calculations and a copy of the calculation sheets used to derive this number.

5. In Item I-C (volume and weight of solids), you indicate the wt% of solids will decrease (with caveats) to less than 2 wt % after caustic addition. Can the volume of solids remaining be estimated? Is it safe to assume that the 2 wt % of solids remaining in this tank would be similar in density to those remaining in AN-102 (at 1.8 wt%) and therefore we should expect approximately 100 kgal of solids remaining after hydroxide addition? In your response to the units of sodium question, you indicate that 3,636 m^3 of supernate will be available for decanting. Does this allow for 10 inches of supernate to remain after decanting, therefore you are assuming approximately 110 kgal of solids remaining after hydroxide addition? Please provide your calculation sheet as backup for this calculation.

6. In Item I-C (volume and weight of solids), you appear to indicate that a majority of the Fe is currently in solution. Is this a correct interpretation of this discussion? If the Fe does drop out, what will be the impact on wt % and vol % solids (it appears that their would only be an increase in wt % solids by10 %).

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APPENDIX B

MILLSAP MEETING MINUTES
SEPTEMBER 23, 1999

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Meeting Notes

Purpose: Purpose of the meeting was to determine which fundamental objectives related to safety and regulatory compliance could potentially distinguish between alternatives in the decision to determine the AN-102 and AN-107 feed delivery strategy and the second staging tank in the AN tank farm.

Date: 23 September 99

Location: MO276/131B

Attendees:

Name		
Jeff Ranschau	RPP Safety	373-4464
Peter L. Smith	NRCS	372-2472
Paul Certa	RSD	376-5429
Dave Foust	Rad Eng	376-8215
Kathy Tollefson	LMHC Envir.	373-3035
Ross D. Potter	WFD Program	373-9315
Dean M. Tulberg		373-5116
Joel Millsap	RSD	376-3676

Paul Certa and Joel Millsap opened the meeting by explaining the decision to be made and by discussing the main issues surrounding the decision. The decision to be make is

> Which combination of the following two choices best meets the Waste Feed Delivery (WFD) Program's objectives:
>
> (1) Choice of the method to deliver AN-102 and AN-107 supernate to BNFL: direct transfer of each tank or transfer to BNFL through an intermediate staging tank
>
> (2) Choice of the second intermediate staging tank in the AN tank farm: Tank AN-102 or Tank AN-106.

After the decision was discussed, the group reviewed the fundamental objectives listed below and chose the ones that they thought could potentially distinguish between the alternatives in this case. The objectives reviewed are listed below; the ones that are non-distinguishing are typed in strike-through.

1.0 Maximize Safety
- ~~1.1 Maximize Public Safety~~
  - ~~(a) Radiological~~
    - ~~(i) Chronic Release~~
    - ~~(ii) Accidental Release~~
  - ~~(b) Chemical~~
    - ~~(i) Chronic Release~~
    - ~~(ii) Accidental Release~~
- 1.2 Maximize Worker Safety
  - ~~(a) Radiological~~
    - ~~(i) Chronic Release~~
    - ~~(ii) Accidental Release~~

(b) Chemical
 ~~(i) Chronic Release~~
 (ii) Accidental Release
~~(c) Industrial~~
~~1.3 Maximize Environmental Safety~~
 ~~(a) Biota (plants and animals)~~
 ~~(b) Groundwater & Vadose Zone~~
 ~~(i) Chronic Release~~
 ~~(ii) Accidental Release~~
 ~~(c) Atmosphere~~
 ~~(i) Chronic Release~~
 ~~(ii) Accidental Release~~

2.0 Maximize Compliance with Regulation
 ~~2.1 DOE~~
 2.2 WA Ecology & EPA
 ~~2.3 WA Health & EPA~~

As can be seen from above, only two of the objectives were determined to be distinguishing for this decision:

(1) Worker Safety from Accidental Release of Chemicals: Since some alternatives require the addition of large amounts (tens of tons) of concentrated sodium hydroxide to be added to the tanks, it was concluded that this objective could be distinguishing.

(2) Compliance with WA Ecology and EPA Regulations: In the case of the possible selection of AN-102 as an intermediate staging tank, it will be necessary under Washington State regulations (Chapter 173-303 WAC) to demonstrate that the tank has sufficient integrity to perform its anticipated functions. This will have to be done to the satisfaction of an independent registered professional engineer. To the groups knowledge, AN-102 has been out of specifications for corrosion (to inhibit stress corrosion cracking) for at least 3 years. Given this background, it is likely to take more effort in the case of AN-102 than AN-106 to convince the regulators that the tank is sound. In the worse case, it is possible for the regulators to conclude that the tank is not sound and cannot be permitted.

An additional result from the meeting was that the characterization program has taken photos in many of the tanks and there might have been some taken in AN-102 and AN-107. Kathy Tollefson can check for this for Dean Tulberg.

APPENDIX C

PROPOSED INTERIM GUIDANCE TO PROJECTS W-211 AND W-211B (W-521) ON WASTE FEED DELIVERY AND USE OF TANKS 241-AN-102 AND 241-AN-107

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INTEROFFICE MEMO LOCKHEED MARTIN

From:	Retrieval System Development	82400-99-060
Phone:	376-5429 R3-73	
Date:	October 28, 1999	
Subject:	PROPOSED INTERIM GUIDANCE TO PROJECT W-211 AND W-211B (W-521) ON WASTE FEED DELIVERY AND USE OF AN-102 AND AN-107	

To: W. T. Thompson R3-73

cc:

S. Blacker	R3-73	C. E. Grenard	R3-73
P. J. Brackenbury	R3-73	J. Jo	R3-73
A. B. Carlson	R3-73	R. A. Kirkbride	R3-73
G. P. Chevrier	S2-48	W. J. Millsap	R3-73
A. F. Choho	R3-73	R. M. Orme	R3-73
T. J. Conrads	R3-73	R. L. Treat	H6-64
G. P. DeWeese	R3-73	D. M. Tulberg	R3-73
E. A. Fredenburg	R1-56	DMIC	R1-29
J. D. Galbraith	R3-73	LB File	R3-73
J. S. Garfield	R3-73		

In August 1999, you recognized that the AGA on AN-102 and AN-107 would not be completed in time to assist Project W-521 (now W-211b) in preparing its Conceptual Design Report. You therefore requested that I provide you with our best judgment on the equipment requirements for operating AN-102 and AN-107 during Phase 1B and Phase 1B Extended Order. The attached paper fulfills this request.

Greg Deweese and Phil Brackenbury have reviewed and concur with our recommendations.

This guidance is based on the data available to us at this time and may require revision as new information is identified. If you have any questions, please contact Dean Tulberg at 531-4040 or myself at 376-5429.

Sincerely yours,

Paul J. Certa

P. J. Certa
Manager

cjh

Attachment

82400-99-060

PROPOSED INTERIM GUIDANCE TO PROJECTS W-211 AND W-211B FOR WASTE FEED DELIVERY AND USE OF 241-AN-102 AND 241-AN-107

Consisting of 9 pages
Including cover page

82400-99-060
Attachment

PROPOSED INTERIM GUIDANCE TO PROJECTS W-211 AND W-211B FOR WASTE FEED DELIVERY AND USE OF 241-AN-102 AND 241-AN-107

INTRODUCTION

An Alternatives Generation and Analysis (AGA) study is being prepared for the selection of a low activity waste feed delivery strategy for tanks 241-AN-102 and 241-AN-107 and selection of a second AN farm staging tank. Concurrently with preparation of the AGA, the Project W-211B Conceptual Design Report (CDR) is being prepared. Completion of the CDR on schedule requires interim guidance based on the AGA team's assessment of which of the alternatives will most likely be selected This assessment is based on the AGA team's current views on the process flow sheets for delivering Envelope C waste to the privatization contractor (British Nuclear Fuels Limited (BNFL)) and on the various enabling assumptions, constraints and requirements that are presented in the "Decision Plan" (currently in final draft review). The AGA team based its decisions on source tank feed delivery and tank future uses on the current baseline (Case 3S4) and on the new guidance just delivered from DOE (LMHC Work Authorization, October 1, 1999 to September 30, 2000, signed September 30, 1999 by J. Peschong, ORP, and M. DeLozier, LMHC)). The results of the AGA team's assessment has been incorporated into the interim guidance provide in this document.

This interim guidance document will discuss the risks associated with the tentative conclusions reached in this document. All the risks discussed in this document will be addressed during AN-102 and AN-107 AGA activities.

The material below is based on the current understanding of the programmatic baseline. If that baseline changes, then the interim conclusions reached in this document will need to be reconsidered.

PURPOSE

Provide interim guidance to Projects W-211 and W-211B on equipment requirements for tanks AN-102 and AN-107 as waste feed source and future use tanks and AN-102 and AN-106 as staging tanks.

CURRENT CONCLUSIONS

1) Install necessary hydroxide addition and mixing equipment in AN-102 and AN-107.

    Since AN-102 and AN-107 do not contain sufficient free hydroxide to conform to the tank lining corrosion protection requirements, hydroxide (most likely in the form of 50 wt % NaOH) needs to be added. The best information on the physical properties and chemical composition of AN-102 and AN-107 are found in the

Tank Characterization Reports for each tank (HNF-SD-WM-ER-545 and WHC-SD-WM-ER-600, respectively).

2) Tank AN-102 will provide the first feed to BNFL and will be the second designated staging tank for Phase 1B. Tank AN-102 supernate will be direct delivered to BNFL.

   Mixing equipment appropriate for current and all future uses of AN-102 is required. Assure that valving and transfer lines are sufficiently flexible to allow for staging through AN-101, if settling is a problem.

3) Tank AN-107 supernate will be delivered directly to BNFL.

   Assure that valving and transfer lines are sufficiently flexible to allow for staging through AN-101, AN-102 or any other available staging tank, if settling is a problem.

4) Provide hydroxide and dilution addition capabilities in the transfer lines (or at the pump inlet) from AN-102 and AN-107 to downstream locations.

   Dilution ratios and target hydroxide concentrations will be defined by the flowsheets being developed for these two tanks.

5) Provide decant capability in AN-102 and AN-107 to remove supernate. Provide appropriate instrumentation to ensure that less than 2 wt % bulk solids (for the complete transfer) and 5 vol % solids (on a near instantaneous basis to prevent line pluggage) enter the transfer lines from AN-102 and AN-107.

   Location of solids layer is likely to be indeterminate.

These conclusions are representative of Alternative "4" described in the draft AN-102 and AN-107 Decision Plan.

KEY FACTORS INFLUENCING HARDWARE DECISIONS

- Impact of hydroxide addition on changes to chemistry of AN-102 and AN-107 Envelope C conforming supernate

  This careful analysis establishes whether hydroxide addition to current waste in source tanks is prudent with respect to possible adverse physical property changes and Envelope C compliance impacts. Ron Orme has been asked to begin evaluating this issue.

- Accelerate electrochemical noise corrosion probe system installation in AN-102 and AN-107. Collect and analyze data as soon as possible.

Only the lack of an early funding commitment prevents having needed corrosion information by the Summer 2000 to establish the need for immediate addition of free hydroxide or to demonstrate that the addition of hydroxide is not required. Current schedule is Fall 2001.

ANALYSIS

The remainder of this document contains an analysis of each of the above conclusions. This analysis presents the technical details and the risks associated with each of these conclusions, following the order presented, above.

1) Free hydroxide addition —

Discussion — Laboratory and in-tank data (Reynolds, 1991, *Summary of Corrosion Studies for Tank 107-AN*, 86434-90-121) suggest that AN-102 and AN-107 tank contents are in a stress corrosion cracking regime. Based on these data, the equipment conceptual design for AN-102 and AN-107 should include hydroxide addition and mixing equipment. In-tank addition and in-line addition (because of current uncertainty about resulting supernate composition, see risk a), below) of hydroxide should be planned. The specific equipment needed for hydroxide addition and its mixing are left to the W-211 and W-211B projects. Right now the assumption is to add 50 wt % NaOH at the mixer pump discharge or immediately adjacent to the mixing apparatus, if a non-pump mixer is used. The intention is to prevent the formation of localized zones of highly concentrated NaOH in the tank that will promote stress corrosion cracking. The volume required will be established by Ron Orme. The expectation now is that about 70 Kgal (for AN-107) and 10 Kgal (for AN-102) will be required. The AGA will evaluate the substitution of KOH to reduce the amount of Na added.

The decision on free hydroxide addition will likely wait until completion in late FY2001 of Equipment Engineering's study on measuring the corrosion rates and potential in AN-102 and AN-107. The information needed for this decision could be accelerated, by more than one year, if funding were provided now to purchase, install, operate, and analyze the corrosion information obtained from AN-102 and AN-107.

Since AN-102 and AN-107 are almost full, some supernate may need to be decanted prior to hydroxide addition (Ron Orme is making these calculations). This removed supernate can be combined with the salt well liquor being added to the DSTs.

Mixing during the hydroxide addition will need to mobilize the solids in each tank. The solids have to settle rapidly enough to assure that the amount of remaining bulk solids in the supernate transferred to BNFL is less than 2 wt %.

Risks — a) Chemistry changes: Adding free hydroxide to AN-102 and AN-107 may significantly change the composition of the resulting supernate in AN-102 and AN-107. The degree of change in Envelope C composition in each tank from hydroxide addition is being evaluated by Ron Orme and should be available by December 1999. If there is a significant adverse chemistry change and if hydroxide has to be added immediately to AN-102 and AN-107, then the current supernate will be decanted and hydroxide will be added in-line as the supernate is transferred to a receiver tank. In this scenario, the solids residual in AN-107 will require additional hydroxide. How best to approach hydroxide addition to AN-107 residuals will be established, if the chemistry results warrant such an outcome. Since AN-102 will be a staging tank, placing mixing equipment in this tank is appropriate whether hydroxide is added or not to AN-102.

b) The results of the in-tank corrosion testing will further substantiate the need for hydroxide addition or determine if it is not necessary. If this information were available today, decisions on the need for mixing equipment in AN-107 could be made now (assuming no chemistry concern, see a), immediately above). Since the corrosion information may be available in 24 months and the current information suggests the need for hydroxide addition to AN-107, designing for the addition of such mixing equipment is prudent. Tank AN-107 is not planned for use as a staging tank, therefore the type of mixing equipment installed in this tank could be very different from the equipment installed in AN-102. The viability of using all or part of the existing hydroxide addition equipment installed in AN-107 has not been assessed.

c) The risks are to spend the time and money designing for hydroxide addition and mixing equipment and not needing the equipment; or, not designing for the equipment and needing it.

d) Hydroxide addition may be required before construction activities are initiated for Project W-211B. The current need for and timing of hydroxide addition should be addressed by the appropriate management over-site committee to ensure prudent actions are taken. If immediate addition of hydroxide is required, Project W-211B would not be able to accommodate the accelerated schedule and alternate approaches would have to be implemented.

