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(a) Author (Print/Sign): Michael E. Johnson	Michael E. Johnson	Date: 6/10/05
(b) Responsible Manager (Print/Sign): Mike Thien	Mike Thien	Date: 6/10/05
(c) Reviewer (Optional, Print/Sign):		Date:
(d) Reviewer (Optional, Print/Sign):		Date:

(12) Distribution:

(a) Name	(b) MSIN	(a) Name	(b) MSIN
Garth Duncan	MS4-D2	Stewart M. Mackay	R2-58
Joel Eacker	H6-03	Billie M. Mauss	H6-60
John Eschenberg	H6-60	Randy Ni	R2-58
Rob A. Gilbert	H6-60	Bob Popielarczyk	R2-58
Jim Honeyman	H6-03	Thomas (Zack) Smith	H6-60
Michael E. Johnson	H6-19	Mike Thien	H6-03

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Strontium and TRU Separation Process in the DST System

M.E. Johnson, CH2M, L. Swanson, DMJM & G.N. Boechler, Lucas EMS, Inc.
for CH2M HILL Hanford Group, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-99RL14047

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Abstract: This report evaluates removing Sr/TRU from AN-102 and AN-107 supernates in the DST system before delivery to the WTP. The in-tank precipitation is a direct alternative to the baseline WTP process, using the same chemical separations. Implementing the Sr/TRU separation in the DST system beginning in 2012 provides ~6 month schedule advantage to the overall mission, without impacting the mission end date or planned SST retrievals.

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Strontium and TRU Separation Process in the DST System

Michael E. Johnson
CH2M HILL Hanford Group, Inc.
Richland, WA. 99352

Lynn Swanson
DMJM Technology
Richland, WA. 99354

G. Nick Boechler
Lucas EMS, Inc.
Richland, WA. 99352

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Contractor for the U.S. Department of Energy
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CH2MHILL
Hanford Group, Inc.

P.O. Box 1500
Richland, Washington

EXECUTIVE SUMMARY

The U.S. Department of Energy, Office of River Protection –Waste Treatment and Immobilization Plant baseline for pretreating supernatant waste received from tanks AN-102 and AN-107 includes a precipitation step for removing radioactive strontium (^{90}Sr) and transuranic (TRU) isotopes before the waste is vitrified. This report summarizes the application of the same precipitation process for removing ^{90}Sr and transuranics in the double shell tank system before delivery of the AN-102 and AN-107 supernatants to the Waste Treatment and Immobilization Plant. This evaluation of the in-tank precipitation is a direct alternative to the Waste Treatment and Immobilization Plant process. Study results indicate that implementation of the Sr/transuranic separation in the double-shell tank system provides an approximate 6 month schedule advantage to the overall mission schedule as modeled by the Hanford Tank Waste Operations Simulator using the Developmental Run as a reference case. The Hanford Tank Waste Operations Simulator modeling also indicates that the Sr/transuranic process can be implemented beginning in 2012 using tank AP-102 without impacting the mission end date or planned single-shell tank retrievals. The additional Tank Farm baseline cost for implementation of this process system is approximately $2.6M. This cost is in addition to costs already in the planning baseline for double-shell tank system components that would be required to implement the Sr/transuranics separation process.

The addition of strontium nitrate and sodium permanganate to tanks AN-102 and AN-107 supernatants precipitates strontium and TRU elements out of the supernatant and eliminates the need to perform this time constrained process in the Waste Treatment and Immobilization Plant. The treated tank AN-102 and tank AN-107 supernatants are expected to meet ^{90}Sr and TRU specifications for immobilized low-activity waste[1].

While specific process implementation decisions (i.e. treatment and delivery timing), and Tank Farm operational protocols (i.e. waste compatibility screening) will be needed, this study concludes that the concept of in-tank strontium and TRU treatment of tank AN-102 and tank AN-107 supernatants is worth pursuing. This study also finds that some additional evaluations are needed to confirm the concept viability before implementation. An additional $2.6M in tank farm work scope and some added feed delivery complexity has the potential to save six months of Waste Treatment and Immobilization Plant operating costs, currently estimated at approximately $1.2M per day.

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[1] The U.S. Department of Energy Office of River Protection, Contract No. DE-AC27-01RV14136, Specification 2.2.2.8, *Radionuclide Concentration Limitations* requires the concentrations of ^{90}Sr and TRU to be less than 20 Ci/m^3 and less than 100 ηCi/gm, respectively in the ILAW.

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LIST OF TERMS

Abbreviations and Acronyms

BBI	best-basis inventory
BNI	Bechtel National, Inc.
CH2M HILL	CH2M HILL Hanford Group, Inc.
DF	decontamination factor
DST	double-shell tank
ENRAF	Enraf-Nonius Series 854
HLW	High-Level Waste
HTWOS	Hanford Tank Waste Operations Simulator
ILAW	immobilized low-activity waste
LAW	low-activity waste
ORP	U.S. Department of Energy, Office of River Protection
TRU	Transuranic
TWINS	Tank Waste Inventory Network System
WFO	Waste Feed Operations
WTP	Waste Treatment and Immobilization Plant

Units

°C	degrees Celsius
Ce	cerium
Ci	Curies
cP	centipoise
°F	degrees Fahrenheit
g	gram
gpm	gallons per minute
in	inch
J/g	joules per gram
kJ/mole	kilojoules per mole
$\underline{M}$	molar concentration (moles per liter)
m^3	cubic meter
mL	milliliter
MT	metric ton
ηCi	nanocuries
µg	microgram
µCi	microcuries
wt%	weight percent
µm	micrometer (micron)

1.0 INTRODUCTION

The supernatants stored in tanks 241-AN-102 (AN-102) and 241-AN-107 (AN-107) contain soluble strontium-90 (^{90}Sr) and transuranic (TRU) elements that require removal prior to vitrification to comply with the Waste Treatment and Immobilization Plant (WTP) immobilized low-activity waste (ILAW) specification and with the 1997 agreement[2] with the Nuclear Regulatory Commission on incidental waste. A precipitation process has been developed and tested with tank waste samples and simulants using strontium nitrate ($Sr(NO_3)_2$) and sodium permanganate ($NaMnO_4$) to separate ^{90}Sr and TRU from these wastes.

The U.S. Department of Energy Office of River Protection (ORP) and CH2M HILL Hanford Group, Inc. (CH2M HILL) have agreed to perform a life-cycle optimization study to evaluate conducting the Sr/TRU precipitation process in the double-shell tank (DST) system and is a direct alternative to the process to be performed at the WTP. The separation of Sr/TRU from the supernatant in tanks AN-102 and AN-107 is currently planned to be performed in the ultrafiltration system within the WTP. While the Sr/TRU precipitation process is being performed within the WTP, high-level waste (HLW) sludge cannot be pretreated because these two pretreatment processes use the same vessels and ultrafiltration system. The WTP is projected to experience a 6 to 24 month[3] interruption in HLW pretreatment processing along with a reduction in HLW melter throughput due to the process limitations when pretreating the AN-102 and AN-107 supernatants. This optimization study evaluates the separation of ^{90}Sr and TRU in an existing DST prior to delivery to the WTP and determines the resulting change (i.e., expected reduction in HLW processing schedule) as compared to the Development Run used as the reference case. Life-cycle cost saving can only be realized if a similar reduction in LAW processing can be achieved for the completion of the overall waste treatment mission. The acceptability of the pretreated supernatants and ^{90}Sr/TRU precipitates for meeting WTP contract requirements, criticality safety limits, and hydrogen generation rates were not included in the study scope.

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[2] Letter, NRC to DOE-RL, *"Classification of Hanford Low-Activity Tank Waste Fraction"*, June 9, 1997, C. J. Paperiello, Director of Nuclear Material Safety and Safeguards, to J. Kinzer, Assistant Manager, Office of Tank Waste Remediation System, U. S. DOE, Richland Operations Office.

[3] ORP-11242, Revision 2, 2003, *River Protection Project System Plan*, page 2-19, CH2M HILL Hanford Group, Inc., Richland, Washington.

Work presented in this report was performed by CH2M HILL and COGEMA Engineering Corporation (COGEMA) and its subcontractors Lucas EMS, Inc. and DMJM Technology. COGEMA and its subcontractors performed this work under a CH2M HILL Contract No. 21843, Release 3, "Engineering Optimization Study Support".

2.0 SUMMARY

The ORP-WTP baseline for pretreating supernatant waste received from tanks AN-102 and AN-107 includes a precipitation step for removing ^{90}Sr and TRU isotopes before the waste is vitrified. This report summarizes the removal of ^{90}Sr and TRU in the DST system before delivery of the AN-102 and AN-107 supernatants to the WTP, using the same process as was developed for the ORP-WTP baseline. This process will be a direct alternative to the current WTP process for these feed streams.

The Sr/TRU precipitation process had been developed through a series of laboratory tests. These test reports, prepared by Savannah River National Laboratory and Battelle Pacific Northwest Division and published for Bechtel National, Inc. (BNI)[4], have demonstrated the effectiveness of the ^{90}Sr and TRU precipitation process. Treated waste must meet Specification 2 of the BNI contract[5] (WTP 2001) for removing ^{90}Sr and TRU elements from the low-activity waste (LAW) solution, i.e., 20 curies per cubic meter (Ci/m^3) for ^{90}Sr and 100 nanocuries per gram (ηCi/g) for TRU. Target decontamination levels for the Sr/TRU removal process have been established at 50% below the LAW requirements[6], which requires percent removals of 90.3% for ^{90}Sr and 38.3% for TRU for tank AN-102 waste and percent removals of 91.3% for ^{90}Sr and 85% for TRU in tank AN-107 waste. Mass balance calculations resulted in percent removals of 94% for ^{90}Sr and 88.3% for TRU in both AN-102 and AN-107 tank wastes. These mass balance calculations, along with the AN-107 sample test results, demonstrate that the pretreated supernatant meets the WTP ILAW ^{90}Sr and TRU specifications.

The design basis used in this report for the Sr /TRU removal process analysis is the addition of strontium nitrate (3 molar (M) $Sr(NO_3)_2$) and sodium permanganate (3.83 M $NaMnO_4$) to diluted Envelope C (i.e. AN-102 and AN-107 supernatants) to produce 0.02 M Sr and 0.02 M MnO_4 in solution. Addition of $Sr(NO3)_2$ results in isotopic dilution of ^{90}Sr and precipitation of $SrCO_3$. Addition of sodium permanganate results in manganese reduction, precipitation of MnO_2, and concomitant TRU precipitation. The precipitation process is performed at a 5.5 M sodium concentration.

Based on the Sr/TRU precipitation process criteria, the Sr/TRU precipitation process cannot be conducted in tanks AN-102 or AN-107 due to the volume of dilution water required to achieve a

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[4]Test plans and studies identified in Bechtel National, Inc. (BNI), 2002. *Research and Technology Plan*, 24590-WTP-PL-RT-01-002, Rev. 1, U.S. Department of Energy, Office of River Protection, Richland, WA.

[5] The U.S. Department of Energy Office of River Protection, Contract No. DE-AC27-01RV14136, Specification 2.2.2.8, *Radionuclide Concentration Limitations* requires the concentrations of ^{90}Sr and TRU to be less than 20 Ci/m^3 and less than 100 ηCi/g, respectively in the ILAW.

[6] The sodium oxide concentration is assumed to be 15wt% in these low-level waste glasses and the glass density is assumed to be 2.76 g/mL.

5.5 M sodium concentration in the supernatant and added reagent volumes. Adequate tank space is not available to perform these addition operations in tanks AN-102 or AN-107. However, tank 241-AP-102 (AP-102) is suitable to receive and process batch transfers of AN-102 and AN-107 supernatants. Based on the total supernatant volumes for treatment and required chemical addition, a batch volume equal to approximately ½ of the existing tank(s) supernatant volume was considered suitable to accommodate the required process volume.

The Sr/TRU precipitation process can be conducted in tank AP-102 by transferring separate batches of tanks AN-102 and AN-107 supernatants into tank AP-102 for treatment. Tank AP-102 supernatant is assumed to be removed, except for a residual supernatant heel of 10 inches. Prior to treatment of AN-102/107 supernatants, these batches are modeled as separate material balances (Appendix A, Attachments 4, 5, 6 and 7). Treated supernatants are transferred into an available LAW tank for storage and/or delivery to the WTP. Strontium and TRU precipitates are accumulated on top of the existing AP-102 sludge layer. The accumulated solids/sludge is diluted to 10 wt% solids and transferred into an available HLW staging tank.

Figure 2-1 is a simplified process flow to treat tanks AN-102 and AN-107 supernatants in tank AP-102, showing primary transfer/flow lines and major equipment requirements. Table 2-1 summarizes the resulting concentrations of ^{90}Sr and TRU in the LAW glass from each of the four batches of treated supernatants and the volume of Sr/TRU precipitate generated for each batch.

Table 2-1. Concentrations of ^{90}Sr and TRU in Low-Level Waste Glass Resulting from Treatment of Tanks AN-102 and AN-107 Supernatants and Volume of Resulting Precipitate

Treated Supernatants	Units	AN-102 Batch #1	AN-102 Supernatant Batch #2	AN-107 Supernatant Batch #3	AN-107 Supernatant Batch #4
TRU in glass[(a), (b)]	ηCi/g	11.52	12.11	61.77	62.05
^{90}Sr in glass [(a), (b)]	Ci/m^3	5.84	6.14	6.59	6.59
TRU in-glass[(c)]	ηCi/g	15.4	16.2	82.4	82.7
^{90}Sr in glass [(c)]	Ci/m^3	7.78	8.19	8.79	8.79
^{90}Sr Concentration (in treated supernatant)	µCi/mL	2.38	2.51	2.69	2.69
Sum of TRU	µCi/mL	0.01	0.01	0.07	0.07
Sr/TRU Precipitate	inches	3.42	3.44	4.22	4.19
Volume Settled Solids (precipitate)[(d)]	gallons	9.41E+03	9.47E+03	1.16E+04	1.15E+04

Notes:

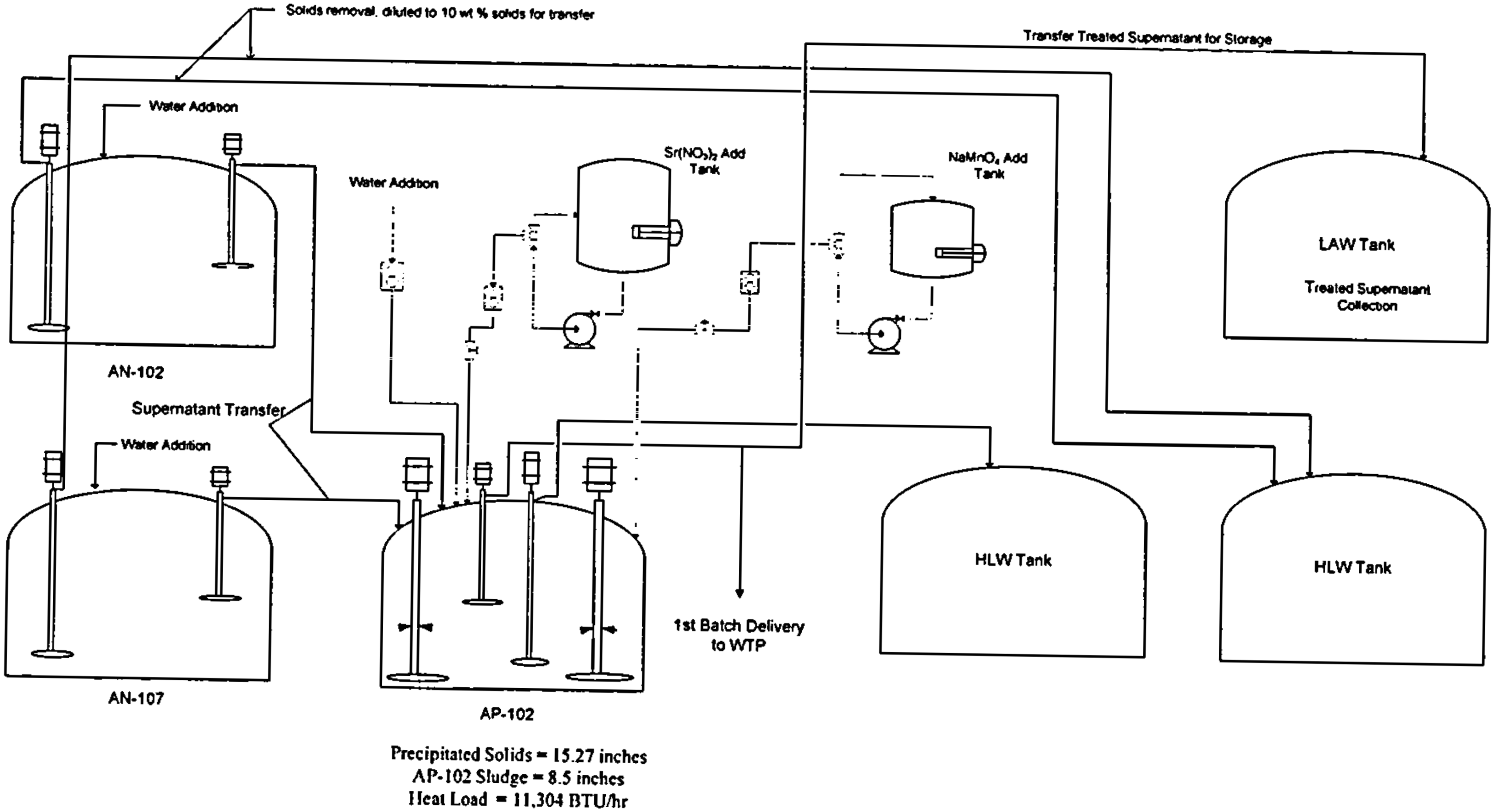
[(a)] The U.S. Department of Energy Office of River Protection, Contract No. DE-AC27-01RV14136, Specification 2.2.2.8, *Radionuclide Concentration Limitations* requires the concentrations of ^{90}Sr and TRU to be less than 20 Ci/m^3 and less than 100 ηCi/g respectively in the immobilized LAW.

[(b)] Assumes a glass density of 2.76 MT/m^3 and 15 wt% Na_2O in the low-level waste glass.

[(c)] Concentrations of ^{90}Sr and TRU at 20 wt% Na_2O in the LAW glass are provided for comparison and shows the sensitivity to increased sodium oxide loading. Assumes a glass density of 2.76 MT/m^3.

[(d)] Assumes 2,750 gallons per inch for AN tanks.

Figure 2-1. Sr/TRU Precipitation of AN-102 and AN-107 Supernatants in Tank AP-102



3.0 PROCESS DESCRIPTION

The WTP has identified the optimal conditions for precipitating ^{90}Sr and TRU from tanks AN-102 and AN-107 supernatants through a series of WTP test reports. These test reports identify and detail a precipitation process using $Sr(NO_3)_2$ to separate ^{90}Sr by isotopic dilution with precipitation of $SrCO_3$; and $NaMnO_4$ to precipitate TRU from these wastes. In addition, recently additional laboratory tests were conducted on a sample of tank AN-107 supernatant to quantify process conditions important to conducting the Sr/TRU precipitation process in the DST system (precipitation behavior of undiluted waste, gravity settling rate of the precipitates, and physical properties of settled precipitates). A separate report will provide detailed results of the laboratory tests conducted with the tank AN-107 supernatant sample. A summary of results from previous testing and available results from the most recent testing are given below. Appendix F provides detailed information on the Sr/TRU precipitation process which includes the basic chemistry, time, and temperature dependency of the precipitation reaction.

3.1 PAST TEST REPORTS SUMMARY

A series of test reports prepared for BNI (Appendix F) from process tests performed on tanks AN-102 and AN-107 samples demonstrated the mechanism of the Sr/TRU precipitation process and determine optimal process conditions. The optimal conditions for precipitating Sr/TRU from the tank AN-102 and AN-107 supernatants were found to be a dilution of the waste to a 5 $\underline{M}$ to 6 $\underline{M}$ sodium concentration, mixing of the waste, and addition of $Sr(NO_3)_2$ and $NaMnO_4$ to achieve a final concentration of 0.02 $\underline{M}$ each, with precipitation reactions conducted at 26 to 29°C. These precipitation conditions have been demonstrated to reduce the ^{90}Sr concentration by ~94% and the TRU concentration by 75% to 85% (PNWD-3340), which corresponds to concentrations of ^{90}Sr and TRU in the LAW glass of ~5 Ci/m^3 and less than 25 ηCi/g, respectively. This optimization study uses conservative estimates for ^{90}Sr and TRU percentages removed from the supernatants, resulting in higher ^{90}Sr and TRU concentrations in the ILAW glass.

3.2 CH2M HILL AT-TANK PRECIPITATION TESTING

Testing of the at-tank precipitation method using representative samples of supernatants from AN-107 were conducted independent of this study (*Test Results for At-Tank Conditions for Strontium/Transuranic Removal from Tank 241-AN-107 Supernatant*, CH2M HILL interoffice memo 7S110-RWW-05-017, dated May 9, 2005, from R.W. Warrant to M.E. Johnson). The WTP has already identified the optimal conditions for precipitating ^{90}Sr and TRU from AN-102 and AN-107 supernatants (PNWD-3141, PNWD-3264, PNWD-3338, and PNWD-3340). Therefore, precipitation reaction conditions were not evaluated. Instead, process conditions important to conducting the Sr/TRU precipitation process in the DST system were quantified, including gravity settling rate of the precipitates and physical properties of settled precipitates.

Two strontium and TRU precipitation tests were conducted with an archived sample of tank AN-107 supernate. In the first test, the archived tank AN-107 sample was used as-is and had analyzed sodium, ^{90}Sr and ^{241}Am concentrations of 8.7 M, 62.1 μCi/ml and 0.466 μCi/ml, respectively. Approximately 100-ml of the tank AN-107 sample were pipetted into a flask that contained a magnetic stir bar. The sample was stirred and 1.25-ml of 3.0 M $Sr(NO_3)_2$ and 1.0-ml of 3.8 M $NaMnO_4$ were added to result in ~0.037 M Sr and ~0.037 M MnO_4 concentrations. The Sr and MnO_4 concentrations in the AN-107 are equivalent to ~0.02 M when AN-107 sample is normalized to 5.0 M Na concentrations. Small, very fine white colored solids were observed to form after several minutes of mixing, indicating precipitation of strontium carbonate and manganese oxide solids was occurring, as expected. The mixing of the sample was stopped after ~4 hours. No solids were initially observed to have settled in the sample. After approximately three days of settling, a thin layer of white solids was observed in this sample. Analysis of the supernate in the treated sample indicated that ~81% of the ^{90}Sr and ~67% of the ^{241}Am were removed. Assuming the treated AN-107 sample was incorporated into an ILAW glass waste form at 15% wt sodium oxide concentration, the ^{90}Sr and ^{241}Am concentrations in this glass waste form would be 16.5 Ci/m^3 and ~80 ηCi/gram, respectively. The ^{90}Sr and ^{241}Am concentrations in the AN-107 ILAW glass are 17.5% and 20% lower than the WTP ILAW glass limits for these radionuclides.

A 73-ml sub-sample of the archived AN-107 supernate was diluted by addition of 42-ml of 0.01 M NaOH to a sodium concentration of approximately 5.9M to prepare 115-ml of diluted AN-107 sample. A 15-ml sample of the diluted AN-107 sample was analyzed and the ^{90}Sr and ^{241}Am concentrations in the diluted tank AN-107 sample were 41.4 μCi/ml and 0.324 μCi/ml, indicating no significant precipitation of ^{90}Sr and ^{241}Am occurred during sample dilution. Approximately 100-ml of the diluted tank AN-107 sample was pipetted into a flask that contained a magnetic stir bar. The sample was stirred and 0.07-ml of 3.0 M strontium nitrate and 0.55-ml of 3.8 M sodium permanganate were added to result in ~0.02 M Sr and ~0.02 M MnO_4 concentrations. Solids were initially visible in the diluted AN-107 sample. Analysis of the supernate in the treated sample indicated that ~82% of the ^{90}Sr and ^{241}Am were removed. Assuming the treated AN-107 sample was incorporated into an ILAW glass waste form at 15 wt% sodium oxide concentration, the ^{90}Sr and ^{241}Am concentrations in this glass waste form would be 15.5 Ci/m^3 and ~58 ηCi/gram, respectively. The ^{90}Sr and ^{241}Am concentrations in the AN-107 ILAW glass are 22.5% and 42% lower than the WTP ILAW glass limits for these radionuclides.

These two tests demonstrated that the Sr/TRU precipitation process can be conducted without diluting tank AN-107 supernate. Due to the opacity of both samples, solids settling rate information could not be obtained. However settling of the Sr/TRU precipitate is not required for conducting this process. The pretreated tank AN-107 (and AN-102) supernate, containing suspended Sr/TRU precipitates can be processed along with HLW sludges in the WTP

Pretreatment ultrafiltration system. By selecting the HLW to be processed along with the pretreated AN-107 (and AN-102) supernate, the resulting HLW glass formulation can be optimized. The need and scope of additional testing for conducting the Sr/TRU precipitation process in the DST system will be evaluated during subsequent phases.

4.0 PERFORMANCE REQUIREMENTS

Bechtel National, Inc. has targeted decontamination levels at 50% below the LAW requirements[7] which corresponds to ^{90}Sr and TRU concentrations in the supernatants of less than 7.48E-04 Ci per mole of sodium and 1.03E-05 Ci per mole of sodium, respectively by performing in-tank precipitation at the WTP. These values assume a 15 wt% sodium oxide loading and a glass density of 2.76 MT/m^3. An increase in sodium oxide loading in LLW glass to 19 or 20 wt% would result in increased ^{90}Sr and TRU concentrations in the LLW glass, below the contract specification 2.2.2.8 limits, but above a 50% target limit for TRU concentration. The performance of the Sr/TRU precipitation process flowsheet for treatment of tanks AN-102 and AN-107 supernatants in the DST system is also evaluated at 50% below the LAW requirements and provides concentrations of ^{90}Sr and TRU less than 20 Ci/m^3 and 100 ηCi/gm, respectively in the ILAW.

A series of test reports have been prepared by Savannah River National Laboratory and Battelle-Pacific Northwest Division and published for BNI[8] which demonstrate the effectiveness of the ^{90}Sr and TRU precipitation process. Many of these studies were conducted with actual tank waste samples of AN-102 and AN-107 supernatant, using a range of experimental conditions, and are cited in Appendix F as they apply to each specific Sr/TRU process condition (i.e., precipitation chemistry, sodium concentration, reaction time and temperature, etc.). The results and/or conclusions of selected test reports containing data inputs for use as performance requirements in this optimization study are given below.

- Dilute to a final target sodium concentration of 5M and do not add additional sodium hydroxide. Basis: PNWD-3141

- Conduct process at a temperature of 25± 5° C, with stirring, add 0.02M strontium nitrate followed by 0.02M sodium permanganate. Basis: PNWD-3141

    - Stir/digest precipitate at 25± 5° C for 4 hours. Basis: PNWD-3141

    - The Decontamination Factors (DFs) for precipitation of ^{90}Sr varied between 5 and 7 at 26° C. The DFs for ^{241}Am were relatively independent of temperature and ranged between 5 and 6 with permanganate addition. Basis: PNWD-3141.

    - The non-radioactive Sr addition should be 0.02M or higher to ensure low levels of ^{90}Sr in the ILAW. Basis: PNWD-3338.

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[7]The U.S. Department of Energy Office of River Protection, Contract No. DE-AC27-01RV14136, Specification 2.2.2.8, *Radionuclide Concentration Limitations* requires the concentrations of ^{90}Sr and TRU to be less than 20 Ci/m^3 and less than 100 ηCi/gm, respectively in the ILAW.

[8]Test plans and studies identified in Bechtel National, Inc. (BNI), 2002. *Research and Technology Plan*, 24590-WTP-PL-RT-01-002, Rev. 1, U.S. Department of Energy, Office of River Protection, Richland, WA.

- TRU removal process is most effective for removing tri-valent actinide ions Am and Cm. These elements make up approximately 95% of the TRU in the waste. Basis: PNWD-3340
- Time dependence of ^{90}Sr and TRU removal: TRU precipitation is independent of time and ^{90}Sr precipitation is shown to be time dependent with an increased ^{90}Sr DF at 24 hours versus 4 hours. Basis: PNWD-3340

4.1 OPERATING SPECIFICATIONS FOR DSTS

The operating specifications for the DSTs identify requirements and limits for processing and storage operations applicable to the AN and AP tanks (OSD-T-151-00007, Rev. I-9). Requirements and limits pertaining to waste transfer or receipt of waste or chemicals within the DST Farm System are identified in the *Tank Farms Waste Transfer Compatibility Program* document (HNF-SD-WM-OCD-015, Rev. 15).

The following limits and/or requirements are identified as applicable to the proposed precipitation process:

a) Tank Bump Controls, OCD Section 3.1.3.2: *Prior to waste transfers into the DSTs, Engineering shall evaluate the end state of the receiving tank to verify that at least one of the following criteria is met:*

- *Total tank heat load is < 58,000 Btu/hr*

  The calculated heat load of the combined Sr/TRU precipitate and tank AP-102 sludge is 11,304 Btu/hr (includes decay heat contribution from ^{90}Sr, ^{137}Cs, and ^{241}Am).

- *Non-convective layer thickness is < 12 in.*

  The cumulative solids layer in AP-102 after treatments is 23.7 in.

- *Supernatant depth is < 39 in.*

  During batch treatments, height of supernatant varies from 264 in. to 312 in.

- *The non-condensable gas generation rate at saturation temperature in the non-convective layer is sufficiently low, such that the ratio of vertical void fraction profile to the neutral buoyant void fraction (buoyancy ratio) is < 1.0 (RPP-6213, Addendum 1, Table 4-2).*

A Waste Compatibility Assessment was not prepared as part of this report. Once specifics of transfer and process parameters are determined, a Waste Compatibility Assessment will be required prior to implementing any Tank Farm operations.

Basis: HNF-SD-WM-OCD-015, Rev. 15

b) Waste Group Re-evaluation Requirements, OCD Section 3.1.3.3, *HNF-IP-1266, Section 5.10, requires that the final state (Waste Group) of the receiving tank be evaluated using the methodology described in RPP-10006 prior to the following operations:*

- *Waste transfers into DSTS that are Waste Group B and C (receiving tank).*
  N/A (requirement is applicable to waste transfers from SSTs into DSTs and is therefore not applicable for this study, which is restricted to waste transfer between DSTs)
- *Large water additions (>10,000 gallons) to DSTs that are Waste Group C.*
  A Waste Compatibility Assessment was not prepared as part of this report. Once specifics of transfer and process parameters are determined, a Waste Compatibility Assessment will have to be performed prior to implementing any Tank Farm operations.
- *Large chemical additions (>10,000 gallons of sodium hydroxide or sodium nitrite) to DSTs that are Waste Group B and C.*
  HNF-IP-1266, Section 5.10.A, Rev. 0a provides the following Waste Group designations:
  - AP-102 – Waste Group C
  - AN-102 – Waste Group B
  - AN-107 – Waste Group C

The requirements of the Waste Compatibility Assessment that must be performed prior to Sr/TRU processing will evaluate and identify the Waste Group(s) for the receiving tanks.

c) DST Waste Chemistry Controls, OCD Section 3.1.4.1: *The receipt or transfer of waste that does not meet chemistry control limits can occur only if the receiving DST will remain within specification limits after the transfer or as part of actions for the mitigation of out-of-specification waste.*

Chemistry limits for DSTs are provided in the Tank Farm Waste Transfer Compatibility Program, Table 3.3. *DST Waste Chemistry Limits.* The concentrations of OH^-, NO_2^-, and NO_3^- are taken from the mass balance for the pretreated supernatant (i.e., diluted supernatant with reagents added) batches and are shown in Table 4.1.

Table 4.1. Concentrations of OH^-, NO_2^-, and NO_3^- in Pretreated Tanks AN-102 and AN-107 Supernatants Compared to DST Waste Chemistry Limits.

Variable	Units	Pretreated Batch #1 (Tank AN-102 Supernatant)	Pretreated Batch #2 (Tank AN-102 Supernatant)	Pretreated Batch #3 (Tank AN-107 Supernatant)	Pretreated Batch #4 (Tank AN-107 Supernatant	DST Waste Chemistry Limits (T<167°F)[(a)]
$[OH^-]$	M	0.338	0.293	0.626	0.638	$0.1 * ([NO_3^-] \leq [OH^-] \leq 10.0$ M
$[NO_2^-]$	M	1.04	1.03	0.879	0.873	NA
$[NO_3^-]$	M	1.86	1.87	2.06	2.07	NA
$[OH^-] + [NO_2^-]$	M	1.38	1.32	1.5	1.51	$\geq 0.4 * ([NO_3^-])$
Comparison Value: (0.4 * NO_3^-	M	0.74	0.53	0.60	0.60	

[(a)] DST Waste Chemistry Limits for $[NO_3]$ range 1.0 M < $[NO_3] \leq 3.0$ M for T <167^0 F, obtained from Table 3-3 of HNF-SD-WM-OCD-015, Rev. 15.

Basis: HNF-SD-WM-OCD-015, Rev. 15

d) Liquid Levels, OSD Section 2.1.1

- The Normal Operating Limit for the AN and AP tanks is given as 416 inches (calculates to 1.14E+06 gallons, RPP-13019). Tank waste liquid level is defined as the surface level irrespective of the amounts of sludge, supernatant, or solids/crust.

  Basis: OSD-T-151-00007, Rev. I-9.

5.0 PROCESS ANALYSIS

The design basis for the Sr/TRU removal process analysis is the addition of a 3 M strontium nitrate solution for isotopic dilution and precipitation of ^{90}Sr as $SrCO_3$, followed by the addition of a 3.83 M sodium permanganate solution for precipitation of the TRU elements. The tank AN-102 and tank AN-107 supernatants are diluted to a sodium concentration of 5.5 M prior to chemical addition for precipitation.

5.1 Sr/TRU PRECIPITATION IN TANKS AN-102 AND AN-107

The feasibility of conducting the Sr/TRU precipitation process for tank AN-102 supernatant in-tank AN-102 and treatment of tank AN-107 supernatant in-tank AN-107 was based primarily on an evaluation of tank capacity, i.e., the available capacity to receive the reagent volumes and dilution water necessary to conduct the Sr/TRU removal process.

5.1.1 Flowsheet Analysis

The material balance for performing the in-tank Sr/TRU precipitation process for tanks AN-102 and AN-107 supernatant assumes treatment of 100% of the in-tank supernatant inventory and associated volume as provided by the best-basis inventory (BBI) data. The normal operating limit for AN tanks is 416 inches (1.14 E+06 gallons)[9]. As discussed in Section 3.0, the optimal conditions for precipitating Sr/TRU from the tank AN-102 and AN-107 supernatants have been established through experimental testing and include dilution of the waste to approximately 5.5 M Na, mixing the waste, addition of $Sr(NO_3)_2$ and $NaMnO_4$ to a final concentrations of 0.02 M each, with precipitation reactions conducted at 26 to 29 °C.