2) AN-102 as first feed and staging tank —

Discussion — ORP-LMHC Work Authorization, September 30, 1999, states that AN-102 will be a staging tank, AN-102 will be the first feed for Phase 1B Waste Feed Delivery, and AN-106 will not be a staging tank for Phase 1B Waste Feed Delivery. The case addressing these changes has not been created yet (i.e., case 3S5). As a result, the future uses of AN-102 are assumed to be the same type/range of future uses previously established for AN-106.

As a result of hydroxide addition and mixing, if solids settling will be a problem in AN-102, the only staging tank available at that time for solids settling is AN-101. But, AN-101 has to be available for early staging of AN-104 feed. The HTWOS run to establish whether AN-102 could be staged through AN-101, if necessary, has not been run. The expectation is that the amount of Envelope C contained in AN-102 will tie up AN-101 for too long to allow early staging of AN-104 supernate as established by the LAW process strategy decision. Therefore, if settling is likely to be a problem, the prudent decision is to feed AN-102 waste directly to BNFL before source tank hydroxide addition is made, if one can wait. Direct delivery of AN-102 feed will require decant equipment (see number 5, below). This direct delivery change will require an alteration in the waste certification procedure in ICD-19.

The physical and chemical properties of AN-102 and AN-107 needed for designing transfer equipment are found in the current Tank Characterization Reports for each tank (HNF-SD-WM-ER-545 and WHC-SD-WM-ER-600, respectively).

The remaining solids in AN-102 have to be cleaned out, prior to AN-102 becoming a staging tank. The current thinking is to run the staging tank mixing pump(s) to mobilize and then transfer the solids stream to a receiver tank, designated in Case 3S5. Ron Orme is making calculations to determine if mobilization of the current solids would result in a compliant Envelope C. If true, then AN-102 could be cleaned during direct delivery of waste to BNFL.

Since AN-102 has not been in corrosion protection specifications for at least three years, there may be some additional requirements imposed on allowing AN-102 to be used as a staging tank. The Washington State Department of Ecology (WAC Section 173-303-640, 2(a) on Tank Systems) requires a determination "...that the tank system is not leaking or is unfit for use." Ross Potter indicates that this determination is becoming more involved. With the current information that AN-102 is not conforming to corrosion protection specifications and data from PNNL (Reynolds, 1991, Summary of Corrosion Studies for Tank 107-AN, 86434-90-121), the data that must be obtained to ensure the tank is fit for use may be considerably greater than for tanks that have operated within accepted corrosion limits. This need for new data may be expensive and time consuming.

Risks — a) The risks discussed in 1) above, associated with chemistry apply here.

b) As a result of hydroxide addition and mixing, the solids in AN-102 and AN-107 that do not dissolve need to settle fast enough to assure that the supernate directly delivered to BNFL has less than 2 wt % bulk solids. The existing data on settling is limited and with the addition of hydroxide, there may be unpredictable chemistry changes that could affect settling rates. This risk is reduced if AN-102 and AN-107 waste is sent to a staging tank.

c) If the amount of solids in AN-102 would result in a feed stream containing greater than 2 wt % bulk solids, then there will be residual solids in AN-102 that need to be removed before AN-102 can become a staging tank. The difficulty in cleaning out residual solids before AN-102 can become a staging tank is not known now. Ron Orme will be addressing the likely composition of the current solids and the new solids after hydroxide addition. This information should provide insight on how to approach solids removal.

d) If determining that AN-102 is fit for use as a staging tank in accordance with WAC 173-303 requires significant new information and analysis, then there is risk that AN-102 may not be available as a staging tank, when needed.

Since having available additional staging tanks decreases the risk of not having feed available, it would be prudent to have AN-106 available as a staging tank early in the feed delivery cycle. Another alternative would be to rely on the backup staging tanks in AP farm. The viability of the AP farm option for this specific purpose has not been assessed. This would reduce risk of missing schedules, if problems/delays arise in establishing AN-102 as "fit for staging tank use." Current data and analysis indicate that the phosphate ring in AN-106 will dissolve when dilute Envelope C supernate is added and will not pose a problem with the Envelope C phosphate limit (Jaiduk Jo analysis, September 1999).

3) **AN-107 direct delivery**

Discussion — Based on the information from the applicable Tank Characterization Reports, the composition of the material in AN-107 should be similar to the material in AN-102. If the supernate of AN-102 can be directly delivered to BNFL, then the same approach should work for AN-107.

Risks — a) If hydroxide has to be added to AN-107 prior to decanting supernate, then the mixed contents may produce a composition of material that may not settle as rapidly as AN-102. Sending AN-107 supernate to a staging tank may be necessary. To address this concern will require that alternative piping and valving be available to transfer AN-107 to another double-shell tank.

b) Since AN-107 has about 3 times more solids than AN-102, there is increased gas trapping in the solids. This increase could create added solids entrainment concerns during decanting. See 5), below.

4) In-line hydroxide addition and dilution capability

Discussion — Since decisions on where to add hydroxide are not established, flexibility needs to be built into the equipment design. If hydroxide addition is required immediately and unacceptable chemistry changes in the supernate result from hydroxide addition to the source tank, then the current supernate in AN-102 and AN-107 need to be moved to another tank. This movement will require in-line (or pump inlet) hydroxide addition.

The specific gravity of the supernate suggests that the material is at or near saturation in Na salts. To assure trouble free transfer, some degree of dilution will be required. The amount of dilution is being established by Ron Orme. In-line dilution will be needed.

In-line dilution will be a standard requirement, so adding a hydroxide capability should be straight forward.

Risks — Addition of chemicals or dilution water at the pump inlet is planned for numerous tanks as a part of waste feed delivery. Safety analysis activities are being preformed to address this issue on a program wide basis. Therefore, these in-line additions should not pose any risks beyond that which the Waste Feed Delivery Program is already addressing.

5) Decant capability

Discussion — Envelope C waste from AN-102 and AN-107 comes from the supernate of each tank. Delivering only supernate requires decanting. Since there are solids in each tank and there is a minimum amount of low activity waste that must be delivered from each tank, sufficient waste must be decanted to meet order requirements, but not so much that excess solids (greater than 2 wt % bulk or 5 vol %) are transferred. The location of the liquid-solids interface needs to be determined so decanting is stopped before significant solids are transferred.

Instrumentation for measuring or detecting sudden increases in solids loading of the entrained solids in the decanted liquid is recommended to assure that solids beyond 2 wt % are not delivered to BNFL.

Risks — a) Decanting supernate will release trapped gases in the solids. There is some risk that the released gas may entrain substantial amounts of solids which will not settle rapidly. Chuck Stewart (gas release) and Ron Orme (settling) will be asked to address these questions. If there is a problem, it will be more pronounced in AN-107.

b) In-line, real-time instrumentation to measure entrained solids in a liquid stream may not be available, so additional supernate may have to be left in the source tank. The more supernate left in AN-102, the more material that has to be cleaned out of AN-102 before AN-102 can become a staging tank. Additionally, more contingency feed is used to meet minimum order quantities.

c) The more supernate that is left in AN-107, the more complexed waste has to be dealt with during evaporator runs of accumulated AN-107 liquid from staging tanks and line flushes.

APPENDIX D

ACTION MEMORANDUM – SIMPLIFYING EFFORT ON TANKS 241-AN-102 AND 241-AN-107 EVALUATIONS

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INTEROFFICE MEMO LOCKHEED MARTIN

From:	Retrieval System Development	82400-99-068
Phone:	376-5429 R3-73	
Date:	November 8, 1999	
Subject:	ACTION MEMORANDUM – SIMPLIFYING EFFORTS ON AN-102 AND AN-107 EVALUATIONS	

To:	W. T. Thompson	R3-73
cc:	S. Blacker	R3-73
	P. J. Certa	R3-73
	T. J. Conrads	R3-73
	G. P. DeWeese	R3-73
	B. M. Johnson	R3-73
	W. J. Millsap	R3-73
	D. M. Tulberg	R3-73
	R. L. Treat	H6-64
	DMIC	R1-29
	LB File	R3-73

Decision

Reduce the efforts on tanks AN-102 and AN-107 by stopping work on the Alternatives Generation and Analysis and associated formal decision. Continue efforts, by now performing the less formal engineering study, to evaluate the risks associated with U.S. Department of Energy Office of River Protection (ORP) direction on use of AN-102 and AN-107 during Phase 1B and Phase 1B Extended Order.

Background

We have been evaluating the equipment needs for AN-102 and AN-107 as waste feed delivery sources and staging tanks for Phase 1B and Phase 1B Extended Order. We have prepared "Memorandum – I: Tanks 2 and 7-AN Engineering Study" (August 9, 1999), where we presented all relevant issues associated with the processing, transferring, and certifying of waste from each of these tanks. In the draft "Decision Plan" (November 1, 1999), we presented issues related to use of AN-102 as a staging tank. We reduced the number of realistic alternatives from a large number (40 plus) to four realistic alternatives (Section 5), by careful development of enabling assumptions, constraints, and requirements (see Attachment 1), presented in Section 3 of that draft Decision Plan.

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Use of AN-102 as a staging tank and the realistic alternatives were covered in our "Interim Guidance to Projects W-211 and W-211B – Waste Feed Delivery and Use of 241-AN-102 and 241-AN-107" (Interim Guidance), October 22, 1999 (see Attachment 2). In this Interim Guidance, we provided our current thinking on equipment requirements for delivering waste from AN-102 and AN-107 and future uses of AN-102 and AN-107 through Phase 1B Extended Order. For each requirement for equipment, we discussed concerns and risks. This Interim Guidance provided the W-211 and W-211B project teams with relevant information to proceed on their conceptual design efforts.

New direction from ORP (Lockheed Martin Hanford Corporation (LMHC) Work Authorization, October 1, 1999 to September 30, 2000, signed September 30, 1999 by J. C. Peschong, ORP, and M. P. DeLozier, LMHC) was incorporated into the Interim Guidance, above. This has changed significantly the need to perform an Alternatives Generation and Analysis (AGA) on tanks AN-102 and AN-107 for waste feed delivery. This new ORP guidance has directed that waste from AN-102 and AN-107 be directly delivered to BNFL Inc., that AN-102 be the first source feed tank for Phase 1B, that AN-102 be the second staging tank for Phase 1B, replacing An-106, and that AN-107 be the third source tank. Each tank would still deliver the appropriate amount of Envelope C feed. We now have the preferred path prescribed.

These directions from ORP have eliminated the need to evaluate and compare alternatives. Only one alternative remains after incorporating our enabling assumptions, constraints, and requirements presented in our draft Decision Plan with ORP direction. There is now a preferred path (i.e., the remaining alternative), with numerous risks associated with that preferred path. These risks are presented in our Interim Guidance. Obtaining the information to address or resolve these presented risks should be the new focus of this effort on AN-102 and AN-107.

The remaining efforts on AN-102 and AN-107 can now be reduced a few basic concerns and their associated risks:

- chemistry changes in the contents of AN-102 and AN-107 after addition of free hydroxide,
- direct delivery of supernate from AN-102 and AN-107 to BNFL, and
- information needed to establish that AN-102 is fit for use as a staging tank.

Each concern and associated risk needs to be studied and addressed. The resolution of these risks, by collection and analysis of definitive data or by the decision maker where the data are not definitive, will determine how waste will be delivered from AN-102 and AN-107 and the future uses of these tanks.

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Benefits

Reducing the AN-102 and AN-107 effort from an AGA to an engineering study on risks will save significant time and funds. This action will allow the technical team to focus on resolving those risks now facing the decision maker. ORP has dictated the preferred path of how waste will be delivered from AN-102 and AN-107 and what will be the future uses of AN-102. Continuing on with the formal AGA process for AN-102 and AN-107 now that there are no alternatives to evaluate and compare, provides no added value.

Proposed New Deliverables and Schedule

By stopping further efforts on the AGA for AN-102 and AN-107, our focus will be on addressing the risks presented in the Interim Guidance. We will use the format in the Interim Guidance to structure our evaluations. The 5 conclusions and associated risks in the Interim Guidance will become the basis for how we pursue our evaluations and structure our engineering study.

- Draft report on evaluation and where possible, resolution, of risks associated with delivering waste from AN-102 and AN-107 and on using AN-102 as a staging tank for Phase 1B --- January 4, 2000
  - chemistry questions
  - corrosion protection
  - settling questions
  - less than 2 wt % solids
  - HTWOS runs
  - AN-102 clean out
  - fit for use
- Review engineering study (internal and external) --- March 2, 2000
- Issue engineering study --- April 4, 2000

This new focus is being described in a work plan that is being prepared.

Cost and Resources

The shift from an AGA to an engineering study will save money. New cost and resource estimates will be included in the work plan mentioned above.

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Summary

Much progress has been made on understanding and evaluating the issues associated with the use of AN-102 and AN-107 for waste feed delivery during Phase 1B and Phase 1B Extended Order. Our analyses during the summer and early fall 1999 were important contributors to ORP decisions on directing Lockheed Martin to pursue a preferred path.

We now have the opportunity to focus our remaining efforts on a narrower scope --- studying those risks associated with delivering feed from and future uses of AN-102 and AN-107. These are the risks that the decision maker will have to understand and balance as he makes decisions on equipment requirements for AN-102 and AN-107 and their implications on Phase 1B waste feed delivery.

Sincerely yours,

Paul J. Certa

P. J. Certa
Manager

cjh

Attachments (2)

CONCURRENCE:

Warren T. Thompson
Program Principal Engineer
Lockheed Martin Hanford

11/11/99
Date

82400-99-068

Attachment 1

Assumption, Constraints, and Requirements

consisting of 7 pages including coversheet

3.1 ASSUMPTIONS, CONSTRAINTS, AND REQUIREMENTS

This section describes the assumptions to be made to facilitate the decision process, along with the requirements and constraints that will be used in assessing the alternatives. Individual assumptions, requirements, and constraints were assessed to determine if they would be treated as tradable or non-tradable for the purposes of this decision. Non-tradable items are considered fixed and cannot be changed. Tradable items, though they may be constraints or requirements, are treated as changeable for the purposes of assessing modifications to the current baseline. During the risk assessment phase of the decision process, the assumptions, constraints, and requirements that are treated as tradable will be specifically assessed for the risks they introduce for each alternative.

3.1.1 Assumptions

In the context of this decision process, assumptions are credible, but non-validated, restrictions and requirements used to further define the boundaries of the decision and to make the decision tractable. Assumptions are summarized in Table 3-1.

Table 3-1. Assumptions.

No.	Assumption	Basis	Type
A-1	Organic vapor discharges to the environment are controlled by the ventilation system described in the DST primary ventilation system emission control and monitoring decision document.	*Decision Document for the Double-Shell Tank Primary Ventilation Systems Emissions Control and Monitoring Decision* (Millsap 1999).	Non-Tradable
A-2	Hydroxide addition equipment will be installed in AN-102 and AN-107 to mitigate the potential for stress corrosion cracking.	The *TWRS Operation and Utilization Plan* (Kirkbride et al. 1999) baseline assumption 3.1 states that the requirements defined by the Tank Farm Waste Transfer Compatibility Program (Fowler 1999) will be followed. These assumptions were approved by the TWRS Major Assumption Board. Basis for adding caustic is defined in Reynolds 1991, *Summary of Corrosion Studies for Tank 107-AN.*	Non-Tradable
A-3	If hydroxide addition is found to be necessary, hydroxide will be added to the tanks soon after the decision to do so is made in FY 2001.	This is an **Enabling Assumption** based on the assumption that if the tanks are found to be in jeopardy of stress cracking, immediate measures will be taken to protect the tanks, as the loss of a tank would severely impact waste feed delivery operations.	Non-Tradable
A-4	The organics/energetic reactions (exothermic reactions) are within Tank Farm Waste Transfer Compatibility Program (Fowler 1999) requirements.	Moisture content in tanks is high, so slightly elevated energetic levels are not a safety concern. (see TCRs for tanks AN-102 and AN-107)	Non-Tradable
A-5	Co-mingling complexed and non-complexed waste in tanks AN-102 and AN-107 as defined by Case 3S4 is allowed.	DOE direction has been provided that allows the RPP to manage wastes, to the extent practical, in a manner to minimize the processing costs (i.e., minimize conversion of Envelope A waste to Envelope C waste). Kinzer 1998	Non-Tradable
A-6	First campaign of Envelope C waste must deliver 500 to 1300 units (based on emerging ICD-19 criteria).	Draft ICD-19, Rev 3B.	Non-Tradable

Table 3-1. Assumptions.

No.	Assumption	Basis	Type
A-7	The quantity of Envelope C waste (between 300 and 2100 units) to be delivered will be a **derived requirement** based on: a) the risk of decanting supernate that has a total of more than 2 wt % solids, and b) the percentage of contingent feed that will be allocated to accommodate reductions of Envelope C feed delivered to BNFL.	a) 2 wt % solids requirement: TWRS Privatization Contract Amendment, (DOE-RL 1998). b) **Enabling assumption** of the volume to be provided by WFD Program Management.	a) Non-Tradabl e b) Tradable
A-8	Only current supernate AN-102 and AN-107 will be used to make up Envelope C waste for delivery to BNFL (i.e., no intentional dissolution of current solids in either AN-102 and AN-107).	*TWRS Operation and Utilization Plan* (Kirkbride et al. 1999)	Non-Tradable
A-9	Specific gravity of waste during transfer operations must be less than 1.35.	**Derived requirement** to assure major component solubility levels below saturation limits; viscosity and specific gravity are in the pumpable range (i.e., ensure maximum pressure requirements for the DST piping are not exceeded).	Non-Tradable
A-10	Transfer routes are available, after AN-107 supernate is transferred, for further use of AN-107 as required to implement the selected alternative (e.g., base case valve pit configurations support transfers and receipts from sources listed in Table 1-2).	**Derived requirement** from *TWRS Operation and Utilization Plan* (Kirkbride et al. 1999).	Non-Tradable
A-11	Transfer routes are available, after AN-102 supernate is transferred, for further use of AN-102 as required to implement the selected alternative (e.g., base case valve pit configurations support transfers and receipts from sources listed in Table 1-1).	**Derived requirement** from *TWRS Operation and Utilization Plan* (Kirkbride et al. 1999).	Non-Tradable

Table 3-1. Assumptions.

No.	Assumption	Basis	Type
A-12	The durations used in HTWOS modeling of non-base case alternatives will be will be as defined by the O & M Concept. Examples include: • Waste Transfer – 10 days • Mixing – 4 days • Settling – 30 days • Sampling – 5 days • Testing/Doc. – 60 days	*Waste Feed Delivery Technical Basis, Volume IV, Operations and Maintenance Concept* (Carlson et al. 1999).	Non-Tradable
A-13	Certification of waste: Follow ICD-19, Section 3.1 procedures if waste is staged. If waste is sent directly to BNFL, a modified procedure for waste certification will be approved.	**Enabling assumption** to allow assessment of feasibility of direct transfer of supernate from AN-102 and AN-107 to BNFL.	Non-Tradable
A-14	If hydroxide addition in AN-102 and AN-107 prior to feed delivery causes constituents in the supernate to become out of compliance with Envelope C requirements then the supernate will be decanted to intermediate storage tanks to preserve its compositional state.	**Enabling assumption** based on engineering judgement that steps will be taken to maintain the supernate within compliance boundaries if it is practical to do so.	Non-Tradable

3.1.2 External Constraints

Constraints are externally imposed restrictions or requirements. In this decision process, constraints are derived from DOE directions and the TWRS Privatization contract between DOE and BNFL (DOE-RL 1998). External Constraints are summarized in Table 3-2.

Table 3-2. External Constraints.

No.	Constraint	Basis	Type
C-1	All delivered LAW is assumed to be within the BNFL facility permits and safety authorization basis; therefore, no feed blending or adjustments are required.	DOE-ORP 1999, Section 3.2.2.1.	Non-Tradable
C-2	Twenty-eight sound DSTs will be available for the duration of Phase 1B Extended Order. No DSTs will develop leaks, and no new DSTs will be constructed.	DOE-ORP 1999, Section 3.2.3, Assumption 7.	Non-Tradable
C-3	If AN-107 is first batch of waste delivered to BNFL, minimum of 300 units of Envelope C waste must be delivered.	DOE-RL 1998, Section H.9.	Non-Tradable
C-4	If AN-102 is the first batch of waste delivered to BNFL, a minimum of 300 units of Envelope C waste must be delivered.	DOE-RL 1998, Section H.9.	Non-Tradable
C-5	No more than 2100 units of Envelope C will be delivered to BNFL during Phase 1B.	DOE-RL 1998, Section H.9.	Non-Tradable
C-6	A minimum order quantity of 6000 units of LAW will be delivered during Phase 1B.	DOE-RL 1998, Section H.9.	Non-Tradable
C-7	The supernate delivered to BNFL from tank AN-107 must comply with Envelope C composition requirements.	DOE-RL 1998, Section C, Specification 7.	Tradable
C-8	The supernate delivered to BNFL from tank AN-102 must comply with Envelope C composition requirements.	DOE-RL 1998, Section C, Specification 7.	Tradable

Table 3-2. External Constraints.

No.	Constraint	Basis	Type
C-9	In accordance with Clause H.43, out-of-specification feed will be processed by BNFL if it is within their technical ability to process the waste, the facility permits, and facility authorization basis.	DOE-RL 1998. DOE-ORP 1999, Section 3.2.3, Assumption 11.	Non-Tradable
C-10	Waste from tanks AN-102 and AN-107 will not be blended with other wastes.	DOE-ORP 1999, Section 3.2.2, Assumption 22c.	Non-Tradable
C-11	BNFL expects that current waste in AN-102 and AN-107 will be the waste that they receive.	Oral communication with Russ Treat (see Meeting Summary, Discussion of Memorandum-I, issued August 26, 1999, item 8).	Tradable
C-12	Sodium molarity: a) must be between 4 M and 10 M b) must be between 3 M and 10 M The more restrictive sodium molarity limits of between 4 M and 10 M will be used.	a) DOE-ORP 1999 b) DOE-RL 1998	Non-Tradable
C-13	Limit each batch to be delivered to a maximum of 600,000 to 800,000 gallons.	DOE-ORP 1999, Section 3.2.3, Assumption 22b.	Non-Tradable
C-14	Complete batch delivery within 30 days of waste transfer date. (R. Treat is requesting DOE extend the duration to 60 days.)	DOE-RL 1998, Clause H.9.	Non-Tradable

3.1.3 Requirements

A requirement is an essential condition with which alternatives must comply in order to satisfy existing physical and chemical limitations of the system. Requirements have been defined by Level 1 DST specifications, operating specifications, and Waste Feed Delivery programmatic direction. Requirements are summarized in Table 3-3.

Table 3-3. Requirements.

No.	Requirement	Basis	Type
R-1	Meet all safety and environmental requirements. The only safety factor identified to distinguish alternatives is accidental chemical exposure to workers. The only environmental factor identified to distinguish alternatives is tank fitness-for-use certification requirements of WAC 173-303.	Grenard et al. 1998, Section 3.3.6. Factors determined to distinguish alternatives were identified in a meeting with cognizant safety and environmental personnel (Meeting Summary, Appendix C).	Non-Tradable
R-2	The materials in tanks AN-102 and AN-107 must meet all applicable compatibility requirements (Memorandum-I, attached).	Kirkbride 1999 et al., *Tank Waste Remediation System Operation and Utilization Plan*, Assumption 3.1. Fowler 1999, *Tank Waste Transfer Compatibility Program*	Non-Tradable
R-3	Transfer waste from AN-107 to staging tank AN-106 (Case 3S4) using waste transfer piping systems (as opposed to trucking or other transfer methods).	Kirkbride et al. 1999, *Tank Waste Remediation System Operation and Utilization Plan*; Grenard et al. 1998.	Tradable
R-4	Transfer waste from AN-102 to staging tanks AN-101 and AN-106 (Case 3S4) using waste transfer piping systems (as opposed to trucking or other transfer methods).	Kirkbride et al. 1999, *Tank Waste Remediation System Operation and Utilization Plan*; Grenard et al. 1998.	Tradable
R-5	Transfer of waste from AN-107 directly to BNFL is allowable.	Treat 1999	Tradable
R-6	Transfer waste from AN-102 directly to BNFL is allowable.	Treat 1999	Tradable
R-7	Reynolds number must be greater than 20,000 for transport of slurries with SpG <1.35 and solids >5 vol%.	Fowler 1999. Estey 1998.	Non-Tradable
R-8	System equipment will be capable of transferring prepared waste in 4 to 9 days.	Grenard et al. 1998.	Tradable

82400-99-068

Attachment 2

Proposed Interim Guidance

consisting of 11 pages including coversheet

See Appendix C at page C-i

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APPENDIX E

CASE 3S6E R2A LOW-ACTIVITY WASTE VS. SPECIFICATION 7

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Case 3S6E R2A Low-Activity Waste vs. Specification 7.

Chemical Analyte	From Tables TS-7.1 and TS-7.2 of Contract: Envelope A	Envelope B	Envelope C	AN-102: LAW-3	A	B	C	LAW-4	A	B	C	AN-107: LAW-7	A	B	C	AN-105: LAW-8	A	B	C	LAW-9	A	B	C
	moles of analyte to moles of sodium																						
Al	2.5E-01	2.5E-01	2.5E-01	5.16E-02				5.16E-02				2.79E-02				1.27E-01	5	5	5	9.02E-02			
Ba	1.0E-04	1.0E-04	1.0E-04	2.01E-05				2.01E-05				0.00E+00				1.82E-05				8.28E-06			
Ca	4.0E-02	4.0E-02	4.0E-02	1.39E-03				1.39E-03				1.55E-03				2.13E-04				2.10E-04			
Cd	4.0E-03	4.0E-03	4.0E-03	5.20E-05				5.20E-05				0.00E+00				4.93E-06				8.33E-07			
Cl	3.7E-02	8.9E-02	3.7E-02	9.65E-03				9.65E-03				5.73E-03				2.50E-02	5		5	2.55E-02	5		5
Cr	6.9E-03	2.0E-02	6.9E-03	7.28E-04				7.28E-04				6.35E-04				4.65E-04				6.50E-04			
F	9.1E-02	2.0E-01	9.1E-02	8.73E-03				8.73E-03				1.93E-02				3.31E-03				8.92E-03			
Fe	1.0E-02	1.0E-02	1.0E-02	3.51E-04				3.51E-04				5.46E-03	5	5	5	5.65E-05				1.85E-05			
Hg	1.4E-05	1.4E-05	1.4E-05	0.00E+00				0.00E+00				1.96E-07				0.00E+00				0.00E+00			
K	1.8E-01	1.8E-01	1.8E-01	8.85E-03				8.85E-03				4.56E-03				1.45E-02				1.21E-02			
La	8.3E-05	8.3E-05	8.3E-05	0.00E+00				0.00E+00				2.71E-05				6.26E-14				3.41E-13			
Ni	3.0E-03	3.0E-03	3.0E-03	6.17E-04				6.17E-04				9.13E-04				5.33E-05				1.56E-05			
NO_2	3.8E-01	3.8E-01	3.8E-01	1.60E-01				1.60E-01				1.43E-01				2.40E-01	5	5	5	2.42E-01	5	5	5
NO_3	8.0E-01	8.0E-01	8.0E-01	3.25E-01				3.25E-01				3.80E-01				2.56E-01				2.82E-01			
Pb	6.8E-04	6.8E-04	6.8E-04	8.64E-05				8.63E-05				2.09E-04				2.65E-05				1.44E-05			
PO_4	3.8E-02	1.3E-01	3.8E-02	4.60E-03				4.60E-03				4.19E-03				2.17E-03				5.34E-03			
SO_4	1.0E-02	7.0E-02	2.0E-02	1.47E-02	N		5	1.47E-02	N		5	9.64E-03	8			4.35E-03				7.33E-03	5		
TIC	3.0E-01	3.0E-01	3.0E-01	1.03E-01				1.03E-01				1.35E-01				4.04E-02				1.09E-01			
TOC	5.0E-01	5.0E-01	5.0E-01	1.98E-01				1.98E-01				3.46E-01	5	5	5	5.63E-02				4.53E-02			
U	1.2E-03	1.2E-03	1.2E-03	6.84E-05				6.84E-05				6.38E-05				5.51E-06				8.96E-07			
Radionuclide	Becquerels of radionuclide to moles of sodium																						
TRU	4.8E+05	4.8E+05	3.0E+06	7.10E+05	N	N		7.03E+05	N	N		3.48E+06	N	N	N	4.47E+04				1.60E+03			
^{137}Cs	4.3E+09	2.0E+10	4.3E+09	8.80E+08				8.38E+08				1.01E+09				9.55E+08				9.80E+08			
^{90}Sr	4.4E+07	4.4E+07	8.0E+08	2.16E+08	N	N		1.94E+08	N	N		3.71E+08	N	N		1.38E+07				9.59E+06			
^{99}Tc	7.1E+06	7.1E+06	7.1E+06	7.15E+05				7.16E+05				5.02E+05				1.42E+06				1.50E+06			
^{60}Co	6.1E+04	6.1E+04	3.7E+05	9.46E+04	N	N		7.34E+04	N	N		1.22E+05	N	N		6.71E+03				3.19E+03			
$^{154}Eu + ^{155}Eu$	1.2E+06	1.2E+06	4.3E+06	6.27E+05	5	5		5.22E+05				4.53E+06	N	N		4.35E+04				7.80E+03			
From Spec 7.2.2.1	mol/L																						
Na	3 to 10			9.00				9.00				8.45				6.93				7.00			
							C				C				C		A				A		
					N	N	Y		N	N	Y		N	N	N		Y	Y	Y		Y	Y	Y
					4	3	0		4	3	0		4	4	1		0	0	0		0	0	0
					4	3	0		4	3	0		5	4	1		0	0	0		0	0	0
					5	4	1		4	3	1		7	6	3		3	2	3		3	1	2