5.1.2 Tank Inventory and Input Data

The starting inventory data for each tank were obtained from the BBI Data located on the Tank Waste Information Network System (TWINS) web page (TWINS 2004). The BBI Effective Date is April 4, 2004 (12:00 am) and is the basis for the tank composition data used for tanks AP-102, AN-102 and AN-107. The BBI reports the density and volume of each phase (supernatant and sludge) in the tanks.

The BBI data does not identify certain supplemental analytes for all waste phases. For this mass balance, two supplemental analytes, Rhodium and Tantalum have supernatant inventory values for tank AN-107, but no values listed for tank AN-102. The BBI supplemental analytes are in addition to the standard list of analytes and are provided if values were available.

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[9] The CH2M HILL volume calculator (RPP-13019) is used to convert between inches and volumes for tanks.

5.1.2.1 Method of Analysis

The method of analysis for this calculation uses a Microsoft Office Excel® 2003 spreadsheet designed to estimate supernatant and solids compositions based on the given design inputs and assumptions for the Sr/TRU precipitation process. The mass balance calculation and spreadsheet were prepared in compliance with the TFC-ENG-DESIGN-C-10, "Engineering Calculations" and TFC-ENG-CHEM-D-33, Rev B, "Spreadsheet Verification". The required spreadsheet verification form is provided as part of Appendix A. An evaluation was performed for in-tank treatment of the entire supernatant contents of tanks AN-107 and AN-102, resulting in two mass balance worksheets:

- *Treat in AN-102* (Appendix A, Attachment 4)
- *Treat in AN-107* (Appendix A, Attachment 5)

Appendix A identifies the specific calculations performed and provides the mass balance worksheets. The specific input data and assumptions were used to:

1. Calculate the volume of water addition necessary to dilute tank AN-102 and tank AN-107 supernatants to a sodium concentration of 5.5 M.

2. Calculate the volume of reagent addition, $NaMnO_4$ and $Sr(NO_3)_2$, necessary to perform the Sr/TRU precipitation of 100% of the supernatant volume in tanks AN-102 and AN-107.

3. Calculate the composition of AN-102 and AN-107 supernatants after addition of $Sr(NO_3)_2$ and $NaMnO_4$ to achieve a final concentrations of 0.02 M in the treated supernatant.

4. Calculate the resulting volume of precipitate for each tank.

5. Calculate the ^{90}Sr and TRU concentration in the LAW glass[10] resulting from the precipitated ^{90}Sr/TRU concentrations in the treated waste (i.e., solids phase).

The *Calculation Page* worksheet, Appendix A, Attachment 3, details these computations and identifies the specific cells or rows of the material balance worksheets which perform the mechanical operations.

5.1.3 Calculation Results

Treatment of the entire supernatant contents in tanks AN-107 and AN-102, respectively, would exceed the normal operating limits (416 inches) of the AN tanks (OSD-T-151-00007, Rev I-9).

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[10] The U.S. Department of Energy Office of River Protection, Contract No. DE-AC27-01RV14136, Specification 2.2.2.8, *Radionuclide Concentration Limitations* requires the concentrations of Sr^{90} and TRU to be less than 20 Ci/m^3 and less than 100 ηCi/gm, respectively in the ILAW. In addition, the sodium concentration is assumed to be 15 wt% in these low-level waste glasses and the glass density is assumed to be 2.76 g/mL.

The volume of dilution water added to achieve the optimal sodium concentration of 5.5 M (PNWD-3141) and the required reagent volumes exceed the available tank capacity.

Table 5-1 summarizes the initial and final supernatant volume conditions for Sr/TRU precipitation in tanks AN-102 and AN-107. Table 5-2 summarizes the volume of reagent addition required to achieve the optimal process conditions.

Table 5-1. Initial and Final Supernatant Volumes in Tanks AN-102 and AN-107

Description	Unit	AN-102 Supernatant Initial	AN-107 Supernatant Initial	AN-102 Supernatant Treated Waste In-Tank AN-102[b] Final	AN-107 Supernatant Treated Waste In-Tank AN-107[b] Final
BBI Supernatant Volume[a]	Liters	3.55E+06	3.30E+06	6.32E+06	5.47E+06
	Gallons	9.38E+05	8.71E+05	1.67E+06	1.44E+06
Height of Supernatant	Inches	341.1	316.8	607.4	525.4
Na concentration	M	9.68	9.02	5.45	5.45
Normal Operating Limit[c]	Gallons	1.14E+06	1.14E+06	1.14E+06	1.14E+06

[a] BBI supernatant volumes are taken from TWINS 2004, effective date April 1, 2004.
[b] The volume contribution due to solids precipitation will increase the final volume in the tank.
[c] Source: ODS-T-151-00007, Rev. I-9.

Table 5-2. Reagent Volumes Added to Tanks AN-102 and AN-107 for Sr/TRU Precipitation[a]

Reagent Addition	Units	AN-102	AN-107
3 M $Sr(NO_3)_2$	Gallons	1.11E+04	9.60E+03
40 wt% $NaMnO_4$ (3.83 M)	Gallons	8.76E+03	7.58E+03
Water	Gallons	7.13E+05	5.57E+05

[a] Sr/TRU precipitation process conditions are 5.5 M Na in the pretreated supernatant with $Sr(NO_3)_2$ and $NaMnO_4$ addition to achieve a final concentration of 0.02 M in treated supernatant.

5.2 SR/TRU PRECIPITATION OF AN-102 AND AN-107 SUPERNATANTS IN TANK AP-102

The calculation results from the treatment of the entire supernatant contents in tanks AN-102 and AN-107 exceed the normal operating limits. However, the removal of Sr/TRU from AN-102 and AN-107 supernatants can be conducted in an alternate DST tank by transferring batches of AN-102 and AN-107 supernatants into a suitable tank for treatment. Tank AP-102 was determined to be a suitable tank for performing the precipitation process.

5.2.1 Alternate Tank Selection

Tank AP-102 was selected as the tank to conduct the Sr/TRU removal from tanks AN-102 and AN-107 supernatants based on the following benefits:

- Tank AP-102 is in good condition.
- AP-102 already contains sludge (23,000 gallons) so the addition of a ^{90}Sr/TRU precipitate layer will not impose extra cost.
- The central pump pit on tank AP-102 has been equipped with a mixer pump (currently inoperative).
- Feed transfer to WTP will be available through equipment supplied by Project W-211 and Project W-314.
- Project W-211 supplies a transfer/decant pump for AP-102.

Further evaluation of the adequacy of tank AP-102 for conducting this process should be addressed in subsequent phases of this project.

5.2.1.1 Flowsheet Analysis

The material balance for conducting the Sr/TRU precipitation process in tank AP-102 is developed as four separate batches. Based on the total supernatant volumes for treatment and required chemical addition, a batch volume equal to approximately ½ of the supernatant volume in each tank (i.e., AN-102 and AN-107) was considered suitable to accommodate the required process volume. The batch size volumes are identified in the mass balance calculation, Appendix A. Tank AP-102 supernatant is assumed to be removed into an available LAW DST for storage before the treatment process is initiated. A residual AP-102 supernatant heel of 10 inches is assumed to remain and is included in the first batch of supernatant for treatment.

Treated supernatants are transferred into an available DST for storage and/or delivery to the WTP. Strontium and TRU precipitates are accumulated on top of the existing tank AP-102 sludge layer. After completing the treatment of the tank AN-102 and AN-107 supernatants, the solids/sludge accumulated in tank AP-102 is diluted to 10 wt% solids and transferred into an available DST.

A process flow diagram, shown in Figure 5-1, was developed to identify the proposed batch transfers from tank AN-102 and AN-107 supernatants into tank AP-102 for treatment.

5.2.1.2 Tank Inventory and Input Data

The inventory data for each tank were obtained from the BBI Inventory Data located on the TWINS web page (TWINS 2004). The BBI Effective Date is April 4, 2004 (12:00 am) is the basis for the tank composition data for tanks AP-102, AN-102 and AN-107 and reports the density and volume of each phase (supernatant and sludge) in the tanks. The BBI data does not identify certain supplement analytes for all waste phases. For this mass balance, two supplemental analytes, Rhodium and Tantalum have supernatant inventory values for AN-107, but no values are listed for AN-102.

5.2.1.3 Method of Analysis

The method of analysis for this calculation uses a Microsoft Office Excel® 2003 spreadsheet designed to estimate supernatant and solids compositions based on the given design inputs and assumptions for the Sr/TRU precipitation process. The mass balance calculation and spreadsheet were prepared in compliance with the TFC-ENG-DESIGN-C-10, "Engineering Calculations" and TFC-ENG-CHEM-D-33, Rev B, "Spreadsheet Verification". The required spreadsheet verification form is provided as part of Appendix A. Using the results of the in-tank AN-102 and AN-107 mass balance, the same calculation process was performed on batches of AN-102 and AN-107 supernatant transferred into tank AP-102. A mass balance was performed for each of the four batches:

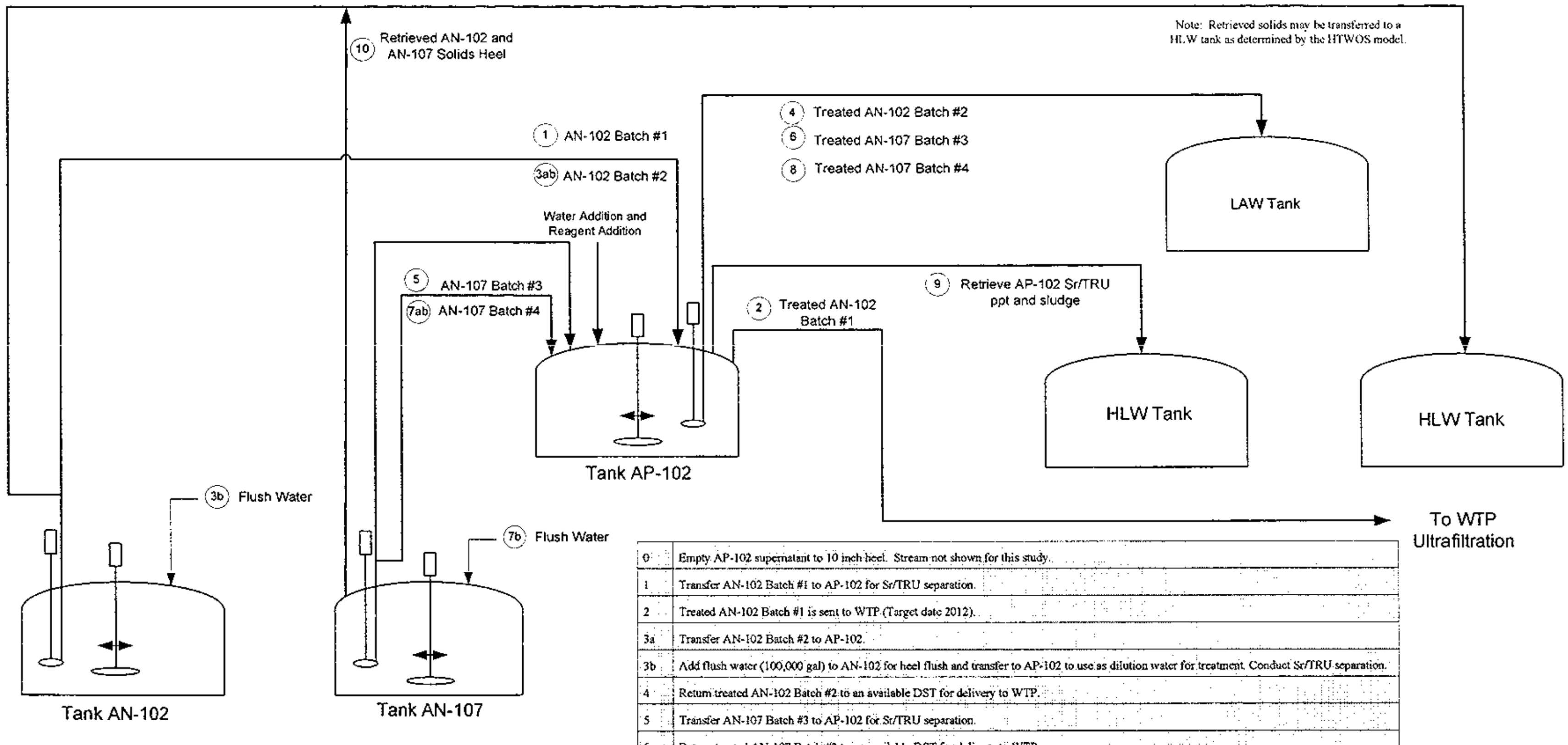
Batch #1 treatment of AN-102 supernatant in tank AP-102 (Appendix A, Attachment 6)

Batch #2 treatment of AN-102 supernatant in tank AP-102 (Appendix A, Attachment 7)

Batch #3 treatment of AN-107 supernatant in tank AP-102 (Appendix A, Attachment 8)

Batch #4 treatment of AN-107 supernatant in tank AP-102 (Appendix A. Attachment 9)

Figure 5-1. Process Flow Diagram



0	Empty AP-102 supernatant to 10 inch heel. Stream not shown for this study.
1	Transfer AN-102 Batch #1 to AP-102 for Sr/TRU separation.
2	Treated AN-102 Batch #1 is sent to WTP (Target date 2012).
3a	Transfer AN-102 Batch #2 to AP-102.
3b	Add flush water (100,000 gal) to AN-102 for heel flush and transfer to AP-102 to use as dilution water for treatment. Conduct Sr/TRU separation.
4	Return treated AN-102 Batch #2 to an available DST for delivery to WTP.
5	Transfer AN-107 Batch #3 to AP-102 for Sr/TRU separation.
6	Return treated AN-107 Batch #3 to an available DST for delivery to WTP.
7a	Transfer AN-107 Batch #4 to AP-102 for Sr/TRU separation.
7b	Add flush water (100,000 gal) to AN-107 for heel flush and transfer to AP-102 to use as dilution water for treatment. Conduct Sr/TRU separation.
8	Transfer treated AN-107 Batch #4 to to an available DST for delivery to WTP.
9	Retrieve AP-102 solids (Sr/TRU ppt and sludge) to an available HLW tank for blending and transfer to WTP.
10	Retrieve AN-102 and AN-107 solids heel to an available HLW.

Appendix A identifies the specific calculations performed and provides the mass balance worksheets. The specific input data and assumptions were used to perform the following calculations:

1. Calculate the volume of water addition necessary to dilute the AN-102 and AN-107 supernatant batches to a sodium concentration of 5.5 <u>M</u>.

2. Calculate the volume of reagent addition, $NaMnO_4$ and $Sr(NO_3)_2$, necessary to perform the Sr/TRU precipitation of the supernatant volume transferred to tank AP-102.

3. Calculate the composition of AN-102 and AN-107 supernatants after addition of $Sr(NO_3)_2$ and $NaMnO_4$ to achieve a final concentrations of 0.02 <u>M</u> in the treated supernatant.

4. Calculate the resulting volume of precipitate for each tank.

5. Calculate the ^{90}Sr and TRU concentration in the LAW glass resulting from treated AN-102 and AN-107 supernatants (i.e., ^{90}Sr and TRU precipitation reactions have occurred with resulting decontamination of supernatant).

The *Calculation Page* worksheet, Appendix A, Attachment 3, details these computations and identifies the specific cells or rows of the material balance worksheets which perform these mathematical operations.

5.2.1.4 Results

The results of the material balance demonstrate that four batches of supernatant (two batches from tank AN-102 and two batches from AN-107) can be treated to meet the requirement of less than 20 Ci/m^3 for ^{90}Sr and 100 ηCi/gm for TRU in the ILAW. A conservative target TRU and ^{90}Sr concentration of 50% below the LAW requirement was also used to evaluate results. The percent removals required to meet target values of 50 ηCi/gm for TRU and 10 Ci/m^3 ^{90}Sr are shown in Table 5-3. The 50% values were conservatively selected as preliminary process limits to avoid exceeding the contractual WTP ILAW glass limits due to data uncertainties (e.g. Na_2O loading, Sr/TRU concentrations, etc.).

Table 5-3 summarizes the resulting concentrations of ^{90}Sr and TRU in the LAW glass from each of the four batches of treated supernatants and the volume of Sr/TRU precipitate generated for each batch. Tank AN-107 supernatant does not meet the target value of 50 ηCi/gm TRU in the ILAW glass, but still meets the WTP contractual concentration limit of 100 ηCi/gm TRU.

Table 5-3. Concentrations of ^{90}Sr and TRU in Low-Level Waste Glass Resulting from Treatment of Tanks AN-102 and AN-107 Supernatants and Volume of Resulting Precipitate

Treated Supernatants	Units	AN-102 Batch #1	AN-102 Supernatant Batch #2	AN-107 Supernatant Batch #3	AN-107 Supernatant Batch #4
TRU in glass [a, b] (Target Value = 50 ηCi/gm)	ηCi/gm	11.52	12.11	61.77	62.05
^{90}Sr in glass [a, b] (Target Value = 10 Ci/m^3)	Ci/m^3	5.84	6.14	6.59	6.59
^{90}Sr Concentration	µCi/ml	2.38	2.51	2.69	2.69
Sum of TRU	µCi/ml	0.01	0.01	0.07	0.07
Sr/TRU Precipitate	inches	3.42	3.44	4.22	4.19
Volume Settled Solids (ppt)	gallons	9.41E+03	9.47E+03	1.16E+04	1.15E+04

(a) The U.S. Department of Energy Office of River Protection, Contract No. DE-AC27-01RV14136, Specification 2.2.2.8, *Radionuclide Concentration Limitations* requires the concentrations of ^{90}Sr and TRU to be less than 20 Ci/m^3 and less than 100 ηCi/gm, respectively in the ILAW.

(b) Assumes a glass density of 2.76 MT/m^3 and 15 wt% Na_2O in the low-level waste glass

5.2.1.5 Uncertainties

Low ^{90}Sr and TRU Decontamination: The ^{90}Sr and TRU precipitation reactions and DF have been demonstrated using liter quantities of actual tank supernatant samples. Pilot-scale demonstrations of the Sr/TRU precipitation process have been conducted with tens of gallons of simulants with the primary purpose to demonstrate crossflow filtration of the precipitated solids. The Sr/TRU precipitation process has not been conducted at the scale proposed for processing in the DSTs. Difficulties could be encountered in achieving effective mixing of the reagents with tank AN-102 or tank AN-107 supernatants leading to reduced ^{90}Sr and TRU decontamination.

Effective mixing of the tank AN-102 (or AN-107) supernatants with reagents may be achieved using a replacement 300-hp mixer pump installed in tank AP-102. Previous testing of a 150-hp mixer pump in tank AP-102 for the now defunct grout treatment program demonstrated this pump is capable of achieving a homogenous waste mixture in tank AP-102 supernatant[11]. Erosion of tank walls and piping systems due to the operation of a 300-hp mixer pump is not considered to be significant because of the short duration required for the reagent mixing operation. Laboratory testing of the Sr/TRU precipitation mechanism has been shown to occur even with no mixing (PNWD-3338, section 3.1, $SrCO_3$ precipitation). Therefore, the risk of poor mixing in tank AP-102 is categorized as low.

[11] WHC-SD-WM-TRP-168, 1994, T. L. Welsh, Tank 241-AP-102 Characterization and Grout Product Test Results, Westinghouse Hanford Company, Richland Washington

Additional ^{90}Sr and TRU removal can be achieved by increasing the concentrations of strontium nitrate and sodium permanganate in the treated supernatants (PNWD-3338). Similarly, if the desired ^{90}Sr and TRU decontamination is not achieved, additional strontium nitrate and/or sodium permanganate can be added to the supernatant to achieve further ^{90}Sr and TRU decontamination. Therefore, the risk of not achieving the desired ^{90}Sr and TRU decontamination is also categorized as low.

Solids Settling: The process flowsheet assumes the Sr/TRU precipitate is settled and accumulated in tank AP-102. The Sr/TRU precipitated solids may remain suspended in the treated supernatant. If the Sr/TRU precipitated solids remain suspended, these solids would be transferred along with the treated supernatant to another DST for interim storage and eventual processing in the WTP. The WTP is equipped with ultrafilters that can separate the suspended Sr/TRU precipitated solids. Therefore, there should be no impact if the Sr/TRU precipitated solids remain suspended. Recent laboratory tests conducted to determine the settling rate for the Sr/TRU precipitate were inconclusive due to the opacity of the sample.

Sodium Concentration: The process flowsheet assumes a target sodium concentration of 5.5 M in the tank AN-102 and tank AN-107 supernatants prior to treatment. The sodium concentration of these supernatants are identified from BBI data as 9.68 M and 9.02 M sodium, respectively. Laboratory tests conducted to determine the ^{90}Sr and TRU decontamination achieved in an undiluted sample of AN-107 supernatant. Results from these laboratory tests (see Section 3.2) indicate addition of dilution water to achieve 5.5 M sodium may be eliminated. Further optimization of the precipitation process is considered a low risk for meeting decontamination requirements, but may benefit DST space management.

5.2.1.6 Process Operation Description

As identified earlier, tank AP-102 is a candidate tank for conducting the proposed Sr/TRU separation. Conceptual operation sequences are described here. In order to use tank AP-102 for this process, approximately 1,075,000 gallons of supernatant presently in the tank will be moved to another DST or tanks that have sufficient storage space. Once that is accomplished, a portion of the tank AN-102 (or the first batch) supernatant will be transferred to tank AP-102. The 300-hp mixer pump installed in tank AP-102 will be operated to mix the tank contents. Then, the necessary quantities of 3 M $Sr(NO_3)_2$ and 3.8 M (40 wt%) $NaMnO_4$ would be added to tank AP-102 via the chemical addition systems and a tank riser. After mixing these chemical reagents with the transferred supernatant in tank AP-102 for a minimum of 4-hours, the mixer pump will be stopped to allow the precipitates to settle. A grab sampling of the treated supernatant will be obtained and analyzed to verify the desired level of ^{90}Sr and TRU (i.e. ^{241}Am and $^{239\text{-}240}Pu$) precipitation has been achieved. If ^{90}Sr and/or TRU present in the AP-102 sludge is inadvertently dissolved by the AN-102 or AN-107 supernatants or inadequate precipitation occurs, then additional 3 M $Sr(NO_3)_2$ and 3.8 M (40 wt%) $NaMnO_4$ will be added and the tank content will be mixed to further reduce the ^{90}Sr and TRU concentration in the pretreated supernatant.

After verifying the ^{90}Sr *and TRU concentration goals have been met, the pretreated batch of* supernatant from tank AP-102 will be transferred either to the WTP or to an another DST for feed staging, depending on the WTP waste processing schedule. Processing of the remaining batches of tanks AN-102 and AN-107 supernatants would be conducted in a manner similar to that described above when space is available in the DST system.

5.3 HANFORD TANK WASTE OPERATIONS SIMULATOR MODEL RUN

The impacts to the mission life cycle and feed delivery dates to the WTP of treating the AN-102 and AN-107 supernatants in the DST systems were evaluated using the Hanford Tank Waste Operations Simulator (HTWOS) model[12]. The HTWOS model simulates the waste storage, retrieval, and treatment processes to provide an integrated flowsheet and mission scenario using agreed upon modeling assumptions. Key assumptions and inputs used in the HTWOS model run to support this optimization study were prepared and submitted to CH2M HILL using the HTWOS Model Change Summary Form and Assumptions Matrix to document the requested model revision for this optimization study. Appendix B presents the assumptions and major inputs for the HTWOS model necessary to implement an HTWOS model run for the Sr/TRU removal process.

Appendix E presents the approved HTWOS Model Modification form supporting this optimization study. Key HTWOS model assumptions include:

- Segregate pretreated tank AN-102 and tank AN-107 supernatants from other DSTs that contain HLW solids to avoid potential for solubilization of ^{90}Sr/TRU precipitates.
- Sr/TRU precipitate settles in tank AP-102.
- Pretreated tank AN-102 and tank AN-107 supernatants are further processed in the WTP, including solids-liquid separation, cesium ion exchange, evaporation, etc.
- Start tank AN-102 pretreatment processing in the tank AP-102 in the year 2013 unless restricted by other model constraints. The processing schedule was optimized in HTWOS.
- Sr/TRU precipitate can be blended with other HLW solids/supernate without impact; the HTWOS model assesses the HLW glass impact of blending.

[12] The HTWOS is programmed in G2, an object-oriented artificial intelligence software package commercially available through the Gensym Corporation. G2 is a trademark of Gensym Corporation. A detailed description of the HTWOS model is available in RPP-7630, Configuration Management Plan for Hanford Tank Waste Operations Simulator Flowsheet Modeling

5.4 HANFORD TANK WASTE OPERATIONS SIMULATOR OUTPUT DATA

The HTWOS modeling of the Sr/TRU precipitation process in tank AP-102 results in a revised feed staging sequence and provides new WTP LAW feed delivery dates for tank AN-102 and tank AN-107 supernatants. The HTWOS outputs include the initial and final supernatant compositions for the treatment of four supernatant batches, as well as the revised WTP LAW feed delivery dates for the treated tank AN-102 and tank AN-107 supernatants. Tables 5.4 and 5.5 summarize the processing dates and volumes optimized by the HTWOS model run for the Development run and this study. The HTWOS model was set up to avoid conflicting transfers and allowes a five day delay between users. These runs determined there was no conflict due to staggered transfer schedule. An assessment of these feed delivery dates is provided in Section 5.5. The HTWOS outputs for the revised WTP LAW feed delivery are provided in Appendix C, *HTWOS Results*.

As shown by the HTWOS run, in-tank processing benefits the WTP production rate. The Sr/TRU precipitation processing of LAW Envelope C supernatants in the WTP is conducted in the same process equipment that is used for pretreatment of HLW solids. Therefore, the WTP must suspend pretreatment of HLW solids while conducting the Sr/TRU precipitation process. In order to maintain HLW vitrification production, the WTP accumulates excess pretreated HLW solids before conducting the Sr/TRU precipitation process. Due to vessel storage capacity limitations and HLW melter feed blending considerations, pretreatment of HLW solids and Sr/TRU precipitation processing of LAW Envelope C supernatants is alternated until all LAW Envelope C supernatant is processed. Under this operating scenario, there is the potential for insufficient pretreated HLW solids available to support full capacity operation of the HLW vitrification facility. Using the HTWOS modeling reference, Development Run for comparison, the HLW vitrification facility could be idle for approximately six months due to unavailability of pretreated HLW solids. Pretreatment of the LAW Envelope C supernatants in the tank farms to separate Sr and TRU elements can eliminate this idle time for the HLW vitrification facility.

In addition to WTP operational impacts, the space constraints (i.e., tank utilization and scheduling) imposed on the DST system are also evaluated using the HTWOS model. This evaluation includes allocation of tank AP-102 for conducting the Sr/TRU precipitation process, continued storage of LAW Envelope C supernatants in tanks AN-102 and AN-107 until pretreatment processing is completed, and blending of the Sr/TRU precipitates accumulated in tank AP-102 with HLW solids present in tank AY-102 for feed to the WTP. The HTWOS model results indicate no apparent impacts to DST tank space or utilization from conducting the Sr/TRU precipitation process in the tank farms.

Table 5-4. HTWOS Output for Sr/TRU Study Run

From	To	Start Date	End Date	Volume (gal)
AN-102	AP-102	10/9/2012	12/12/2012	5.00E+05
Process Dilution	AP-102	10/16/2012	10/19/2012	4.70E+05
AP-102	Pretreatment	4/23/2013	4/23/2013	9.70E+05
Flush	AP-102	4/23/2013	4/23/2013	5.00E+02
AN-102	AP-102	4/27/2013	4/29/2013	4.11E+05
Process Dilution	AP-102	5/3/2013	5/5/2013	3.78E+05
AP-102	Pretreatment	8/12/2013	8/12/2013	7.92E+05
Flush	AP-102	8/12/2013	8/12/2013	5.00E+02
AN-107	AP-102	8/16/2013	8/19/2013	4.50E+05
Process Dilution	AP-102	8/23/2013	8/25/2013	3.01E+05
AP-102	Pretreatment	11/24/2014	11/24/2014	7.52E+05
Flush	AP-102	11/24/2014	11/24/2014	5.00E+02
AN-107	AP-102	11/28/2014	11/30/2014	3.94E+05
Process Dilution	AP-102	12/4/2014	12/5/2014	2.61E+05
AP-102	Pretreatment	3/11/2015	3/11/2015	6.56E+05
Flush	AP-102	3/11/2015	3/11/2015	5.00E+02

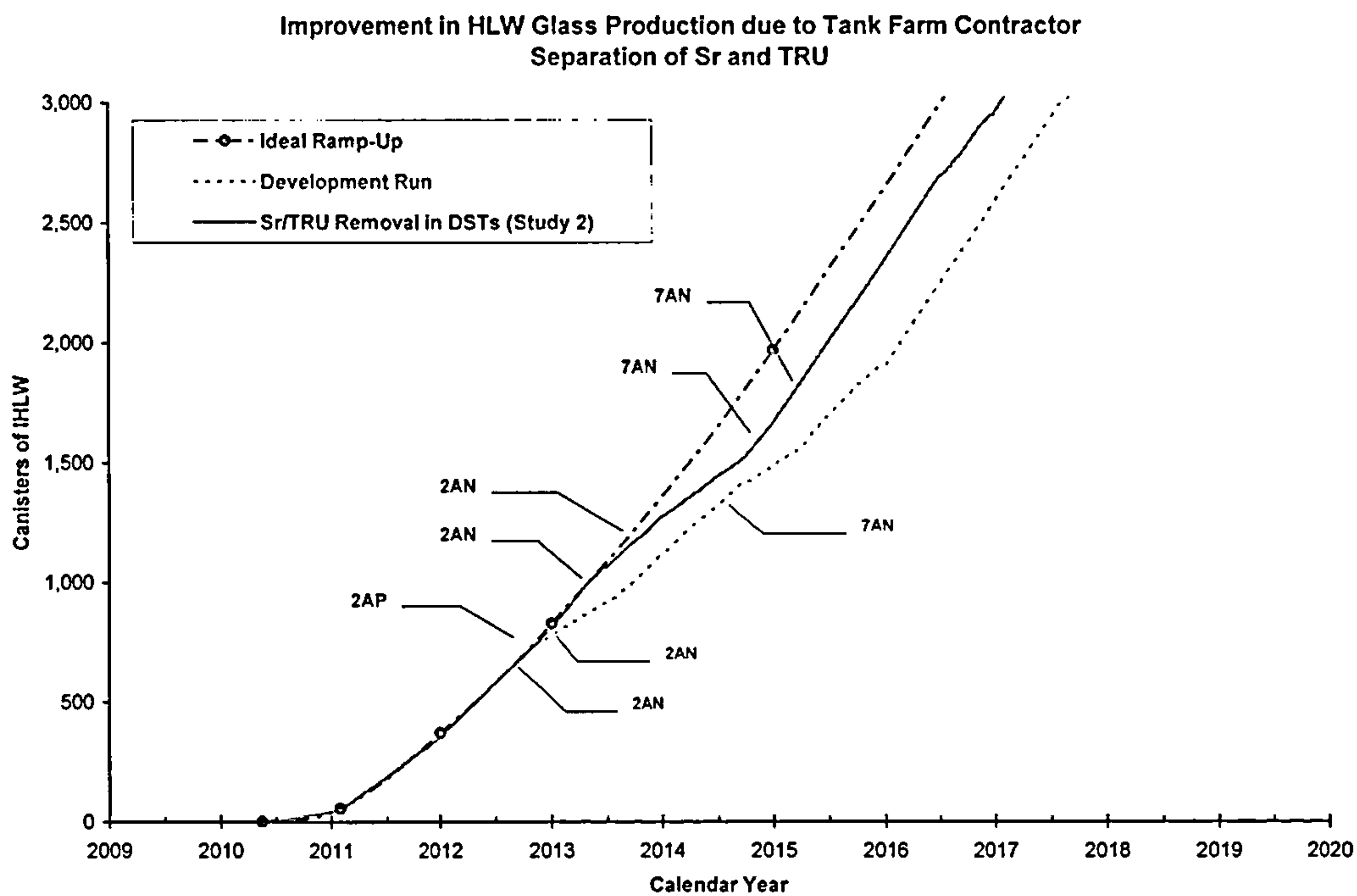
Table 5-5. HTWOS Output for Development Run

From	To	Start Date	End Date	Volume (gal)	Dilution H_2O (gal)
Flush	AN-102	8/30/2012	8/30/2012	5.00E+02	0
AN-102	Pretreatment	8/30/2012	8/30/2012	5.12E+05	2.44E+05
Flush	AN-102	2/9/2013	2/9/2013	5.00E+02	0
AN-102	Pretreatment	2/9/2013	2/9/2013	5.12E+05	2.44E+05
Flush	AN-107	8/28/2014	8/28/2014	5.00E+02	0
AN-107	Pretreatment	8/28/2014	8/28/2014	9.00E+05	0
AP-102	Pretreatment	1/17/2016	1/17/2016	1.21E+06	0

5.5 MISSION LIFE-CYCLE IMPACTS

The HTWOS model includes a simulation of the WTP operations in order to estimate the volume of immobilized high-level waste and ILAW glass resulting from delivered feeds. The HLW waste canister production curve can be used to evaluate any advantage (i.e., schedule improvement) of the HTWOS output. The results of the HTWOS run compared to the Developmental Run, as shown in Figure 5.2, indicate that implementation of the Sr/TRU separation in the DST system provides an approximate 6 month schedule advantage to the overall mission schedule using the Developmental Run as a reference case. The tank notations on the figure indicate the approximate supernate delivery date to the WTP from the stated tank. The HTWOS modeling indicates the Sr/TRU precipitate process can be implemented beginning in 2012 using tank AP-102 without impacting the overall mission and date or planned SST retrievals. No impacts to other ORP mission requirements were identified.

Figure 5-2. Developmental Run



6.0 NEW EQUIPMENT REQUIREMENTS

The AP tank farm consists of eight DSTs, each with a nominal capacity of one-million gallons. The following general observations were made regarding equipment needs:

- No modifications to the existing transfer lines or pit jumpers are needed beyond those already included in Project W-314.

- The following upgrades are needed to provide the proper mixing and transferring capabilities:

    - New 300-hp mixer pump in AP-102
    - One each transfer/decant pump with adjustable suction in AP-102, AN-102 and AN-107.

It is also noted that the AP ventilation system may need to be upgraded. Further analysis will be needed if implementation of the Sr/TRU separation process is initiated, equipment needs should be reviewed to assure timely integration with identified supporting projects.

6.1 CHEMICAL TRANSFER SYSTEMS

Two chemical transfer systems will be required. The chemical systems are $Sr(NO_3)_2$ and $NaMnO_4$. Each of the systems will have a dedicated 8 ft. x 12 ft. skid. The skids will be located at least 10 feet outside the 241- AP tank farm. The skids will be powered from AP-102 central pump pit junction box. Due to the simplicity of batch operation, the chemical system controls will be locally mounted on the skid for manual operation.

Skid mounted chemical storage and transfer systems are the basis for the design developed in this study and cost estimate. Due to the relatively infrequent need for the chemical additions to the tanks, it may be possible to eliminate these skids with a tank-truck supplied chemical feed. This option would require further investigation in later stages of design development. For such an approach, potential operational and safety concerns that could be inherent with a truck supplied chemical system must be addressed.

The Sodium Permanganate System will include a 3,200 gallon type 316 stainless steel tank. The Strontium Nitrate System will include a 4,000 gallon type 316 stainless steel tank. The pumps supplying the chemicals will be 100 gpm capacity at a maximum of 100 ft. head. Voltage is 230v/30/60 Hz and operating temperature is up to 120° F. The system is intended for outside operation.

The interface between the chemical transfer system and tank AP-102 and the 4 inch riser #27 will be with a flexible hose bolted to the 4 inch riser flange.

6.2 IN-TANK EQUIPMENT

In-tank equipment required for transfer of tank AN-102 and tank AN-107 supernatants to tank AP-102 and conduct the Sr/TRU precipitation process in tank AP-102 include:

1. transfer/decant pumps,
2. mixer pump, and
3. thermocouple trees, tank liquid level Enraf-Nonius Series 854 (ENRAF), sludge level indicator, and leak detection instrumentation.

6.2.1 Transfer/decant pumps

One each Transfer /Decant Pump will be required in tanks AP-102, AN-102 and AN-107 to transfer both slurry and/or supernatant. All three tanks currently have transfer pumps with stick legs installed. However, the pumps are dated and are underpowered to make the transfers required for this application. All three of these pumps are presently in the scope of project W-211 for replacement. The new pumps are scheduled for installation during the 2009 to 2012 time frame.

The pumps will be designed to deliver the rated 140 gpm at 450 feet of head (normal operating point) for 1.25 specific gravity (60 HP). The pumps design will include provisions for the addition of dilution water at 100 psig or less pressure, injected at the suction of the pumps in a manner that directs the diluents into the pumps.

6.2.2 Mixing Pump

One mixing pump will be required in tank AP-102. Currently no mixing pump is installed in tank AP-102. Project W-211 is scheduled to install one mixing pump in the center pump pit (riser #11) of tank AP-102 during the 2006 to 2009 time frame.

Tank AN-107 has an inoperable mixer pump and project W-211 is scheduled to install one mixing pump in tank AN-102. For this proposed pretreatment process, no operations require mixer pumps in these tanks. However, the mixer pumps will be required to retrieve the sludge and solids that reside at the bottom of the tanks, or if chemistry control by caustic addition requires mixing.

6.2.3 Thermocouple Trees, Tank Liquid Level, Sludge Level Indicator and Leak Detection Instrumentation

The ENRAFs, sludge level indicators and leak detection instrumentation equipment in tanks AP-102, AN-102 and AN-107 are all currently functioning and in good operating order. No instrumentation modifications or replacements are anticipated.

6.2.4 AP Tank Farm Ventilation

Project W-211 originally included the replacement of the AP tank farm exhausters but project scope was reduced to exclude the exhauster upgrade. However, the current AP tank farm ventilation system is in good operating order and is assumed of sufficient capacity to ventilate tank AP-102 during the mixing and transferring operations of the proposed pretreatment process. This assumption will require further evaluation backed up by appropriate calculations on emissions control.

The 241-AP Tank Farm consists of eight DSTs that are ventilated by a common exhaust system. The exhaust system provides ventilation by maintaining a negative pressure on the tanks with respect to the outside atmosphere. The 241-AP Tank Farm Primary Ventilation System interfaces with various interlock control systems, including a high-efficiency particulate air filter differential pressure interlock and continuous air monitor interlock. Each primary exhaust train consists of an inlet isolation valve, an outlet isolation valve, and an exhaust fan. Each exhaust fan has a rated capacity in excess of 1,000 standard ft^3/min. The isolation valves are used to direct the airflow through one of the two independent exhaust trains.

6.2.5 AN Tank Farm Ventilation

The AN tank farm exhausters are presently being upgraded with high capacity exhausters sufficient to ventilate tanks AN-102 and AN-107 during the operations in this study. No modifications are anticipated.

6.2.6 Transfer Lines

Transfer lines and valving are required from tanks AN-102 and AN-107 to and from tank AP-102. Transfer lines and valving are also required from tank AP-102 to HLW and LAW tanks.

Currently all pit jumpers required to do these transfers are not in place. However, project W-314 is scheduled to have all the required jumpers installed to make these transfers by the end of 2005.

The flow paths for the waste are as follows:

- From 241-AN-107 transfer pump, through 241-AN-A Valve Pit, through 241-AN-B Valve Pit, through TK-AN-101 Valve Pit, through 241-AZ Valve Pit, through 241-AP-102 Pit 02D and into tank AP-102. Use the reverse flow path for AP-102 to AN-107.

- From AN-102 transfer pump, through 241-AN-B Valve Pit, through TK-AN-101 Valve Pit, through 241-AZ Valve Pit, through 241-AP-102 Pit 02D and into tank. AP-102. Use the reverse flow path for tank AP-102 to AN-102.

The HTWOS model output for this study determined there was no conflict due to the staggered transfer schedule. If implementation of the Sr/TRU separation process in the DST system is initiated, equipment needs should be reviewed to assure timely integration with identified supporting projects.

6.3 EQUIPMENT ASSUMPTIONS

1) Project W-211's time frame (2009 to 2012) of installing transfer /decant pumps in tanks AP-102, AN-102 and AN-107 will be funded and on schedule.

2) Project W-211's transfer /decant pumps will have the required horse power to make the required waste transfers.

3) Current Thermocouple Trees, Tank Liquid Level (ENRAFs), Sludge Level Indicators and Leak Detection Instrumentation will be maintained and remain in good operating order.

4) Current AP tank farm exhauster is of sufficient capacity to ventilate tank AP-102 during operations and is maintained in good operating condition. Further evaluation of exhauster system will be required.

7.0 PROJECT COST ESTIMATES

The following cost estimate is for the design, fabrication, procurement and installation of a system that would separate strontium and TRU elements from tank AN-102 and tank AN-107 supernatants within the DST system. The costs presented are in 2005 dollars and are not intended for budgetary purposes, but are intended to allow for a relative and representative comparison of the various waste management options. An estimate of the Total Capital Costs and total Non-Capital Costs are provided in Table 7-1 and Table 7-2, resulting in a total project cost of $2,597,521.00.

The cost estimate includes Project management, Construction Management, Title I, II and III Engineering and Construction cost. Other project costs include program management, technical support, environmental, safety, health and quality support, Authorization Basis amendment, procedure development, training, and an allowance of an Operational Readiness Review and System start-up. An allowance has also been included for system closure costs. A 40% contingency factor was applied to capital cost elements due to the designs pre-conceptual level. Exception to this are a 25% contingency rate being applied to the estimated project management and construction management costs and a 30% contingency rate being applied to the mechanical systems costs due to having received vendor quotes for the chemical skids. The cost estimate includes the design, fabrication, procurement and installation of the following equipment:

- One skid mounted strontium nitrate chemical handling system.
- One skid mounted sodium permanganate chemical handling system
- Concrete pads
- Tank interface equipment
- In-tank distribution head
- Flexible hoses from the skids to the tanks
- All power and instrumentation lines to the skids

It is assumed that all in-tank instrumentation (i.e. temperature, liquid level, sludge level, pressure and leak detection) are intact and will be maintained adequately such that no equipment costs will be incurred for this system. It is also assumed that all mixer pumps, transfer pumps, transfer line jumpers and exhauster upgrades needed for this system will be installed and costed under other currently scheduled elements under CH2M HILL Projects W-314 (Tank Farm Restoration and Safe Operations) and W-211 (Initial Tank Retrieval Systems). If this project is performed in advance of these projects, the budgets and upgrades would have to be reprogrammed into this project.

Resources in this estimate were based upon the detail found in CH2M HILL's project W-211 cost estimates and escalated as appropriate to 2005 costs using a 2.5% annual escalation rate. The chemical handling equipment costs were based on estimates provided by Precision Pumping Systems (Kelso, WA). Other miscellaneous costs were based on interviews with tank farm cognizant engineers and good engineering practices.

The cost of tank farm operations personnel to perform the transfers, chemical additions, mixing, and sampling are not included in this cost estimate but are considered covered in the Tank Farm Contractor Baseline Cost Estimate. In addition, *if execution of the Sr/TRU separation process in* the DST system is pursued for implementation, an integration of the full scope of this process, with existing Waste Feed Operations (WFO) Projects, must be performed in order to ensure a realistic scope, schedule, cost, and risk basis. A detailed cost estimate is provided in Appendix D.

Table 7-1. Capital Cost Estimate	
Cost Element	Cost
Management Costs	
Project Management	$40,800
Construction Management	$39,000
Subtotal	**$79,800**
Engineering, Design and Inspection	
Title I	$98,100
Title II	$215,300
Title III	$120,000
Engineering Support	$66,750
Subtotal	**$500,150**
Construction	
General Conditions	$58,064
Site Work & Demo	$4,499
Concrete	$23,075
Mechanical	$249,264
Electrical	$26,675
General Labor Support	$31,676
Other Costs	$294,334
Subtotal	**$687,587**
Construction Support	$90,518
Startup	$303,120
Contingency	$627,574
TOTAL CAPITAL COSTS	**$2,288,749**

Table 7-2. Non-Capital Cost Estimate	
Other Project Costs	$171,255
Operations	$0
Closure	$137,517
TOTAL NON-CAPITAL COSTS	**$308,772**

TOTAL PROJECT COSTS **$2,597,521**

8.0 *STUDY FINDINGS/RESULTS*

The addition of 3 M $Sr(NO_3)_2$ and 3.83 M $NaMnO_4$ to diluted Envelope C (i.e. AN-102 and AN-107 supernatants) to produce 0.02 M Sr and 0.02 M MnO_4 in solution can be conducted in tank AP-102. If implemented, this process will be a direct alternative to the WTP pretreatment process for these feed streams. Based on HTWOS model runs, such implementation in the DST system has a potential to achieve a WTP operation schedule savings of six months.

The Sr/TRU precipitation process can be conducted in tank AP-102 by transferring separate batches of tank AN-102 and tank AN-107 supernatants into AP-102 for treatment. The results of the material balance for the treated supernatants results in accumulated precipitated solids of 23.7-inches in tank AP-102. Treated tank AN-102 and tank AN-107 supernatants meet the requirements of less than 20 Ci/m^3 for ^{90}Sr and 100 ηCi/gm for TRU in the ILAW. The concentrations of ^{90}Sr on TRU in LLW glass resulting from Sr/TRU decontamination of tanks AN-102 and AN-107 supernatants are summarized in Table 8-1.

Table 8-1. Sr/TRU Separation of Tanks AN-102 and AN-107 Supernatants

Treated Supernatants[(a)]	TRU in ILAW Glass[(b)]	^{90}Sr Concentration in ILAW Glass[(b)]
AN-102 Batch #1	11.52 ηCi/gm	5.84 Ci/m^3
AN-102 Batch #2	12.11 ηCi/gm	6.14 Ci/m^3
AN-107 Batch #3	61.77 ηCi/gm	6.59 Ci/m^3
AN-107 Batch #4	62.05 ηCi/gm	6.59 Ci/m^3

(a) The U.S. Department of Energy Office of River Protection, Contract No. DE-AC27-01RV14136, Specification 2.2.2.8, *Radionuclide Concentration Limitations* requires the concentrations of ^{90}Sr and TRU to be less than 20 Ci/m^3 and less than 100 ηCi/g respectively in the ILAW.

(b) Assumes a glass density of 2.76 MT/m^3 and 15 wt% Na_2O in the low-level waste glass.

The strontium and TRU precipitates are accumulated on top of the existing tank AP-102 sludge layer. The accumulated solids/sludge is diluted to 10 wt% solids and transferred into an available HLW tank.

The estimated capital costs for the design, procurement of associated construction of the equipment required to implement this option are approximately $2.3M in FY 2005 dollars. This estimate includes an aggregate contingency level of 37%. When associated non-capital costs are included, the total Project Cost is approximately $2.6M. These costs do not include all needed items, including equipment needed for implementation of this process option, since these items are presently planned for installation and budgeted in Projects W-314, Tank Farm Restoration and Safe Operations Project and W-211, Initial Tank Retrieval System. These excluded items include tank transfer pumps, transfer line and pit upgrades. If pursued, a priority next step toward implementing the Sr/TRU separation process will be an integration of the full process into the WFO projects.

In addition, for implementation of the Sr/TRU pretreatment process in the DST systems the following issues/items will need to be addressed.

- Waste compatibility assessment.
- Evaluation of impacts of Sr/TRU precipitate settling behavior.
- Long-term storage of Sr/TRU precipitate and mixing with other HLW solids/supernatants.
- Integration of in-tank Sr/TRU precipitation process with current and planned Tank Farm upgrades, DST utilization, and process tank selection.
- Assessment of permit modification and Authorization Basis modification.

While specific process implementation decisions (i.e. treatment and delivery timing), and Tank Farm operational protocols (i.e. waste compatibility screening) will be needed, this study concludes that the concept of in-tank strontium and TRU treatment of tank AN-102 and tank AN-107 supernatants is worth pursuing. An additional $2.6M in tank farm work scope and some added feed delivery complexity has the potential to save 6 months of Waste Treatment and Immobilization Plant operating costs, currently estimated at approximately $1.2M per day.

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APPENDIX A

STRONTIUM/TRU PRECIPITATION FLOWSHEET AND CALCULATION

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A1.0 OBJECTIVE/PURPOSE

The purpose of this calculation is to calculate the changes in the quantity and composition of tank 241-AN-102 and tank 241-AN-107 supernatants after addition of a calculated quantity and composition of sodium permanganate ($NaMnO_4$) and strontium nitrate ($Sr(NO_3)_2$) used to precipitate the soluble ^{90}Sr and transuranics (TRU). The objective of this precipitation process is to reduce the concentrations of ^{90}Sr and transuranics in the AN-102 and AN-107 supernatants to meet the Waste Treatment Plant contract limits[1] for these radionuclides. This calculation provides a basis for specifying the amount of reagent and water addition necessary to achieve the optimal reaction conditions, calculating the quantity and composition of precipitate generated from treating AN-102 and AN-107 supernatants, and the resulting decontamination factor of ^{90}Sr and TRU.

The calculation addresses two operating scenarios:

1. Treatment of supernatant in tanks AN-102 and AN-107, respectively
2. Treatment of supernatant, from tanks AN-102 and AN-107 in tank AP-102

A1-1 SCOPE

The scope of this calculation is limited to determining a mass balance for the feed and product compositions of treating AN-102 and AN-107 supernatants and the estimated ^{90}Sr and TRU loadings that would be expected in ILAW glass made from the treated supernatant. Solids generated by this process are not dispositioned except to quantify the water dilution necessary to transfer 10 wt% solids slurry for DST storage.

A2.0 SUMMARY OF RESULTS AND CONCLUSIONS

Based on the precipitation process criteria and data input, the precipitation process in tanks AN-102 or AN-107 will not be suitable based primarily on the volume of dilution water required to achieve a 5.5 M sodium concentration for the process. Adequate tank space is not available to perform the operations. However, AN-102 and AN-107 supernatant can be transferred into AP-102, after removal of AP-102 supernatant, where the Sr/TRU precipitation process can be conducted in suitable batch sizes. A summary of the results of these two options is provided in Sections A2-1 and A2-2.

Using the reference process conditions and assumed percent removals, the material balance for treatment of 100% of the AN-102 and AN-107 supernatants provides concentrations of ^{90}Sr and TRU in the low-activity waste glass below the specification limits of 20 Ci/m^3 ^{90}Sr and less than 100 ηCi/gm TRU:

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[1] The U.S. Department of Energy Office of River Protection, Contract No. DE-AC27-01RV14136, Specification 2.2.2.8, *Radionuclide Concentration Limitations* requires the concentrations of ^{90}Sr and TRU to be less than 20 Ci/m^3 and less than 100 ηCi/gm, respectively in the immobilized low-activity waste.

- AN-102 Supernatant: 12.1 nCi/gm TRU, 6.14 Ci/m^3 ^{90}Sr (Batch #2)
  Basis: Treat in AN-102 Worksheet
- AN-107 Supernatant: 62.1 ηCi/gm TRU, 6.59 Ci/m^3 ^{90}Sr (Batch #4)
  Basis: Treat in AN-107 Worksheet

A2-1 SR/TRU PRECIPITATION IN-TANKS 241-AN-102 AND 241-AN-107

Treatment of the entire supernatant volume in tanks AN-102 and AN-107, respectively, would exceed the normal operating limit (416 inches) of the AN tanks (Ref. OSD-T-151-00007, Rev. I-9). Table A2-1 provides the initial and final volume conditions from reagent and water addition in AN-102 and AN-107. Table A2-2 summarizes the volume of reagent addition required to achieve the optimal process conditions.

Table A2-1. Initial and Final Supernatant Volumes in Tanks AN-102 and AN-107.*

Description	Unit	AN-102 Supernatant Initial	AN-107 Supernatant Initial	AN-102 Supernatant Treated Waste In-Tank AN-102	AN-107 Supernatant Treated Waste In-Tank AN-107
Total Volume	Liters	3.55E+06	3.30E+06	6.32E+06	5.47E+06
	Gallons	9.38E+05	8.71E+05	1.67E+06	1.44E+06
Height of Supernatant	Inches	341.1	316.8	607.4	525.4
Na concentration	M	9.68	9.02	5.45	5.45
Normal Operating Limit	Gallons	1.14E+06	1.14E+06	1.14E+06	1.14E+06

*The volume contribution due to solids precipitation will increase the final volume in the tank.

Table A2-2. Reagent Volumes Added to Tanks AN-102 and AN-107 for Sr/TRU Precipitation.*

Reagent Addition	Units	AN-102	AN-107
3M $Sr(NO_3)_2$	Gallons	1.11E+04	9.60E+03
40 wt% $NaMnO_4$ (3.83M)	Gallons	8.76E+03	7.58E+03
Water Addition	Gallons	7.13E+05	5.57E+05

*Sr/TRU precipitation process conditions are 5.5M Na in the pretreated supernatant and $Sr(NO_3)_2$ and $NaMnO_4$ addition to achieve a final concentration of 0.02M in treated supernatant

A2-2 SR/TRU PRECIPITATION IN TANK 241-AP-102

The Sr/TRU precipitation process can be conducted in tank AP-102 by transferring separate batches of AN-102 and AN-107 supernatants into AP-102 for treatment. Tank AP-102 supernatant is assumed to be removed, except for a residual supernatant heel of 10 inches, prior to treatment of AN-102/107 supernatants. The Sr/TRU precipitation process material balance is developed as four separate batches. Treated supernatants are transferred into an available LAW tank for storage and/or delivery to the WTP. Strontium and transuranic precipitates are accumulated on top of the existing AP-102 sludge layer. The accumulated solids/sludge is diluted to 10 wt% solids and transferred into an available double-shell tank.

Table A2-3 summarizes the resulting concentrations of ^{90}Sr and TRU in the low-activity waste glass from each of the four batches of treated supernatants and the volume of Sr/TRU precipitate generated for each batch. Attachment 1, *Summary*, provides a more detailed summary for each batch material balance.

Table A2-3. Concentrations of ^{90}Sr and TRU in Low-Level Waste Glass Resulting from Treatment of AN-102 and AN-107 Supernatants and Volume of Resulting Precipitate.

Treated Supernatants	Units	AN-102 Batch #1 + AP-102	AN-102 Supernatant Batch #2	AN-107 Supernatant Batch #3	AN-107 Supernatant Batch #4
TRU in glass[(a)(b)]	ηCi/gm	11.52	12.11	61.77	62.05
Sr-90 in glass[(a)(b)]	Ci/m^3	5.84	6.14	6.59	6.59
Sr-90 Concentration	µCi /ml	2.38	2.51	2.69	2.69
Sum of TRU	µCi /ml	0.01	0.01	0.07	0.07
Sr/TRU Precipitate	inches	3.42	3.44	4.22	4.19
Volume Settle Solids (ppt)	Gallons	9.41E+03	9.47E+03	1.16E+04	1.15E+04

[(a)] The U.S. Department of Energy Office of River Protection, Contract No. DE-AC27-01RV14136, Specification 2.2.2.8, Radionuclide Concentration Limitations requires the concentrations of 90Sr and TRU to be less than 20 Ci/m3 and less than 100 ηCi/gm, respectively in the immobilized low-activity waste.

[(b)] Assumes a glass density of 2.76 MT/m3 and 15 wt% Na2O in the low-level waste glass.

A3.0 INTRODUCTION/BACKGROUND

The supernatants stored in tanks 241-AN-102 (AN-102) and 241-AN-107 (AN-107) contain soluble strontium-90 (^{90}Sr) and transuranic elements (TRU) that require removal prior to vitrification to comply with the Waste Treatment and Immobilization Plant (WTP) immobilized low-activity waste (ILAW) specification. A precipitation process has been developed and tested with tank waste samples and simulants using sodium permanganate ($NaMnO_4$) and strontium nitrate ($Sr(NO_3)_2$) to separate ^{90}Sr and TRU from these wastes. The WTP includes this precipitation step for removing ^{90}Sr and transuranic isotopes; however, the WTP is projected to experience a 6 to 24 month interruption in HLW pretreatment processing while AN-102 and AN-107 supernatants are pretreated. Conducting the Sr/TRU precipitation process in the DST system may avoid the interruption in the WTP HLW pretreatment operations.

This calculation provides an evaluation of pretreating AN-102 and AN-107 supernatants in the double shell tank system using the optimal conditions for precipitation of ^{90}Sr and TRU identified from laboratory testing. A series of test reports have been prepared by Savannah River National Laboratory and Battelle-Pacific Northwest Division and published for Bechtel National, Inc.[2] which demonstrate the effectiveness of the ^{90}Sr and TRU precipitation process. Many of these studies were conducted with actual tank waste samples of AN-102 and AN-107 supernatant, using a range of experimental conditions. These test reports were summarized by Mike Johnson, CH2M HILL[3] and provided as information to be used as data inputs and in this calculation. The results and/or conclusions of selected test reports contain the data inputs for use in this calculation and are cited as applicable.

A4.0 INPUT DATA

Specific information used for this calculation has been established through published laboratory input data as cited, requirements for final concentrations of ^{90}Sr and TRU in the treated supernatant, tank operating specifications, as well as assumptions used to perform the material balance.

A4-1 DESIGN INPUTS

1. Tank Inventory Basis:

    - BBI Effective Date April 4, 2004, 12:00 am is the basis for the tank composition data for tanks AP-102, AN-102 and AN-107 (Reference: BBI is located on the Tank Waste Information Network System (TWINS) web page).

    Basis: Inventory data for each tank, obtained from TWINS, http://twinsweb.pnl.gov/twins.htm,

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[2]Test plans and studies identified in Bechtel National, Inc. (BNI), 2002. *Research and Technology Plan*, 24590-WTP-PL-RT-01-002, Rev. 1, U.S. Department of Energy, Office of River Protection, Richland, WA.

[3] E-mail correspondence dated April 4, 2005

2. Optimal Process Conditions:
   - Dilute supernatant to 5.5 M Na by the addition of water
   - Ambient Temperature (15°C to 50°C)

   Basis: PNWD-3340, PNWD-3341, and PNWD-3338

3. Reagent Addition
   - $Sr(NO_3)_2$ addition to achieve a final concentration of 0.02M
   - $NaMnO_4$ addition to achieve a final concentration of 0.02 M

   Basis: PNWD-3141 (WTP-RPT-029

4. Reaction chemistry is given as follows:
   - Isotopic Dilution Reactions:
     - $Sr(NO_3)_2 + {}^{90}Sr{\cdot}Chelant + Na_2CO_3 \leftrightarrow Sr{\cdot}Chelant + {}^{90}SrCO_3 + 2NaNO_3$
     - $Sr(NO_3)_2 + Na_2CO_3 \leftrightarrow SrCO_3 + 2NaNO_3$

     Basis: (PNWD-3340, section 3.1)
   - An example of the manganese reactions with formate are as follows:
     - $2Mn^{VII}O_4^- + HCO_2^- + 3OH^- \rightarrow 2Mn^{VI}O_4^{-2} + CO_3^{-2} + 2H_2O$
     - $3Mn^{VI}O_4^{-2} + 2H_2O \leftrightarrow 2Mn^{VII}O_4^- + Mn^{IV}O_2 + 4OH^-$

     Basis: PNWD-3263, section 3.1

5. Solids Density:
   - Sr/TRU precipitate slurry is 39 weight percent.

     Basis: PNWD-3035, section 3.5. The weight percent settle solids in a diluted and caustic adjusted tank AN-107 supernatant sample was 42 ± 3 weight percent.
   - ILAW Glass density = 2.76 MT/m^3

A4-2 CRITERIA

1. Chemistry limits for DSTs are provided in the Tank Farm Waste Transfer Compatibility Program, Table 3.3. *DST Waste Chemistry Limits.* The concentrations of OH^-, NO_2, and NO_3 are taken from the mass balance for the pretreated supernatant (i.e., diluted supernatant with reagents added) batches and are shown in Table A4-1.

Table A4-1. Concentrations of OH^-, NO_2, and NO_3 in Pretreated Tanks AN-102 and AN-107 Supernatants Compared to DST Waste Chemistry Limits.

Variable	Units	Pretreated Batch #1 (Tank AN-102 Supernatant)	Pretreated Batch #2 (Tank AN-102 Supernatant)	Pretreated Batch #3 (Tank AN-107 Supernatant)	Pretreated Batch #4 (Tank AN-107 Supernatant	DST Waste Chemistry Limits (T<167°F)*
$[OH^-]$	M	0.342	0.296	0.633	0.646	$0.010\underline{M} \leq [OH^-] \leq 8.0\underline{M}$
$[NO_2^-]$	M	1.06	1.04	0.890	0.884	$0.011\underline{M} \leq [NO_2^-] \leq 5.5\underline{M}$
$[NO_3^-]$	M	1.84	1.86	2.05	2.06	$[NO_3^-] \leq 1.0\underline{M}$
$[NO_3^-]/[OH^-] + [NO_2^-]$		1.31	1.39	1.35	1.35	<2.5

*DST Waste Chemistry Limits for $[NO_3]$ range ≤ 1.0M obtained from Table 3-3 of HNF-SD-WM-OCD-015, Rev. 13.

Basis: HNF-SD-WM-OCD-015, Rev. 15

2. Normal Operating Limit for the AN and AP tanks is 416 inches (1.14E+06 gallons). Tank waste liquid level is defined as the surface level irrespective of the amounts of sludge, supernatant, or solids/crust.

   Basis: OSD-T-151-00007, Rev. I-9

3. Tank Bump Controls: The specific criteria for tank bump controls in DSTs require that at least one of the following criteria is met:

   - Total tank heat load is < 58,000 Btu/hr (Rev. 15)
   - Non-convective layer thickness is < 12 in.
   - Supernatant depth is < 39 in.
   - The non-condensable gas generation rate at saturation temperature in the non-convective layer is sufficiently low, such that the ratio of vertical void fraction profile to the neutral buoyant void fraction (buoyancy ratio) is < 1.0.

   Basis: HNF-SD-WM-OCD-015, Rev. 15

4. ^{90}Sr/TRU Limits: The RPP-WTP contract requires that the immobilized low-activity waste (ILAW) product contain less than 100 ηCi/g TRU and that the average ^{90}Sr be less than 20 Ci/m^3.

   Basis: WTP 2001

5. The ^{90}Sr and TRU concentrations in the supernatants are targeted to be less than 7.48E-04 Ci per mole of sodium and 1.03E-05 Ci per mole of sodium, respectively following the separation process.

   Basis: Statement of Work (Requisition #: 117038, *Engineering Optimization Study Support*)

A5.0 ASSUMPTIONS

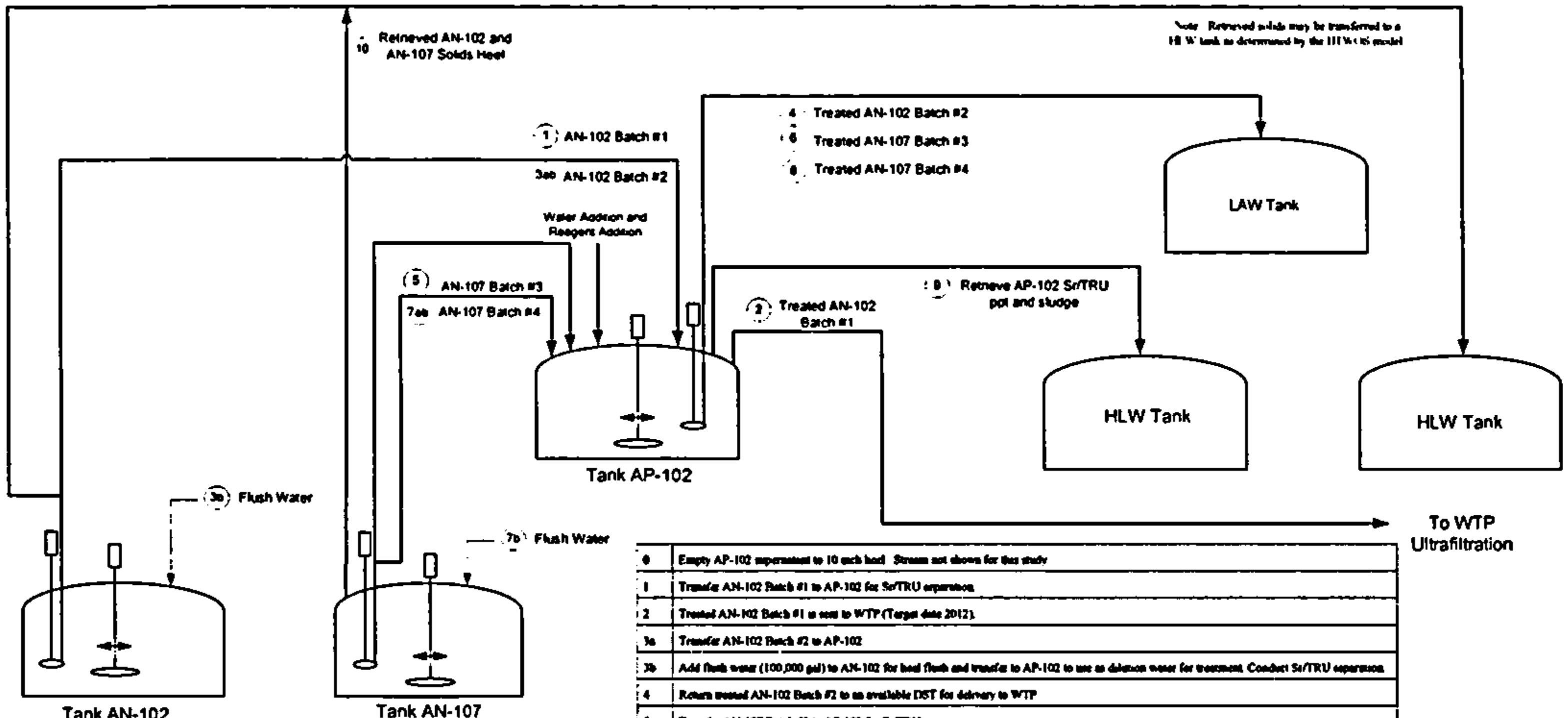
Assumptions used in this calculation are provided in Attachment 2.

A6.0 METHOD OF ANALYSIS

The method of analysis for this calculation uses a Microsoft Office Excel® 2003 spreadsheet designed to estimate supernatant and solids compositions based on the given design inputs and assumptions for the Sr/TRU precipitation (ppt) process. An evaluation of AN-102 precipitation, in-tank AN-102, was performed for AN-102 supernatant. The same evaluation was performed for AN-107 supernatant, in-tank AN-107. Based on the results of the in-tank AN-102 and AN-107 evaluation, the same ppt process was performed on batches of AN-102 and AN-107 supernatant after transfer into tank AP-102. A material balance was performed for each tank and each batch, resulting in six separate worksheets and provided as attachments for the calculation:

- Treatment of AN-102 supernatant in tank AN-102 (Attachment 4)
- Treatment of AN-107 supernatant in tank AN-107 (Attachment 5)
- Batch #1 treatment of AN-102 in tank AP-102 (Attachment 6)
- Batch #2 treatment of AN-102 in tank AP-102 (Attachment 7)
- Batch #3 treatment of AN-107 in tank AP-102 (Attachment 8)
- Batch #4 treatment of AN-107 in tank AP-102 (Attachment 9)

A process block diagram, Figure A6-1 was developed to identify the proposed batch transfers from AN-102 and AN-107 supernatants into AP-102 for treatment.



0	Empty AP-102 supernatant to 10 inch heel. Stream not shown for this study
1	Transfer AN-102 Batch #1 to AP-102 for Sr/TRU separation.
2	Treated AN-102 Batch #1 is sent to WTP (Target date 2012).
3a	Transfer AN-102 Batch #2 to AP-102
3b	Add flush water (100,000 gal) to AN-102 for heel flush and transfer to AP-102 to use as dilution water for treatment. Conduct Sr/TRU separation.
4	Return treated AN-102 Batch #2 to an available DST for delivery to WTP
5	Transfer AN-107 Batch #3 to AP-102 for Sr/TRU separation.
6	Return treated AN-107 Batch #3 to an available DST for delivery to WTP
7a	Transfer AN-107 Batch #4 to AP-102 for Sr/TRU separation.
7b	Add flush water (100,000 gal) to AN-107 for heel flush and transfer to AP-102 to use as dilution water for treatment. Conduct Sr/TRU separation.
8	Transfer treated AN-107 Batch #4 to to an available DST for delivery to WTP
9	Retrieve AP-102 solids (Sr/TRU ppt and sludge) to an available HLW tank for blending and transfer to WTP.
10	Retrieve AN-102 and AN-107 solids heel to an available HLW.

Figure A6-1. Proposed Batch Transfers from AN-102 and AN-107 Supernatants into AP-102 for Treatment.

A6.1 CALCULATIONS

Formulas and equations used to perform the material balance are shown in Attachment 3, *Reagent Calculation* and *Calculation Page* worksheets. Most of the analyses performed are algebraic addition and subtraction operations.

The *Reagent Calculation* worksheet, Attachment 3, is used to determine volumes of strontium nitrate and sodium permanganate that must be added to AN-102 and AN-102 wastes to produce 0.02M Sr and 0.02M MnO_4 in solution. The Sr and MnO_4 molarities from the reagent worksheet are linked to the six material balance worksheets for use in calculating volume additions of reagent.

The *Calculation Page* worksheet, Attachment 3, identifies the calculations performed in specific cells, rows, or columns of the material balance worksheets. The specific input data and assumptions were used to:

1. Calculate the volume of water addition necessary to dilute tanks AN-102 and AN-107 supernatant batches to a sodium concentration of 5.5M.
2. Calculate the volume of reagent addition, $NaMnO_4$ and $(Sr(NO_3)_2$, necessary to perform the precipitation of Sr and TRU in 100% of the supernatants in tanks AN-102 and AN-107.
3. Calculate the composition of each supernatant after addition of $Sr(NO_3)_2$ and $NaMnO_4$ to achieve a final concentrations of 0.02M each.
4. Calculate the resulting volume of precipitate for each tank, or each batch, as applicable.
5. Calculate the ^{90}Sr and TRU concentration in the low-activity waste glass[4] resulting from the ^{90}Sr and TRU concentrations in the treated supernatants.