LEGEND:

- ☐ Meets Spec, < 50% of maximum
- [5] Meets Spec, > 50% of maximum
- [8] Meets Spec, > 80% of maximum
- [N] Does not meet Spec

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APPENDIX F

FLOWSHEET INPUT ON TANK 241-AN-102 WASTE

(PROVIDED BY R. M. ORME)

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DON'T SAY IT — *Write It!*

DATE: April 12, 2000

TO: Paul Certa

FROM: Ron Orme

cc: Stan Blacker

John Garfield

Dean Tulberg

Telephone:

SUBJECT: FLOWSHEET INPUT TO AN-102/AN-107 AGA

A considerable amount of time has been spent on framing and honing the issues and identifying the precise technical information needed to complete the AN-102 and AN-107 Alternative Generation and Analysis (AGA) effort. We are now at a point where additional specific information is needed.

Since you are the key technical person in this area of knowledge, I request that you provide the answers to the specific questions listed below. This information should be provided in written form and will be referenced in the AN-102 and AN-107 AGA.

Please provide this written information to Dean Tulberg by November 15, 1999.

To complete the evaluation of alternatives, mini-flowsheets of the process variants are required. The discussion below identifies the flowsheets required and the information the flowsheets should contain as a minimum.

Note: The following response applies to AN-102. Responses to your latest round of questions are underlined to distinguish them from the earlier answers.

Flowsheet #1

An enabling assumption is that hydroxide will be added to the waste in AN-102 and AN-107 to make it comply with the applicable tank corrosion protection requirements. One alternative is to add hydroxide to directly to AN-102 and AN-107 and thoroughly mix the waste, both solids and liquids. After caustic addition, the supernate will be decanted from AN-102 and AN-107 and transferred either directly to BNFL or to a staging tank. The mini-flowsheet for this alternative should identify the following:

1-A. What are the caustic needs for the entire contents of AN-102 and AN-107 to meet corrosion specification requirements in their respective tanks:

- What is the target [OH^-] concentration for the waste?

Rollosson et al. (1999) establishes as recently as July the concentrations in AN-102 (p. 2-4). Nitrate, free hydroxide, and nitrite are 3.63 *M*, 0.21 *M*, and 1.8 *M*, respectively. For this nitrate level, free hydroxide should be at least 0.3 *M*, and [OH]+[NO_2] at least 1.2 *M*. **The target concentration for the planned flowsheet revision is 0.5 *M* OH.**

- What is the nominal concentration and volume of the caustic supply to meet the target [OH^-] concentration?

Caustic is normally supplied in bulk as a 50 wt% (or 19 *M*) solution. If caustic is to be added to this tank, my preference is to adopt an approach that satisfies the corrosion specification and also facilitates later feed delivery retrieval. My preferred approach is to take advantage of some of the freeboard to do a caustic adjustment and dilution simultaneously, thus improving the settling characteristics (maximize the fraction of the tank that is retrievable). **Assume we use 200 m^3 of the freeboard by adding 53,700 L of caustic and the balance as water (equivalent to adding 5.1 *M* NaOH).** The final free hydroxide will be 0.5 *M*, and [OH]+[NO_2] will be 2.2 *M*.

The alternate approach is to add just full-strength caustic, about 48,900 L. This will adjust free hydroxide to 0.5 *M*, but it also increases the bulk Na concentration (total sodium divided by total volume).

Caustic requirements are based on a lab study that determined AN-102 waste has very little buffering capacity (Herting 1996).

(Response to Item 3. The free hydroxide was established with 1994/1995 data so I used the corresponding volume in my calcs. Since we are adjusting the whole tank, we should use the total volume. The total volume was 4,050 m^3 rather than 3,796 m^3 used by Dean. Making this adjustment, the final solution molarity on Dean's table is 0.44 M. Herting's caustic requirement equation has a 0.06 M offset, and the final concentration is 0.5 M. My caustic consumption tables attached to this package are done in an Excel spreadsheet that solves Herting's equation, so the 0.06 M offset is inherent in the solution. In other words, based on Herting's data, it doesn't take quite as much to get to 0.5 M as you might think.)

- What is the maximum concentration of the caustic supply allowed (i.e., can 19 M caustic be used without damaging the tank)?

The components of the caustic delivery system must be compatible with 50 wt% caustic. I would make caustic adds with mixer pumps operating to dissipate high concentration and local hot spots. Full-strength caustic would never come in contact with the tank.

1-B. How much room is currently available in each tank to add the caustic?

Available freeboard is about 300 m^3 in AN-102.

Is there sufficient room to add all the caustic needed and not have a problem mixing the "full" tank?

Yes.

If there is not enough room, how much current *supernate* should be removed to assure that there will be no problem with the addition (heating, expansion from gas generation and chemical reaction, etc). If there is not sufficient room, what would be the resulting free hydroxide level if caustic was added utilizing only the existing space available in the tank.

1-C. If the necessary amount of caustic is added, what will be the compositional changes in the current contents of AN-102 and AN-107?

See the table. By inspection of the composition information, it is clear that the sludge layer is enriched in the usual culprits (Ca, CO_3, Cr, Fe, Mn, Pb, Si, SO_4, Sr, U, Zr). The mg/L of as-is supernate is compared to a hypothetical supernate after adjustment **assuming conservatively** that everything in the sludge layer dissolves. Of the above list, only the carbonate and sulfate are likely to dissolve to any extent as a result of the adjustment. There does not appear to be much solid phase Al in this tank, which is consistent with the above observation that the sludge layer is only slightly buffered.

(Response to Item 4. My answer does seem to imply that there are no sodium salts, and I will address that first. My answer below and in 2-B points out that 2/3 of the solids appear to be dissolvable with an extensive dilution, and these are more than likely sodium salts. The empirical data suggest that these are carbonates and sulfates, but the ESP model suggests that there could also be some fluoride/phosphate and fluoride/sulfate double salts. Although it hasn't showed up, there is undoubtedly some sodium oxalate as well. The caustic adjustment will not dissolve these salts. It is doubtful that there are solid nitrate or nitrite salts.

Do the multivalent cations exist as oxides, hydroxides, sulfates, or phosphates? Yes, there's probably a little bit of everything. We only have chemical analyses to work with, so the speciation of solid phases is speculative.)

Will the resulting composition of the supernate meet Envelope C limits?

The adjustment will not put the supernate out of specification. After adjustment, sulfate is the only analyte with a potential to have a higher analyte/Na ratio than the original supernate, but the increase in sulfate does not exceed the feed specification.

What will be the estimated volume and weight of solids remaining?

The estimate of initial solids content based on empirical data is 101,100 kg (1.8 wt%). The ESP model does not simulate complexed wastes very well at this point in time, but a reasonable interpretation of the ESPed inventory shows about 1.3 wt%. I regard this as tentative because both estimates are linked to an official sludge volume that is questionable (in my opinion). One cannot state categorically that this tank is under the 2 wt% solids as-is.

(Response to Item 5. I think it could be as high as 4 wt% solids.)

(Response to Item 6. Herting 1996 says the average solids content of sludge is 17.2 wt% and the average solids content of centrifuged sludge is 25 wt%. Because sampling disturbs the sludge, I split the difference and called it 20 wt%.

337,000 L x 1.5 kg/L = 505,500 kg sludge x 20 wt% = 101,100 kg solids

3,755,000 L x 1.4 kg/L = 5,257,000 kg supernate

101,100 kgs / (sludge + supernate) = 1.8 wt% solids

Herting (1996) and Person (as reported in Esch 1998) both got up to 67% of these solids to dissolve with a 100 wt% dilution, but the proposed dilution is only a few percent. Person's results suggest that no more than 5 wt% of the solids would dissolve during the adjustment. The adjustment will have little effect on the solids content.

(Response to Item 7. Diluent was determined relative to the mass of initial centrifuged solids. Herting did 100% and 300%; Person did several dilutions up to 100%.)

What will be the new estimate of units of LAW delivered, assuming that we will decant to 10 inches above the solids? Create a new Appendix I (TWRSO&UP) table factoring in the new supernate compositions.

When all is said and done, the volume of supernate available is increased by the volume of the adjustment, the supernate Na concentration will be about the same, and the volume of sludge will be about the same. The Na delivered is 886 MT or ~~770~~ 1,020 units.

(Response to Items 8 and 9. Yes, includes the added sodium. I divided by 1.15 when I should have multiplied. The units should be 1,020.)

1-D. Since the addition of the caustic to AN-102 and AN-107 will require the thorough mixing of the tank contents, provide information on the settling of the remaining solids after addition and mixing. *Discuss what fraction of the stirred tank can be recovered as* supernate and how certain your information is, after allowing 6 months for settling.

Persons observed the settling of solids in nine sample bottles that contained solids (Esch 1998, p. 106). See the plot of dimensionless volume vs. time. The samples differed only in the centrifuged solids content, that ranged from 13.5 to 28.7 wt%. These settling curves exhibit typical behavior – an initial rapid settling period that is long enough to determine a free settling velocity, settling rate begins to slow down when the slurry volume is about twice the terminal volume, and an extended period of compaction. At the supernate recovery rates exhibited in these curves, the supernate would be fully recovered in under 6 months.

(Response to Item 10. As noted above, centrifuged solids are about 25 wt% solid phase. Therefore, the sample bottles ranged from 3.4 to 7.2 wt% solids. Solids content does appear to affect the initial settling rate adversely, but the in tank solids content is less than (or on the low end) of this range. I would expect a 2 wt% slurry to settle faster than any of the lab tests did.)

1-E. What will be the temperature rise in the tank that results from heat of mixing, shaft work, etc.?

Dilution of the caustic into the waste causes about one degree temperature rise. The projected temperature rise in a tank from mixer pump operation is about 11°C every 5 days (two pumps, full tank, 114 scfm primary flow, 1053 scfm annulus flow).

(Response to Item 11. I have attached the thermal modeling results to this package. By the way, a half full tank goes up 20 °C every five days, also attached.)

1-F. What is the volume (ratio water to supernate) of dilution required to meet safe transfer requirements for supernate transfers to either staging tanks or direct to BNFL? What is the viscosity and density of the supernate after dilution?

We are targeting diluted streams to have a density of 1.35 or less. For AN-102, the minimum water addition is 0.23 L of water per L of supernate. Viscosity of full-strength supernate is between 8.1 and 29.2 cP over the temperature range 30 °C to 7 °C. After dilution, supernate should be less than 10 cP based on experience with other liquids that have been diluted and measured.

(Response to Item 12. The viscosity data is from Rollosson p. B-58.)

(Response to Item 13. The dilution target in the HTWOS model is 7 M Na. Tank specific flowsheets establish the minimum water addition to get to the maximum acceptable density of 1.35. Any higher density requires a line plugging evaluation. Either dilution is acceptable for making the transfer to BNFL, Inc., so it probably makes no difference which one you use.)

Flowsheet #2

Given the results of Flowsheet # 1 and the solids that remain after delivering the supernate, a second (continuation) flowsheet is required to address removal of the solids in AN-102 such that it can be used as a staging tank in place of using AN-106 as a staging tank. One primary driver in this assessment will be the cleanout of the tank residuals prior to use as a staging tank. To assess the cleanout requirements, Flowsheet #2 needs to address the following:

2-A. What are the volumes of solids and other materials in AN-102 that would have to be removed so it can be a staging tank (i.e., will not provide over 2 wt. % solids and will not alter the envelope feed being staged)?

If there is little entrainment of solids during retrieval, there could be a residual heel containing up to 100,000 kg of solid. As noted above, the adjustment will dissolve very little of the solid, so the final sludge composition is similar to the initial sludge composition. The heel could be 3.5 to 4 feet deep consisting of the original sludge and 10 " of supernate.

If AN-102 is retrieved properly, it may be possible to use as a staging tank without doing any cleanout. AN-102 feed delivery should be conducted in such a way that solids entrainment up to 2 wt% is achieved (i.e., stir the tank and begin delivery shortly thereafter). As noted above, the solids content of the tank is probably less than 2 wt% as-is. It is probable that this tank could be retrieved down to a 10" heel that has 2 wt% solids.

2-B. What are the chemical and physical composition of the solids and other materials (e.g., solubility, pumpability) in AN-102 that would have to be removed? This information is important for the determination of the equipment needed to remove the solids and other materials.