A6.1.1 Definition of Batch Feeds

Table A6-1 defines the source of the feed batches used for each of the four material balance worksheets.

[4] The U.S. Department of Energy Office of River Protection, Contract No. DE-AC27-01RV14136, Specification 2.2.2.8, *Radionuclide Concentration Limitations* requires the concentrations of ^{90}Sr and TRU to be less than 20 Ci/m^3 and less than 100 ηCi/gm, respectively in the immobilized low-activity waste.

Table A6-1. Material Balance Feed Definitions.

Batch Number	Feed Source	Source of 10 Inch Heel	Total Volume for Treatment (gallons)
Batch #1	AN-102 supernatant	10 inches AP-102 supernatant	4.83E+05
Batch #2	AN-102 supernatant	10 inches of AN-102 supernatant	8.49E+05
Batch #3	AN-107 supernatant	10 inches of Batch #2 treated supernatant	1.70E+06
Batch #4	AN-107 supernatant	10 inches of Batch #3 treated supernatant	1.70E+06

A7.0 USE OF COMPUTER SOFTWARE

Microsoft Office Excel® 2003.

A8.0 RESULTS

Treatment of the entire supernatant contents in tanks AN-107 and AN-102, respectively, would exceed the normal operating limits (416 inches) of the AN tanks (OSD-T-151-00007, Rev I-9). The volume of dilution water added to achieve the optimal sodium concentration of 5.5$\underline{M}$ (PNWD 3141) and the required reagent volumes exceed the available tank capacity.

Treatment of tanks AN-102 and AN-107 supernatants in tank AP-102 is modeled as four separate batches for treatment which generate a cumulative 15.3 inches of precipitated solids, with a total solids layer in AP-102 of 23.7 inches. A heat load of 11,304 BTU/hr is estimated from the precipitated solids and assumes contributions from ^{90}Sr, ^{241}Am and ^{137}Cs only).

The results of the Sr/TRU decontamination of tanks AN-102 and AN-107 supernatants are summarized in Table A8-1 and are shown to meet the LAW requirements to provide concentrations of Sr^{90} and TRU less than 20 Ci/m^3 and 100 ηCi/gm, respectively in the immobilized low-activity waste.

An evaluation of the final state of the receiving tank, AP-102, including hydrogen generation and retained gas parameters would be performed as part of the Waste Compatibility Assessment per HNF-SD-WM-OCD-015.

Additional material balance summary detail is provided in Attachment 1, *Summary* worksheet.

Table A8-1. Sr/TRU Separation of Tanks AN-102 and AN-107 Supernatants.

Treated Supernatants[(a)]	Units	TRU in ILAW Glass[(b)]	^{90}Sr Concentration
AN-102 Batch #1	ηCi/gm	11.52	2.38
AN-102 Batch #2	ηCi/gm	12.11	2.51
AN-107 Batch #3	Ci/m^3	61.77	2.69
AN-107 Batch #4	Ci/m^3	62.05	6.59

(a) Percent removals from supernatants for TRU and ^{90}Sr are modeled as 85% and 94%, respectively.

(b) Assumes a glass density of 2.76 MT/m^3 and 15 wt% Na_2O in the low-level waste glass.

A9.0 CONCLUSIONS

The addition of strontium nitrate (3M $Sr(NO_3)_2$) and sodium permanganate (3.83M MnO_4) to diluted Envelope C (i.e., AN-102 and AN-107 supernatants) to produce 0.02M Sr and 0.02M MnO_4 in solution can be conducted in tank AP-102.

The results of the material balance demonstrate that four batches of supernatant can be treated to meet the requirement of less than 20 Ci/m^3 for ^{90}Sr and 100 ηCi/gm for TRU in the immobilized low-activity waste. A target concentration 50% below the LAW requirement of 10 Ci/m^3 for ^{90}Sr and 50 ηCi/gm for TRU in the immobilized low-activity waste can be also be met for treated tank AN-102 and AN-07 supernatants with the exception of tank AN-107. As shown in Table A8-1, treated tank AN-107 supernatant results in approximately 62 ηCi/gm TRU in the ILAW glass.

A10.0 RECOMMENDATIONS

The process flowsheet assumes a target sodium concentration of 5.5M in the tank AN-102 and tank AN-107 supernatants prior to treatment. These supernatants are identified from BBI data as 9.68M sodium and 9.02M sodium, respectively. Laboratory tests are being conducted to determine the ^{90}Sr and TRU decontamination achieved in an undiluted sample of AN-107 supernatant. Results from these laboratory tests may indicate addition of dilution water to achieve 5.5M sodium may be eliminated and treatment in-tank AN-102 and in-tank AN-107 may be possible.

A11.0 REFERENCES

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ATTACHMENT 1

SR/TRU PRECIPITATION SUMMARY

Calculation Summary for Sr/TRU Precipitation Process

Treat In-Tank AN-102 and Treat In-Tank AN-107

Tank Volumes, Initial and Final Conditions	Units	AN-102	AN-107
BBI Supernatant Volume	liters	3.55E+06	3.30E+06
	gal	9.38E+05	8.71E+05
	inches	341.1	316.8
Normal Operating Limit for AN and AP Tanks	gal	1.14E+06	1.14E+06
	inches	416	416
Flowsheet Total Volume	Liters	6.32E+06	5.47E+06
	Gallons	1.67E+06	1.44E+06
Volume Reagent Addition, 3M $Sr(NO_3)_2$	Gallons	1.11E+04	9.60E+03
Volume Reagent Addition, 40wt% $NaMnO_4$ (3.83M)	Gallons	8.76E+03	7.56E+03
Volume Water Addition	Gallons	7.13E+05	5.57E+05
Flowsheet Height of Supernatant	inches	607.4	525.4
Flowsheet Final Na Concentration	M	5.45	5.45

Treatment of the entire supernatant contents in AN-107 and AN-102 would exceed the maximum operating capacity of the AN tanks based on the volume of dilution water to achieve the optimal sodium molarity of 5.5 and the required reagent volumes. In addition, the volume contribution due to solids precipitation would increase the final volume.

Heat Load of Precipitated Solids and Existing AP-102 Sludge in AP-102

	Units	
Batch #4 Solids (includes Sr-90, Cs-137, Am-241)	BTU/hr	11,304
Operating Specification Limit	BTU/hr	58,000

AN-102 BATCH #1 SUPERNATE	UNITS	AN-102 Supernate Batch #1	AP-102 Supernate	AN-102 + AP-102 Heel Adjusted Concentration	Diluted AN-102 + AP-102	3M $Sr(NO_3)_2$	40wt% $NaMnO_4$ (3.83M)	AN-102 Batch #1 + AP-102 Heel Treated Waste
Batch Volume	Liters	1.72E+06	1.04E+05	1.83E+06	3.19E+06	2.15E+04	1.70E+04	3.23E+06
Batch Volume	Gallons	4.56E+05	2.75E+04	4.83E+05	8.44E+05	5.67E+03	4.48E+03	8.54E+05
Height of Supernatant	inches	166.7	10	175.7	306.9			310.6
Na concentration	M	9.06	8.40	9.61	5.50			5.45
Density	gm/ml	1.40	1.39	1.40	1.23			
Strontium Concentration	M					3.00		0.02
Moles Sr Added	moles					6.44E+04		
MnO_4, M	M						3.83	0.02
Mole Mn Added	moles						6.50E+04	
Sum of TRU	uCi/ml	0.16	0.00	0.15	0.09			0.01
Sr-90 Concentration	uCi/ml	74.46	0.38	70.26	40.22			2.38
TRU in glass	nCi/gm	81.06	1.96	77.07	77.1			11.52
TRU Removal Required to achieve 50 nCi/gm	% removal	38.3%	n/a	35.1%	35.1%			
Sr-90 in glass	Ci/m3	102.77	0.81	97.66	97.65			5.64
Sr-90 Removal Required to achieve 10 Ci/m³	% removal	90.3%	n/a	89.8%	89.8%			

AN-102 BATCH #1 SOLIDS	UNITS	Precipitated Solids Batch #1
Total Sludge/Solids	kgs	1.81E+04
Wt% Settled solids	wt%	39.0%
Settled solids density	gm/ml	1.3
Volume Supernate and Volume Settled Solids	liters	3.56E+04
	gallons	9.41E+03
Batch #1	inches	3.42
AP-102 sludge layer + Batch #1	inches	11.9

AN-102 BATCH #2 SUPERNATE	UNITS	AN-102 Supernate Batch #2 Adjusted Concentration	AN-102 + Heel Note (a)	AN-102 Supernate Batch #2 Adjusted Concentration	Diluted AN-102 Batch #2	3M $Sr(NO_3)_2$	40wt% $NaMnO_4$ (3.83M)	AN-102 Batch #2 Treated Waste
Batch Volume	Liters	1.83E+06		1.83E+06	3.21E+06	2.16E+04	1.71E+04	3.25E+06
Batch Volume	Gallons	4.82E+05		4.82E+05	8.49E+05	5.71E+03	4.51E+03	8.59E+05
Height of Supernatant	inches	175.4		175.4	306.7			312.4
Na concentration	M	9.68		9.68	5.50			5.45
Density	gm/ml	1.40		1.40	1.23			
Strontium Concentration	M					3.00		0.02
Moles Sr Added	moles					6.48E+04		
MnO_4, M	M						3.83	0.02
Mole Mn Added	moles						6.54E+04	
Sum of TRU	uCi/ml	0.162		0.162	0.092			0.01
Sr-90 Concentration	uCi/ml	74.48		74.48	42.33			2.61
TRU in glass	nCi/gm	81.06		81.06	81.1			12.11
TRU Removal Required to achieve 50 nCi/gm	% removal	38.3%		38.3%	0.4			
Sr-90 in glass	Ci/m3	102.77		102.77	102.8			6.14
Sr-90 Removal Required to achieve 10 Ci/m³	% removal	90.3%		90.3%	0.9			

AN-102 BATCH #2 SOLIDS	UNITS	Precipitated Solids Batch #2
Total Sludge/Solids	kgs	1.82E+04
Wt% Settled solids	wt%	39.0%
Settled solids density	gm/ml	1.3
Volume Settled Solids	liters	3.56E+04
	gallons	9.47E+03
Batch #2	inches	3.44
Cummulative Solids Total	inches	15.3

Note (a) Volume of 10" heel (same composition as AN-102) included in Batch #2 adjusted concentration

AN-107 BATCH #3 SUPERNATE	UNITS	AN-107 Supernate Batch #3	AN-102 + Batch #1 Heel	Diluted AN-102 Batch #2	3M $Sr(NO_3)_2$	40wt% $NaMnO_4$ (3.83M)	AN-102 Batch #3 Treated Waste
			Adjusted Concentration				
Batch Volume	Liters	1.60E+06	1.70E+06	2.72E+06	1.83E+04	1.44E+04	2.75E+06
Batch Volume	Gallons	4.22E+05	4.50E+05	7.19E+05	4.83E+03	3.82E+03	7.26E+05
Height of Supernatant	Inches	153.47	163.47	261.47			264.61
Na concentration	M	9.02	8.80	5.50			5.46
Density	gm/ml	1.43	1.42	1.26			
Strontium Concentration	M				3.00		0.02
Moles Sr Added	moles				5.49E+04		
MnO_4 M	M					3.83	0.02
Mole Mn Added	moles					5.54E+04	
Sum of TRU	uCi/ml	0.800	0.751	0.470			0.07
Sr-90 Concentration	uCi/ml	77.22	72.66	46.42			2.69
TRU in glass	nCi/gm	429.15	413.34	413.3			61.77
TRU Removal Required to achieve 50 nCi/gm	% removal	88.3%	87.9%	87.9%			
Sr-90 in glass	Ci/m3	114.39	110.29	110.29			6.59
Sr-90 Removal Required to achieve 10 Ci/m³	% removal	91.3%	90.9%	90.9%			

AN-102 BATCH #3 SOLIDS		Precipitated Solids Batch #3
Total Sludge/Solids	kgs	2.23E+04
Existing AP sludge	inches	
Wt% Settled solids	wt%	39.0%
Settled solids density	gm/ml	1.30E+00
Volume Settled Solids	liters	4.39E+04
	gallons	1.16E+04
Batch #3	inches	4.22
Cummulative Solids Total	inches	19.5

AN-107 BATCH #4 SUPERNATE	UNITS	AN-107 Supernate Batch #4	AN-107 + Batch #3 Heel	Diluted AN-107 Batch #4	3M $Sr(NO_3)_2$	40wt% $NaMnO_4$ (3.83M)	AN-107 Batch #4 Treated Waste
			Adjusted Concentration				
Batch Volume	Liters	1.60E+06	1.70E+06	2.72E+06			2.75E+06
Batch Volume	Gallons	4.22E+05	4.50E+05	7.19E+05			7.26E+05
Height of Supernatant	Inches	153.5	163.5	261.5			264.6
Na concentration	M	9.02	8.80	5.50			5.46
Density	gm/ml	1.43	1.42	1.26			
Strontium Concentration	M				3.00		
Moles Sr Added	moles				5.49E+04		
MnO_4 M	M					3.83	
Mole Mn Added	moles					5.54E+04	
Sum of TRU	uCi/ml	0.80	0.75	0.47			0.07
Sr-90 Concentration	uCi/ml	77.22	72.66	46.43			2.69
TRU in glass	nCi/gm	429.15	415.22	415.22			62.05
TRU Removal Required to achieve 50 nCi/gm	% removal	88.3%	88.0%	88.0%			
Sr-90 in glass	Ci/m3	114.4	110.3	110.3			6.59
Sr-90 Removal Required to achieve 10 Ci/m³	% removal	91.3%	90.9%	90.9%			

AN-102 BATCH #4 SOLIDS		Precipitated Solids Batch #4
Total Sludge/Solids	kgs	2.21E+04
Existing AP sludge	inches	8.46
Wt% Settled solids	wt%	39.0%
Settled solids density	gm/ml	1.3
Volume Settled Solids	liters	4.36E+04
	gallons	1.15E+04
Batch #4	inches	4.19
Cummulative Solids (all batches)	inches	19.6
Cummulative Solids (all batches + AP sludge)	inches	23.7
Cummulative Solids (all batches)	liters	2.47E+05
Cummulative Solids (all batches)	gallons	6.52E+04

Volume and Na Molarity Selections

AN-107 Plus AN-102 Supernate Heel

Na Molarity	Selector	Selected Case
5	0	5.5
5.5	1	
6	0	
6.5	0	
7	0	
8	0	

AN-107 Waste Volume for Treatment

Liters	Gallons Waste	Selector	Selected Case
1.89E+05	50,000	0	1.60E+06
3.79E+05	1.00E+05	0	
3.30E+06	8.71E+05	0	Total Volume Supernatant
1.60E+06	4.22E+05	1	AN-107 Batch Volume
1.02E+05	26,920	0	Volume in 10 inch heel

AN-102 Plus AP-102 Supernate Heel

Na Molarity	Selector	Selected Case
5	0	5.5
5.5	1	
6	0	
6.5	0	
7	0	

AN-102 Waste Volume for Treatment

Liters	Gallons Waste	Selector	Selected Case
1.89E+05	50,000	0	1.72E+06
3.90E+06	1.03E+06	0	HTWOS B% volume
3.55E+06	9.38E+05	0	Total Volume Supernatant
1.72E+06	4.56E+05	1	AN-102 Batch volume
1.02E+05	26,920	0	Volume in 10 inch heel

ATTACHMENT 2

REAGENT CALCULATION AND CALCULATION PAGE

Mass Balance Assumptions for Optimization Study Task 2: Sr/TRU Separation Process in the DST System				
Starting Inventory	AN-102 BBI			Tank Composition Data obtained from BBI Effective Date April 4, 2004, 12:00 am
	AN-107 BBI			Tank Composition Data obtained from BBI Effective Date April 4, 2004, 12:00 am
	AP-102 BBI			Tank Composition Data obtained from BBI Effective Date April 4, 2004, 12:00 am
Sum of TRU	Row 100			TRU is Am-241, Am-243, Np-237, Pu-238, Pu-239, Pu-240, Pu-242, Cm-243 and Cm-244. Pu-241 is not included as it is a beta emitter (half life is 14.35 yrs).
Molecular Weights	MW worksheet			Molecular weights are used for unit conversion. See MW worksheet for specific values.
Radionuclide Decay				Radionuclide decay is not included in the material balance worksheet. LAW feed delivery dates are calculated by the HTWOS model and radionuclide decay is incorporated into the output data of that model.
Aroclors (Total PCB)	Rows 51 and 175			The fate of the organics in the tank waste is unknown. Composition in treated waste is left blank.
Worksheet / Description	**Cell ID**	**Value**	**Units**	**Calculation Information or Assumptions**
Treat in AN-102	Column E	0.00		Set AP-102 supernatant and sludge to zero for conducting the Sr/TRU ppt process in Tank AN-102.
Treat in AN-107	Column E	0.00		Set AP-102 supernatant and sludge to zero for conducting the Sr/TRU ppt process in Tank AN-107.
Treat in AN-102 - Starting Volume	C117	3.55E+06	gal	This volume used for calculation is the BBI inventory dated: Apr 1 2004 12:00AM
Treat in AN-107 - Starting Volume	C117	8.71E+05	gal	This volume used for calculation is the BBI inventory dated: Apr 1 2004 12:00AM
Dilution Water (all material balance worksheets)	H117	Tank Dependent		Dilution water is added to adjust the supernatants of AN-107 and AP-102 to 5.5 M Na which is the optimal sodium concentration to perform the precipitation reactions.
Sodium Concentration (all material balance worksheets)	I105	5.50	M	Supernatants for treatment are diluted to achieve a 5.5 mol/L sodium concentration. Column I, Row 105 is provided as a calculation check on the targeted sodium molarity.
10 inch heels (all material balance worksheets)		2.69E+04	gal	A 10 inch heel = 26,920 gallons (from volume calculator: RPP-13019, 2003, *Determination of Hanford Waste Tank Volumes*, S. A. Barker, CH2M HILL Hanford Group Inc., Richland, Washington). This assumption is also used as an HTWOS model assumption, and is based on decant pump performance and the assumption of removing supernatant to a level that will will not disturb settle solids layer(s).
AN-102 Batch Size for Treatment	C117	4.56E+05	gal	Assume tank AN-102 supernate will be treated in approximately two equal batches. It is assumed 10 inch supernatant heel will remain after transfer of the 2nd batch. A batch volume selection "switch" is provided on the Summary worksheet and sets the volume for each batch.
AN-102 Batch 1	E119	10	inches	Assume a 10 inch supernatant heel, composition of AP-102, mixes with AN-102 Batch #1.
AN-102 Batch 2	E119	10	inches	Assume a 10 inch heel, composition of AN-102. AN-102 Batch 2 mass balance adds 10 inches to supernatant height.
AN-107 Batch #3 and #4		4.22E+05	gal	Assume tank AN-107 supernate will be treated in approximately two equal batches. . It is assumed 10 inch supernatant heel will remain after transfer of the 2nd batch. A batch volume selection "switch" is provided on the Summary worksheet and sets the volume for each batch.
AN-107 Batch 3	E119	10	inches	Assume a 10 inch heel of composition AN-102 Batch #2
AN-107 Batch 4	E119	10	inches	Assume a 10 inch heel of composition AN-107 Batch #3
Sodium Oxide Loading in Glass, AN-102 Batch #1 Only	E107	20	wt%	A Na_2O loading of 20 wt% is selected to evaluate the loading of Sr and TRU in the glass based on just the AP-102 supernate. From the values calculated, it can be seen that the mixing of 10 inches of AP-102 supernate does not constitute a dilution of the Sr and TRU components for the AN-107and AN-102.
Sodium Oxide Loading in Glass	Row 107	15	wt%	A Na_2O loading of 15 wt% is selected to evaluate the loading of Sr and TRU in glass for the treated AN-102 and AN-107 supernatants.

Percent Sr Removal from Supernatant	O88	94%	wt%	Sr-90 concentration in the treated supernatant is based on a 94% removal for Sr-90 and 94% removal for total Sr.
Percent Mn Removal from Supernatant	N72	30 0%	wt%	The percent removal is for the Mn present in the sample before addition of permanganate. All added permanganate precipitates. AN-107 averaged 96% removal. AN-102 averaged 30% removal.
Carbonate Removal from Supernatant	O92			The moles of carbonate removed are equal to the amount of Sr added. TIC in the BBI data is assumed to be CO_3.
Other Percent Removal from Supernatant	Column N		wt%	Ba = 19%, Basis: Measured value from AN-107 supernatant, PNWD 3340.
			wt%	Ca = 19%, Basis Measured value from AN-107 supernatant, PNWD 3340.
			wt%	Ce = 85%, Basis: Ppt behavior is assumed to be similar to TRU, PNWD 3340.
			wt%	Cr = 21%, Basis: Measured value fromAN-107 supernatant, PNWD-3340
			wt%	Fe = 97%, Basis: Measured value from AN-107 supernatant, PNWD-3340
			wt%	La = 85%, Basis: Ppt behavior is assumed to be similar to TRU, PNWD 3340.
			wt%	Nd = 85% Basis: Ppt behavior is assumed to be similar to TRU, PNWD 3340
			wt%	Pb = 30%, Basis: Measured value from AN-107 supernatant, PNWD-3340
			wt%	Sr total = 94%, Basis: Assume same removal as Sr-90.
		TIC as CO_3	wt%	Assume the moles of CO3 removed is equal to the amount (moles) of Sr added.
		TOC = 0%	wt%	
			wt%	Zr = 82%, Basis: Measured value on AN-107 Supernatant, PNWD-3340
Radionuclide Percent Removal from Supernatant	Column N		wt%	Sr^{90} – 94%, Basis: Measured value from AN-107 supernatant, PNWD 3340
		Np^{237} = 85%,	wt%	Assume removal behavior is similar to Am^{241}
		Pu^{238} = 85%	wt%	Assume removal behavior is similar to Am^{241}
		Pu^{239} = 85%	wt%	Assume removal behavior is similar to Am^{241}
		Pu^{240} = 85%	wt%	Assume removal behavior is similar to Am^{241}
			wt%	Am^{241} = 85%, Basis: Measured value from AN-107 supernatant, PNWD 3340
		Pu^{241} = 85%	wt%	Assume removal behavior is similar to Am^{241}
		Pu^{242} = 85%	wt%	Assume removal behavior is similar to Am^{241}
		Cm^{242} = 85%	wt%	Assume removal behavior is similar to Am^{241}
		Am^{243} = 85%	wt%	Assume removal behavior is similar to Am^{241}
		Cm^{243} = 85%	wt%	Assume removal behavior is similar to Am^{241}
		Cm^{244} = 85%	wt%	Assume removal behavior is similar to Am^{241}.
		Eu^{152} = 85%	wt%	Assume removal behavior is similar to Am^{241}.
		Eu^{154} = 85%	wt%	Assume removal behavior is similar to Am^{241}
		Eu^{155} = 85%	wt%	Assume removal behavior is similar to Am^{241}

ATTACHMENT 3

ASSUMPTIONS

Sr/TRU Precipitation Process Calcuation Worksheet to Support Material Balance Worksheets

The following equations are applicable, except where noted to all the material balance worksheets, Attachments 4, 5, 6, and 7.

List of Conversions

3.785 L/gal
2750 gal/inch
3.4129 BTU/hr per watt

Constants

Molecular Weights - See End of Calculation Page(s)

Decay Heat Generation Rates		
	Cs-137	1.01E-03 W/Ci
	Sr-90 Y-90	6.69E-03 W/Ci
	Am-241	3.28E-02 W/Ci

Design Criteria

glass density	2.76 MT/m3
settled solids	39 wt%
ppt density	1.3 g/ml

6.69E-03 Watts/Ci Sr-90Y-90 couple (Base Sd-RE-TI-131, Rev 0, "Base and values for specific activity and decay heat generation rates for selected radionuc

Equation 1a ***Combining Supernatants for AN supernatant and AP-102 supernatnant heel***
Column G Calculation, Supernatant

Purpose: Determine the composition of the combined AN supernatant and AP-102 supernatant heel for Batch #1, or for addition of two supernatant streams in Columns C and E, Rows 3 through 99.

Inputs:
Density of AN-102 supernatant = 1.40 gm/ml per BBI
Density of AP-102 supernatant = 1.39 gm/ml per BBI
Mass concentration or activity concentration of each component from BBI data.
Volume contribution from Column C, Row 117 and Column E, Row 117.

Example: Calculate Column G for Batch #1, using uCi/g. Similar calculation for ug/g addition.

$$\text{Column G, uCi/g} = \frac{[(\text{AN component, uCi/g})(\text{AN volume, L})(\text{AN density, g/ml}) + (\text{AP component, uCi/g})(\text{AP volume, L})(\text{AP density, g/ml})]}{[(\text{AN volume, L})(\text{AN density, g/ml}) + (\text{AP volume, L})(\text{AP density, g/ml})]}$$

Equation 1b ***Column G, AP-102 Sludge*** Column G values for AP-102 Sludge are BBI values.

Equation 2 ***Column H, Dilution Water***

Purpose: Calculate Dilution Water. Determine volume of water addition to achieve 5.5 M sodium in the supernatant.

Inputs:
Assume water density = 1.0
Constant for tanks: 2750 gal/inch
Volume of AP-102 supernatant assumes a 10 inch heel = 27,500 gallons

$$5.5\ \text{mol Na/L} = \frac{(\text{mol Na/L AN-102})(\text{volume AN-102}) + (\text{mol Na/L AP-102})(\text{volume AP-102})}{\text{Total volume}}$$

$$5.5\ \text{mol Na/L} = \frac{(\text{mol Na/L AN-102})(\text{volume AN-102}) + (\text{mol Na/L AP-102})(\text{volume AP-102})}{\text{volume AN-102} + \text{volume AP-102} + \text{volume water}}$$

$$\text{volume water, L} = \frac{[(\text{mol Na/L AN-102})(\text{volume AN-102}) + (\text{mol Na/L AP-102})(\text{volume AP-102})]}{5.5\ \text{mol Na/L}} - (\text{volume AN-102} - \text{volume AP-102})$$

Using AN-102, Batch #1 for example calculation, where volume AN-102 is located in Column C, Row 117 and volume AP-102 is Column E, Row 117:

$$\text{volume water, L} = \frac{(9.68\ \text{mol Na/L} \times 1.72\text{E+06 L}) + (8.46\ \text{mol Na/L} \times 1.04\text{E+05 L})}{5.5\ \text{mol Na/L}} - 1.72\text{E+06 L} - 1.04\text{E+05 L}$$

volume water, L = 1.36E+06 (Cell H117 may calculate slightly different due to the increased number of significant digits included in the excel calculation cells).

Equation 3 ***Column G, Row 101***

Purpose. Calculate combined supernatant density (Column G, Row 101)

Combined AN-102/AP-102 supernatant density =

$$\frac{(\text{AN supernatant density} \times \text{volume AN supernatant}) + (\text{AP supernatant density} \times \text{volume AP supernatant})}{\text{Volume AN supernatant} + \text{Volume AP supernatant}}$$

$$\text{New density, g/ml} = \frac{(1.40\ \text{g/ml} \times 183{,}000\ \text{L}) + (1.39\ \text{g/ml} \times 104{,}000\ \text{L})}{183{,}000\ \text{L} + 104{,}000\ \text{L}} = 1.396\ \text{g/ml}$$ (Example values from AN-102 Batch #1)

Perform similar calcualion to obtain the supernatant density after water addition to reach 5.5 M Na.

Equation 4 ***Column I, Diluted Supernate***

Purpose: Calculate concentration of diluted supernatant (AN-102 and 10" heel of AP-102 supernatant).

Column G represents the combined AN and AP supernatants. The concentration of each analyte in this column is used to calculate a new concentration for each analyte after water dilution. See Equation 3.

Component concentration of diluted AN/AP supernatant = (Component concentration, uCi/g or ug/g X volume, L X density, g/ml) / [(diluted volume, L) x (density of diluted supernant, g/ml)]

Equation 5 ***Column K, Diluted Supernate***

Column K is provided to change the mass concentration units, ug/g and uCi/g, in Column I to molarities (mol/L) for the non-radioactive analytes and to uCi/ml for the radionuclides.

Equation 6 ***Column L, 3M Sr(NO3)2 Addition***

Purpose. Determine the adddition of 3M $Sr(NO_3)_2$

Inputs: Assume a 3M strontium nitrate solution is used (see column L, Row 121)

From the *Reagent Calculation* worksheet, chemical addition of 6.723 gal of Sr(NO3)2 for every 1000 gal of waste is needed to achieve a 0.02M Sr(NO3)2 solution

Volume Sr(NO3)2 addition, L = (volume waste for treatment, L) x (volume Sr(NO3)2, gal / 1000 gal waste)

Volume Sr(NO3)2 addition, L, is calculated in Column L, Row 117 using the volume waste for treatment from Column I, Row 117.

Equation 7 ***Column M, 40wt% $NaMnO_4$ (3.83M) Addition***

Purpose: Determine the adddition of 3.8M NaMnO4

Inputs: Assume a 3.83 M sodium permanganate solution is used (see column M, Row 123)
From the *Reagent Calculation* worksheet, chemcial addition of 5.308 gal of $NaMnO_4$ for every1000 gal of waste is needed to achieve a 0.02M $NaMnO_4$ solution.

Volume $NaMO_4$ addition, L = (volume waste for treatment, L) x (volume $NaMnO_4$, gal / 1000 gal waste)

Volume $NaMnO_4$ addition, L, is cacluated in Column M, Row 117 using the volume waste for treatmenat from Column I, Row 117.

Equation 8a ***Column O, Rows 3 through 99: Treated Waste Supernatant Composition***

Purpose: Calculate the composition of the treated supernatant

Inputs: The percent removals for selected analytes are given in the *Assumptions* worksheet. These removals are based on information from the laboratory testing (PNWD-3340).

Reagent 1 = $Sr(NO_3)2$ = A

Reagent 2 = $NaMnO_4$ = B

Total treated supernate = [supernatant + heel + water + reagents]

Treated Supernatant Component Composition, uCi/ml = (1-% removal) X $\dfrac{\text{[(uCi/ml A)(vol. A, L) + (uCi/ml B)(vol. B) + (uCi/ml analyte)(vol. supernatant)]}}{\text{total L of treated supernate}}$

Treated Supernatant Component Composition, M = (1-% removal) X $\dfrac{\text{[(mol/L A)(vol. A, L) + (mole/L B)(vol. B) + (mol/L analyte)(vol supernatant)]}}{\text{total L of treated supernate}}$

For most analytes, the % removal from supernatant to solid phase is zero.

Equation 8b ***Column O, Rows 174-201: Treated Waste Composition, Solids Layer***

Calculate the treated waste solids layer composition.

(1) For Treated Sludge Non-Rad Analytes, A = concentration component in diluted, untreated supernatant
B = concentration component in treated supernatant
C = kg component or analyte (i.e., Al, Bi, Ca, etc.) in solids layer
MW = molecular weight of component

Mass Treated Solids, Kg = C + [(A mol/L)(total L diluted supernatant) - (B mol/L)(total L treated waste)](MW, g/mol)(kg/1000 g)

(2) For Treated Sludge Radionuclides, Ci = (sludge component, Ci) + [(concentration diluted supernate component, uCi/ml) x (total L diluted supernatant) x (1000 ml/L) x Ci/1,000,000uCi) - (concentration supernate component in treated waste, uCi/ml) x (total L treated supernatant) x (1000 ml/L) x (Ci/1,000,000uCi)]

Equation 9 ***Column S, Mass of Precipitated Solids***

Calculate the mass of precipitated solids.

From the precipitation reactions provided in the calculation inputs, the following compounds will precipitate:
$CaCO_3$, $Cr(OH)_3$, $Fe(OH)_3$, $La(OH)_3$, $NaMn(O)(OH)(O)$, $Pb(OH)_4$, $SrCO_3$, $Zr(OH)_4$

Let A = kg precipitated compound
B = kg/ kg-mol for component
C = kg/ kg-mol for compound

Mass A, kg = $\dfrac{\text{(mass of analyte ppt, kg, column P)}}{\text{B}}$ X C

For example, kg $CaCO_3$ = $\dfrac{\text{kg Ca}}{\text{Ca/ kg-mol } CaCO_3}$ x (100 kg-$CaCO_3$/kg-mol $CaCO_3$)

Equation 10 ***Column S, Rows 209 through 213***

Calculation the volume and height of solids.

Gvien: Sum of the mass of precipated solids calculated from Equation 9
39 wt% solids (data input), Row 209
1.3 g/ml solids density (data input), Row 210

Calculate the volume for ppt solids: $\dfrac{\text{kg ppt}}{\text{wt\% x density, kg/L}}$ = L ppt

Calculate gallons, Row 212: L ppt x gal/3.785 L

Calculate inches, Row 213: gal ppt/ 2750 gal/in

Equation 11 ***Row 110*** ***Grams glass per liter of waste***

Calculate grams glass per liter of waste:

Given: 15 wt% Na2O loading in glass
Given: AN-102 Na concentration = 9.68 M

gm glass/L of waste = $\dfrac{\text{(9.68 gmol Na/L waste) * (gmol Na2O/2 gmol Na) * (62 g Na2O/gmol Na2O)}}{\text{15 g Na2O/100 g glass}}$

Equation 12 ***Rows 215 through 234 on AN-102 Batch 1 Worksheet***

10 inches AN-107 Supernatant at 5.5. M Na		
Volume	L	27,500
Density	kg/L	1.26
Mass supernatant	kg	3.47E+04

Calculate water addition to dilute solids collected in AP-102 after all 4 batches of precipitate. Dilute solids to 10 wt% for transfer to another HLW tank.

10 wt% solution = $\dfrac{\text{mass solids}}{\text{mass solids + mass water}}$

Solve for mass of water, where
MW = mass water, kg
MS = mass solids, kg

$0.1 = \dfrac{MS}{MS + MW}$

0.1(MS + MW) = MS
0.1 MW = MS - 0.1MS
MW = $\dfrac{0.9\ MS}{0.1}$ = 9 x MS = 9 x 8.05E+04 = 7.24E+05

Include calculated mass from 10 inch heel of AN-107 supernate as part of the dilution water.
AP-107 heel Volume, L = 27,500
Density, kg/L = 1.26
Mass, kg = 3.47E+04

Mass of dilution water required to dilute solids to 10 wt% = MW - 3.47E+04 = 7.24E+05 - 3.47E+04 = 6.89E+05 L

Equation 13 ***Calculate Heat Load in Batch #4 Solids***

The purpose of this calculation is to compare the heat load from the cummulative solids to the OSD limit of <38,000 BTU/hr. Assume major heat contributors to be: Sr-90, Cs-137, Am-241.

Inputs	Cs-137	1.01E-03	W/Ci		
	Sr-90 Y-90	6.69E-03	W/Ci	3.4129	BTU/hr per watt
	Am-241	3.28E-02	W/Ci		
Batch #4 Solids	Cs-137	1.25E+04	Ci	4.31E+01	BTU/hr
	Sr-90 Y-90	4.81E+05	Ci	1.10E+04	
	Am-241	2.48E+03	Ci	2.77E+02	
			Total	11304	BTU/hr

Molecular Weights

Analyte	MW Analyte g/mol		Analyte	MW Analyte g/mol	HTWOS Specific Activity Ci/gm (3-7-05)
			Isotopes		Ci/g
Ag	107 8682		3H	3 01605	9 62E+03
Al	26 981539		14C	14 003241	4 47E+00
Aroclors (Total PCB) A\	319 86		59Ni	58 934342	7.97E-02
As	74 92159		60Co	59 933813	1.13E+03
B	10 811		63Ni	62 92964	5 67E+01
Ba	137.327		79Se	78 918494	6 96E-03
Be	9 012182		90Sr	89 907747	1 38E+02
Bi	208 98037		90Y	89 907163	5 43E+05
Ca	40 078		93mNb	92 906382	2 39E+02
Cd	112 411		93Zr	92 90645	2 56E-03
Ce	140 115		99Tc	98 906249	1.70E-02
Cl	35 4527		106Ru	105 907322	3 31E+03
Co	58 9332		113mCd	112 904409	2 24E+02
Cr	51 9961		125Sb	124 905232	1 04E+03
Cu	63 546		126Sn	125 90764	1.14E-02
F	18 9984032		129I	128 904987	1.77E-04
Fe	55 847		134Cs	133 906823	1 29E+03
Free OH	17 00734		137Cs	136 90677	8 68E+01
Hg	200 59		137mBa	136 9055	5 38E+08
K	39 0983		151Sm	150 919919	2 63E+01
La	138 9055		152Eu	151 921749	1.74E+02
Li	6 941		154Eu	153 923053	2 70E+02
Mg	24 305		155Eu	154 92293	4 86E+02
Mn	54 93805		226Ra	226 025438	9 89E-01
Mo	95 94		227Ac	227 027774	7.23E+01
Na	22 989768		228Ra	228 031096	2 72E+02
Nd	144 24		229Th	229 031781	2 14E-01
NH3			231Pa	231 035903	4 72E-02
Ni	58 69		232Th	232 038079	1.10E-07
NO2	46 00554		232U		2 21E+01
NO3	62 00494		233U		9 64E-03
Oxalate	88 0196	0 27291649 kg Carbon/kg oxalate	234U		6 21E-03
Pb	207 2		235U		2 16E-06
PO4	94 971362		236U		6 47E-05
			237Np	237 048195	7 05E-04
Sb	121 75		238Pu	238 049582	1.71E+01
Se	78 96		238U		3 36E-07
Si	28 0855		239Pu	239 052175	6 21E-02
SO4	96 0636		240Pu	240 05608	2 27E-01
Sr	87.62		241Am	241.05685	3 43E+00
			241Pu	241.056873	1.03E+02
Th	232 0381		242Cm	242 05888	3 31E+03
Ti	47 88		242Pu	242 058769	3 94E-03
TIC as CO3	60 0092		243Am	243 061393	2 00E-01
Tl	204 383		243Cm	243 0614	5 06E+01
TOC (w/o oxalate)	12 011		244Cm	244 062775	8 10E+01
UTOTAL	238 0289				
V	50 9415				
Y	88 90585				
Zn	65 39				
Zr	91 224				
MW H					
MW O					

swansonl:
Note: worksheet uses Mwt = 86 for oxalate

Purpose:

Determine volumes of strontium nitrate and sodium permanganate that must be added to diluted Envelope C (i.e. AN-102 and AN-107 supernates) wastes to produce 0.02M Sr and 0.02M MnO_4 in solution.

Assumptions:

1. 40 wt% to 42 wt% sodium permanganate is commericially available from Carus Chemical Company Assume that 40 wt% sodium permanganate is used.

2. Strontium nitrate is commercially available in solid form, 99% pure per MIL-S-20322B. (http://www.steroidcatalog.com/smo3_d.html)

3. The solubility of strontium nitrate in water is 71 grams per 100 ml at 18°C. (MSDS from J. T. Baker Chemicals, http://www.jtbaker.com)
   The solubility of strontium nitrate in water is 40 grams per 100 ml at 0°C.
   (*Chemical Engineers' Handbook*, Fifth Edition, 1973, page 3-23, Perry and Chilton, McGraw-Hill Book Company.)

4. It is assumed that a commercial company will prepare a 3M $Sr(NO_3)_2$ solution from the dry chemical.

5. Molecular weight of compounds are:

$NaMnO_4$	141.93 g/mole				
$Sr(NO_3)_2$	211.65 g/mole	CAS	10042-76-9	MWt	211.63
$SrCO_3$	147.63 g/mole				
$NaMn(O)(OH)(O) \cdot nH_2O$	126.94 g/mole				

6. The density of 40 wt% sodium permanganate is 1.36 to 1.39 gm/ml at 25°C.
   Carus Chemical Company Sodium Permanganate (LIQUOX®) Fact Sheet, http://www.caruschem.com/
   Assume density is 1.36 g/ml for 40 wt% sodium permanganate.

7. Units g = grams ml = milliliter
   L = liter
   M = moles/liter

Calculations

1. Determine molar concentration of 40 wt% $NaMnO_4$ solution.

Molarity = compound wt% * 1000 * solution density / molecular weight of compound

40 wt% = 400 grams per 1000 grams of solution

Molarity = (400 grams of $NaMnO_4$ / 1000 grams of solution) *(1.36 g/ml) / 141.93 g/mole) * (1000 ml/L)

Molarity 3.83 at 25°C

2. Determine molarity of saturated $Sr(NO_3)_2$ solution at 18°C.

Molarity = (solubility (g/100 ml) in water at 18°C) * (1000 ml/L) / molecular weight

Molarity = (70 g/ 100 ml) * (1000 ml/ L) /211.65 g/mol

Molarity 3.35 at 18°C
3 M

Assumes that 3M strontium nitrate solution is used.

> Strontium Nitrate is a highly water soluble crystalline Strontium source for uses compatible with nitrates and lower (acidic) pH. Strontium Nitrate is generally immediately available in most volumes. *High purity, submicron and nanopowder forms may be considered.*

3. Determine volumes of 3.83M $NaMnO_4$ and $Sr(NO_3)_2$ needed per 1000-gallons of waste to form 0.02M Sr and 0.02M MnO_4 in waste.

equation 1 $0.02M = (Sr(NO_3)_2 \text{ Molarity} * \text{Added X Volume of } Sr(NO_3)_2) / (1000 \text{ gallons} + X + Y)$

equation 2 $0.02M = (NaMnO_4 \text{ Molarity} * \text{Added Y Volume of Na } MnO_4) / (1000 \text{ gallons} + X + Y)$

Substituting the concentrations of the reagents added to the waste in equations 1 and 2 yields equations 3 and 4.

equation 3 $0.02M = (3.0 * \text{Added X Volume of } Sr(NO_3)_2) / (1000 \text{ gallons} + X + Y)$

equation 4 $0.02M = (3.8 * \text{Added Y Volume of Na } MnO_4) / (1000 \text{ gallons} + X + Y)$

Equating equation 3 with equation 4 yields equation 5

equation 5 $3X = 3.8Y$

$X = (3.8/3)Y$

Substituing equation 5 into equation 4 yields and solving for Y yields

$0.02 = (3.8Y) / (1000 + (3.8/3)Y + Y)$

$0.02 = (3.8Y) / (1000 + (4.8/3)Y)$

$0.02 * (1000 + 1.6Y) = 3.8Y$

$20 = 3.768Y$

$Y =$ *5.308 gallons of 3.8M $NaMnO_4$ per 1,000 gallons of waste*

Substituting the value for Y in equation 5 yields the value for X

$X = (3.8/3)*(5.3079)$

$X =$ 6.723 gallons of 3M $Sr(NO_3)_2$ per 1,000 gallons of waste

Based on these results, 6.723 gallons of 3M Strontium Nitrate and 5.308 gallons of 3.8M Sodium Permanganate must be added to every 1,000 gallons of waste to result in a final concentrations of 0.02M Sr and 0.02M MnO_4.

ATTACHMENT 4

TREAT IN AN-102

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Supernatant (assume ppt in AN-102 only--delete AP-102 contributions)		An-102 Supernate (from BBI)		AP-102 Supernate		AN-102 Supernate	Dilution Water	Diluted AN-102		Diluted AN-102	3M Sr(NO3)2	40wt% NaMnO4 (3.83M)	Percent Removal from Supernate	Treated Waste	Precipitate
2	Analyte	Units	Adjusted Concentration		Adjusted Concentration		Adjusted Concentration			Units	Values for Unit Change					
3	106Ru	uCi/g	3.63E-09		0.00E+00		3.63E-09		2.35E-09	uCi/ml	2.89E-09			0.0%	2.85E-09	
4	113mCd	uCi/g	1.58E-02		0.00E+00		1.58E-02		1.02E-02	uCi/ml	1.26E-02			0.0%	1.24E-02	
5	125Sb	uCi/g	2.24E-03		0.00E+00		2.24E-03		1.45E-03	uCi/ml	1.78E-03			0.0%	1.76E-03	
6	126Sn	uCi/g	4.64E-03		0.00E+00		4.64E-03		3.01E-03	uCi/ml	3.69E-03			0.0%	3.65E-03	
7	129I	uCi/g	9.05E-05		0.00E+00		9.05E-05		5.87E-05	uCi/ml	7.20E-05			0.0%	7.11E-05	
8	134Cs	uCi/g	2.08E-03		0.00E+00		2.08E-03		1.35E-03	uCi/ml	1.65E-03			0.0%	1.64E-03	
9	137Cs	uCi/g	2.63E+02		0.00E+00		2.63E+02		1.70E+02	uCi/ml	2.09E+02			0.0%	2.07E+02	
10	137mBa	uCi/g	2.48E+02		0.00E+00		2.48E+02		1.61E+02	uCi/ml	1.97E+02			0.0%	1.95E+02	
11	14C	uCi/g	4.90E-04		0.00E+00		4.90E-04		3.18E-04	uCi/ml	3.90E-04			0.0%	3.85E-04	
12	151Sm	uCi/g	2.41E+00		0.00E+00		2.41E+00		1.56E+00	uCi/ml	1.92E+00			0.0%	1.89E+00	
13	152Eu	uCi/g	2.66E-04		0.00E+00		2.66E-04		1.72E-04	uCi/ml	2.12E-04			85.0%	3.14E-05	
14	154Eu	uCi/g	1.23E-01		0.00E+00		1.23E-01		7.97E-02	uCi/ml	9.79E-02			85.0%	1.45E-02	
15	155Eu	uCi/g	7.08E-03		0.00E+00		7.08E-03		4.59E-03	uCi/ml	5.63E-03			85.0%	8.35E-04	
16	226Ra	uCi/g	2.66E-08		0.00E+00		2.66E-08		1.72E-08	uCi/ml	2.12E-08			0.0%	2.09E-08	
17	227Ac	uCi/g	3.28E-06		0.00E+00		3.28E-06		2.13E-06	uCi/ml	2.61E-06			0.0%	2.58E-06	
18	228Ra	uCi/g	7.60E-06		0.00E+00		7.60E-06		4.93E-06	uCi/ml	6.05E-06			0.0%	5.97E-06	
19	229Th	uCi/g	1.32E-08		0.00E+00		1.32E-08		8.56E-09	uCi/ml	1.05E-08			0.0%	1.04E-08	
20	231Pa	uCi/g	3.44E-05		0.00E+00		3.44E-05		2.23E-05	uCi/ml	2.74E-05			0.0%	2.70E-05	
21	232Th	uCi/g	1.55E-07		0.00E+00		1.55E-07		1.00E-07	uCi/ml	1.23E-07			0.0%	1.22E-07	
22	232U	uCi/g	1.39E-07		0.00E+00		1.39E-07		9.01E-08	uCi/ml	1.11E-07			0.0%	1.09E-07	
23	233U	uCi/g	8.54E-06		0.00E+00		8.54E-06		5.54E-06	uCi/ml	6.79E-06			0.0%	6.71E-06	
24	234U	uCi/g	6.04E-06		0.00E+00		6.04E-06		3.92E-06	uCi/ml	4.81E-06			0.0%	4.75E-06	
25	235U	uCi/g	2.39E-07		0.00E+00		2.39E-07		1.55E-07	uCi/ml	1.90E-07			0.0%	1.88E-07	
26	236U	uCi/g	4.09E-07		0.00E+00		4.09E-07		2.65E-07	uCi/ml	3.25E-07			0.0%	3.22E-07	
27	237Np	uCi/g	3.42E-05		0.00E+00		3.42E-05		2.22E-05	uCi/ml	2.72E-05			85.0%	4.03E-06	
28	238Pu	uCi/g	2.40E-04		0.00E+00		2.40E-04		1.56E-04	uCi/ml	1.91E-04			85.0%	2.83E-05	
29	238U	uCi/g	4.73E-06		0.00E+00		4.73E-06		3.07E-06	uCi/ml	3.76E-06			0.0%	3.72E-06	
30	239Pu	uCi/g	3.30E-03		0.00E+00		3.30E-03		2.14E-03	uCi/ml	2.63E-03			85.0%	3.89E-04	
31	240Pu	uCi/g	8.59E-04		0.00E+00		8.59E-04		5.57E-04	uCi/ml	6.83E-04			85.0%	1.01E-04	
32	241Am	uCi/g	1.11E-01		0.00E+00		1.11E-01		7.20E-02	uCi/ml	8.83E-02			85.0%	1.31E-02	
33	241Pu	uCi/g	1.51E-02		0.00E+00		1.51E-02		9.79E-03	uCi/ml	1.20E-02			85.0%	1.78E-03	
34	242Cm	uCi/g	2.18E-04		0.00E+00		2.18E-04		1.41E-04	uCi/ml	1.73E-04			85.0%	2.57E-05	
35	242Pu	uCi/g	9.10E-08		0.00E+00		9.10E-08		5.90E-08	uCi/ml	7.24E-08			85.0%	1.07E-08	
36	243Am	uCi/g	7.31E-05		0.00E+00		7.31E-05		4.74E-05	uCi/ml	5.82E-05			85.0%	8.62E-06	
37	243Cm	uCi/g	1.20E-05		0.00E+00		1.20E-05		7.78E-06	uCi/ml	9.55E-06			85.0%	1.42E-06	
38	244Cm	uCi/g	2.85E-04		0.00E+00		2.85E-04		1.85E-04	uCi/ml	2.27E-04			85.0%	3.36E-05	
39	3H	uCi/g	3.76E-04		0.00E+00		3.76E-04		2.44E-04	uCi/ml	2.99E-04			0.0%	2.96E-04	
40	59Ni	uCi/g	1.69E-04		0.00E+00		1.69E-04		1.10E-04	uCi/ml	1.34E-04			0.0%	1.33E-04	
41	60Co	uCi/g	3.62E-02		0.00E+00		3.62E-02		2.35E-02	uCi/ml	2.88E-02			0.0%	2.85E-02	
42	63Ni	uCi/g	1.58E-02		0.00E+00		1.58E-02		1.02E-02	uCi/ml	1.26E-02			0.0%	1.24E-02	
43	79Se	uCi/g	4.21E-04		0.00E+00		4.21E-04		2.73E-04	uCi/ml	3.35E-04			0.0%	3.31E-04	
44	90Sr	uCi/g	5.32E+01		0.00E+00		5.32E+01		3.45E+01	uCi/ml	4.23E+01			94.0%	2.51E+00	
45	90Y	uCi/g	5.32E+01		0.00E+00		5.32E+01		3.45E+01	uCi/ml	4.23E+01			0.0%	4.18E+01	
46	93mNb	uCi/g	1.53E-02		0.00E+00		1.53E-02		9.92E-03	uCi/ml	1.22E-02			0.0%	1.20E-02	
47	93Zr	uCi/g	1.85E-02		0.00E+00		1.85E-02		1.20E-02	uCi/ml	1.47E-02			0.0%	1.45E-02	
48	99Tc	uCi/g	9.75E-02		0.00E+00		9.75E-02		6.32E-02	uCi/ml	7.76E-02			0.0%	7.66E-02	
49	Ag	ug/g	1.97E+00				1.97E+00		1.28E+00	M	1.45E-05			0.0%	1.44E-05	
50	Al	ug/g	9.65E+03		0.00E+00		9.65E+03		6.26E+03	M	2.84E-01			0.0%	2.81E-01	
51	Aroclors (Total PCB)	ug/g	8.61E-03		0.00E+00		8.61E-03		5.58E-03							
52	As	ug/g	1.85E+01				1.85E+01		1.20E+01	M	1.96E-04			0.0%	1.94E-04	
53	B	ug/g	2.67E+01				2.67E+01		1.73E+01	M	1.97E-03			0.0%	1.94E-03	
54	Ba	ug/g	7.56E+00				7.56E+00		4.90E+00	M	4.38E-05			19.0%	3.51E-05	
55	Be	ug/g	4.79E-01				4.79E-01		3.11E-01	M	4.23E-05			0.0%	4.18E-05	

BEST AVAILABLE COPY

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
56	Bi	ug/g	1.85E+01		0.00E+00		1.85E+01		1.20E+01	M	7.04E-05			0.0%	6.96E-05					
57	Ca	ug/g	2.95E+02		0.00E+00		2.95E+02		1.91E+02	M	5.87E-03			19.0%	4.70E-03					
58	Cd	ug/g	4.16E+01				4.16E+01		2.70E+01	M	2.94E-04			0.0%	2.91E-04					
59	Ce	ug/g	7.55E+00				7.55E+00		4.89E+00	M	4.29E-05			85.0%	6.35E-06					
60	Cl	ug/g	2.72E+03		0.00E+00		2.72E+03		1.76E+03	M	6.10E-02			0.0%	6.03E-02					
61	Co	ug/g	1.82E+00				1.82E+00		1.18E+00	M	2.46E-05			0.0%	2.43E-05					
62	Cr	ug/g	1.71E+02		0.00E+00		1.71E+02		1.11E+02	M	2.62E-03			21.0%	2.04E-03					
63	Cu	ug/g	1.80E+01				1.80E+01		1.17E+01	M	2.25E-04			0.0%	2.23E-04					
64	F	ug/g	4.29E+01		0.00E+00		4.29E+01		2.78E+01	M	1.80E-03			0.0%	1.78E-03					
65	Fe	ug/g	2.67E+01		0.00E+00		2.67E+01		1.73E+01	M	3.80E-04			97.0%	1.13E-05					
66	Free OH	ug/g	6.33E+03		0.00E+00		6.33E+03		4.10E+03	M	2.96E-01			0.0%	2.93E-01					
67	Hg	ug/g	3.48E-02		0.00E+00		3.48E-02		2.26E-02	M	1.38E-07			0.0%	1.36E-07					
68	K	ug/g	1.42E+03		0.00E+00		1.42E+03		9.21E+02	M	2.89E-02			0.0%	2.86E-02					
69	La	ug/g	9.35E+00		0.00E+00		9.35E+00		6.06E+00	M	5.36E-05			85.0%	7.93723E-06					
70	Li	ug/g	6.41E-01				6.41E-01		4.16E-01	M	7.35E-05			0.0%	7.26E-05					
71	Mg	ug/g	1.88E+01				1.88E+01		1.22E+01	M	6.15E-04			0.0%	6.08E-04					
72	Mn	ug/g	1.18E+01		0.00E+00		1.18E+01		7.65E+00	M	1.71E-04		3.83	30.0%	1.18E-04					
73	Mo	ug/g	3.39E+01				3.39E+01		2.20E+01	M	2.81E-04			0.0%	2.78E-04					
74	Na	ug/g	1.59E+05		0.00E+00		1.59E+05		1.03E+05	M	5.50E+00		3.83	0.0%	5.45E+00					
75	Nd	ug/g	1.43E+01				1.43E+01		9.27E+00	M	7.89E-05			85.0%	1.17E-05					
76	NH3	ug/g	9.19E+01				9.19E+01		5.96E+01	M	4.30E-03			0.0%	4.25E-03					
77	Ni	ug/g	2.77E+02		0.00E+00		2.77E+02		1.80E+02	M	3.75E-03			0.0%	3.71E-03					
78	NO2	ug/g	6.01E+04		0.00E+00		6.01E+04		3.90E+04	M	1.04E+00			0.0%	1.03E+00					
79	NO3	ug/g	1.44E+05		0.00E+00		1.44E+05		9.33E+04	M	1.85E+00	6		0.0%	1.87E+00					
80	Oxalate	ug/g	5.88E+02		0.00E+00		5.88E+02		3.81E+02	M	5.44E-03			0.0%	5.37E-03					
81	Pb	ug/g	1.11E+02		0.00E+00		1.11E+02		7.20E+01	M	4.26E-04			30.0%	2.95E-04					
82	PO4	ug/g	3.63E+03		0.00E+00		3.63E+03		2.35E+03	M	3.04E-02			0.0%	3.00E-02					
83	Rh																			
84	Sb	ug/g	1.43E-01				1.43E-01		9.27E-02	M	9.34E-07			0.0%	9.23E-07					
85	Se	ug/g	1.86E+01				1.86E+01		1.21E+01	M	1.87E-04			0.0%	1.85E-04					
86	Si	ug/g	3.06E+01		0.00E+00		3.06E+01		1.98E+01	M	8.67E-04			0.0%	8.56E-04					
87	SO4	ug/g	1.03E+04		0.00E+00		1.03E+04		6.68E+03	M	8.54E-02			0.0%	8.43E-02					
88	Sr	ug/g	1.67E+00		0.00E+00		1.67E+00		1.08E+00	M	1.52E-05	3.00		94.0%	1.59E-03					
89	Ta																			
90	Th	ug/g	1.41E+00		0.00E+00		1.41E+00		9.14E-01	M	4.83E-06			0.0%	4.78E-06					
91	Ti	ug/g	4.58E-01				4.58E-01		2.97E-01	M	7.61E-06			0.0%	7.52E-06					
92	TIC as CO3	ug/g	5.36E+04		0.00E+00		5.36E+04		3.47E+04	M	7.11E-01			2.8%	6.82E-01					
93	Tl	ug/g	1.32E+00				1.32E+00		8.56E-01	M	5.14E-06			0.0%	5.08E-06					
94	TOC	ug/g	1.94E+04		0.00E+00		1.94E+04		1.26E+04	M	1.29E+00			0.0%	1.27E+00					
95	UTOTAL	ug/g	1.42E+01		0.00E+00		1.42E+01		9.21E+00	M	4.75E-05			0.0%	4.69E-05					
96	V	ug/g	1.85E+00				1.85E+00		1.20E+00	M	2.89E-05			0.0%	2.85E-05					
97	Y	ug/g	1.46E+00				1.46E+00		9.46E-01	M	1.31E-05			0.0%	1.29E-05					
98	Zn	ug/g	1.88E+00				1.88E+00		1.22E+00	M	2.29E-05			0.0%	2.26E-05					
99	Zr	ug/g	4.96E+00		0.00E+00		4.96E+00		3.22E+00	M	4.33E-05			82.0%	7.69E-06					
100	Sum of TRU	uCi/g	1.16E-01				1.16E-01		7.51E-02											
101	Supernate density	gm/ml	1.40				1.40	1.00	1.23	gm/ml	1.23									
102	Sum of TRU	uCi/ml	1.62E-01				1.62E-01		9.21E-02	uCi/ml					1.37E-02					
103	Sr-90	uCi/ml	74.48				74.48		42.33	uCi/ml	42.33				2.51E+00					
104																				
105	Na concentration	M	9.68				9.68		5.50						5.45					
106																				
107	wt% Na2O in glass		15.0%				15.0%		15.0%						15.0%					
108	wt% SO3 in glass		0.6%				0.6%		0.6%						0.6%					
109	MT/m3 glass density		2.76				2.76		2.76						2.76					
110	gm glass/liter of waste		2.00E+03				2.00E+03		1.14E+03						1.13E+03					
111	m3 per liter of waste		7.25E-04				7.25E-04		4.12E-04						4.08E-04					
112																				
113	TRU in glass	nCi/gm	81.06				81.06		81.1	nCi/gm					12.1	85%				
114	TRU Removal Required to achieve 50 nCi/gm		38.3%		-23.4%		38.3%	n/a	38.3%											
115	Sr-90 in glass	Ci/m3	102.77				102.77		102.77	Ci/m3					6.14	94%				
116	Sr-90 Removal Required to achieve 10 Ci/m^3		90.3%				90.3%	n/a	90.3%											
117	Volume	Liters	3.55E+06				3.55E+06	2.70E+06	6.25E+06	Liters	6.25E+06	4.20E+04	3.32E+04	Liters	6.32E+06					
118		Gallons	9.38E+05				9.38E+05	7.13E+05	1.65E+06	Gallons	1.65E+06	1.11E+04	8.76E+03	Gallons	1.67E+06					
119	Height of Supernatant	Inches	341.1				341.1		600.2		600.2				607.4					
120	Target Na M							5.50												
121	Sr M											3.00			0.02					
122	Moles Sr Added											1.26E+05								
123	MnO_4 M												3.83		0.02					
124	Mole Mn Added												1.27E+05							
125																				

The percent removal is for the Mn present in the sample before addition of permanganate. All added permanganate precipitates. AN-107 averaged 96% removal. AN-102 averaged 30% removal.

The moles of carbonate removed are equal to the amount of Sr added.

BEST AVAILABLE COPY

	A	B	E	G	I	L–M	O	P	Q	R	S	T
126	Sludge		AP-102	AN-102 + AP-102 Heel	Diluted AN-102 + AP-102		Treated Waste	Mass Precipitated	Species	M.W.	Mass of Precipitated Solids	
127	Analyte	Units										
128	106Ru	Ci	0.00E+00	0.00E+00	0.00E+00		0.00E+00					
129	113mCd	Ci	0.00E+00				-1.42E-14					
130	125Sb	Ci	0.00E+00				0.00E+00					
131	126Sn	Ci	0.00E+00				0.00E+00					
132	129I	Ci	0.00E+00				-5.55E-17					
133	134Cs	Ci	0.00E+00				-1.78E-15					
134	137Cs	Ci	0.00E+00				0.00E+00					
135	137mBa	Ci	0.00E+00				0.00E+00					
136	14C	Ci	0.00E+00				0.00E+00					
137	151Sm	Ci	0.00E+00				-1.82E-12					
138	152Eu	Ci	0.00E+00				1.12E+00					
139	154Eu	Ci	0.00E+00				5.20E+02					
140	155Eu	Ci	0.00E+00				2.99E+01					
141	226Ra	Ci	0.00E+00				-2.71E-20					
142	227Ac	Ci	0.00E+00				3.47E-18					
143	228Ra	Ci	0.00E+00				0.00E+00					
144	229Th	Ci	0.00E+00				0.00E+00					
145	231Pa	Ci	0.00E+00				-2.78E-17					
146	232Th	Ci	0.00E+00				0.00E+00					
147	232U	Ci	0.00E+00				0.00E+00					
148	233U	Ci	0.00E+00				0.00E+00					
149	234U	Ci	0.00E+00				0.00E+00					
150	235U	Ci	0.00E+00				0.00E+00					
151	236U	Ci	0.00E+00				0.00E+00					
152	237Np	Ci	0.00E+00				1.44E-01					
153	238Pu	Ci	0.00E+00				1.01E+00					
154	238U	Ci	0.00E+00				0.00E+00					
155	239Pu	Ci	0.00E+00				1.39E+01					
156	240Pu	Ci	0.00E+00				3.63E+00					
157	241Am	Ci	0.00E+00				4.69E+02					
158	241Pu	Ci	0.00E+00				6.38E+01					
159	242Cm	Ci	0.00E+00				9.21E-01					
160	242Pu	Ci	0.00E+00				3.84E-04					
161	243Am	Ci	0.00E+00				3.09E-01					
162	243Cm	Ci	0.00E+00				5.07E-02					
163	244Cm	Ci	0.00E+00				1.20E+00					
164	3H	Ci	0.00E+00				0.00E+00					
165	59Ni	Ci	0.00E+00				-1.11E-16					
166	60Co	Ci	0.00E+00				0.00E+00					
167	63Ni	Ci	0.00E+00				-1.42E-14					
168	79Se	Ci	0.00E+00				0.00E+00					
169	90Sr	Ci	0.00E+00				2.49E+05					
170	90Y	Ci	0.00E+00				-5.82E-11					
171	93mNb	Ci	0.00E+00				0.00E+00					
172	93Zr	Ci	0.00E+00				0.00E+00					
173	99Tc	Ci	0.00E+00				-5.68E-14					
174	Al	kg	0.00E+00				-6.29E-12	-6.29E-12		M.W.	Mass of Precipitated Solids	
175	Aroclors (Total PCB)	kg	0.00E+00									
176	Br	kg	0.00E+00				0.00E+00	0.00E+00				
177	Ca	kg	0.00E+00				2.79E+02	2.79E+02	CaCO3	100	6.96E+02	
178	Cl	kg	0.00E+00				0.00E+00	0.00E+00				
179	Cr	kg	0.00E+00				2.02E+02	2.02E+02	Cr(OH)3	103	4.01E+02	
180	F	kg	0.00E+00				0.00E+00	0.00E+00				
181	Fe	kg	0.00E+00				1.29E+02	1.29E+02	Fe(OH)3	106.85	2.46E+02	
182	Free OH	kg	0.00E+00			Includes added Mn that precipitates.	3.95E-12	3.96E-12				
183	Hg	kg	0.00E+00				0.00E+00	0.00E+00				
184	K	kg	0.00E+00				0.00E+00	0.00E+00				
185	La	kg	0.00E+00				3.95E+01	3.95E+01	La(OH)3	189.9	5.40E+01	
186	Mn	kg	0.00E+00				7.00E+03	7.00E+03	NaMn(O)(OH)(O)	126.94	1.62E+04	
187	Na	kg	0.00E+00				4.51E-10	0.00E+00				
188	Ni	kg	0.00E+00				0.00E+00	0.00E+00				
189	NO2	kg	0.00E+00				4.28E-11	4.28E-11				
190	NO3	kg	0.00E+00				3.61E-11	3.61E-11				
191	Oxalate	kg	0.00E+00				0.00E+00	0.00E+00				
192	Pb	kg	0.00E+00			Includes added Sr that precipitates	1.66E+02	1.66E+02	Pb(OH)4	275.2	2.20E+02	
193	PO4	kg	0.00E+00				0.00E+00	0.00E+00				
194	Si	kg	0.00E+00				0.00E+00	0.00E+00				
195	SO4	kg	0.00E+00				0.00E+00	0.00E+00				
196	Sr	kg	0.00E+00				1.02E+04	1.02E+04	SrCO3	147.62	1.71E+04	
197	Th	kg	0.00E+00				0.00E+00	0.00E+00				
198	TIC as CO3	kg	0.00E+00				7.56E+03	7.56E+03				
199	TOC	kg	0.00E+00				0.00E+00	0.00E+00				
200	UTOTAL	kg	0.00E+00			Total inches precipitate.	0.00E+00	0.00E+00				
201	Zr	kg	0.00E+00				2.02E+01	2.02E+01	Zr(OH)4	159.22	3.53E+01	
202												
203	Density	gm/ml	0.00E+00									
204	Volume	Liters	0.00E+00									
205	Inches of sludge		0.00E+00				6.6	Volume conversion to inches uses 2750 gal/in in the DSTs. Note this should not be used when workig with the lower 6 inches of the tank. Use volume calculator from RPP-13019 (CH2M Hill).				
206												
207	Total	kgs									3.50E+04	kg
208												
209	wt% settled solids	wt%									39.0%	wt%
210	settled solids density	gm/ml									1.3	gm/ml
211	volume of settled solids	liters									6.89E+04	liters
212		gallons									1.82E+04	gallons
213		inches									6.6	inches