The solid salt phases should all dissolve given enough dilution. Herting and Persons both determined that about 2/3 of these solids will dissolve in a 100% water dilution. The left over solid phase would be 33,000 kgs of aluminosilicates, U, Fe, Pb, and Cr oxides.

(Response to Item 14. We do not know what compounds are present in the solid phase. All we have is chemical analysis. I have attached the results of two experiments that Herting completed. Note that the unit on these tables is grams per 100 grams of initial sludge. The table shows the wt% of initial sludge that is unwashed (initial) solids and the wt% of initial sludge that is washed (residual) solids. These samples are very similar, but we don't know if they're representative.)

(Response to Item 15. Once again, we don't know the compounds present in the solid phase. I have postulated the range of solids content based on the depth of the core sample vs. the "official" depth that was used for the inventory. The depth in 1989 was 32 ", in 1990 core sample 57". Subsequent measurements have been somewhere in between. The inventory basis is the 1989 depth and the 1990 core composition. I have attached Table D3-3 from Rollosson that compares sludge composition from various sampling events. The core sample and February 1998 grab sample are fairly similar, but the July 1998 grab sample is quite different. This suggests that the sludge layer is far from uniform.)

(Response to Item 16. Herting's tables show that solid phase Al doesn't wash out. His caustic adjustment study shows that sludge and supernate consume the same, evidence that solid phase Al is something other than gibbsite. If it doesn't wash and it isn't gibbsite, we assume that it's some kind of inert aluminosilicate. It isn't created by dilution; it's there from the beginning.

(Response to Item 17. Since the residual heel is likely to be 4 ft deep (sludge and residual supernate) and have a density of 1.45, a 100% dilution would require about 6 ft of water (750,000 L or 200,000 gal). This volume is similar to the 140,000 gal flushes between envelopes that HTWOS does in the staging tanks.)

References:

Herting 1996, Tank 241-AN-102 Caustic Demand and Sludge Characterization, Internal Memo 75764-PCS96-085, August 22, 1996.

Person 1998, Solubility Screening Tests for Tank 241-AN-102, Internal Memo 8C510-98-026, August 31, 1998.

Rollosson, M. I. and L. C. Amato, 1999, Tank Characterization Report for Double-Shell Tank 241-AN-102, HNF-SD-WM-ER-545 Rev. 2, LATA.

Caustic consumption with simultaneous dilution

Target [OH]	0.5
Current [OH]	0.21
Current Volume (m^3)	4050
Caustic Volume (L)	200000
Caustic Conc. [NaOH]	5.098 = Z

f(Z) = 1E-06 *Solver manipulates Z until f(Z)=0 (or a very small number)*

How much sodium added?

23449 kg

Caustic consumption (no simutaneous dilution)

Target [OH]	0.5	
Current [OH]	0.21	
Current Volume (m^3)	*4050*	
Caustic Volume (L)	48898	= Z
Caustic Conc. [NaOH]	19.49	

f(Z) = 4.1E-08 Solver manipulates Z until f(Z)=0 (or a very small number)

AN-102 BBI Summary

Component	kg sludge	kg supernate	kg crust	kg total	mg/L sludge	mg/L supernate	mg/L crust	mg/L total	After adjustment mg/L	new/old	As-is Analyte/Na	After adjustment Analyte/Na	
Al	6170	56700		62900	18309	15[illegible]00		15371	14655	0.971	0.063	0.061	Al
Ca	1050	1630		2680	3116	434		655	624	1.438	0.002	0.003	Ca
Cl	1040	14300		15300	3086	3808		3739	3565	0.936	0.016	0.015	Cl
CO3	31100	248000		279000	92285	66045		68182	65005	0.984	0.275	0.271	CO3
Cr	693	1120		1810	2056	298		442	422	1.414	0.001	0.002	Cr
F	450	6980		7430	1335	1859		1816	1731	0.931	0.008	0.007	F
Fe	844	191		1040	2504	51		254	242	4.764	0.000	0.001	Fe
K	880	14600		15400	2611	3888		3763	3588	0.923	0.016	0.015	K
Mn	242	147		389	718	39		95	91	2.315	0.000	0.000	Mn
Na	118000	901000		1020000	350148	239947		249267	261100	1.088	1.000	1.088	Na
Ni	215	1430		1650	638	381		403	384	1.009	0.002	0.002	Ni
NO2	19900	310000		330000	59050	82557		80645	76887	0.931	0.344	0.320	NO2
NO3	56600	845000		901000	167953	225033		220186	209925	0.933	0.938	0.875	NO3
Pb	137	682		820	407	182		200	191	1.052	0.001	0.001	Pb
PO4	1530	18100		19600	4540	4820		4790	4567	0.947	0.020	0.019	PO4
Si	687	75.9		763	2039	20		186	178	8.795	0.000	0.001	Si
SO4	13100	51800		64900	38872	13795		15860	15121	1.096	0.057	0.063	SO4
Sr	10.1	7.07		17.1	30	2		4	4	2.116	0.000	0.000	Sr
TOC	8240	98400		107000	24451	26205		26149	24930	0.951	0.109	0.104	TOC
U	804	77.2		881	2386	21		215	205	9.984	0.000	0.001	U
Zr	280	35.3		315	831	9		77	73	7.807	0.000	0.000	Zr
Volume	337	3755		4092					4292				
Hanlon	337	3675		4012									
				303 Space available									

Acetate	1200
Citrate	8500
Formate	10000
Gluconate	
Glycolate	18600
EDTA	5620
HEDTA	2100
Oxalate	

Comments

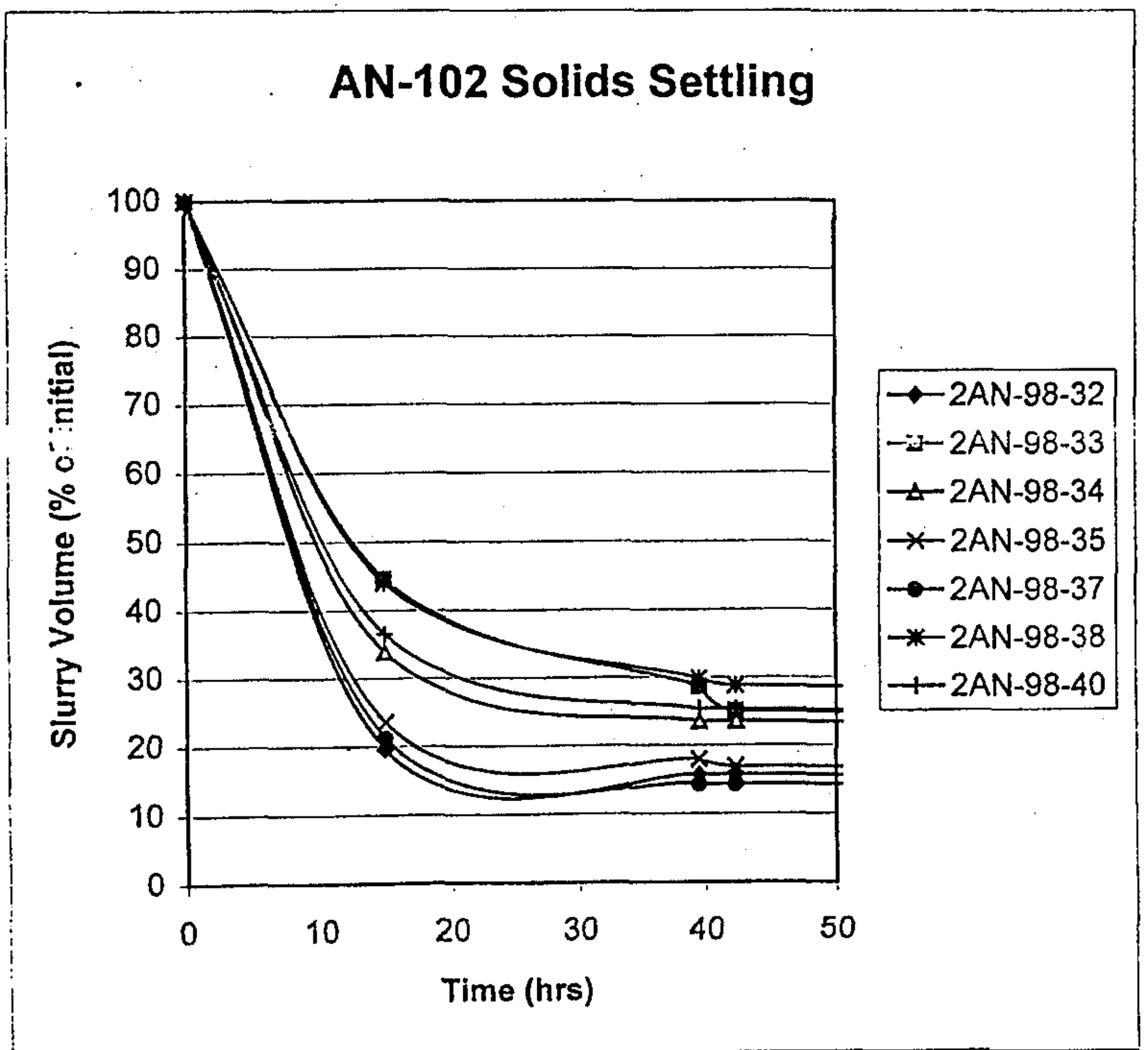
Liquid Phase Concentration

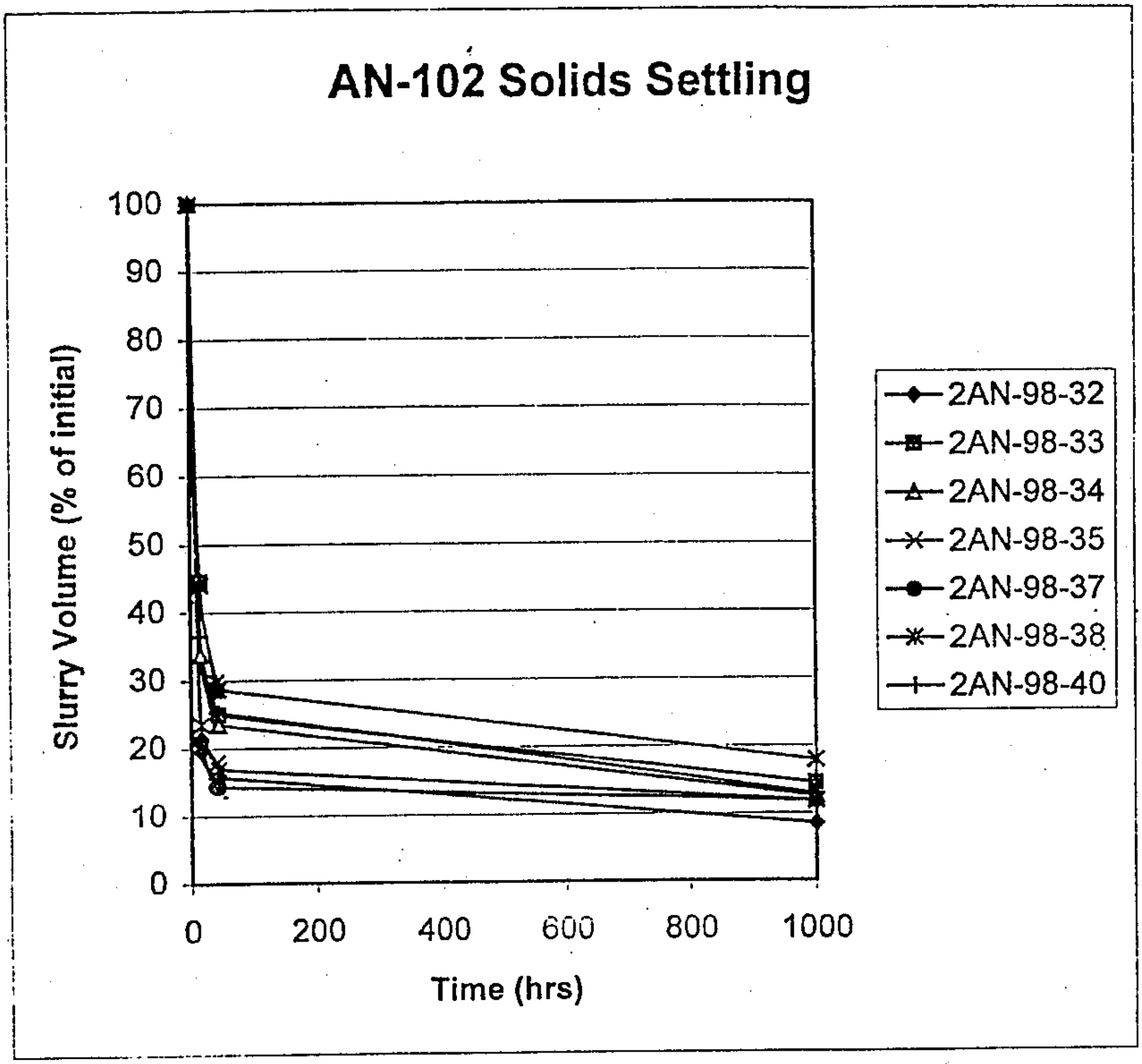
	Lab says	Model says	
Al	15 g/l	3.6 g/L	Model needs to complex more
Cr	0.3 g/L	.33 g/L	
Fe	0.051 g/L	4E-9 g/L	Model needs to complex more
OH	.21 M	.3 M	

Settling data for AN-102

Time	2AN-98-32	2AN-98-33	2AN-98-34	2AN-98-35	2AN-98-37	2AN-98-38	2AN-98-40
0	100	100	100	100	100	100	100
15	19.5	44.6	33.8	23.5	21.2	44	36.5
39.5	15.7	28.6	23.5	17.9	14.3	29.8	25.3
42.3	15.7	25	23.5	16.9	14.3	28.7	25.3
1000	8.5	14.5	12.5	11.8	11.8	17.9	12.9

	2AN-98-29
0	100
24.9	21.6
95.3	20.5
145	18.2
187.3	17.2
1000	11.8




AN-102 Solids Settling
Slurry Volume (% of initial)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
Time (hrs)
2AN-98-32
2AN-98-33
2AN-98-34
2AN-98-35
2AN-98-37
2AN-98-38
2AN-98-40