ATTACHMENT 5

TREAT IN AN-107

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	*Supernatant (assume ppt in AN-107 only--delete AP-102 contributions)*		*AN-107 Supernate (from BBI)*		*AP-102 Supernate*		*AN-107 Supernate*	*Dilution Water*	*Diluted AN-107*		*Diluted AN-107*	*3M $Sr(NO_3)_2$*	*40wt% $NaMnO_4$ (3.83M)*	*Percent Removal from Supernate*	*Treated Waste*	*Precipitate*
2	Analyte	Units	Adjusted Concentration		Adjusted Concentration		Adjusted Concentration			Units	Unit Change					
3	106Ru	uCi/g	3.15E-09				3.15E-09		2.18E-09	uCi/ml	2.75E-09			0.0%	2.72E-09	
4	113mCd	uCi/g	1.37E-02				1.37E-02		9.47E-03	uCi/ml	1.20E-02			0.0%	1.18E-02	
5	125Sb	uCi/g	1.32E-03				1.32E-03		9.12E-04	uCi/ml	1.15E-03			0.0%	1.14E-03	
6	126Sn	uCi/g	6.62E-03				6.62E-03		4.58E-03	uCi/ml	5.78E-03			0.0%	5.71E-03	
7	129I	uCi/g	8.13E-05				8.13E-05		5.62E-05	uCi/ml	7.09E-05			0.0%	7.01E-05	
8	134Cs	uCi/g	1.80E-03				1.80E-03		1.24E-03	uCi/ml	1.57E-03			0.0%	1.55E-03	
9	137Cs	uCi/g	2.18E+02				2.18E+02		1.51E+02	uCi/ml	1.90E+02			0.0%	1.88E+02	
10	137mBa	uCi/g	2.06E+02				2.06E+02		1.42E+02	uCi/ml	1.80E+02			0.0%	1.78E+02	
11	14C	uCi/g	4.36E-04				4.36E-04		3.01E-04	uCi/ml	3.80E-04			0.0%	3.76E-04	
12	151Sm	uCi/g	2.09E+00				2.09E+00		1.44E+00	uCi/ml	1.82E+00			0.0%	1.80E+00	
13	152Eu	uCi/g	2.31E-04				2.31E-04		1.60E-04	uCi/ml	2.02E-04			85.0%	2.99E-05	
14	154Eu	uCi/g	2.52E-01				2.52E-01		1.74E-01	uCi/ml	2.20E-01			85.0%	3.26E-02	
15	155Eu	uCi/g	1.37E-01				1.37E-01		9.47E-02	uCi/ml	1.20E-01			85.0%	1.77E-02	
16	226Ra	uCi/g	2.31E-08				2.31E-08		1.60E-08	uCi/ml	2.02E-08			0.0%	1.99E-08	
17	227Ac	uCi/g	2.84E-06				2.84E-06		1.96E-06	uCi/ml	2.48E-06			0.0%	2.45E-06	
18	228Ra	uCi/g	6.94E-06				6.94E-06		4.80E-06	uCi/ml	6.05E-06			0.0%	5.98E-06	
19	229Th	uCi/g	1.14E-08				1.14E-08		7.88E-09	uCi/ml	9.95E-09			0.0%	9.83E-09	
20	231Pa	uCi/g	2.98E-05				2.98E-05		2.06E-05	uCi/ml	2.60E-05			0.0%	2.57E-05	
21	232Th	uCi/g	1.36E-06				1.36E-06		9.40E-07	uCi/ml	1.19E-06			0.0%	1.17E-06	
22	232U	uCi/g	6.97E-07				6.97E-07		4.82E-07	uCi/ml	6.08E-07			0.0%	6.01E-07	
23	233U	uCi/g	4.28E-05				4.28E-05		2.96E-05	uCi/ml	3.73E-05			0.0%	3.69E-05	
24	234U	uCi/g	3.03E-05				3.03E-05		2.09E-05	uCi/ml	2.64E-05			0.0%	2.61E-05	
25	235U	uCi/g	1.20E-06				1.20E-06		8.29E-07	uCi/ml	1.05E-06			0.0%	1.03E-06	
26	236U	uCi/g	2.05E-06				2.05E-06		1.42E-06	uCi/ml	1.79E-06			0.0%	1.77E-06	
27	237Np	uCi/g	4.00E-05				4.00E-05		2.76E-05	uCi/ml	3.49E-05			85.0%	5.17E-06	
28	238Pu	uCi/g	2.31E-03				2.31E-03		1.60E-03	uCi/ml	2.02E-03			85.0%	2.99E-04	
29	238U	uCi/g	2.37E-05				2.37E-05		1.64E-05	uCi/ml	2.07E-05			0.0%	2.04E-05	
30	239Pu	uCi/g	3.18E-02				3.18E-02		2.20E-02	uCi/ml	2.77E-02			85.0%	4.11E-03	
31	240Pu	uCi/g	8.27E-03				8.27E-03		5.72E-03	uCi/ml	7.21E-03			85.0%	1.07E-03	
32	241Am	uCi/g	5.15E-01				5.15E-01		3.56E-01	uCi/ml	4.49E-01			85.0%	6.66E-02	
33	241Pu	uCi/g	1.45E-01				1.45E-01		1.00E-01	uCi/ml	1.27E-01			85.0%	1.87E-02	
34	242Cm	uCi/g	1.96E-03				1.96E-03		1.35E-03	uCi/ml	1.71E-03			85.0%	2.53E-04	
35	242Pu	uCi/g	8.75E-07				8.75E-07		6.05E-07	uCi/ml	7.63E-07			85.0%	1.13E-07	
36	243Am	uCi/g	3.38E-04				3.38E-04		2.34E-04	uCi/ml	2.95E-04			85.0%	4.37E-05	
37	243Cm	uCi/g	5.56E-05				5.56E-05		3.84E-05	uCi/ml	4.85E-05			85.0%	7.19E-06	
38	244Cm	uCi/g	1.32E-03				1.32E-03		9.12E-04	uCi/ml	1.15E-03			85.0%	1.71E-04	
39	3H	uCi/g	4.51E-04				4.51E-04		3.12E-04	uCi/ml	3.93E-04			0.0%	3.88E-04	
40	59Ni	uCi/g	1.49E-02				1.49E-02		1.03E-02	uCi/ml	1.30E-02			0.0%	1.28E-02	
41	60Co	uCi/g	4.53E-02				4.53E-02		3.13E-02	uCi/ml	3.95E-02			0.0%	3.91E-02	
42	63Ni	uCi/g	1.04E+00				1.04E+00		7.19E-01	uCi/ml	9.07E-01			0.0%	8.97E-01	
43	79Se	uCi/g	5.65E-04				5.65E-04		3.90E-04	uCi/ml	4.93E-04			0.0%	4.87E-04	
44	90Sr	uCi/g	5.40E+01				5.40E+01		3.73E+01	uCi/ml	4.71E+01			94.0%	2.79E+00	
45	90Y	uCi/g	5.40E+01				5.40E+01		3.73E+01	uCi/ml	4.71E+01			0.0%	4.66E+01	
46	93mNb	uCi/g	1.33E-02				1.33E-02		9.19E-03	uCi/ml	1.16E-02			0.0%	1.15E-02	
47	93Zr	uCi/g	1.60E-02				1.60E-02		1.11E-02	uCi/ml	1.40E-02			0.0%	1.38E-02	
48	99Tc	uCi/g	5.69E-02				5.69E-02		3.93E-02	uCi/ml	4.96E-02			0.0%	4.91E-02	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
49	Ag	ug/g	1.34E+00				1.34E+00		9.26E-01	M	1.08E-05			0.0%	1.07E-05			
50	Al	ug/g	7.85E+02				7.85E+02		5.43E+02	M	2.54E-02			0.0%	2.51E-02			
51	Aroclors (Total PCB)	ug/g	2.80E-03				2.80E-03		1.94E-03									
52	As	ug/g	9.09E-01				9.09E-01		6.28E-01	M	1.06E-05			0.0%	1.05E-05			
53	B	ug/g	1.57E+01				1.57E+01		1.09E+01	M	1.27E-03			0.0%	1.25E-03			
54	Ba	ug/g	6.63E+00				6.63E+00		4.58E+00	M	4.21E-05			19.0%	3.37E-05			
55	Be	ug/g	1.32E-01				1.32E-01		9.12E-02	M	1.28E-05			0.0%	1.26E-05			
56	Bi	ug/g	5.83E+00				5.83E+00		4.03E+00	M	2.43E-05			0.0%	2.40E-05			
57	Ca	ug/g	3.89E+02				3.89E+02		2.69E+02	M	8.48E-03			19.0%	6.78E-03			
58	Cd	ug/g	4.38E+01				4.38E+01		3.03E+01	M	3.40E-04			0.0%	3.36E-04			
59	Ce	ug/g	3.38E+01				3.38E+01		2.34E+01	M	2.10E-04			85.0%	3.12E-05			
60	Cl	ug/g	1.24E+03				1.24E+03		8.57E+02	M	3.05E-02			0.0%	3.02E-02			
61	Co	ug/g	2.92E+00				2.92E+00		2.02E+00	M	4.32E-05			0.0%	4.27E-05			
62	Cr	ug/g	1.19E+02				1.19E+02		8.22E+01	M	2.00E-03			21.0%	1.56E-03			
63	Cu	ug/g	2.01E+01				2.01E+01		1.39E+01	M	2.76E-04			0.0%	2.73E-04			
64	F	ug/g	6.79E+01				6.79E+01		4.69E+01	M	3.12E-03			0.0%	3.08E-03			
65	Fe	ug/g	1.15E+03				1.15E+03		7.95E+02	M	1.80E-02			97.0%	5.33E-04			
66	Free OH	ug/g	1.26E+04				1.26E+04		8.71E+03	M	6.47E-01			0.0%	6.39E-01			
67	Hg	ug/g	1.53E-01				1.53E-01		1.06E-01	M	6.65E-07			0.0%	6.58E-07			
68	K	ug/g	1.21E+03				1.21E+03		8.36E+02	M	2.70E-02			0.0%	2.67E-02			
69	La	ug/g	2.23E+01				2.23E+01		1.54E+01	M	1.40E-04			85.0%	2.07583E-05			
70	Li	ug/g	2.04E+00				2.04E+00		1.41E+00	M	2.56E-04			0.0%	2.53E-04			
71	Mg	ug/g	9.75E-01				9.75E-01		6.74E-01	M	3.50E-05			0.0%	3.46E-05			
72	Mn	ug/g	3.41E+02				3.41E+02		2.36E+02	M	5.41E-03		3.83	96.0%	2.14E-04			
73	Mo	ug/g	2.34E+01				2.34E+01		1.62E+01	M	2.13E-04			0.0%	2.10E-04			
74	Na	ug/g	1.45E+05				1.45E+05		1.00E+05	M	5.50E+00		3.83	0.0%	5.45E+00			
75	Nd	ug/g	6.42E+01				6.42E+01		4.44E+01	M	3.88E-04			85.0%	5.76E-05			
76	NH3	ug/g	3.41E+01				3.41E+01		2.36E+01	M	1.75E-03			0.0%	1.73E-03			
77	Ni	ug/g	3.66E+02				3.66E+02		2.53E+02	M	5.44E-03			0.0%	5.37E-03			
78	NO2	ug/g	4.66E+04				4.66E+04		3.22E+04	M	8.84E-01			0.0%	8.73E-01			
79	NO3	ug/g	1.46E+05				1.46E+05		1.01E+05	M	2.05E+00	6.00		0.0%	2.07E+00			
80	Oxalate	ug/g	6.37E+02				6.37E+02		4.40E+02	M	6.46E-03			0.0%	6.39E-03			
81	Pb	ug/g	2.62E+02				2.62E+02		1.81E+02	M	1.10E-03			30.0%	7.63E-04			
82	PO4	ug/g	1.08E+03				1.08E+03		7.46E+02	M	9.92E-03			0.0%	9.80E-03			
83	Rh	ug/g	1.75E+01				1.75E+01		1.21E+01	M	1.48E-04			0.0%	1.47E-04			
84	Sb	ug/g	2.24E-01				2.24E-01		1.55E-01	M	1.61E-06			0.0%	1.59E-06			
85	Se	ug/g	5.67E-01				5.67E-01		3.92E-01	M	6.26E-06			0.0%	6.19E-06			
86	Si	ug/g	9.18E+00				9.18E+00		6.34E+00	M	2.85E-04			0.0%	2.82E-04			
87	SO4	ug/g	5.71E+03				5.71E+03		3.95E+03	M	5.19E-02			0.0%	5.13E-02			
88	Sr	ug/g	1.32E+00				1.32E+00		9.12E-01	M	1.31E-05	3.00		94.0%	1.77E-03			
89	Te	ug/g	1.70E+01				1.70E+01		1.17E+01	M	8.20E-05			0.0%	8.10E-05			
90	Th	ug/g	1.24E+01				1.24E+01		8.57E+00	M	4.66E-05			0.0%	4.61E-05			
91	Tl	ug/g	9.98E-01				9.98E-01		6.90E-01	M	1.82E-05			0.0%	1.80E-05			
92	TIC as CO3	ug/g	5.16E+04				5.16E+04		3.57E+04	M	7.50E-01			2.7%	7.21E-01			
93	Ti	ug/g	8.73E-02				8.73E-02		6.03E-02	M	3.73E-07			0.0%	3.68E-07			
94	TOC	ug/g	2.26E+04				2.26E+04		1.56E+04	M	1.64E+00			0.0%	1.62E+00			
95	UTOTAL	ug/g	7.12E+01				7.12E+01		4.92E+01	M	2.61E-04			0.0%	2.58E-04			
96	V	ug/g	4.91E-01				4.91E-01		3.39E-01	M	8.41E-06			0.0%	8.31E-06			
97	Y	ug/g	6.02E+00				6.02E+00		4.16E+00	M	5.91E-05			0.0%	5.84E-05			
98	Zn	ug/g	1.32E+01				1.32E+01		9.12E+00	M	1.76E-04			0.0%	1.74E-04			
99	Zr	ug/g	4.19E+01				4.19E+01		2.90E+01	M	4.01E-04			82.0%	7.13E-05			
100	Sum of TRU	uCi/g	0.559				0.559		0.388					uCi/g	0.057			
101	Supernate density	gm/ml	1.43				1.43	1.00	1.26	gm/ml	1.26							
102	Sum of TRU	uCi/ml	8.00E-01				8.00E-01		4.88E-01	uCi/ml					7.23E-02			
103	Sr-90	uCi/ml	77.22				77.22		47.11	uCi/ml	47.11				2.79E+00			
104																		
105	Na concentration	M	9.02				9.02		5.50						5.45			
106																		
107	wt% Na2O in glass		15.0%				15.0%		15.0%						15.0%			
108	wt% SO3 in glass		0.4%				0.4%		0.4%						0.4%			
109	MT/m3 glass density		2.76				2.76		2.76						2.76			
110	gm glass/liter of waste		1.66E+03				1.66E+03		1.14E+03						1.13E+03			
111	m3 per liter of waste		6.75E-04				6.75E-04		4.12E-04						4.08E-04			
112								Water										
113	TRU in glass	nCi/gm	429.15				429.15		429.1	nCi/gm					64.1			
114	TRU Removal Required to achieve 50 nCi/gm		88.3%		76.7%		88.3%	n/a	88.3%									
115	Sr-90 in glass	Ci/m3	114.39				114.39		114.39	Ci/m3					6.84			
116	Sr-90 Removal Required to achieve 10 Ci/m³		91.3%				91.3%	n/a	91.3%									
117	Volume	Liters	3.30E+06				3.30E+06	2.11E+06	5.40E+06	Liters	5.40E+06	3.63E+04	2.87E+04	Liters	5.47E+06	6.90E+09	grams final supernatant	
118		Gallons	8.71E+05				8.71E+05	5.57E+05	1.43E+06	Gallons	1.43E+06	9.60E+03	7.58E+03	Gallons	1.44E+06	4.71E+09	grams initial supernatant	
119	Height of Supernatant	Inches	316.8				316.8		519.2		519.2				525.4			
120	Target Na M							5.50										
121	Sr M											3.00			0.02			
122	Moles Sr Added						1.97E+06					1.09E+05						
123	MnO_4 M												3.83		0.02			
124	Mole Mn Added												1.10E+05					

The percent removal is for the Mn present in the sample before addition of permanganate. All added permanganate precipitates.
AN-107 averaged 96% removal. AN-102 averaged 30% removal.

The moles of carbonate removed are equal to the amount of Sr added.

BEST AVAILABLE COPY

Row	A	B	C	E	G	I	J	O	P	Q	R	S	T
126	Sludge			Inventory AP-102	AP-102 Heel	AP-102		Treated Waste	Precipitate	Species	M.W.	Mass of Precipitated Solids	
127	Analyte	Units					Units						
128	106Ru	Ci				0.00E+00	Ci	0.00E+00					
129	113mCd	Ci				0.00E+00	Ci	-1.42E-14					
130	125Sb	Ci				0.00E+00	Ci	8.88E-16					
131	126Sn	Ci				0.00E+00	Ci	-3.55E-15					
132	129I	Ci				0.00E+00	Ci	5.55E-17					
133	134Cs	Ci				0.00E+00	Ci	0.00E+00					
134	137Cs	Ci				0.00E+00	Ci	1.16E-10					
135	137mBa	Ci				0.00E+00	Ci	0.00E+00					
136	14C	Ci				0.00E+00	Ci	-4.44E-16					
137	151Sm	Ci				0.00E+00	Ci	1.82E-12					
138	152Eu	Ci				0.00E+00	Ci	9.26E-01					
139	154Eu	Ci				0.00E+00	Ci	1.01E+03					
140	155Eu	Ci				0.00E+00	Ci	5.49E+02					
141	226Ra	Ci				0.00E+00	Ci	-1.36E-20					
142	227Ac	Ci				0.00E+00	Ci	0.00E+00					
143	228Ra	Ci				0.00E+00	Ci	0.00E+00					
144	229Th	Ci				0.00E+00	Ci	0.00E+00					
145	231Pa	Ci				0.00E+00	Ci	0.00E+00					
146	232Th	Ci				0.00E+00	Ci	0.00E+00					
147	232U	Ci				0.00E+00	Ci	-4.34E-19					
148	233U	Ci				0.00E+00	Ci	-2.78E-17					
149	234U	Ci				0.00E+00	Ci	-2.78E-17					
150	235U	Ci				0.00E+00	Ci	6.67E-19					
151	236U	Ci				0.00E+00	Ci	1.73E-18					
152	237Np	Ci				0.00E+00	Ci	1.60E-01					
153	238Pu	Ci				0.00E+00	Ci	9.26E+00					
154	238U	Ci				0.00E+00	Ci	-1.39E-17					
155	239Pu	Ci				0.00E+00	Ci	1.27E+02					
156	240Pu	Ci				0.00E+00	Ci	3.31E+01					
157	241Am	Ci				0.00E+00	Ci	2.06E+03					
158	241Pu	Ci				0.00E+00	Ci	5.81E+02					
159	242Cm	Ci				0.00E+00	Ci	7.85E+00					
160	242Pu	Ci				0.00E+00	Ci	3.51E-03					
161	243Am	Ci				0.00E+00	Ci	1.35E+00					
162	243Cm	Ci				0.00E+00	Ci	2.23E-01					
163	244Cm	Ci				0.00E+00	Ci	5.29E+00					
164	3H	Ci				0.00E+00	Ci	0.00E+00					
165	59Ni	Ci				0.00E+00	Ci	1.42E-14					
166	60Co	Ci				0.00E+00	Ci	-7.84E-14					
167	63Ni	Ci				0.00E+00	Ci	-9.09E-13					
168	79Se	Ci				0.00E+00	Ci	0.00E+00					
169	90Sr	Ci				0.00E+00	Ci	2.39E+05					
170	90Y	Ci				0.00E+00	Ci	0.00E+00					
171	93mNb	Ci				0.00E+00	Ci	-7.11E-15					
172	93Zr	Ci				0.00E+00	Ci	0.00E+00					
173	99Tc	Ci				0.00E+00	Ci	0.00E+00					
174	Al	kg				0.00E+00	kg	0.00E+00	0.00E+00		M.W.	Mass of Precipitated Solids	
175	Aroclors (Total PCB)	kg				0.00E+00	kg						
176	Bi	kg				0.00E+00	kg	0.00E+00	0.00E+00				
177	Ca	kg				0.00E+00	kg	3.48E+02	3.48E+02	CaCO3	100	8.71E+02	
178	Cl	kg				0.00E+00	kg	0.00E+00	0.00E+00				
179	Cr	kg				0.00E+00	kg	1.34E+02	1.34E+02	Cr(OH)3	103	2.64E+02	
180	F	kg				0.00E+00	kg	0.00E+00	0.00E+00				
181	Fe	kg				0.00E+00	kg	5.26E+03	5.26E+03	Fe(OH)3	106.65	1.01E+04	
182	Free OH	kg				0.00E+00	kg	0.00E+00	0.00E+00				
183	Hg	kg				0.00E+00	kg	0.00E+00	0.00E+00				
184	K	kg				0.00E+00	kg	0.00E+00	0.00E+00				
185	La	kg				0.00E+00	kg	8.94E+01	8.94E+01	La(OH)3	189.9	1.22E+02	
186	Mn	kg				0.00E+00	kg	7.56E+03	7.56E+03	NaMn(O)(OH)(O)	126.94	1.75E+04	
187	Na	kg				0.00E+00	kg	1.93E-10	0.00E+00				
188	Ni	kg				0.00E+00	kg	0.00E+00	0.00E+00				
189	NO2	kg				0.00E+00	kg	0.00E+00	0.00E+00				
190	NO3	kg				0.00E+00	kg	-5.41E-11	-5.41E-11				
191	Oxalate	kg				0.00E+00	kg	0.00E+00	0.00E+00				
192	Pb	kg				0.00E+00	kg	3.71E+02	3.71E+02	Pb(OH)4	275.2	4.92E+02	
193	PO4	kg				0.00E+00	kg	0.00E+00	0.00E+00				
194	Si	kg				0.00E+00	kg	0.00E+00	0.00E+00				
195	SO4	kg				0.00E+00	kg	0.00E+00	0.00E+00				
196	Sr	kg				0.00E+00	kg	8.71E+03	8.71E+03	SrCO3	147.62	1.47E+04	
197	Th	kg				0.00E+00	kg	0.00E+00	0.00E+00				
198	TIC as CO3	kg				0.00E+00	kg	6.54E+03	6.54E+03				
199	TOC	kg				0.00E+00	kg	0.00E+00	0.00E+00				
200	UTOTAL	kg				0.00E+00	kg	0.00E+00	0.00E+00				
201	Zr	kg				0.00E+00	kg	1.62E+02	1.62E+02	Zr(OH)4	159.22	2.83E+02	
202													
203	Density	gm/ml				0.00E+00							
204	Volume	Liters	0			0.00E+00							
205	Inches of sludge		0.0			0.00E+00		6.4					
206													
207	Total	kgs										4.43E+04	kg
208													
209	wt% settled solids	wt%										39.0%	wt%
210	settled solids density	gm/ml										1.3	gm/ml
211	volume of settled solids	liters										8.74E+04	liters
212		gallons										2.31E+04	gallons
213		inches										6.4	inches

Includes added Mn that precipitates.

Includes added Sr that precipitates

Volume conversion to inches uses 2750 gal/in in the DSTs. Note this should not be used when working with the lower 6 inches of the tank. Use volume calculator from RPP-13019 (CH2M Hill.

ATTACHMENT 6

AN-102 BATCH #1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	*Supernatant*		*AN-102 Supernate*		*AP-102 Supernate*		*AN-102 + AP-102 Heel*	*Dilution Water*	*Diluted AN-102 + AP-102*		*Diluted AN-102+ AP-102*	*3M $Sr(NO_3)_2$*	*40wt% $NaMnO_4$ (3.83M)*	*Percent Removal from Supernate*	*Treated Waste*
2	Analyte	Units	*Adjusted Concentration*		*Adjusted Concentration*		*Adjusted Concentration*			*Units*	*Values for Unit Change*				
3	106Ru	uCi/g	3.63E-09		2.49E-09		3.57E-09		2.32E-09	uCi/ml	2.86E-09			0.0%	2.82E-09
4	113mCd	uCi/g	1.58E-02		1.64E-02		1.58E-02		1.03E-02	uCi/ml	1.27E-02			0.0%	1.25E-02
5	125Sb	uCi/g	2.24E-03		4.90E-03		2.39E-03		1.56E-03	uCi/ml	1.91E-03			0.0%	1.89E-03
6	126Sn	uCi/g	4.64E-03		6.01E-04		4.41E-03		2.88E-03	uCi/ml	3.53E-03			0.0%	3.49E-03
7	129I	uCi/g	9.05E-05		2.19E-04		9.78E-05		6.37E-05	uCi/ml	7.83E-05			0.0%	7.74E-05
8	134Cs	uCi/g	2.08E-03		1.26E-04		1.97E-03		1.28E-03	uCi/ml	1.58E-03			0.0%	1.56E-03
9	137Cs	uCi/g	2.63E+02		1.71E+02		2.58E+02		1.68E+02	uCi/ml	2.06E+02			0.0%	2.04E+02
10	137mBa	uCi/g	2.48E+02		1.62E+02		2.43E+02		1.59E+02	uCi/ml	1.95E+02			0.0%	1.92E+02
11	14C	uCi/g	4.90E-04		1.93E-03		5.71E-04		3.73E-04	uCi/ml	4.58E-04			0.0%	4.52E-04
12	151Sm	uCi/g	2.41E+00		3.22E+00		2.46E+00		1.60E+00	uCi/ml	1.97E+00			0.0%	1.94E+00
13	152Eu	uCi/g	2.66E-04		7.82E-04		2.95E-04		1.92E-04	uCi/ml	2.36E-04			85.0%	3.50E-05
14	154Eu	uCi/g	1.23E-01		2.23E-02		1.17E-01		7.65E-02	uCi/ml	9.40E-02			85.0%	1.39E-02
15	155Eu	uCi/g	7.08E-03		1.25E-02		7.39E-03		4.82E-03	uCi/ml	5.92E-03			85.0%	8.77E-04
16	226Ra	uCi/g	2.66E-08		4.05E-08		2.74E-08		1.79E-08	uCi/ml	2.19E-08			0.0%	2.17E-08
17	227Ac	uCi/g	3.28E-06		6.49E-07		3.13E-06		2.04E-06	uCi/ml	2.51E-06			0.0%	2.48E-06
18	228Ra	uCi/g	7.60E-06		5.37E-05		1.02E-05		6.65E-06	uCi/ml	8.18E-06			0.0%	8.08E-06
19	229Th	uCi/g	1.32E-08		1.76E-06		1.12E-07		7.30E-08	uCi/ml	8.97E-08			0.0%	8.86E-08
20	231Pa	uCi/g	3.44E-05		1.13E-06		3.25E-05		2.12E-05	uCi/ml	2.60E-05			0.0%	2.57E-05
21	232Th	uCi/g	1.55E-07		8.61E-06		6.33E-07		4.13E-07	uCi/ml	5.07E-07			0.0%	5.01E-07
22	232U	uCi/g	1.39E-07		4.53E-06		3.87E-07		2.53E-07	uCi/ml	3.10E-07			0.0%	3.07E-07
23	233U	uCi/g	8.54E-06		1.92E-05		9.14E-06		5.96E-06	uCi/ml	7.32E-06			0.0%	7.24E-06
24	234U	uCi/g	6.04E-06		3.55E-06		5.90E-06		3.85E-06	uCi/ml	4.73E-06			0.0%	4.67E-06
25	235U	uCi/g	2.39E-07		1.41E-07		2.33E-07		1.52E-07	uCi/ml	1.87E-07			0.0%	1.85E-07
26	236U	uCi/g	4.09E-07		1.14E-07		3.92E-07		2.56E-07	uCi/ml	3.14E-07			0.0%	3.11E-07
27	237Np	uCi/g	3.42E-05		3.38E-04		5.14E-05		3.35E-05	uCi/ml	4.12E-05			85.0%	6.10E-06
28	238Pu	uCi/g	2.40E-04		5.74E-06		2.27E-04		1.48E-04	uCi/ml	1.82E-04			85.0%	2.69E-05
29	238U	uCi/g	4.73E-06		3.16E-06		4.64E-06		3.03E-06	uCi/ml	3.72E-06			0.0%	3.67E-06
30	239Pu	uCi/g	3.30E-03		2.21E-04		3.13E-03		2.04E-03	uCi/ml	2.50E-03			85.0%	3.71E-04
31	240Pu	uCi/g	8.59E-04		3.73E-05		8.13E-04		5.30E-04	uCi/ml	6.51E-04			85.0%	9.65E-05
32	241Am	uCi/g	1.11E-01		1.24E-03		1.05E-01		6.83E-02	uCi/ml	8.39E-02			85.0%	1.24E-02
33	241Pu	uCi/g	1.51E-02		2.65E-04		1.43E-02		9.30E-03	uCi/ml	1.14E-02			85.0%	1.69E-03
34	242Cm	uCi/g	2.18E-04		3.98E-06		2.06E-04		1.34E-04	uCi/ml	1.65E-04			85.0%	2.44E-05
35	242Pu	uCi/g	9.10E-08		2.28E-09		8.60E-08		5.61E-08	uCi/ml	6.89E-08			85.0%	1.02E-08
36	243Am	uCi/g	7.31E-05		4.54E-08		6.90E-05		4.50E-05	uCi/ml	5.52E-05			85.0%	8.19E-06
37	243Cm	uCi/g	1.20E-05		5.10E-07		1.14E-05		7.40E-06	uCi/ml	9.09E-06			85.0%	1.35E-06
38	244Cm	uCi/g	2.85E-04		7.42E-06		2.69E-04		1.76E-04	uCi/ml	2.16E-04			85.0%	3.20E-05
39	3H	uCi/g	3.76E-04		7.66E-03		7.88E-04		5.14E-04	uCi/ml	6.31E-04			0.0%	6.24E-04
40	59Ni	uCi/g	1.69E-04		2.22E-04		1.72E-04		1.12E-04	uCi/ml	1.38E-04			0.0%	1.36E-04
41	60Co	uCi/g	3.62E-02		2.66E-03		3.43E-02		2.24E-02	uCi/ml	2.75E-02			0.0%	2.72E-02
42	63Ni	uCi/g	1.58E-02		2.06E-02		1.61E-02		1.05E-02	uCi/ml	1.29E-02			0.0%	1.27E-02
43	79Se	uCi/g	4.21E-04		5.47E-04		4.28E-04		2.79E-04	uCi/ml	3.43E-04			0.0%	3.39E-04
44	90Sr	uCi/g	5.32E+01		2.76E-01		5.02E+01		3.27E+01	uCi/ml	4.02E+01			94.0%	2.38E+00
45	90Y	uCi/g	5.32E+01		2.76E-01		5.02E+01		3.27E+01	uCi/ml	4.02E+01			0.0%	3.97E+01
46	93mNb	uCi/g	1.53E-02		5.20E-03		1.47E-02		9.60E-03	uCi/ml	1.18E-02			0.0%	1.17E-02
47	93Zr	uCi/g	1.85E-02		6.04E-03		1.78E-02		1.16E-02	uCi/ml	1.43E-02			0.0%	1.41E-02
48	99Tc	uCi/g	9.75E-02		1.16E-01		9.85E-02		6.42E-02	uCi/ml	7.89E-02			0.0%	7.80E-02

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
49	Ag	ug/g	1.97E+00				1.86E+00		1.21E+00	M	1.35E-05			0.0%	1.36E-05					
50	Al	ug/g	9.65E+03		2.21E+04		1.04E+04		6.75E+03	M	3.07E-01			0.0%	3.04E-01					
51	Aroclors (Total PCB)	ug/g	8.61E-03		1.42E-02		8.93E-03		5.82E-03											
52	As	ug/g	1.35E+01				1.75E+01		1.14E+01	M	1.87E-04			0.0%	1.84E-04					
53	B	ug/g	2.67E+01				2.52E+01		1.64E+01	M	1.87E-03			0.0%	1.84E-03					
54	Ba	ug/g	7.56E+00				7.13E+00		4.65E+00	M	4.16E-05			19.0%	3.33E-05					
55	Be	ug/g	4.79E-01				4.52E-01		2.95E-01	M	4.02E-05			0.0%	3.97E-05					
56	Bi	ug/g	1.85E+01		1.61E+01		1.84E+01		1.20E+01	M	7.04E-05			0.0%	6.95E-05					
57	Ca	ug/g	2.95E+02		1.84E+01		2.79E+02		1.82E+02	M	5.59E-03			19.0%	4.48E-03					
58	Cd	ug/g	4.16E+01				3.92E+01		2.56E+01	M	2.80E-04			0.0%	2.76E-04					
59	Ce	ug/g	7.55E+00				7.12E+00		4.64E+00	M	4.07E-05			85.0%	6.04E-06					
60	Cl	ug/g	2.72E+03		4.32E+03		2.81E+03		1.83E+03	M	6.35E-02			0.0%	6.27E-02					
61	Co	ug/g	1.82E+00				1.72E+00		1.12E+00	M	2.33E-05			0.0%	2.31E-05					
62	Cr	ug/g	1.71E+02		4.20E+02		1.85E+02		1.21E+02	M	2.85E-03			21.0%	2.23E-03					
63	Cu	ug/g	1.80E+01				1.70E+01		1.11E+01	M	2.14E-04			0.0%	2.12E-04					
64	F	ug/g	4.29E+01		9.02E+01		4.56E+01		2.97E+01	M	1.92E-03			0.0%	1.90E-03					
65	Fe	ug/g	2.67E+01		4.23E+00		2.54E+01		1.66E+01	M	3.65E-04			97.0%	1.08E-05					
66	Free OH	ug/g	6.33E+03		2.29E+04		7.27E+03		4.74E+03	M	3.42E-01			0.0%	3.38E-01					
67	Hg	ug/g	3.48E-02		2.26E-06		3.28E-02		2.14E-02	M	1.31E-07			0.0%	1.30E-07					
68	K	ug/g	1.42E+03		2.91E+03		1.50E+03		9.81E+02	M	3.08E-02			0.0%	3.05E-02					
69	La	ug/g	9.35E+00		1.89E+00		8.93E+00		5.82E+00	M	5.15E-05			85.0%	7.63069E-06					
70	Li	ug/g	6.41E-01				6.05E-01		3.94E-01	M	6.98E-05			0.0%	6.90E-05					
71	Mg	ug/g	1.88E+01				1.77E+01		1.16E+01	M	5.84E-04			0.0%	5.71E-04					
72	Mn	ug/g	1.18E+01		1.73E+00		1.12E+01		7.32E+00	M	1.64E-04		3.83	30.0%	1.13E-04					
73	Mo	ug/g	3.39E+01				3.20E+01		2.09E+01	M	2.67E-04			0.0%	2.64E-04					
74	Na	ug/g	1.59E+05		1.40E+05		1.56E+05		1.03E+05	M	5.50E+00		3.83	0.0%	5.45E+00					
75	Nd	ug/g	1.43E+01				1.35E+01		8.80E+00	M	7.49E-05			85.0%	1.11E-05					
76	NH3	ug/g	9.19E+01				8.67E+01		5.65E+01	M	4.09E-03			0.0%	4.04E-03					
77	Ni	ug/g	2.77E+02		6.17E+00		2.62E+02		1.71E+02	M	3.57E-03			0.0%	3.53E-03					
78	NO2	ug/g	6.01E+04		7.05E+04		6.07E+04		3.96E+04	M	1.06E+00			0.0%	1.04E+00					
79	NO3	ug/g	1.44E+05		1.20E+05		1.43E+05		9.30E+04	M	1.84E+00	6		0.0%	1.86E+00					
80	Oxalate	ug/g	5.88E+02		2.20E+03		6.79E+02		4.43E+02	M	6.33E-03			0.0%	6.25E-03					
81	Pb	ug/g	1.11E+02		3.69E+01		1.07E+02		6.96E+01	M	4.13E-04			30.0%	2.86E-04					
82	PO4	ug/g	3.63E+03		2.32E+03		3.56E+03		2.32E+03	M	3.00E-02			0.0%	2.96E-02					
83	Rh																			
84	Sb	ug/g	1.43E-01				1.35E-01		8.80E-02	M	8.88E-07			0.0%	8.77E-07					
85	Se	ug/g	1.86E+01				1.75E+01		1.14E+01	M	1.78E-04			0.0%	1.76E-04					
86	Si	ug/g	3.06E+01		3.22E+01		3.07E+01		2.00E+01	M	8.75E-04			0.0%	8.65E-04					
87	SO4	ug/g	1.03E+04		1.76E+03		9.82E+03		6.40E+03	M	8.19E-02			0.0%	8.09E-02					
88	Sr	ug/g	1.67E+00		8.28E-01		1.62E+00		1.06E+00	M	1.48E-05	3.00		94.0%	1.20E-03	1.51E-03				
89	Ta																			
90	Th	ug/g	1.41E+00		7.84E+01		5.76E+00		3.76E+00	M	1.99E-05			0.0%	1.97E-05					
91	Ti	ug/g	4.58E-01				4.32E-01		2.82E-01	M	7.23E-06			0.0%	7.14E-06					
92	TIC as CO3	ug/g	5.36E+04		8.65E+03		5.11E+04		3.33E+04	M	6.82E-01			3.0%	6.54E-01					
93	Tl	ug/g	1.32E+00				1.25E+00		8.12E-01	M	4.88E-06			0.0%	4.82E-06					
94	TOC	ug/g	1.94E+04		2.16E+03		1.84E+04		1.20E+04	M	1.23E+00			0.0%	1.22E+00					
95	UTOTAL	ug/g	1.42E+01		9.47E+00		1.39E+01		9.08E+00	M	4.69E-05			0.0%	4.63E-05					
96	V	ug/g	1.85E+00				1.75E+00		1.14E+00	M	2.74E-05			0.0%	2.71E-05					
97	Y	ug/g	1.46E+00				1.38E+00		8.98E-01	M	1.24E-05			0.0%	1.23E-05					
98	Zn	ug/g	1.88E+00				1.77E+00		1.16E+00	M	2.17E-05			0.0%	2.15E-05					
99	Zr	ug/g	4.96E+00		1.49E+00		4.76E+00		3.11E+00	M	4.18E-05			82.0%	7.44E-06					
100	Sum of TRU	uCi/g	1.16E-01		1.85E-03		1.09E-01		7.13E-02											
101	Supernate density	gm/ml	1.40		1.39		1.40	1.00	1.23	gm/ml	1.23									
102	Sum of TRU	uCi/ml	1.62E-01		2.57E-03		1.53E-01		8.76E-02	uCi/ml					1.30E-02					
103	Sr-90	uCi/ml	74.48		0.38		70.26		40.22	uCi/ml	40.22				2.38E+00					
104																				
105	Na concentration	M	9.68		8.46		9.61		5.50						5.45					
106																				
107	wt% Na2O in glass		15.0%		20.0%		15.0%		15.0%						15.0%					
108	wt% SO3 in glass		0.6%		0.2%		0.6%		0.6%						0.6%					
109	MT/m3 glass density		2.76		2.76		2.76		2.76						2.76					
110	gm glass/liter of waste		2.00E+03		1.31E+03		1.99E+03		1.14E+03						1.13E+03					
111	m3 per liter of waste		7.25E-04		4.75E-04		7.20E-04		4.12E-04						4.08E-04					
112																				
113	TRU in glass	nCi/gm	81.06		1.96		77.07		77.1	nCi/gm					11.5					
114	TRU Removal Required to achieve 50 nCi/gm		38.3%		n/a		35.1%	n/a	35.1%											
115	Sr-90 in glass	Ci/m3	102.77		0.81		97.65		97.65	Ci/m3					5.84					
116	Sr-90 Removal Required to achieve 10 Ci/m^3		90.3%		n/a		89.8%	n/a	89.8%											
117	Batch Volume	Liters	[redacted]		1.04E+05		1.83E+06	1.37E+06	3.19E+06	Liters	3.19E+06	2.15E+04	1.70E+04	Liters	3.23E+06					
118		Gallons	4.56E+05		2.75E+04		4.83E+05	3.61E+05	8.44E+05	Gallons	8.44E+05	5.67E+03	4.45E+03	Gallons	8.54E+05					
119	Height of Supernatant	Inches	165.7		10.0		175.7		306.9		306.9				310.6					
120	Target Na M							[redacted]												
121	Sr M											3.00								
122	Moles Sr Added						1.57E+07					6.44E+04			0.02					
123	MnO$_4$ M												3.83							
124	Mole Mn Added												6.50E+04		0.02					

Fate of organics is unknown, concentration in treated waste is left blank.