Outp

AP-102 (2) 300 hp mixer pumps

WASTE DENSITY = 84.300 LBM/FT^3
WASTE SPECIFIC HEAT = 0.765 BTU/LBM -DEG F
DECAY HEAT = 0.124 BTU/FT^3 - HR
VAPOR PRESSURE WRT H20 = 0.450
FRACTION OF TANK COVERED BY CRUST = 0.000
DOME FLOW = 114.000 SCFM
ANNULUS FLOW = 1053.000 SCFM
INLET AIR TEMP = 77.000 DEG F

TIME (HRS)	OUTLET M.R. (LBMH20/LBMAIR)	TEMP WASTE(deg-F)	PUMP POWER (HP)	LEVEL (FT)	OUTLET TEMP ANNULUS(deg-F)	OUTLET TEMP DOME(deg-F)
0.00	0.00	102.00	600.00	30.00	0.00	0.00
2.00	0.02	102.35	600.00	30.00	101.54	99.43
4.00	0.02	102.70	600.00	30.00	101.89	99.67
6.00	0.02	103.05	600.00	30.00	102.21	99.92
8.00	0.02	103.40	600.00	30.00	102.56	100.17
10.00	0.02	103.75	600.00	30.00	102.89	100.42
12.00	0.02	104.10	600.00	30.00	103.26	100.66
14.00	0.02	104.45	600.00	30.00	103.59	100.91
16.00	0.02	104.80	600.00	30.00	103.93	101.16
18.00	0.02	105.15	600.00	30.00	104.27	101.41
20.00	0.02	105.50	600.00	30.00	104.62	101.66
22.00	0.02	105.85	600.00	30.00	104.96	101.91
24.00	0.02	106.20	600.00	30.00	105.30	102.16
26.00	0.02	106.55	600.00	30.00	105.62	102.41
28.00	0.02	106.90	600.00	30.00	105.98	102.66
30.00	0.02	107.25	600.00	30.00	106.33	102.91
32.00	0.02	107.60	600.00	30.00	106.67	103.17
34.00	0.02	107.95	600.00	30.00	107.01	103.42
36.00	0.02	108.30	600.00	30.00	107.34	103.67
38.00	0.02	108.65	600.00	30.00	107.67	103.93
40.00	0.02	109.00	600.00	30.00	108.04	104.18
42.00	0.02	109.35	600.00	30.00	108.35	104.44
44.00	0.02	109.69	600.00	30.00	108.71	104.69
46.00	0.02	110.04	600.00	30.00	109.07	104.95

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Outp

48.00 2 day	0.02	110.39	600.00	30.00	109.39	105.20
50.00	0.03	110.74	600.00	30.00	109.72	105.46
52.00	0.03	111.09	600.00	30.00	110.06	105.72
54.00	0.03	111.43	600.00	30.00	110.40	105.97
56.00	0.03	111.78	600.00	30.00	110.74	106.23
58.00	0.03	112.13	600.00	30.00	111.08	106.49
60.00	0.03	112.48	600.00	30.00	111.44	106.75
62.00	0.03	112.82	600.00	30.00	111.77	107.01
64.00	0.03	113.17	600.00	30.00	112.13	107.27
66.00	0.03	113.52	600.00	30.00	112.45	107.53
68.00	0.03	113.87	600.00	30.00	112.78	107.79
70.00	0.03	114.21	600.00	30.00	113.13	108.05
72.00 3 day	0.03	114.56	600.00	30.00	113.48	108.31
74.00	0.03	114.91	600.00	30.00	113.79	108.57
76.00	0.03	115.25	600.00	30.00	114.14	108.83
78.00	0.03	115.60	600.00	30.00	114.48	109.09
80.00	0.03	115.94	600.00	30.00	114.82	109.36
82.00	0.03	116.29	600.00	30.00	115.16	109.62
84.00	0.03	116.64	600.00	30.00	115.50	109.89
86.00	0.03	116.98	600.00	30.00	115.84	110.15
88.00	0.03	117.33	600.00	30.00	116.17	110.42
90.00	0.03	117.67	600.00	30.00	116.51	110.68
92.00	0.03	118.02	600.00	30.00	116.84	110.95
94.00	0.03	118.36	600.00	30.00	117.21	111.21
96.00 4 day	0.03	118.71	600.00	30.00	117.54	111.48
98.00	0.03	119.05	600.00	30.00	117.87	111.74
100.00	0.03	119.40	600.00	30.00	118.19	112.01
102.00	0.03	119.74	600.00	30.00	118.56	112.28
104.00	0.03	120.09	600.00	30.00	118.88	112.55
106.00	0.03	120.43	600.00	30.00	119.20	112.82
108.00	0.03	120.78	600.00	30.00	119.57	113.09
110.00	0.03	121.12	600.00	30.00	119.89	113.36
112.00	0.03	121.46	600.00	30.00	120.23	113.63
114.00	0.03	121.81	600.00	30.00	120.57	113.90
116.00	0.04	122.15	600.00	30.00	120.90	114.17
118.00	0.04	122.49	600.00	30.00	121.24	114.44
120.00 5 day	0.04	122.84 50C	600.00	30.00	121.58	114.71
122.00	0.04	123.18	600.00	30.00	121.91	114.98
124.00	0.04	123.52	600.00	30.00	122.24	115.25

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Outp

AP-102 (2) 300 hp mixer pumps

WASTE DENSITY = 84.300 LBM/FT^3
WASTE SPECIFIC HEAT = 0.765 BTU/LBM -DEG F
DECAY HEAT = 0.124 BTU/FT^3 - HR
VAPOR PRESSURE WRT H20 = 0.450
FRACTION OF TANK COVERED BY CRUST = 0.000
DOME FLOW = 114.000 SCFM
ANNULUS FLOW = 1053.000 SCFM
INLET AIR TEMP = 77.000 DEG F

TIME (HRS)	OUTLET M.R. (LBMH20/LBMAIR)	TEMP WASTE (deg-F)	PUMP POWER (HP)	LEVEL (FT)	OUTLET TEMP ANNULUS (deg-F)	OUTLET TEMP DOME (deg-F)
0.00	0.00	102.00	600.00	15.00	0.00	0.00
2.00	0.02	102.70	600.00	15.00	101.56	99.61
4.00	0.02	103.40	600.00	15.00	102.21	100.10
6.00	0.02	104.09	600.00	15.00	102.90	100.58
8.00	0.02	104.79	600.00	15.00	103.57	101.07
10.00	0.02	105.49	600.00	15.00	104.25	101.56
12.00	0.02	106.18	600.00	15.00	104.93	102.05
14.00	0.02	106.88	600.00	15.00	105.60	102.54
16.00	0.02	107.57	600.00	15.00	106.27	103.03
18.00	0.02	108.27	600.00	15.00	106.95	103.53
20.00	0.02	108.96	600.00	15.00	107.61	104.02
22.00	0.02	109.65	600.00	15.00	108.28	104.51
24.00	0.02	110.35	600.00	15.00	108.97	105.01
26.00	0.03	111.04	600.00	15.00	109.65	105.50
28.00	0.03	111.73	600.00	15.00	110.32	106.00
30.00	0.03	112.42	600.00	15.00	110.97	106.50
32.00	0.03	113.11	600.00	15.00	111.65	107.00
34.00	0.03	113.80	600.00	15.00	112.33	107.49
36.00	0.03	114.49	600.00	15.00	113.00	108.00
38.00	0.03	115.18	600.00	15.00	113.66	108.50
40.00	0.03	115.87	600.00	15.00	114.31	109.00
42.00	0.03	116.56	600.00	15.00	115.01	109.50
44.00	0.03	117.25	600.00	15.00	115.67	110.00
46.00	0.03	117.93	600.00	15.00	116.33	110.51

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Outp

48.00	0.03	118.62	600.00	15.00	117.01	111.01
50.00	0.03	119.31	600.00	15.00	117.68	111.52
52.00	0.03	119.99	600.00	15.00	118.32	112.03
54.00	0.03	120.68	600.00	15.00	118.99	112.54
56.00	0.03	121.36	600.00	15.00	119.68	113.04
58.00	0.04	122.05	600.00	15.00	120.33	113.55
60.00	0.04	122.73	600.00	15.00	120.99	114.06
62.00	0.04	123.41	600.00	15.00	121.67	114.58
64.00	0.04	124.09	600.00	15.00	122.31	115.09
66.00	0.04	124.78	600.00	15.00	122.99	115.60
68.00	0.04	125.46	600.00	15.00	123.66	116.12
70.00	0.04	126.14	600.00	15.00	124.29	116.63
72.00	0.04	126.82	600.00	15.00	124.96	117.15
74.00	0.04	127.50	600.00	15.00	125.62	117.66
76.00	0.04	128.18	600.00	15.00	126.28	118.18
78.00	0.04	128.85	600.00	15.00	126.94	118.70
80.00	0.04	129.53	600.00	15.00	127.60	119.22
82.00	0.04	130.21	600.00	15.00	128.27	119.74
84.00	0.05	130.89	600.00	15.00	128.94	120.26
86.00	0.05	131.56	600.00	15.00	129.59	120.78
88.00	0.05	132.24	600.00	15.00	130.24	121.30
90.00	0.05	132.91	600.00	15.00	130.90	121.82
92.00	0.05	133.59	600.00	15.00	131.56	122.35
94.00	0.05	134.26	600.00	15.00	132.20	122.87
96.00	0.05	134.93	600.00	15.00	132.89	123.40
98.00	0.05	135.61	600.00	15.00	133.52	123.92
100.00	0.05	136.28	600.00	15.00	134.17	124.45
102.00	0.05	136.95	600.00	15.00	134.83	124.98
104.00	0.05	137.62	600.00	15.00	135.48	125.51
106.00	0.06	138.29	600.00	15.00	136.13	126.04
108.00	0.06	138.96	600.00	15.00	136.80	126.57
110.00	0.06	139.63	600.00	15.00	137.42	127.10
112.00	0.06	140.30	600.00	15.00	138.09	127.63
114.00	0.06	140.96	600.00	15.00	138.74	128.16
116.00	0.06	141.63	600.00	15.00	139.38	128.69
118.00	0.06	142.30	600.00	15.00	140.04	129.22
120.00	0.06	142.96	600.00	15.00	140.68	129.76
122.00	0.06	143.63	600.00	15.00	141.31	130.29
124.00	0.07	144.29	600.00	15.00	141.98	130.83

Table 9a. Composition of Unwashed and Washed Solids in Sample Sludge-94A (grams per 100 grams sludge; radionuclides in µCi per gram sludge)

	C-Solids	ISL	Unwashed Solids	WW-Solids	WW-ISL	Washed Solids
TOC[1]	1.10	0.960	0.14	0.10	0.10	0.00
TIC[1]	2.05	0.469	1.58	0.71	0.14	0.57
Al	0.69	0.550	0.14	0.20	0.05	0.15
B	0.006	0.002	0.004	0.003	0.000	0.003
Ca	0.037	0.019	0.018	0.009	0.003	0.006
Cd	0.002	0.002	0.000	0.000	0.000	0.000
Cr	0.081	0.010	0.071	0.072	0.001	0.071
Cu	0.001	0.001	0.000	0.000	0.000	0.000
Fe	0.074	0.003	0.071	0.073	0.000	0.073
K	0.088	0.076	0.011	0.010	0.008	0.001
La	0.002	0.001	0.002	0.001	0.000	0.001
Mn	0.016	0.001	0.015	0.015	0.000	0.015
Mo	0.002	0.002	0.000	0.000	0.000	0.000
Na	12.68	8.86	3.82	2.19	1.10	1.09
Nd	0.004	0.001	0.003	0.003	0.000	0.003
Ni	0.016	0.015	0.001	0.002	0.001	0.000
P	0.091	0.058	0.032	0.010	0.009	0.001
Pb	0.013	0.006	0.007	0.007	0.001	0.006
S	0.759	0.138	0.621	0.079	0.071	0.008
Si	0.001	0.002	0.007	0.007	0.000	0.007
Sr	0.00006	0.00012	0.00035	0.00035	0.00001	0.00034
AT	0.30	0.09	0.21	0.23	0.01	0.23
TB	257	172	85	92	17	75
^{90}Sr	72	25	47	44	3	41
^{137}Cs	123	131	-7	15	11	3
Chem Wt	41.72	28.66	14.72	8.26	3.51	4.59
H_2O Wt	24.40	24.40	0.00	8.38	8.38	0.00
Mass-Calc	66.12	53.06	14.72	16.64	11.89	4.59
Mass-Measured	66.79	49.90	16.89	17.38	11.88	5.50

[1] TOC and TIC not measured in centrifuged solids or washed solids; values assigned as described in text.

9b. Composition of Unwashed and Washed Solids in Sample Sludge-948 (grams per 100 grams sludge; radionuclides in μCi per gram sludge)

	C-Solids	ISL	Unwashed Solids	WW-Solids	WW-ISL	Washed Solids
TOC[1]	1.20	1.11	0.10	0.11	0.11	0.00
TIC[1]	2.14	0.42	1.72	0.78	0.13	0.64
Al	0.64	0.52	0.12	0.21	0.04	0.17
B	0.003	0.001	0.002	0.001	0.000	0.001
Ca	0.035	0.018	0.017	0.009	0.003	0.006
Cd	0.002	0.002	0.000	0.000	0.000	0.000
Cr	0.085	0.009	0.076	0.076	0.001	0.076
Cu	0.001	0.001	0.000	0.000	0.000	0.000
Fe	0.078	0.003	0.075	0.077	0.000	0.077
K	0.088	0.073	0.016	0.010	0.008	0.003
La	0.002	0.001	0.002	0.002	0.000	0.002
Mn	0.017	0.001	0.016	0.016	0.000	0.016
Mo	0.001	0.002	0.000	0.000	0.000	0.000
Na	13.28	8.43	4.85	2.32	1.09	1.23
Nd	0.004	0.001	0.003	0.003	0.000	0.003
Ni	0.014	0.014	0.000	0.002	0.001	0.001
P	0.084	0.055	0.028	0.009	0.007	0.002
Pb	0.011	0.006	0.006	0.006	0.000	0.006
S	0.634	0.131	0.503	0.082	0.055	0.027
Si	0.010	0.002	0.008	0.008	0.000	0.001
Sr	0.00028	0.00009	0.00019	0.00017	0.00001	0.00016
AT	0.33	0.07	0.26	0.25	0.01	0.25
TB	261	160	101	91	17	74
^{90}Sr	76	26	49	47	3	44
^{137}Cs	114	116	-3	16	11	4
Chem Wt	42.78	27.68	15.92	8.70	3.37	5.22
H_2O Wt	24.15	24.15	0.00	8.40	8.38	0.00
Mass-Calc	66.92	51.83	15.92	17.10	11.75	5.22
Mass-Measured	67.12	48.10	19.02	17.42	11.76	5.66

[1] TOC and TIC not measured in centrifuged solids or washed solids; values assigned as described in text.