The percent removal is for the Mn present in the sample before addition of permanganate. All added permanganate precipitates. AN-107 averaged 96% removal. AN-102 averaged 30% removal.

Consistency check: Calculate the Sr-90 concentration using the equilibrium concentration of Sr-90 / total Sr equal to 0.018 µCi/µg

The moles of carbonate removed are equal to the amount of Sr added.

Selector switch available on Summary sheet to change volume selection.

Selector Switch available on Summary sheet to change sodium molarity.

Row	A	B	E	F	G	I	O	P	Q	R	S
126	Sludge		AP-102		AP-102 Sludge Layer		Treated Waste	Mass Precipitated	Species	M.W.	Mass of Precipitated Solids
127	Analyte	Units									
128	106Ru	Ci	2.42E-07		2.42E-07	2.42E-07	2.42E-07				
129	113mCd	Ci	1.53E+00		1.53E+00	1.53E+00	1.53E+00				
130	125Sb	Ci	7.30E-01		7.30E-01	7.30E-01	7.30E-01				
131	126Sn	Ci	5.71E-02		5.71E-02	5.71E-02	5.71E-02				
132	129I	Ci	1.77E-02		1.77E-02	1.77E-02	1.77E-02				
133	134Cs	Ci	7.13E-03		7.13E-03	7.13E-03	7.13E-03				
134	137Cs	Ci	1.25E+04		1.25E+04	1.25E+04	1.25E+04				
135	137mBa	Ci	1.18E+04		1.18E+04	1.18E+04	1.18E+04				
136	14C	Ci	7.41E-01		7.41E-01	7.41E-01	7.41E-01				
137	151Sm	Ci	3.08E+02		3.08E+02	3.08E+02	3.08E+02				
138	152Eu	Ci	7.34E-02		7.34E-02	7.34E-02	7.15E-01				
139	154Eu	Ci	6.16E+00		6.16E+00	6.16E+00	2.61E+02				
140	155Eu	Ci	1.37E+00		1.37E+00	1.37E+00	1.74E+01				
141	226Ra	Ci	3.82E-06		3.82E-06	3.82E-06	3.82E-06				
142	227Ac	Ci	4.04E-05		4.04E-05	4.04E-05	4.04E-05				
143	228Ra	Ci	4.70E-03		4.70E-03	4.70E-03	4.70E-03				
144	229Th	Ci	1.66E-04		1.66E-04	1.66E-04	1.66E-04				
145	231Pa	Ci	1.09E-04		1.09E-04	1.09E-04	1.09E-04				
146	232Th	Ci	7.70E-04		7.70E-04	7.70E-04	7.70E-04				
147	232U	Ci	2.22E-03		2.22E-03	2.22E-03	2.22E-03				
148	233U	Ci	9.38E-03		9.38E-03	9.38E-03	9.38E-03				
149	234U	Ci	1.63E-03		1.63E-03	1.63E-03	1.63E-03				
150	235U	Ci	6.47E-05		6.47E-05	6.47E-05	6.47E-05				
151	236U	Ci	5.22E-05		5.22E-05	5.22E-05	5.22E-05				
152	237Np	Ci	3.88E-02		3.88E-02	3.88E-02	1.51E-01				
153	238Pu	Ci	1.85E-03		1.85E-03	1.85E-03	4.95E-01				
154	238U	Ci	1.45E-03		1.45E-03	1.45E-03	1.45E-03				
155	239Pu	Ci	7.21E-02		7.21E-02	7.21E-02	6.87E+00				
156	240Pu	Ci	1.22E-02		1.22E-02	1.22E-02	1.78E+00				
157	241Am	Ci	1.07E-01		1.07E-01	1.07E-01	2.28E+02				
158	241Pu	Ci	8.58E-02		8.58E-02	8.58E-02	3.11E+01				
159	242Cm	Ci	2.77E-04		2.77E-04	2.77E-04	4.48E-01				
160	242Pu	Ci	7.41E-07		7.41E-07	7.41E-07	1.88E-04				
161	243Am	Ci	3.89E-06		3.89E-06	3.89E-06	1.50E-01				
162	243Cm	Ci	2.29E-05		2.29E-05	2.29E-05	2.47E-02				
163	244Cm	Ci	1.97E-04		1.97E-04	1.97E-04	5.86E-01				
164	3H	Ci	4.09E+00		4.09E+00	4.09E+00	4.09E+00				
165	59Ni	Ci	3.82E-02		3.82E-02	3.82E-02	3.82E-02				
166	60Co	Ci	2.13E-01		2.13E-01	2.13E-01	2.13E-01				
167	63Ni	Ci	3.51E+00		3.51E+00	3.51E+00	3.51E+00				
168	79Se	Ci	5.05E-03		5.05E-03	5.05E-03	5.05E-03				
169	90Sr	Ci	5.66E+01		5.66E+01	5.66E+01	1.21E+05				
170	90Y	Ci	5.66E+01		5.66E+01	5.66E+01	5.66E+01				
171	93mNb	Ci	3.99E-01		3.99E-01	3.99E-01	3.99E-01				
172	93Zr	Ci	4.62E-01		4.62E-01	4.62E-01	4.62E-01				
173	99Tc	Ci	1.05E+01		1.05E+01	1.05E+01	1.05E+01				
174	Al	kg	1.57E+04		1.57E+04	1.57E+04	1.57E+04	0.00E+00		M.W.	Mass of Precipitated Solids
175	Aroclors (Total PCB)	kg	3.85E+00		3.85E+00	3.85E+00					
176	Bi	kg	1.52E+00		1.52E+00	1.52E+00	1.52E+00	0.00E+00			
177	Ca	kg	1.65E+04		1.65E+04	1.65E+04	1.66E+04	1.36E+02	CaCO3	100	3.40E+02
178	Cl	kg	2.91E+02		2.91E+02	2.91E+02	2.91E+02	0.00E+00			
179	Cr	kg	2.59E+01		2.59E+01	2.59E+01	1.39E+02	1.13E+02	Cr(OH)3	103	2.23E+02
180	F	kg	8.21E+00		8.21E+00	8.21E+00	8.21E+00	0.00E+00			
181	Fe	kg	9.07E-01		9.07E-01	9.07E-01	6.40E+01	6.31E+01	Fe(OH)3	106.85	1.21E+02
182	Free OH	kg	1.20E+03		1.20E+03	1.20E+03	1.20E+03	0.00E+00			
183	Hg	kg	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00			
184	K	kg	1.85E+02		1.85E+02	1.85E+02	1.85E+02	0.00E+00			
185	La	kg	4.60E-01		4.60E-01	4.60E-01	1.99E+01	1.94E+01	La(OH)3	189.9	2.65E+01
186	Mn	kg	1.49E+00		1.49E+00	1.49E+00	3.58E+03	3.58E+03	NaMn(O)(OH)(O)	126.94	8.27E+03
187	Na	kg	9.18E+03		9.18E+03	9.18E+03	9.18E+03	0.00E+00			
188	Ni	kg	1.28E+00		1.28E+00	1.28E+00	1.28E+00	0.00E+00			
189	NO2	kg	4.67E+03		4.67E+03	4.67E+03	4.67E+03	0.00E+00			
190	NO3	kg	7.58E+03		7.58E+03	7.58E+03	7.58E+03	1.09E-11			
191	Oxalate	kg	4.10E+01		4.10E+01	4.10E+01	4.10E+01	0.00E+00			
192	Pb	kg	2.65E+00		2.65E+00	2.65E+00	8.46E+01	8.20E+01	Pb(OH)4	275.2	1.09E+02
193	PO4	kg	2.65E+04		2.65E+04	2.65E+04	2.65E+04	0.00E+00			
194	Si	kg	3.74E+00		3.74E+00	3.74E+00	3.74E+00	0.00E+00			
195	SO4	kg	1.51E+02		1.51E+02	1.51E+02	1.51E+02	0.00E+00			
196	Sr	kg	1.53E-01		1.53E-01	1.53E-01	5.31E+03	5.31E+03	SrCO3	147.62	8.96E+03
197	Th	kg	6.99E+00		6.99E+00	6.99E+00	6.99E+00	0.00E+00			
198	TIC as CO3	kg	1.10E+03		1.10E+03	1.10E+03	4.97E+03	3.87E+03			
199	TOC	kg	2.16E+02		2.16E+02	2.16E+02	2.16E+02	0.00E+00			
200	UTOTAL	kg	4.36E+00		4.36E+00	4.36E+00	4.36E+00	0.00E+00			
201	Zr	kg	8.25E-01		8.25E-01	8.25E-01	[illegible]	9.96E+00	Zr(OH)4	159.22	1.74E+01
202											
203	Density	gm/ml	1.75		1.75	1.75					
204	Volume	Liters	88,000		88,000	88,000					
205	Inches of sludge		8.5		8.5	8.5					
206				gal	2.32E+04						
207	Total	kgs			1.54E+05					kg	1.81E+04
208			calculate 0.5wt%		7.70E+02			1.32E+04			
209	wt% settled solids	wt%								wt%	39.0%
210	settled solids density	gm/ml								gm/ml	1.3
211	volume of settled solids	liters								liters	3.56E+04
212	volume of settled solids	gallons								gallons	9.41E+03
213		inches								inches	3.4

Includes added Mn that precipitates.

Includes added Sr that precipitates

Total inches: sludge plus precipitates

Volume conversion to inches uses 2750 gal/in in the OSTs. Note this should not be used when workig with the lower 6 inches of the tank. Use volume calculator from RPP-13019 (CH2M Hill).

Purpose: Dilute precipitated solids to 10 wt% solids for transfer to available DST:
1. Use this worksheet (*AN-102 Batch #1*) to obtain total mass of solids generated from treatment of total AN-102 supernatant with 10 inches AP-102 supernatant. The worksheet volume selector switch must be re-set to treat 100% of the AN-102 supernatant and will include the contribution from AP-102. Volume switch will be at 9.38E+05 gallons to obtain correct inches and kgs of treated solids for this calculation.

2. Use *Treat in AN-107* worksheet to calculate the mass of ppt. solids generated from treatment of all of AN-107 supernatant. (AP-102 contribution is set to zero).

3. Add total mass (kg) of precipitate generated from treatment of AN-102, AN-107, including existing mass of AP-102 sludge. Dilute this mass to 10 wt% with water. Assume an existing volume of liquid from 10 inches of AN-107 supernatant.

	A	B	C	I	J	K	L–N
214							
215							
216				Treated AN-102 Supernatant plus AP-102 sludge			
217							
218				Solids	inches	15.3	Value is caculated by changing volume selector switch on summary worksheet.
219					kgs	3.62E+04	
220							
221				Treated AN-107 Supernatant			
222							
223				Solids	inches	8.4	
224					kgs	4.43E+04	
225							
226				Total Solids	inches	23.7	
227					kgs	8.05E+04	
228							
229				10 inches AN-107 Supernatant at 5.5 M Na			
230	mass dilution water	kg	7.24E+05	Volume	L	27,500	
231	water density	kg/L	1	Density	kg/L	1.26	
232	volume dilution water	L	6.90E+05	Mass supernatant	kg	3.47E+04	
233		gal	1.82E+05				
234							

BEST AVAILABLE COPY

ATTACHMENT 7

AN-102 BATCH #2

	A	B	C	E	G	H	I	J	K	L	M	N	O	P	T	U	V	W
1	Supernatant - Batch 2		AN-102 Supernate	Set AP-102 Supernate to ZERO for Batch 2	AN-102 Supernate	Dilution Water	Diluted AN-102 Batch #2		Diluted AN-102	3M $Sr(NO_3)_2$	40wt% $NaMnO_4$ (2.83M)	Percent Removal from Supernate	Treated Waste	Precipitate			Change Units	AN-102 Batch #2 Heel Composition
2	Analyte	Units	Adjusted Concentration	Adjusted Concentration	Adjusted Concentration			Units	Values for Unit Change						Molecular Wt	Analyte	Units	
3	106Ru	uCi/g	3.63E-09	0	3.63E-09		2.35E-09	uCi/ml	2.89E-09			0.0%	2.85E-09			106Ru	uCi/g	2.33E-09
4	113mCd	uCi/g	1.58E-02	0	1.58E-02		1.02E-02	uCi/ml	1.26E-02			0.0%	1.24E-02			113mCd	uCi/g	1.01E-02
5	125Sb	uCi/g	2.24E-03	0	2.24E-03		1.45E-03	uCi/ml	1.76E-03			0.0%	1.76E-03			125Sb	uCi/g	1.43E-03
6	126Sn	uCi/g	4.64E-03	0	4.64E-03		3.01E-03	uCi/ml	3.69E-03			0.0%	3.65E-03			126Sn	uCi/g	2.97E-03
7	129I	uCi/g	9.05E-05	0	9.05E-05		5.87E-05	uCi/ml	7.20E-05			0.0%	7.11E-05			129I	uCi/g	5.80E-05
8	134Cs	uCi/g	2.08E-03	0	2.08E-03		1.35E-03	uCi/ml	1.65E-03			0.0%	1.64E-03			134Cs	uCi/g	1.33E-03
9	137Cs	uCi/g	2.63E+02	0	2.63E+02		1.70E+02	uCi/ml	2.09E+02			0.0%	2.07E+02			137Cs	uCi/g	1.68E+02
10	137mBa	uCi/g	2.48E+02	0	2.48E+02		1.61E+02	uCi/ml	1.97E+02			0.0%	1.95E+02			137mBa	uCi/g	1.59E+02
11	14C	uCi/g	4.90E-04	0	4.90E-04		3.18E-04	uCi/ml	3.90E-04			0.0%	3.85E-04			14C	uCi/g	3.14E-04
12	151Sm	uCi/g	2.41E+00	0	2.41E+00		1.56E+00	uCi/ml	1.92E+00			0.0%	1.89E+00			151Sm	uCi/g	1.54E+00
13	152Eu	uCi/g	2.66E-04	0	2.66E-04		1.72E-04	uCi/ml	2.12E-04			85.0%	3.14E-05			152Eu	uCi/g	2.56E-05
14	154Eu	uCi/g	1.23E-01	0	1.23E-01		7.97E-02	uCi/ml	9.79E-02			85.0%	1.45E-02			154Eu	uCi/g	1.18E-02
15	155Eu	uCi/g	7.08E-03	0	7.08E-03		4.59E-03	uCi/ml	5.63E-03			85.0%	8.35E-04			155Eu	uCi/g	6.80E-04
16	226Ra	uCi/g	2.66E-08	0	2.66E-08		1.72E-08	uCi/ml	2.12E-08			0.0%	2.09E-08			226Ra	uCi/g	1.70E-08
17	227Ac	uCi/g	3.28E-06	0	3.28E-06		2.13E-06	uCi/ml	2.61E-06			0.0%	2.58E-06			227Ac	uCi/g	2.10E-06
18	228Ra	uCi/g	7.60E-06	0	7.60E-06		4.93E-06	uCi/ml	6.05E-06			0.0%	5.97E-06			228Ra	uCi/g	4.87E-06
19	229Th	uCi/g	1.32E-08	0	1.32E-08		8.56E-09	uCi/ml	1.05E-08			0.0%	1.04E-08			229Th	uCi/g	8.46E-09
20	231Pa	uCi/g	3.44E-05	0	3.44E-05		2.23E-05	uCi/ml	2.74E-05			0.0%	2.70E-05			231Pa	uCi/g	2.20E-05
21	232Th	uCi/g	1.55E-07	0	1.55E-07		1.00E-07	uCi/ml	1.23E-07			0.0%	1.22E-07			232Th	uCi/g	9.93E-08
22	232U	uCi/g	1.39E-07	0	1.39E-07		9.01E-08	uCi/ml	1.11E-07			0.0%	1.09E-07			232U	uCi/g	8.90E-08
23	233U	uCi/g	8.54E-06	0	8.54E-06		5.54E-06	uCi/ml	6.79E-06			0.0%	6.71E-06			233U	uCi/g	5.47E-06
24	234U	uCi/g	6.04E-06	0	6.04E-06		3.92E-06	uCi/ml	4.81E-06			0.0%	4.75E-06			234U	uCi/g	3.87E-06
25	235U	uCi/g	2.39E-07	0	2.39E-07		1.55E-07	uCi/ml	1.90E-07			0.0%	1.88E-07			235U	uCi/g	1.53E-07
26	236U	uCi/g	4.09E-07	0	4.09E-07		2.65E-07	uCi/ml	3.25E-07			0.0%	3.22E-07			236U	uCi/g	2.62E-07
27	237Np	uCi/g	3.42E-05	0	3.42E-05		2.22E-05	uCi/ml	2.72E-05			85.0%	4.03E-06			237Np	uCi/g	3.29E-06
28	238Pu	uCi/g	2.40E-04	0	2.40E-04		1.56E-04	uCi/ml	1.91E-04			85.0%	2.83E-05			238Pu	uCi/g	2.31E-05
29	238U	uCi/g	4.73E-06	0	4.73E-06		3.07E-06	uCi/ml	3.76E-06			0.0%	3.72E-06			238U	uCi/g	3.03E-06
30	239Pu	uCi/g	3.30E-03	0	3.30E-03		2.14E-03	uCi/ml	2.63E-03			85.0%	3.89E-04			239Pu	uCi/g	3.17E-04
31	240Pu	uCi/g	8.59E-04	0	8.59E-04		5.57E-04	uCi/ml	6.83E-04			85.0%	1.01E-04			240Pu	uCi/g	8.25E-05
32	241Am	uCi/g	1.11E-01	0	1.11E-01		7.20E-02	uCi/ml	8.83E-02			85.0%	1.31E-02			241Am	uCi/g	1.07E-02
33	241Pu	uCi/g	1.51E-02	0	1.51E-02		9.79E-03	uCi/ml	1.20E-02			85.0%	1.78E-03			241Pu	uCi/g	1.45E-03
34	242Cm	uCi/g	2.18E-04	0	2.18E-04		1.41E-04	uCi/ml	1.73E-04			85.0%	2.57E-05			242Cm	uCi/g	2.09E-05
35	242Pu	uCi/g	9.10E-08	0	9.10E-08		5.90E-08	uCi/ml	7.24E-08			85.0%	1.07E-08			242Pu	uCi/g	8.74E-09
36	243Am	uCi/g	7.31E-05	0	7.31E-05		4.74E-05	uCi/ml	5.82E-05			85.0%	8.62E-06			243Am	uCi/g	7.02E-06
37	243Cm	uCi/g	1.20E-05	0	1.20E-05		7.78E-06	uCi/ml	9.55E-06			85.0%	1.42E-06			243Cm	uCi/g	1.15E-06
38	244Cm	uCi/g	2.85E-04	0	2.85E-04		1.85E-04	uCi/ml	2.27E-04			85.0%	3.36E-05			244Cm	uCi/g	2.74E-05
39	3H	uCi/g	3.76E-04	0	3.76E-04		2.44E-04	uCi/ml	2.99E-04			0.0%	2.96E-04			3H	uCi/g	2.41E-04
40	59Ni	uCi/g	1.69E-04	0	1.69E-04		1.10E-04	uCi/ml	1.34E-04			0.0%	1.33E-04			59Ni	uCi/g	1.08E-04
41	60Co	uCi/g	3.62E-02	0	3.62E-02		2.35E-02	uCi/ml	2.88E-02			0.0%	2.85E-02			60Co	uCi/g	2.32E-02
42	63Ni	uCi/g	1.58E-02	0	1.58E-02		1.02E-02	uCi/ml	1.26E-02			0.0%	1.24E-02			63Ni	uCi/g	1.01E-02
43	79Se	uCi/g	4.21E-04	0	4.21E-04		2.73E-04	uCi/ml	3.35E-04			0.0%	3.31E-04			79Se	uCi/g	2.70E-04
44	90Sr	uCi/g	5.32E+01	0	5.32E+01		3.45E+01	uCi/ml	4.23E+01			94.0%	2.51E+00			90Sr	uCi/g	2.04E+00
45	90Y	uCi/g	5.32E+01	0	5.32E+01		3.45E+01	uCi/ml	4.23E+01			0.0%	4.18E+01			90Y	uCi/g	3.41E+01
46	93mNb	uCi/g	1.53E-02	0	1.53E-02		9.92E-03	uCi/ml	1.22E-02			0.0%	1.20E-02			93mNb	uCi/g	9.80E-03
47	93Zr	uCi/g	1.85E-02	0	1.85E-02		1.20E-02	uCi/ml	1.47E-02			0.0%	1.45E-02			93Zr	uCi/g	1.18E-02
48	99Tc	uCi/g	9.75E-02	0	9.75E-02		6.32E-02	uCi/ml	7.76E-02			0.0%	7.66E-02			99Tc	uCi/g	6.25E-02
49	Ag	ug/g	1.97E+00		1.97E+00		1.28E+00	M	1.45E-05			0.0%	1.44E-05		107.87	Ag	ug/g	1.26E+00
50	Al	ug/g	9.65E+03	0	9.65E+03		6.26E+03	M	2.64E-01			0.0%	2.81E-01		26.98	Al	ug/g	6.18E+03
51	Aroclors (Total PCB)	ug/g	8.61E-03	0	8.61E-03		5.58E-03								319.86	Aroclors (Tot	ug/g	0.00E+00
52	As	ug/g	1.85E+01		1.85E+01		1.20E+01	M	1.96E-04			0.0%	1.94E-04		74.92	As	ug/g	1.18E+01
53	B	ug/g	2.67E+01		2.67E+01		1.73E+01	M	1.97E-03			0.0%	1.94E-03		10.81	B	ug/g	1.71E+01
54	Ba	ug/g	7.56E+00		7.56E+00		4.90E+00	M	4.38E-05			19.0%	3.51E-05		137.33	Ba	ug/g	3.92E+00
55	Be	ug/g	4.79E-01		4.79E-01		3.11E-01	M	4.23E-05			0.0%	4.18E-05		9.01	Be	ug/g	3.07E-01
56	Bi	ug/g	1.85E+01	0	1.85E+01		1.20E+01	M	7.04E-05			0.0%	6.96E-05		208.98	Bi	ug/g	1.18E+01
57	Ca	ug/g	2.95E+02	0	2.95E+02		1.91E+02	M	5.87E-03			19.0%	4.70E-03		40.08	Ca	ug/g	1.53E+02
58	Cd	ug/g	4.16E+01		4.16E+01		2.70E+01	M	2.94E-04			0.0%	2.91E-04		112.41	Cd	ug/g	2.66E+01
59	Ce	ug/g	7.55E+00		7.55E+00		4.89E+00	M	4.29E-05			85.0%	6.35E-06		140.12	Ce	ug/g	7.25E-01
60	Cl	ug/g	2.72E+03	0	2.72E+03		1.76E+03	M	6.10E-02			0.0%	6.03E-02		35.45	Cl	ug/g	1.74E+03
61	Co	ug/g	1.82E+00		1.82E+00		1.18E+00	M	2.46E-05			0.0%	2.43E-05		58.93	Co	ug/g	1.17E+00
62	Cr	ug/g	1.71E+02	0	1.71E+02		1.11E+02	M	2.62E-03			21.0%	2.04E-03		52.00	Cr	ug/g	8.65E+01
63	Cu	ug/g	1.80E+01		1.80E+01		1.17E+01	M	2.25E-04			0.0%	2.23E-04		63.55	Cu	ug/g	1.15E+01
64	F	ug/g	4.29E+01	0	4.29E+01		2.78E+01	M	1.80E-03			0.0%	1.78E-03		19.00	F	ug/g	2.75E+01
65	Fe	ug/g	2.67E+01	0	2.67E+01		1.73E+01	M	3.80E-04			97.0%	1.13E-05		55.85	Fe	ug/g	5.13E-01
66	Free OH	ug/g	6.33E+03	0	6.33E+03		4.10E+03	M	2.96E-01			0.0%	2.93E-01		17.01	Free OH	ug/g	4.06E+03
67	Hg	ug/g	3.48E-02	0	3.48E-02		2.26E-02	M	1.38E-07			0.0%	1.36E-07		200.59	Hg	ug/g	2.23E-02
68	K	ug/g	1.42E+03	0	1.42E+03		9.21E+02	M	2.89E-02			0.0%	2.86E-02		39.10	K	ug/g	9.10E+02
69	La	ug/g	9.35E+00	0	9.35E+00		6.06E+00	M	5.35E-05			85.0%	7.9372E-06		138.91	La	ug/g	8.98E-01
70	Li	ug/g	6.41E-01		6.41E-01		4.16E-01	M	7.35E-05			0.0%	7.26E-05		6.94	Li	ug/g	4.11E-01
71	Mg	ug/g	1.88E+01		1.88E+01		1.22E+01	M	8.15E-04			0.0%	8.06E-04		24.31	Mg	ug/g	1.20E+01
72	Mn	ug/g	1.18E+01	0	1.18E+01		7.65E+00	M	1.71E-04		3.63	30.0%	1.18E-04		54.94	Mn	ug/g	5.29E+00
73	Mo	ug/g	3.39E+01		3.39E+01		2.20E+01	M	2.81E-04			0.0%	2.78E-04		95.94	Mo	ug/g	2.17E+01
74	Na	ug/g	1.59E+05	0	1.59E+05		1.03E+05	M	5.50E+00		3.63	0.0%	5.45E+00		22.99	Na	ug/g	1.02E+05
75	Nd	ug/g	1.43E+01		1.43E+01		9.27E+00	M	7.89E-05			85.0%	1.17E-05		144.24	Nd	ug/g	1.37E+00
76	NH3	ug/g	9.19E+01		9.19E+01		5.96E+01	M	4.30E-03			0.0%	4.25E-03		17.00	NH3	ug/g	5.89E+01
77	Ni	ug/g	2.77E+02	0	2.77E+02		1.80E+02	M	3.75E-03			0.0%	3.71E-03		58.69	Ni	ug/g	1.77E+02
78	NO2	ug/g	8.01E+04	0	8.01E+04		3.90E+04	M	1.04E+00			0.0%	1.03E+00		46.01	NO2	ug/g	3.85E+04

The percent removal is for the Mn present in the sample before addition of permanganate. All added permanganate precipitates. AN-107 averaged 96% removal. AN-102 averaged 30% removal

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
79	NO3	ug/g	1.44E+05		0		1.44E+05		9.33E+04	M	1.85E+00	6		0.0%	1.87E+00					62.00	NO3	ug/g	9.43E+04
80	Oxalate	ug/g	5.88E+02		0		5.88E+02		3.81E+02	M	5.44E-03			0.0%	5.37E-03					88.02	Oxalate	ug/g	3.85E+02
81	Pb	ug/g	1.11E+02		0		1.11E+02		7.20E+01	M	4.26E-04			30.0%	2.95E-04					207.20	Pb	ug/g	4.98E+01
82	PO4	ug/g	3.63E+03		0		3.63E+03		2.35E+03	M	3.04E-02			0.0%	3.00E-02					94.97	PO4	ug/g	2.32E+03
83	Rh																						0.00E+00
84	Sb	ug/g	1.43E-01				1.43E-01		9.27E-02	M	9.34E-07			0.0%	9.23E-07					121.75	Sb	ug/g	9.16E-02
85	Se	ug/g	1.86E+01				1.86E+01		1.21E+01	M	1.87E-04			0.0%	1.85E-04					78.96	Se	ug/g	1.19E+01
86	Si	ug/g	3.06E+01		0		3.06E+01		1.98E+01	M	8.67E-04			0.0%	8.56E-04					28.09	Si	ug/g	1.96E+01
87	SO4	ug/g	1.03E+04		0		1.03E+04		6.68E+03	M	8.54E-02			0.0%	8.43E-02					96.06	SO4	ug/g	6.60E+03
88	Sr	ug/g	1.67E+00		0		1.67E+00		1.08E+00	M	1.52E-05	3.00		94.0%	1.20E-03	1.59E-03				87.62	Sr	ug/g	8.54E+01
89	Ta																						0.00E+00
90	Th	ug/g	1.41E+00		0		1.41E+00		9.14E-01	M	4.83E-06			0.0%	4.78E-06					232.04	Th	ug/g	9.03E-01
91	Ti	ug/g	4.58E-01				4.58E-01		2.97E-01	M	7.61E-06			0.0%	7.52E-06					47.88	Ti	ug/g	2.93E-01
92	TIC as CO3	ug/g	5.36E+04		0		5.36E+04		3.47E+04	M	7.11E-01			2.8%	6.82E-01					60.01	TIC as CO3	ug/g	3.34E+04
93	Tl	ug/g	1.32E+00				1.32E+00		8.56E-01	M	5.14E-06			0.0%	5.08E-06					204.38	Tl	ug/g	8.46E-01
94	TOC	ug/g	1.94E+04		0		1.94E+04		1.26E+04	M	1.29E+00			0.0%	1.27E+00					12.01	TOC	ug/g	1.24E+04
95	UTOTAL	ug/g	1.42E+01		0		1.42E+01		9.21E+00	M	4.75E-05			0.0%	4.69E-05					238.03	UTOTAL	ug/g	9.10E+00
96	V	ug/g	1.85E+00				1.85E+00		1.20E+00	M	2.89E-05			0.0%	2.85E-05					50.94	V	ug/g	1.18E+00
97	Y	ug/g	1.46E+00				1.46E+00		9.46E-01	M	1.31E-05			0.0%	1.29E-05					88.91	Y	ug/g	9.35E-01
98	Zn	ug/g	1.88E+00				1.88E+00		1.22E+00	M	2.29E-05			0.0%	2.26E-05					65.39	Zn	ug/g	1.20E+00
99	Zr	ug/g	4.96E+00		0		4.96E+00		3.22E+00	M	4.33E-05			82.0%	7.69E-06					91.22	Zr	ug/g	5.72E-01
100	Sum of TRU	uCi/g	1.16E-01		0		1.16E-01		7.51E-02														
101	Supernate density	gm/ml	1.40		0		1.40	1.00	1.23	gm/ml	1.23												
102	Sum of TRU	uCi/ml	1.62E-01		0		1.62E-01		9.21E-02	uCi/ml					1.37E-02								
103	Sr-90	uCi/ml	74.48		0.00		74.48		42.33	uCi/ml	42.33				2.51E+00								
104																							
105	Na concentration	M	9.68		0.00		9.68		5.50						5.45								
106																							
107	wt% Na2O in glass		15.0%				15.0%		15.0%						15.0%								
108	wt% SO3 in glass		0.6%				0.6%		0.6%						0.6%								
109	MT/m3 glass density		2.76				2.76		2.76						2.76								
110	gm glass/liter of waste		2.00E+03				2.00E+03		1.14E+03						1.13E+03								
111	m3 per liter of waste		7.25E-04				7.25E-04		4.12E-04						4.08E-04								
112																							
113	TRU in glass	nCi/gm	81.06				81.06		81.1	nCi/gm					12.1								
114	TRU Removal Required to achieve 50 nCi/gm		38.3%				38.3%	n/a	38.3%														
115	Sr-90 in glass	Ci/m3	102.77				102.77		102.77	Ci/m3					6.14								
116	Sr-90 Removal Required to achieve 10 Ci/m^3		90.3%				90.3%	n/a	90.3%														
117	Batch Volume	Liters	1.83E+06				1.83E+06	1.39E+06	3.21E+06	Liters	3.21E+06	2.16E+04	1.71E+04	Liters	3.25E+06								
118		Gallons	4.82E+05				4.82E+05	3.67E+05	8.49E+05	Gallons	8.49E+05	5.71E+03	4.51E+03	Gallons	8.59E+05								
119	Height of Supernatant	Inches	175.4				175.4		308.7		308.7				312.4								
120	Target Na M							[redacted]															
121	Sr M											3.00			0.02								
122	Moles Sr Added											6.48E+04											
123	MnO_4 M												3.83		0.02								
124	Mole Mn Added												6.54E+04										
125																							

Consistency check: Calculate the Sr-90 concentration using the equilibrium concentration of Sr-90 / total Sr equal to 0.018 µCi/µg.

The moles of carbonate removed are equal to the amount of Sr added.

Set Batch 2 Volume equal to Batch #1 volume plus volume of 10 inch supernatant heel.

Selector Switch available on Summary sheet to change sodium molarity.