Table D3-3. Comparison of Tank 241-AN-102 1990 Core Sample and 1998 Solids Data Sets for Nonradioactive Components.

Analyte	1990 Core Sample[1] µg/g	February 1998 Grab Solid and Dissolution Composite (Acid Digest) µg/g	February 1998 Grab Solid and Dissolution Composite (Fusion Digest) µg/g	July 1998 Grab Solid Sample (Acid Digest) µg/g
Al	12,200	16,100	15,600	9,960
Bi	n/r	<50.3	<1,920	<39.4
Ca	2,070	434	<1,920	345
Cl	2,060	n/r	n/r	n/r
TIC	12,300	10,100	n/r	1,560
Cr	1,370	1,830	1,740	335
F	<890	n/r	n/r	n/r
Fe	1,670	1,830	1,280	176
Hg	n/r	n/r	n/r	n/r
K	<1,740	1,390	n/r	1,450
La	<29.5	37.3	<958	<19.7
Mn	479	295	301	41.5
Na	2.34E+05	1.51E+05	1.50E+05	1.42E+05
Ni	425	254	821	257
NO_2	39,300	n/r	n/r	n/r
NO_3	1.12E+05	n/r	n/r	n/r
Pb	<272	[illegible]	[illegible]	125
PO_4	3,030	3,680[2]	<11,700[2]	n/r
Si	1,360	63.0	<958	51.7
SO_4	25,900	10,700[3]	10,400[3]	n/r
Sr	19.9	<5.03	<192	<3.94
TOC	16,300	24,800	n/r	22,500
U_{TOTAL}	1,590	<252	<9,580	<197
Zr	554	62.7	<192	13.9
Density	1.5 g/mL[4]	n/r	n/r	1.64 g/mL

Notes:

[1]See Table B2-27, Appendix B

[2]Based on the phosphorus result obtained by ICP.

[3]Based on the sulfur result obtained by ICP.

[4]Result is from a direct measurement performed on the sludge, and was not calculated by recombining centrifuged liquid and solid fractions.

Your response of November 15, 1999 to my DSI entitled Flowsheet Input to AN-102/AN-107 AGA is appreciated. After review of the information you provided, the following questions and requests for clarifications have been developed.

1. When you responded back to the questions sent for Flowsheet Input to AN-102/AN-107, you used the original electronic version of my previous DSI to you without revising it to show that the information was now coming from you and being sent to me. Can you please revise this to show the DSI is "From" you, "To" me, so that the source of the data can be properly referenced.

2. In Item I-A, Rollosson et al. (1999) is referenced, however this is not listed in the reference section. Please provide this additional reference information.

3. In Item I-A, a check has been run on the calculations that shows the hydroxide added in both the diluted and undiluted case only brings the free hydroxide concentration to 0.455. Table 1 contains calculations using your numbers. Please review the calculations in Table 1 and identify the differences from your methodology and correct Table 1, as appropriate.

4. In Item I-C (sludge compositional changes), identifies several cations and one anion (SO_4) in the sludge. Do these cations exist in an oxide, hydroxide or sulfate form. Are there significant quantities of anions such as CO_3, NO_2, NO_3 in the sludge, and if so, in what form? Based on the list of cations, it is assumed that no sodium salts exist in the sludge; is that a correct interpretation of the data provided?

5. In Item I-C (volume and weight of solids), you indicate the wt% estimates are tentative based on questionable volume estimates. Can you provide a probable range of wt% solids based on the range of sludge volume measurements seen in the tank.

6. Item I-C (volume and weight of solids) indicates 1.8 wt% solids based on empirical data. Please provide a reference for the empirical data source and show the methodology used to calculate the weight percentage of solids.

7. Item I-C (solids estimates) indicates that a 100 wt% dilution will dissolve 67% of the solids. What is the basis of the 100 wt%; is this wt % of centrifuged solids (including interstitial liquid) wt% of uncentrifuged solids (including interstitial liquid), or wt % of the actual solids components (i.e., 101,100 kg)?

8. In Item 1-C (Units of Na), it indicates 886 MT of Na. It is assumed that this includes the Na added to increase the free hydroxide up to 0.5 M. Please verify this assumption.

9. In Item 1-C (Units of Na) it indicates 770 units of Na in AN-102. In TWRSO&UP (Revision 1 dated May 1999, p 2-8) it shows that tank AN-102 contains 1080 units of Na. Can you explain the large variation.

10. In Item 1-D, it indicates settling data is based on samples with centrifuged solids of 13.5 to 28.7 %. Estimates in Item 1-C indicated the overall tank will be at about 1.8 wt% solids.

Would you expect the settling rates in actual tank conditions to be more or less than that shown in the laboratory tests, and why?

11. In Item 1-E it indicates at temperature rise from mixing of 11°C every 5 days. Please provide a citation for this data.

12. Item 1-F, please provide a citation for the data provided.

13. Item 1-F indicates a water addition of 0.23 L of water per L of supernate. Data used in the recent development of Case 3S5 indicates 0.58 L of water per L of supernate will be used. Which dilution water value should be used for our evaluation of AN-102?

14. Item 2-B, please identify the compounds that exist in the solids phase for the cations identified. Provide the relative percentages of the solids compounds that make up the 33,000 kg solids listed. Provide the basis (or citation) by which the species were identified.

15. Item 2-B, from question 5, you identify a range for the wt percent solids. Would you expect the fraction of specific solid compounds to remain the same throughout this range or would their be a bias towards on specific compound depending on which end of the range you are in?

16. Item 2-B, Aluminosilicates were not identified as part of the 101,100 kg original solids in the tank, does this specie show up only after dilution?

17. Item 2-B, indicates that a 100% dilution will dissolve 2/3 of the solids. How much water would need to be added to AN-102 after the LAW is removed to achieve a 100% dilution.

Table 1. Hydroxide Addition Calculations

Non Dilution Water Addition Case

Liquid Volume (Hanlon, 8/99)	1,003 Kgals 3,796,355 Liters
Current OH Conc.	0.21 Molar
Added Caustic (19.49 M)	48,900 Liters
Moles of original OH	797,235 moles
Moles of added OH	953,061 moles
Total Moles OH	1,750,296 moles
Total Volume of Liquid	3,845,255 Liters
Final solution molarity	0.455 Molar

Dilution Water Addition Case

Liquid Volume (Hanlon, 8/99)	1,003 Kgals 3,796,355 Liters
Current OH Conc.	0.21 Molar
Added "Dilute" Caustic (5.1 M)	200,000 Liters
Added Caustic (19 M)	53,684 Liters
Added Water	146,316 Liters
Moles of original OH	797,235 moles
Moles of added OH	1,020,000 moles
Total Moles OH	1,817,235 moles
Total Volume of Liquid	3,996,355 Liters
Final solution OH Concentration	0.455 Molar

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APPENDIX G

TANK 241-AN-102 FITNESS FOR USE MEETING MINUTES

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Meeting Summary -- Final
December 9, 1999

Summary of Fit for Use Meeting --- November 10, 1999

Objective

Define what specific information is needed to determine if AN-102 is fit for use (WAC 173-303 640) as a staging tank.

Determine:

- which information is available,
- which information can be extrapolated from other tanks and their operations,
- which information needs to be collected, and
- how long will it take and how much will it cost to collect that information?

If information is burdensome to collect, then compare the effort on AN-102 with what would be needed to make the same determination for AN-106.

This effort will focus on assessing issues that are unique to AN-102 (relative to AN-106) due to the current condition and history of AN-102. This assessment will help us discriminate between the cost and time differences in preparing AN-102 rather than AN-106 for staging waste during Phase 1B and Phase 1B Extended Order. Although the items raised in this meeting have broader implications, these broader items will be addressed in another effort.

Participants

Bob Nicholson – Design Authority
Tarlok Hundal – Independent Qualified, Registered Professional Engineer
Ed Fredenburg – Tank Integrity
Keith Scott – Tank Integrity
R.P. Anantatmula – Tank Integrity
Larr Julyk – Tank Integrity
Dave Becker – Tank Integrity
Al Friberg – Tank Farm Engineering
Charles Mulkey – Regulatory Compliance
Ross Potter – Regulatory Compliance
Dean Tulberg – 2 and 7-AN Engineering Study
Stan Blacker – 2 and 7-AN Engineering Study

Bob Nicholson and Tarlok Hundal are responsible, as signatories, to conclude that they have the data they need to establish that AN-102 is fit for use as a staging tank. Other participants are technical resources to answer questions that Bob and Tarlok have and to make sure that all relevant concerns are raised and discussed.

Discussion

Information -- The meeting began with a summary of what information we have on AN-102 relative to its being fit for use as a staging tank.

Info – 1) There is no ultrasonic testing (UT) data from AN-102. There is recent UT data fro AN-105, AN-106, and AN-107, performed under a task through Ed Fredenburg's group (HNF-3353, Final Results of Double Shell Tank 241-AN-107 Ultrasonic Inspection; HNF 4816, Final Results of Double Shell Tank 241-AN-105 Ultrasonic Inspection; HNF-4817, Final Results of Double Shell Tank 241-AN-106 Ultrasonic Inspection). The question was raised as to whether results of UT from other AN tanks could be extrapolated to AN-102. The answer is UT may need to be done on AN-102, if results from other tanks examined cannot be accepted as representative of AN-102 in its future use as a staging tank. Since AN-102 is proposed for use as a staging tank, which will subject it to new and different operating conditions, UT examination to reduce uncertainty about the current tank conditions is needed.

Info – 2) Stress analysis has been done on AN-105 by Larry Julyk (See Appendix B of HNF 4860, 241-AN Double Shell Tank Integrity Assessment Report, 1999) and he found that stresses on the tank lining increase with depth and have the potential to be worrisome in the knuckle area, where the vertical lining connects with the tank bottom.

Info – 3) Videos of the annuli of all AN farm tanks were taken (WHC-SD-WM-RPT-061, 1993). There was no leaking observed in any AN tank annulus.

Info – 4) Videos of the insides of only AP-104 and AP-107 were recently done (HNF-SD-WM-RPT-037, 1997).

Info – 5) Useful life estimates were performed by R. P. Anantatmula (WHC-SD-WM-ER-585, 1996). These estimates were not tank waste-specific, but were performed based on a vapor phase model involving tank-specific relative humidity in the vapor space of each tank and a liquid phase model. The tanks, in general are aging within normal expectations based on modelling and UT results.

Info – 6) An integrity assessment was performed by Tarlok Hundal on AN Tank Farm (HNF 4860). Tarlok concluded that all AN farm tanks remain fit for use based on current use. That current use is derived from knowledge of current waste in the tanks and their continued use as storage tanks. Use of these tanks as staging tanks was not specifically evaluated.

Tarlok did evaluate the deployment of two 300 hp jet mixer pumps (based on the information available on other DSTs) and concluded that these pumps would not pose a problem. This evaluation was not performed specifically on AN-102.

The evaluation of deployment of 300 hp mixer pumps evaluation was from the tank's structural integrity assessment point of view (WHC-SD-WM-DA-05, Analysis of Underground Double-Shell Tank 241-AZ-101, and PNL-7816, Corrosion Studies of Carbon Steel Under Impinging Jets of Simulated Slurries of Neutralized Current Acid Waste (NCAW) and Neutralized Cladding Removal Waste (NCRW)). The effect on the primary tank wall due to mixer pump loads is considered to be insignificant as compared to the other applicable design loads of much higher magnitude. The effect on internal elements due to mixer pumps is reported in document (HNF-SD-W151-DA-008, Evaluation of Effect of Project W-151 Mixer Pump Jets on In Tank Equipment Considering Potential Sludge Buildup on Equipment in Waste Tank 241-AZ-101) with operational limits to preclude overstressing of these elements.

Conditions -- The group then discussed the current conditions of AN-102 to determine if there were unique factors associated with AN-102 that needed further evaluation, before AN-102 can be determined to be fit for use as a staging tank.

Condition – 1) The free hydroxide in AN-102 has been below the acceptable corrosion specification value for at least 4 years (Tank Characterization Report for Double-Shell Tank 241-AN-102, HNF-SD-WM-ER-545). The current value is 0.21 M (general consensus) with the corrosion protection specification value being 0.3 M (Operating Specifications for 241 AN, AP, AW, AY, AZ, & SY Tank Farms, OSD-T-151-00007). The contents of AN-102 place AN-102 in the stress corrosion cracking region which could enhance the propagation of a crack, if there were an initiating flaw.

Due to the out-of-spec tank waste chemistry, stress conditions in the primary shell, and probable presence of an initiating site (no steel plate would be free of flaws), and even though tank design, material selection, and construction methods (e.g., post-weld heat treatment) would have minimized the likelihood of crack propagation, there is now some increased probability of failure of AN-102 due to stress-corrosion cracking. There is now also some increased probability of deterioration of the tank from uniform corrosion or pitting, at a faster rate than would be the case if the tank waste chemistry was within spec limits. There is a need to evaluate the present condition of the tank to assess its degree of deterioration due to corrosion. If there is pitting, then this will increase the probability for stress corrosion cracking.

New Information -- The group then listed the information which they would like to have to assess fitness for use of AN-102 as a waste staging tank.

New Info – 1) Perform an adequate UT examination of AN-102. The UT examination was performed on AN-106 and the tank was found to have no excess uniform corrosion, pitting, or cracking problems beyond that expected for a tank half way through its useful life of 50 years.

Tarlok and Bob wanted UT performed on AN-102 to address the extent of uniform corrosion or pitting.

New Info – 2) All new waste entering AN-102 after the current waste in AN-102 has been transferred has to meet the established and protective corrosion specifications for DST operations at the time of transfer. This is established procedure during waste feed delivery and will apply to all waste delivery operations during Phase 1B and Phase 1B Extended Order.

New Info – 3) Establish the boundary or range of the chemical and physical properties of the new waste that is planned for placement in AN-102. The boundary or range of these chemical and physical properties will cover and be protective of all staging tanks (i.e., conform to established protective corrosion specifications) and will not be unique to AN-102.

New Info – 4) The expected future uses of AN-102 are provided in Attachment 1 (provided by Dean Tulberg at the meeting). These uses were based on AN-106 as the staging tank and Phase 1B and Phase 1B Extended Order. Since AN-102 is to replace AN-106 and the new baseline case using AN 102 as a staging tank is not yet developed, the types of uses for AN 102 should be similar to that already planned for AN-106. The current belief is that there is nothing unique about the future expected uses of AN-102 as a staging tank that require special attention, assuming that the boundary/range of chemical and physical conditions discussed in New Info – 3), immediately above, are conformed to.

New Info – 5) Need for placement of a new corrosion probe into AN-102. Corrosion probes might be justified in tanks where the conditions were present for triggering stress corrosion cracking or where there is a desire to monitor for potential corrosion. If AN-106 were found to be a serious candidate for use as a staging tank, there is no need to place a corrosion probe in AN-106 before selecting that tank (i.e., there is no history of reduced levels of free hydroxide in AN-106).

Tarlok and Bob concluded that there was no added value in collecting information from a new corrosion probe in AN-102 to assess its fitness for use as a staging tank. With the UT examination and existing data, they have sufficient information to determine if AN-102 is fit for use as a staging tank.

Tarlok specifically said: a) AN-102 is slightly out of specification with low concentration of hydroxide, but the corrosion also depends on the combined effect of main constituents of waste, such as nitrate, nitrite, and hydroxide concentrations which mutually support each other against corrosion, b) stress calculations on the knuckle for stress corrosion cracking should suffice meeting the criteria and UT would substantiate the findings as additional level of confidence of corrosion protection specifications for the tanks (note: UT of AN-107 knuckle showed no cracks), and c) the basic reason he pointed out against installing the corrosion probes versus the UT data was that the corrosion probes are a long term data collection and evaluation process for it to be reliable.

For the corrosion probe to provide the most information, data gathering must begin upon placement of the stressed coupon in the waste. Since the coupon is already predisposed to cracking, any time delay may miss the actual cracking event. From this perspective, the corrosion probe could be a short term data collection event. Thus, if the probes are designed and working properly, they can provide valuable corrosion information very quickly, which may be construed as an extremely short-term data collection syste (additional clarifying text from discussions with Ed Fredenburg's group).

(From Larry Julyk) It may be possible to show that even though AN-102 has been out of the enveloping specification requirements, that the tank was still within limits to preclude stress corrosion cracking (SCC). To simplify operations the corrosion specification provide an enveloping set of conditions. By looking at the actual operating history in terms of chemistry and temperature and comparing them to the basis information for the corrosion specification, a more quantitative argument may be able to be established to add to our confidence that SCC is not a concern. Clearly the specific gravity of the waste, waste level, and operating temperature are below the design conditions for the AN Tank Farm. Hence, the calculated stress condition of the tank is less than predicted in the design analysis, therefore there is a reduced probability for SCC. A review of the basis information for the corrosion specification may also indicate that for the actual AN-102 operating temperature (~100 F), the actual chemistry is within limits to prevent SSC. However, at a minimum it would be prudent to perfor a UT examination of AN-102 as verification before committing to AN 102 as the staging tank.

(From R.P. Anantatmula). I can provide a little bit of support to the argument that stress corrosion cracking (SCC) may not be of concern in this tank. We know that the lower knuckle area is the most susceptible region for SCC to occur. The knuckle area has been in contact with the sludge for at least the last 10 years. My estimate of the aggressiveness of the sludge, based on the best basis inventories listed in the tank characterization report, indicates that the sludge is very benign from a corrosion perspective. Therefore, under these conditions, the probability for the occurrence of SCC is very small even if we assume that stresses are high in the knuckle region. Although the tank has been full for the last 15 years, the maximum temperature based on the records of the last 10 years has been about 103^{0}F (which is far below the design limit) and the specific gravity has been below the design limit. This suggests, as Larry points out, that the stresses are lower than those predicted by the design analysis. Since we know that it is relatively easier to install the UT equipment and make measurements, we should at least perform the UT examination as a means to quickly verify the absence of SCC prior to using AN-102 as a staging tank.

New Info – 6) Repeat visual examination of the annulus of AN-102 for leaks.

Tarlok and Bob agreed that this would be relatively inexpensive and simple to do and worthwhile to perform.

New Info – 7) Perform stress calculations on knuckle.

Tarlok would like this calculation specifically performed on AN-102.

New Info – 8) Perform leak test of AN-102. During the daily operations of these tanks, the equivalent of a leak test is performed for the current waste storage conditions (e.g., specific gravity, liquid level). It should be noted that this daily assessment of leak tightness does not simulate tank design conditions.

Tarlok and Bob would like this measurement made and documented at the appropriate time.

New Info – 9) Provide temporary hook-ups to the existing probes to measure electrochemical potential to determine if the waste chemistry in AN-102 is within stress corrosion cracking regime.

Bob wanted to make these measurements.

Overall Conclusions

Conclusion – 1) The UT examination will take from start to finish about 6 months and $600 K (estimate provided by Ed Fredenburg). Tarlok and Bob request that this examination be performed to provide the data they require to establish that AN-102 is fit for use as a staging tank.

The UT examination of AN-102 should be performed as soon as possible, recognizing that tank integrity could not fund this work until FY 2001. If the data show unacceptable corrosion levels, then there is adequate time to turn to AN-106 (or another tank) as a substitute staging tank for Phase 1B and Phase 1B Extended Order. The longer one waits to perform this UT examination of AN-102, the higher the risk that there may not be sufficient time to position another staging tank.

Conclusion –2) Perform stress calculations on the knuckle of AN-102.

Conclusion –3) The other measurements proposed by Tarlok and Bob (i.e., new info –3, 6, 8, 9) are either relatively easy and inexpensive to do or are required measurements that need to be done on any tank to establish that it is fit for use as a staging tank. None of these measures are burdensome or need to be done now on AN-102 because no one felt that there would be any surprises.

BOTTOM LINE CONCLUSION -- AN-102 should continue to be considered as the second staging tank for Phase 1B and Phase 1B Extended Order.

(Issues related to when to add caustic to AN-102 to supply adequate free hydroxide to meet corrosion protection levels will be determined by operations and by the degree of chemical change in the supernate that would result by such addition.)

Meeting Summary -- Final
December 9, 1999

Attachment 1

Sample Staging Tank Operational Uses					
(Basis: 106-AN from Case 3S4)					
Receive Waste From	Send Waste To	Begin Date	End Date	liq. vol. (gal)	sol. vol. (gal)
AN-101		3/13/03	3/13/03	40,000	-
AN-101		3/25/03	3/25/03	40,000	-
WATER		3/31/03	4/1/03	250,000	-
	AP-107	9/1/05	9/4/05	470,000	-
AN-107		9/4/05	9/6/05	478,400	1,045
AN-107		9/6/05	9/8/05	474,500	1,036
	SPARE-101	8/1/06	8/5/06	969,200	3,592
AN-102		8/5/06	8/9/06	779,200	1,215
	SPARE-101	2/5/10	2/8/10	782,900	1,272
	AN-107	2/9/10	2/10/10	140,000	37
AP-102		2/10/10	2/13/10	721,800	-
	SPARE-101	3/29/12	4/2/12	721,800	7
	AN-107	4/2/12	4/3/12	140,000	0.2
AW-101		4/3/12	4/8/12	862,400	1,322
	SPARE-101	1/10/14	1/14/14	866,300	1,282
AN-104		1/14/14	1/15/14	144,400	1,124
AN-104		5/28/14	6/2/14	963,300	7,606

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APPENDIX H

BEST BASIS INVENTORY DATA FOR CASE 3S5

(SUPPLIED BY D. L. PENWELL)

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	2-AN				7-AN			
Constituent	Conc	Units	moles/g (Bq/g)	moles/mole Na (bq/mole Na)	Conc	Units	moles/g (Bq/g)	moles/mole Na (bq/mole Na)
137Cs	260.9	uCi/g	9.65E+06	1.29E+09	2.99E+02	uCi/g	1.10E+07	1.71E+09
137mBa	246.8	uCi/g	9.13E+06	1.22E+09	2.82E+02	uCi/g	1.04E+07	1.62E+09
154Eu	0.3	uCi/g	1.03E+04	1.37E+06	1.03E+00	uCi/g	3.82E+04	5.92E+06
155Eu	0.21530	uCi/g	7.97E+03	1.06E+06	9.46E-01	uCi/g	3.50E+04	5.43E+06
232U	0.00001	uCi/g	2.53E-01	3.37E+01	6.45E-05	uCi/g	2.39E+00	3.70E+02
233U	0.00003	uCi/g	9.69E-01	1.29E+02	2.47E-04	uCi/g	9.14E+00	1.42E+03
234U	0.00001	uCi/g	2.00E-01	2.66E+01	3.16E-05	uCi/g	1.17E+00	1.81E+02
235U	0.00000	uCi/g	7.95E-03	1.06E+00	1.23E-06	uCi/g	4.54E-02	7.05E+00
236U	0.00000	uCi/g	7.10E-03	9.46E-01	1.12E-06	uCi/g	4.14E-02	6.42E+00
238Pu	0.00012	uCi/g	4.27E+00	5.68E+02	9.23E-04	uCi/g	3.41E+01	5.30E+03
238U	0.00000	uCi/g	1.76E-01	2.35E+01	2.73E-05	uCi/g	1.01E+00	1.57E+02
239/240Pu	0.00419	uCi/g	1.55E+02	2.06E+04	3.40E-02	uCi/g	1.26E+03	1.95E+05
239Pu	0.00356	uCi/g	1.32E+02	1.75E+04	2.89E-02	uCi/g	1.07E+03	1.66E+05
240Pu	0.00063	uCi/g	2.32E+01	3.09E+03	5.11E-03	uCi/g	1.89E+02	2.93E+04
241Am	0.09927	uCi/g	3.67E+03	4.89E+05	5.90E-01	uCi/g	2.18E+04	3.39E+06
241Pu	0.00826	uCi/g	3.06E+02	4.07E+04	6.62E-02	uCi/g	2.45E+03	3.80E+05
242Cm	0.00028	uCi/g	1.02E+01	1.36E+03	1.54E-03	uCi/g	5.70E+01	8.85E+03
242Pu	0.00000	uCi/g	1.63E-03	2.18E-01	3.54E-07	uCi/g	1.31E-02	2.03E+00
243Am	0.00000	uCi/g	1.44E-01	1.92E+01	2.41E-05	uCi/g	8.92E-01	1.38E+02
243Cm	0.00003	uCi/g	9.73E-01	1.30E+02	1.47E-04	uCi/g	5.43E+00	8.42E+02
244Cm	0.00023	uCi/g	8.43E+00	1.12E+03	1.13E-03	uCi/g	4.17E+01	6.47E+03
60Co	0.12821	uCi/g	4.74E+03	6.32E+05	2.42E-01	uCi/g	8.95E+03	1.39E+06
90Sr	55.42611	uCi/g	2.05E+06	2.73E+08	8.50E+01	uCi/g	3.15E+06	4.88E+08
90Y	55.42611	uCi/g	2.05E+06	2.73E+08	8.50E+01	uCi/g	3.15E+06	4.88E+08
99Tc	0.1	uCi/g	3.63E+03	4.83E+05	5.13E-02	uCi/g	1.90E+03	2.95E+05
Al	10862.5	ug/g	4.03E-04	5.36E-02	2.14E+02	ug/g	7.93E-06	1.23E-03
Ba			0.00E+00	0.00E+00			0.00E+00	0.00E+00
Ca	312.2	ug/g	7.79E-06	1.04E-03	4.32E+02	ug/g	1.08E-05	1.67E-03
Cd	46.5	ug/g	4.13E-07	5.50E-05			0.00E+00	0.00E+00
Cl	2740.8	ug/g	7.73E-05	1.03E-02	1.47E+03	ug/g	4.16E-05	6.45E-03
Cr	213.7	ug/g	4.11E-06	5.47E-04	1.26E+02	ug/g	2.41E-06	3.75E-04
F	1338.0	ug/g	7.04E-05	9.38E-03	3.05E+03	ug/g	1.61E-04	2.49E-02
Fe	36.6	ug/g	6.56E-07	8.73E-05	1.22E+03	ug/g	2.18E-05	3.39E-03
Hg			0.00E+00	0.00E+00	3.65E-01		1.82E-09	2.82E-07
K	2791.2	ug/g	7.14E-05	9.51E-03	1.32E+03	ug/g	3.38E-05	5.24E-03
La			0.00E+00	0.00E+00	2.58E+01		1.85E-07	2.88E-05
Na	172649.7	ug/g	7.51E-03	1.00E+00	1.48E+05	ug/g	6.45E-03	1.00E+00
Ni	274.1	ug/g	4.67E-06	6.22E-04	4.02E+02	ug/g	6.85E-06	1.06E-03
NO2	59420.3	ug/g	9.58E-04	1.28E-01	4.81E+04	ug/g	7.76E-04	1.20E-01
NO3	161859.1	ug/g	2.07E-03	2.76E-01	1.74E+05	ug/g	2.23E-03	3.46E-01
Pb	128.9	ug/g	6.22E-07	8.29E-05	2.90E+02	ug/g	1.40E-06	2.17E-04
PO4	3467.4	ug/g	3.65E-05	4.86E-03	2.15E+03	ug/g	2.26E-05	3.51E-03
SO4	9927.4	ug/g	1.03E-04	1.38E-02	6.55E+03	ug/g	6.82E-05	1.06E-02
TIC as CO3	47478.7	ug/g	7.91E-04	1.05E-01	5.51E+04	ug/g	9.18E-04	1.42E-01
TOC	18847.6	ug/g	1.57E-03	2.09E-01	3.01E+04	ug/g	2.50E-03	3.89E-01
UTOTAL	14.3	ug/g	6.00E-08	7.99E-06	8.18E+01	ug/g	3.43E-07	5.33E-05

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