	A	B	E	I	O	P	Q	R	S	U
126	Sludge		AP-102 Inventory Use Column I for Running Totals	AN-102 Batch 1 Treated Waste	Treated Waste	Mass Precipitated	Species	M W	Mass of Precipitated Solids	Sludge
127	Analyte	Units								
128	106Ru	Ci	2.42E-07	2.42E-07	2.42E-07					
129	113mCd	Ci	1.53E+00	1.53E+00	1.53E+00					
130	125Sb	Ci	7.30E-01	7.30E-01	7.30E-01					
131	126Sn	Ci	5.71E-02	5.71E-02	5.71E-02					
132	129I	Ci	1.77E-02	1.77E-02	1.77E-02					
133	134Cs	Ci	7.13E-03	7.13E-03	7.13E-03					
134	137Cs	Ci	1.25E+04	1.25E+04	1.25E+04					
135	137mBa	Ci	1.18E+04	1.18E+04	1.18E+04					
136	14C	Ci	7.41E-01	7.41E-01	7.41E-01					
137	151Sm	Ci	3.08E+02	3.08E+02	3.08E+02					
138	152Eu	Ci	7.34E-02	7.15E-01	1.29E+00					
139	154Eu	Ci	6.16E+00	2.61E+02	5.29E+02					
140	155Eu	Ci	1.37E+00	1.74E+01	3.28E+01					
141	226Ra	Ci	3.82E-06	3.82E-06	3.82E-06					
142	227Ac	Ci	4.04E-05	4.04E-05	4.04E-05					
143	228Ra	Ci	4.70E-03	4.70E-03	4.70E-03					
144	229Th	Ci	1.66E-04	1.66E-04	1.66E-04					
145	231Pa	Ci	1.09E-04	1.09E-04	1.09E-04					
146	232Th	Ci	7.70E-04	7.70E-04	7.70E-04					
147	232U	Ci	2.22E-03	2.22E-03	2.22E-03					
148	233U	Ci	9.36E-03	9.36E-03	9.36E-03					
149	234U	Ci	1.63E-03	1.63E-03	1.63E-03					
150	235U	Ci	6.47E-05	6.47E-05	6.47E-05					
151	236U	Ci	5.22E-05	5.22E-05	5.22E-05					
152	237Np	Ci	3.83E-02	1.51E-01	2.25E-01					
153	238Pu	Ci	1.85E-03	4.95E-01	1.02E+00					
154	238U	Ci	1.45E-03	1.45E-03	1.45E-03					
155	239Pu	Ci	7.21E-02	6.87E+00	1.40E+01					
156	240Pu	Ci	1.22E-02	1.78E+00	3.65E+00					
157	241Am	Ci	1.07E-01	2.28E+02	4.69E+02					
158	241Pu	Ci	8.58E-02	3.11E+01	6.39E+01					
159	242Cm	Ci	2.77E-04	4.48E-01	9.22E-01					
160	242Pu	Ci	7.41E-07	1.88E-04	3.85E-04					
161	243Am	Ci	3.89E-06	1.50E-01	3.09E-01					
162	243Cm	Ci	2.29E-05	2.47E-02	5.08E-02					
163	244Cm	Ci	1.97E-04	5.86E-01	1.21E+00					
164	3H	Ci	4.09E+00	4.09E+00	4.09E+00					
165	59Ni	Ci	3.82E-02	3.82E-02	3.82E-02					
166	60Co	Ci	2.13E-01	2.13E-01	2.13E-01					
167	63Ni	Ci	3.51E+00	3.51E+00	3.51E+00					
168	79Se	Ci	5.05E-03	5.05E-03	5.05E-03					
169	90Sr	Ci	5.66E+01	1.21E+05	2.49E+05					
170	90Y	Ci	5.66E+01	5.66E+01	5.66E+01					
171	93mNb	Ci	3.99E-01	3.99E-01	3.99E-01					
172	93Zr	Ci	4.62E-01	4.62E-01	4.62E-01					
173	99Tc	Ci	1.05E+01	1.05E+01	1.05E+01					
174	Al	kg	1.57E+04	1.57E+04	1.57E+04	0.00E+00		M.W	Mass of Precipitated Solids	
175	Aroclors (Total PCB)	kg	3.85E+00	0						
176	Bi	kg	1.52E+00	1.52E+00	1.52E+00	0.00E+00				
177	Ca	kg	1.65E+04	1.66E+04	1.68E+04	1.43E+02	CaCO3	100	3.58E+02	
178	Cl	kg	2.91E+02	2.91E+02	2.91E+02	0.00E+00				
179	Cr	kg	2.59E+01	1.39E+02	2.43E+02	1.04E+02	Cr(OH)3	103	2.06E+02	
180	F	kg	8.21E+00	8.21E+00	8.21E+00	0.00E+00				
181	Fe	kg	9.07E-01	6.40E+01	1.30E+02	6.62E+01	Fe(OH)3	106.85	1.27E+02	
182	Free OH	kg	1.20E+03	1.20E+03	1.20E+03	0.00E+00				
183	Hg	kg	0.00E+00	0	-1.11E-17	-1.11E-17				
184	K	kg	1.85E+02	1.85E+02	1.85E+02	0.00E+00				
185	La	kg	4.60E-01	1.99E+01	4.02E+01	2.03E+01	La(OH)3	189.9	2.78E+01	
186	Mn	kg	1.49E+00	3.58E+03	7.18E+03	3.60E+03	NaMn(O)(OH)(O)	126.94	8.32E+03	
187	Na	kg	9.18E+03	9.18E+03	9.18E+03	0.00E+00				
188	Ni	kg	1.28E+00	1.28E+00	1.28E+00	0.00E+00				
189	NO2	kg	4.67E+03	4.67E+03	4.67E+03	-2.18E-11				
190	NO3	kg	7.58E+03	7.58E+03	7.58E+03	7.28E-12				
191	Oxalate	kg	4.10E+01	4.10E+01	4.10E+01	0.00E+00				
192	Pb	kg	2.65E+00	8.46E+01	1.70E+02	8.51E+01	Pb(OH)4	275.2	1.13E+02	
193	PO4	kg	2.65E+04	2.65E+04	2.65E+04	0.00E+00				
194	Si	kg	3.74E+00	3.74E+00	3.74E+00	0.00E+00				
195	SO4	kg	1.51E+02	1.51E+02	1.51E+02	0.00E+00				
196	Sr	kg	1.53E-01	5.31E+03	1.07E+04	5.34E+03	SrCO3	147.62	9.00E+03	
197	Th	kg	6.99E+00	6.99E+00	6.99E+00	0.00E+00				
198	TIC as CO3	kg	1.10E+03	4.97E+03	8.85E+03	3.89E+03				
199	TOC	kg	2.16E+02	2.16E+02	2.16E+02	5.60E-12				
200	UTOTAL	kg	4.36E+00	4.36E+00	4.36E+00	0.00E+00				
201	Zr	kg	8.25E-01	1.06E+01	2.12E+01	1.04E+01	Zr(OH)4	159.22	1.81E+01	
202										
203	Density	gm/ml	1.75							
204	Volume	Liters	88,000							
205	Inches of sludge		8.5	11.9	15.3					
206										
207	Total	kgs						kg	1.82E+04	
208										
209	wt% settled solids	wt%						wt%	39.0%	
210	settled solids density	gm/ml						gm/ml	1.3	
211	volume of settled solids	liters						liters	3.58E+04	
212		gallons						gallons	9.47E+03	
213		inches						inches	3.4	

AN-102 composition is from AN-102 Batch #1 Treated Waste. Includes AP-102 sludge inventory.

Includes added Mn that precipitates.

Includes added Sr that precipitates.

Cummulative Inches of AP-102 Sludge plus batch precipitates.

Volume conversion to inches uses 2750 gal/in in the DSTs. Note this should not be used when workig with the lower 6 inches of the tank. Use volume calculator from RPP-13019 (CH2M Hill).

ATTACHMENT 8

AN-107 BATCH #3

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	*Supernatant -Batch 3*		*AN-107 Supernate*		*AN-102 Batch #2 Treated Waste Composition*		*AN-107 + AN-102 Batch 2 Heel*	*Dilution Water*	*Diluted AN-107 + AN-102*		*Diluted AN-107 + AN-102*	*3M $Sr(NO_3)_2$*	*40wt% $NaMnO_4$ (3.83M)*	*Percent Removal from Supernate*	*Treated Waste*	*Precipitate*			
2	Analyte	Units	Adjusted Concentration		Treated Waste Concentration		Adjusted Concentration			Units	Unit Change								
3	106Ru	uCi/g	3.15E-09		2.33E-09		3.11E-09		2.18E-09	uCi/ml	2.75E-09			0.0%	2.72E-09				
4	113mCd	uCi/g	1.37E-02		1.01E-02		1.35E-02		9.49E-03	uCi/ml	1.20E-02			0.0%	1.18E-02				
5	125Sb	uCi/g	1.32E-03		1.43E-03		1.33E-03		9.32E-04	uCi/ml	1.18E-03			0.0%	1.16E-03				
6	126Sn	uCi/g	6.62E-03		2.97E-03		6.43E-03		4.52E-03	uCi/ml	5.70E-03			0.0%	5.63E-03				
7	129I	uCi/g	8.13E-05		5.80E-05		8.01E-05		5.63E-05	uCi/ml	7.10E-05			0.0%	7.01E-05				
8	134Cs	uCi/g	1.80E-03		1.33E-03		1.78E-03		1.25E-03	uCi/ml	1.57E-03			0.0%	1.55E-03				
9	137Cs	uCi/g	2.18E+02		1.68E+02		2.15E+02		1.51E+02	uCi/ml	1.91E+02			0.0%	1.89E+02				
10	137mBa	uCi/g	2.06E+02		1.59E+02		2.04E+02		1.43E+02	uCi/ml	1.80E+02			0.0%	1.78E+02				
11	14C	uCi/g	4.36E-04		3.14E-04		4.30E-04		3.02E-04	uCi/ml	3.81E-04			0.0%	3.76E-04				
12	151Sm	uCi/g	2.09E+00		1.54E+00		2.06E+00		1.45E+00	uCi/ml	1.83E+00			0.0%	1.80E+00				
13	152Eu	uCi/g	2.31E-04		2.56E-05		2.20E-04		1.55E-04	uCi/ml	1.95E-04			85.0%	2.89E-05				
14	154Eu	uCi/g	2.52E-01		1.18E-02		2.39E-01		1.68E-01	uCi/ml	2.12E-01			85.0%	3.14E-02				
15	155Eu	uCi/g	1.37E-01		6.80E-04		1.30E-01		9.12E-02	uCi/ml	1.15E-01			85.0%	1.70E-02				
16	226Ra	uCi/g	2.31E-08		1.70E-08		2.28E-08		1.60E-08	uCi/ml	2.02E-08			0.0%	1.99E-08				
17	227Ac	uCi/g	2.84E-06		2.10E-06		2.80E-06		1.97E-06	uCi/ml	2.48E-06			0.0%	2.45E-06				
18	228Ra	uCi/g	6.94E-06		4.87E-06		6.83E-06		4.80E-06	uCi/ml	6.05E-06			0.0%	5.98E-06				
19	229Th	uCi/g	1.14E-08		8.46E-09		1.12E-08		7.90E-09	uCi/ml	9.97E-09			0.0%	9.85E-09				
20	231Pa	uCi/g	2.98E-05		2.20E-05		2.94E-05		2.07E-05	uCi/ml	2.60E-05			0.0%	2.57E-05				
21	232Th	uCi/g	1.36E-06		9.93E-08		1.29E-06		9.09E-07	uCi/ml	1.15E-06			0.0%	1.13E-06				
22	232U	uCi/g	6.97E-07		8.90E-08		6.65E-07		4.67E-07	uCi/ml	5.89E-07			0.0%	5.82E-07				
23	233U	uCi/g	4.28E-05		5.47E-06		4.08E-05		2.87E-05	uCi/ml	3.62E-05			0.0%	3.58E-05				
24	234U	uCi/g	3.03E-05		3.87E-06		2.89E-05		2.03E-05	uCi/ml	2.56E-05			0.0%	2.53E-05				
25	235U	uCi/g	1.20E-06		1.53E-07		1.14E-06		8.04E-07	uCi/ml	1.01E-06			0.0%	1.00E-06				
26	236U	uCi/g	2.05E-06		2.62E-07		1.96E-06		1.37E-06	uCi/ml	1.73E-06			0.0%	1.71E-06				
27	237Np	uCi/g	4.00E-05		3.29E-06		3.81E-05		2.67E-05	uCi/ml	3.37E-05			85.0%	5.00E-06				
28	238Pu	uCi/g	2.31E-03		2.31E-05		2.19E-03		1.54E-03	uCi/ml	1.94E-03			85.0%	2.88E-04				
29	238U	uCi/g	2.37E-05		3.03E-06		2.26E-05		1.59E-05	uCi/ml	2.00E-05			0.0%	1.98E-05				
30	239Pu	uCi/g	3.18E-02		3.17E-04		3.01E-02		2.12E-02	uCi/ml	2.67E-02			85.0%	3.96E-03				
31	240Pu	uCi/g	8.27E-03		8.25E-05		7.84E-03		5.51E-03	uCi/ml	6.95E-03			85.0%	1.03E-03				
32	241Am	uCi/g	5.15E-01		1.07E-02		4.88E-01		3.43E-01	uCi/ml	4.33E-01			85.0%	6.41E-02				
33	241Pu	uCi/g	1.45E-01		1.45E-03		1.37E-01		9.66E-02	uCi/ml	1.22E-01			85.0%	1.80E-02				
34	242Cm	uCi/g	1.96E-03		2.09E-05		1.86E-03		1.31E-03	uCi/ml	1.65E-03			85.0%	2.44E-04				
35	242Pu	uCi/g	8.75E-07		8.74E-09		8.29E-07		5.83E-07	uCi/ml	7.35E-07			85.0%	1.09E-07				
36	243Am	uCi/g	3.38E-04		7.02E-06		3.20E-04		2.25E-04	uCi/ml	2.84E-04			85.0%	4.21E-05				
37	243Cm	uCi/g	5.56E-05		1.15E-06		5.27E-05		3.70E-05	uCi/ml	4.67E-05			85.0%	6.92E-06				
38	244Cm	uCi/g	1.32E-03		2.74E-05		1.25E-03		8.80E-04	uCi/ml	1.11E-03			85.0%	1.64E-04				
39	3H	uCi/g	4.51E-04		2.41E-04		4.40E-04		3.09E-04	uCi/ml	3.90E-04			0.0%	3.85E-04				
40	59Ni	uCi/g	1.49E-02		1.08E-04		1.41E-02		9.92E-03	uCi/ml	1.25E-02			0.0%	1.24E-02				
41	60Co	uCi/g	4.53E-02		2.32E-02		4.41E-02		3.10E-02	uCi/ml	3.91E-02			0.0%	3.86E-02				
42	63Ni	uCi/g	1.04E+00		1.01E-02		9.85E-01		6.93E-01	uCi/ml	8.73E-01			0.0%	8.63E-01				
43	79Se	uCi/g	5.65E-04		2.70E-04		5.49E-04		3.86E-04	uCi/ml	4.87E-04			0.0%	4.81E-04				
44	90Sr	uCi/g	5.40E+01		2.04E+00		5.12E+01		3.60E+01	uCi/ml	4.54E+01			94.0%	2.69E+00				
45	90Y	uCi/g	5.40E+01		3.41E+01		5.29E+01		3.72E+01	uCi/ml	4.69E+01			0.0%	4.64E+01				
46	93mNb	uCi/g	1.33E-02		9.80E-03		1.31E-02		9.22E-03	uCi/ml	1.16E-02			0.0%	1.15E-02				
47	93Zr	uCi/g	1.60E-02		1.18E-02		1.58E-02		1.11E-02	uCi/ml	1.40E-02			0.0%	1.38E-02				
48	99Tc	uCi/g	5.69E-02		6.25E-02		5.72E-02		4.02E-02	uCi/ml	5.07E-02			0.0%	5.01E-02				

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
49	Ag	ug/g	1.34E+00		1.26E+00		1.34E+00		9.39E-01	M	1.10E-05			0.0%	1.08E-05				
50	Al	ug/g	7.65E+02		6.16E+03		1.07E+03		7.52E+02	M	3.51E-02			0.0%	3.47E-02				
51	Aroclors (Total PCB)	ug/g	2.80E-03		0.00E+00		2.65E-03		1.86E-03										
52	As	ug/g	9.09E-01		1.18E+01		1.49E+00		1.05E+00	M	1.76E-05			0.0%	1.74E-05				
53	B	ug/g	1.57E+01		1.71E+01		1.58E+01		1.11E+01	M	1.29E-03			0.0%	1.28E-03				
54	Ba	ug/g	6.63E+00		3.92E+00		6.49E+00		4.56E+00	M	4.19E-05			19.0%	3.35E-05				
55	Be	ug/g	1.32E-01		3.07E-01		1.41E-01		9.93E-02	M	1.39E-05			0.0%	1.37E-05				
56	Bi	ug/g	5.83E+00		1.18E+01		6.15E+00		4.32E+00	M	2.61E-05			0.0%	2.58E-05				
57	Ca	ug/g	3.89E+02		1.53E+02		3.77E+02		2.65E+02	M	8.34E-03			19.0%	6.68E-03				
58	Cd	ug/g	4.38E+01		2.66E+01		4.29E+01		3.01E+01	M	3.38E-04			0.0%	3.34E-04				
59	Ce	ug/g	3.38E+01		7.25E-01		3.20E+01		2.25E+01	M	2.03E-04			85.0%	3.00E-05				
60	Cl	ug/g	1.24E+03		1.74E+03		1.27E+03		8.90E+02	M	3.17E-02			0.0%	3.13E-02				
61	Co	ug/g	2.92E+00		1.17E+00		2.83E+00		1.99E+00	M	4.25E-05			0.0%	4.20E-05				
62	Cr	ug/g	1.19E+02		8.65E+01		1.17E+02		8.24E+01	M	2.00E-03			21.0%	1.56E-03				
63	Cu	ug/g	2.01E+01		1.15E+01		1.96E+01		1.38E+01	M	2.74E-04			0.0%	2.71E-04				
64	F	ug/g	6.79E+01		2.75E+01		6.58E+01		4.62E+01	M	3.07E-03			0.0%	3.03E-03				
65	Fe	ug/g	1.15E+03		5.13E-01		1.09E+03		7.65E+02	M	1.73E-02			97.0%	5.12E-04				
66	Free OH	ug/g	1.26E+04		4.06E+03		1.21E+04		8.54E+03	M	6.33E-01			0.0%	6.26E-01				
67	Hg	ug/g	1.53E-01		2.23E-02		1.46E-01		1.03E-01	M	6.45E-07			0.0%	6.38E-07				
68	K	ug/g	1.21E+03		9.10E+02		1.19E+03		8.39E+02	M	2.71E-02			0.0%	2.67E-02				
69	La	ug/g	2.23E+01		8.98E-01		2.12E+01		1.49E+01	M	1.35E-04			85.0%	2.00162E-05				
70	Li	ug/g	2.04E+00		4.11E-01		1.95E+00		1.37E+00	M	2.49E-04			0.0%	2.47E-04				
71	Mg	ug/g	9.75E-01		1.20E+01		1.56E+00		1.10E+00	M	5.69E-05			0.0%	5.62E-05				
72	Mn	ug/g	3.41E+02		5.29E+00		3.23E+02		2.27E+02	M	5.21E-03		3.83	96.0%	2.06E-04				
73	Mo	ug/g	2.34E+01		2.17E+01		2.33E+01		1.64E+01	M	2.15E-04			0.0%	2.13E-04				
74	Na	ug/g	1.45E+05		1.02E+05		1.43E+05		1.00E+05	M	5.50E+00		3.83	0.0%	5.45E+00				
75	Nd	ug/g	6.42E+01		1.37E+00		6.09E+01		4.28E+01	M	3.74E-04			85.0%	5.54E-05				
76	NH3	ug/g	3.41E+01		5.89E+01		3.54E+01		2.49E+01	M	1.85E-03			0.0%	1.82E-03				
77	Ni	ug/g	3.66E+02		1.77E+02		3.56E+02		2.50E+02	M	5.37E-03			0.0%	5.31E-03				
78	NO2	ug/g	4.66E+04		3.85E+04		4.62E+04		3.24E+04	M	8.90E-01			0.0%	8.79E-01				
79	NO3	ug/g	1.46E+05		9.43E+04		1.43E+05		1.01E+05	M	2.05E+00	6.00		0.0%	2.06E+00				
80	Oxalate	ug/g	6.37E+02		3.85E+02		6.24E+02		4.38E+02	M	6.43E-03			0.0%	6.35E-03				
81	Pb	ug/g	2.62E+02		4.98E+01		2.51E+02		1.76E+02	M	1.07E-03			30.0%	7.42E-04				
82	PO4	ug/g	1.08E+03		2.32E+03		1.15E+03		8.05E+02	M	1.07E-02			0.0%	1.06E-02				
83	Rh	ug/g	1.75E+01				1.66E+01		1.16E+01	M	1.43E-04			0.0%	1.41E-04				
84	Sb	ug/g	2.24E-01		9.16E-02		2.17E-01		1.52E-01	M	1.58E-06			0.0%	1.56E-06				
85	Se	ug/g	5.67E-01		1.19E+01		1.17E+00		8.21E-01	M	1.31E-05			0.0%	1.30E-05				
86	Si	ug/g	9.18E+00		1.96E+01		9.73E+00		6.84E+00	M	3.07E-04			0.0%	3.03E-04				
87	SO4	ug/g	5.71E+03		6.60E+03		5.76E+03		4.05E+03	M	5.32E-02			0.0%	5.25E-02				
88	Sr	ug/g	1.32E+00		8.54E+01		5.77E+00		4.06E+00	M	5.84E-05	3.00		94.0%	1.20E-03	1.71E-03			
89	Ta	ug/g	1.70E+01				1.61E+01		1.13E+01	M	7.89E-05			0.0%	7.79E-05				
90	Th	ug/g	1.24E+01		9.03E-01		1.18E+01		8.29E+00	M	4.50E-05			0.0%	4.45E-05				
91	Ti	ug/g	9.98E-01		2.93E-01		9.61E-01		6.75E-01	M	1.78E-05			0.0%	1.76E-05				
92	TIC as CO3	ug/g	5.16E+04		3.34E+04		5.06E+04		3.56E+04	M	7.48E-01			2.7%	7.19E-01				
93	Tl	ug/g	8.73E-02		8.46E-01		1.27E-01		8.96E-02	M	5.53E-07			0.0%	5.46E-07				
94	TOC	ug/g	2.26E+04		1.24E+04		2.21E+04		1.55E+04	M	1.63E+00			0.0%	1.61E+00				
95	UTOTAL	ug/g	7.12E+01		9.10E+00		6.79E+01		4.77E+01	M	2.53E-04			0.0%	2.50E-04				
96	V	ug/g	4.91E-01		1.18E+00		5.28E-01		3.71E-01	M	9.18E-06			0.0%	9.07E-06				
97	Y	ug/g	6.02E+00		9.35E-01		5.75E+00		4.04E+00	M	5.73E-05			0.0%	5.66E-05				
98	Zn	ug/g	1.32E+01		1.20E+00		1.26E+01		8.83E+00	M	1.70E-04			0.0%	1.68E-04				
99	Zr	ug/g	4.19E+01		5.72E-01		3.97E+01		2.79E+01	M	3.86E-04			82.0%	6.86E-05				
100	Sum of TRU	uCi/g	5.59E-01		1.11E-02		5.30E-01		3.73E-01										
101	Supernate density	gm/ml	1.43		1.23		1.42	1.00	1.26	gm/ml	1.26								
102	Sum of TRU	uCi/ml	8.00E-01		1.37E-02		7.51E-01		4.70E-01	uCi/ml					6.96E-02				
103	Sr-90	uCi/ml	77.22		2.51		72.65		45.42	uCi/ml	45.42				2.69E+00				
104																			
105	Na concentration	M	9.02		5.45		8.80		5.50						5.45				
106																			
107	wt% Na2O in glass		15.0%		15.0%		15.0%		15.0%						15.0%				
108	wt% SO3 in glass		0.4%		0.6%		0.4%		0.4%						0.4%				
109	MT/m3 glass density		2.76		2.76		2.76		2.76						2.76				
110	gm glass/liter of waste		1.86E+03		1.13E+03		1.82E+03		1.14E+03						1.13E+03				
111	m3 per liter of waste		6.75E-04		4.08E-04		6.59E-04		4.12E-04						4.08E-04				
112																			
113	TRU in glass	nCi/gm	429.15		12.12		413.34		413.3	nCi/gm					61.8				
114	TRU Removal Required to achieve 50 nCi/gm		88.3%		n/a		87.9%	n/a	87.9%										
115	Sr-90 in glass	Ci/m3	114.39		6.15		110.29		110.29	Ci/m3					6.59				
116	Sr-90 Removal Required to achieve 10 Ci/m^3		91.3%		n/a		90.9%	n/a	90.9%										
117	Batch Volume	Liters	[redacted]		1.04E+05		1.70E+06	1.02E+06	2.72E+06	Liters	2.72E+06	1.83E+04	1.44E+04	Liters	2.75E+06				
118		Gallons	4.22E+05		2.75E+04		4.50E+05	2.70E+05	7.19E+05	Gallons	7.19E+05	4.83E+03	3.82E+03	Gallons	7.28E+05				
119	Height of Supernatant	inches	153.5		10.0		163.5		261.5		261.5				264.6				
120	Target Na M							[redacted]											
121	Sr M											3.00			0.02				
122	Moles Sr Added											5.49E+04							
123	MnO_4 M												3.83		0.02				
124	Mole Mn Added												5.54E+04						
125																			

The percent removal is for the Mn present in the sample before addition of permanganate. All added permanganate precipitates.
AN-107 averaged 96% removal. AN-102 averaged 30% removal.

Consistency check: Calculate the Sr-90 concentration using the equilibrium concentration of Sr-90 / total Sr equal to 0.018 µCi/µg.

The moles of carbonate removed are equal to the amount of Sr added.

	A	B	C	E	G	I	J	M	O	P	Q	R	S
126	Sludge			Inventory AP-102	Inventory AP-102	AN-102 Batch 2 Treated Waste			Treated Waste	Precipitate	Species	M.W.	Mass of Precipitated Solids
127	Analyte	Units					Units						
128	106Ru	Ci		2.42E-07	2.42E-07	2.42E-07	Ci		2.42E-07				
129	113mCd	Ci		1.53E+00	1.53E+00	1.53E+00	Ci		1.53E+00				
130	125Sb	Ci		7.30E-01	7.30E-01	7.30E-01	Ci		7.30E-01				
131	126Sn	Ci		5.71E-02	5.71E-02	5.71E-02	Ci		5.71E-02				
132	129I	Ci		1.77E-02	1.77E-02	1.77E-02	Ci		1.77E-02				
133	134Cs	Ci		7.13E-03	7.13E-03	7.13E-03	Ci		7.13E-03				
134	137Cs	Ci		1.25E+04	1.25E+04	1.25E+04	Ci		1.25E+04				
135	137mBa	Ci		1.18E+04	1.18E+04	1.18E+04	Ci		1.18E+04				
136	14C	Ci		7.41E-01	7.41E-01	7.41E-01	Ci		7.41E-01				
137	151Sm	Ci		3.08E+02	3.08E+02	3.08E+02	Ci		3.08E+02				
138	152Eu	Ci		7.34E-02	7.34E-02	1.29E+00	Ci		1.74E+00				
139	154Eu	Ci		6.16E+00	6.16E+00	5.29E+02	Ci		1.02E+03				
140	155Eu	Ci		1.37E+00	1.37E+00	3.26E+01	Ci		2.99E+02				
141	226Ra	Ci		3.82E-06	3.82E-06	3.82E-06	Ci		3.82E-06				
142	227Ac	Ci		4.04E-05	4.04E-05	4.04E-05	Ci		4.04E-05				
143	228Ra	Ci		4.70E-03	4.70E-03	4.70E-03	Ci		4.70E-03				
144	229Th	Ci		1.66E-04	1.66E-04	1.66E-04	Ci		1.66E-04				
145	231Pa	Ci		1.09E-04	1.09E-04	1.09E-04	Ci		1.09E-04				
146	232Th	Ci		7.70E-04	7.70E-04	7.70E-04	Ci		7.70E-04				
147	232U	Ci		2.22E-03	2.22E-03	2.22E-03	Ci		2.22E-03				
148	233U	Ci		9.38E-03	9.38E-03	9.38E-03	Ci		9.38E-03				
149	234U	Ci		1.63E-03	1.63E-03	1.63E-03	Ci		1.63E-03				
150	235U	Ci		6.47E-05	6.47E-05	6.47E-05	Ci		6.47E-05				
151	236U	Ci		5.22E-05	5.22E-05	5.22E-05	Ci		5.22E-05				
152	237Np	Ci		3.88E-02	3.88E-02	2.25E-01	Ci		3.03E-01				
153	238Pu	Ci		1.85E-03	1.85E-03	1.02E+00	Ci		5.50E+00				
154	238U	Ci		1.45E-03	1.45E-03	1.45E-03	Ci		1.45E-03				
155	239Pu	Ci		7.21E-02	7.21E-02	1.40E+01	Ci		7.58E+01				
156	240Pu	Ci		1.22E-02	1.22E-02	3.66E+00	Ci		1.97E+01				
157	241Am	Ci		1.07E-01	1.07E-01	4.69E+02	Ci		1.47E+03				
158	241Pu	Ci		6.58E-02	6.58E-02	6.39E+01	Ci		3.46E+02				
159	242Cm	Ci		2.77E-04	2.77E-04	9.22E-01	Ci		4.73E+00				
160	242Pu	Ci		7.41E-07	7.41E-07	3.85E-04	Ci		2.09E-03				
161	243Am	Ci		3.89E-06	3.89E-06	3.09E-01	Ci		9.66E-01				
162	243Cm	Ci		2.29E-05	2.29E-05	5.08E-02	Ci		1.59E-01				
163	244Cm	Ci		1.97E-04	1.97E-04	1.21E+00	Ci		3.77E+00				
164	3H	Ci		4.09E+00	4.09E+00	4.09E+00	Ci		4.09E+00				
165	59Ni	Ci		3.82E-02	3.82E-02	3.82E-02	Ci		3.82E-02				
166	60Co	Ci		2.13E-01	2.13E-01	2.13E-01	Ci		2.13E-01				
167	63Ni	Ci		3.51E+00	3.51E+00	3.51E+00	Ci		3.51E+00				
168	79Se	Ci		5.05E-03	5.05E-03	5.05E-03	Ci		5.05E-03				
169	90Sr	Ci		5.66E+01	5.66E+01	2.49E+05	Ci		3.65E+05				
170	90Y	Ci		5.66E+01	5.66E+01	5.66E+01	Ci		5.66E+01				
171	93mNb	Ci		3.99E-01	3.99E-01	3.99E-01	Ci		3.99E-01				
172	93Zr	Ci		4.62E-01	4.62E-01	4.62E-01	Ci		4.62E-01				
173	99Tc	Ci		1.06E+01	1.06E+01	1.05E+01	Ci		1.05E+01			M.W.	Mass of Precipitated Solids
174	Al	kg		1.57E+04	1.57E+04	1.57E+04	kg		1.57E+04	0.00E+00			
175	Aroclors (Total PCB)	kg		3.85E+00	3.85E+00		kg						
176	Bi	kg		1.52E+00	1.52E+00	1.52E+00	kg		1.52E+00	0.00E+00			
177	Ca	kg		1.65E+04	1.65E+04	1.68E+04	kg		1.70E+04	1.73E+02	CaCO3	100	4.31E+02
178	Cl	kg		2.91E+02	2.91E+02	2.91E+02	kg		2.91E+02	0.00E+00			
179	Cr	kg		2.59E+01	2.59E+01	2.43E+02	kg		3.10E+02	6.73E+01	Cr(OH)3	103	1.33E+02
180	F	kg		8.21E+00	8.21E+00	8.21E+00	kg	Includes added Mn that precipitates.	8.21E+00	0.00E+00			
181	Fe	kg		9.07E-01	9.07E-01	1.30E+02	kg		2.68E+03	2.55E+03	Fe(OH)3	106.85	4.88E+03
182	Free OH	kg		1.20E+03	1.20E+03	1.20E+03	kg		1.20E+03	3.87E-12			
183	Hg	kg		0.00E+00	0.00E+00		kg		0.00E+00	0.00E+00			
184	K	kg		1.85E+02	1.85E+02	1.85E+02	kg		1.85E+02	0.00E+00			
185	La	kg		4.60E-01	4.60E-01	4.02E+01	kg		8.36E+01	4.34E+01	La(OH)3	189.9	5.93E+01
186	Mn	kg		1.49E+00	1.49E+00	7.18E+03	kg		1.10E+04	3.79E+03	NaMn(O)(OH)(O)	126.94	8.76E+03
187	Na	kg		9.18E+03	9.18E+03	9.18E+03	kg		9.18E+03	0.00E+00			
188	Ni	kg		1.28E+00	1.28E+00	1.28E+00	kg		1.28E+00	0.00E+00			
189	NO2	kg		4.67E+03	4.67E+03	4.67E+03	kg		4.67E+03	0.00E+00			
190	NO3	kg		7.58E+03	7.58E+03	7.58E+03	kg		7.58E+03	1.62E-11			
191	Oxalate	kg		4.10E+01	4.10E+01	4.10E+01	kg	Includes added Sr that precipitates.	4.10E+01	0.00E+00			
192	Pb	kg		2.65E+00	2.65E+00	1.70E+02	kg		3.51E+02	1.81E+02	Pb(OH)4	275.2	2.41E+02
193	PO4	kg		2.65E+04	2.65E+04	2.65E+04	kg		2.65E+04	0.00E+00			
194	Si	kg		3.74E+00	3.74E+00	3.74E+00	kg		3.74E+00	0.00E+00			
195	SO4	kg		1.51E+02	1.51E+02	1.51E+02	kg		1.51E+02	0.00E+00			
196	Sr	kg		1.53E-01	1.53E-01	1.07E+04	kg		1.52E+04	4.53E+03	SrCO3	147.62	7.64E+03
197	Th	kg		6.99E+00	6.99E+00	6.99E+00	kg		6.99E+00	0.00E+00			
198	TIC as CO3	kg		1.10E+03	1.10E+03	8.85E+03	kg		1.21E+04	3.29E+03			
199	TOC	kg		2.16E+02	2.16E+02	2.16E+02	kg		2.16E+02	0.00E+00			
200	UTOTAL	kg		4.36E+00	4.36E+00	4.36E+00	kg		4.36E+00	0.00E+00			
201	Zr	kg		8.25E-01	8.25E-01	2.12E+01	kg		9.98E+01	7.85E+01	Zr(OH)4	159.22	1.37E+02
202													
203	Density	gm/ml		1.75	1.75								
204	Volume	Liters	0	88,000	88,000								
205	Inches of sludge		0.0	8.5	8.5	15.3			19.5				
206													
207	Total	kgs										kg	2.23E+04
208													
209	wt% settled solids	wt%						Volume conversion to inches uses 2750 gal/in in the DSTs. Note this should not be used when working with the lower 6 inches of the tank. Use volume calculator from RPP-13019 (CH2M Hill).				wt%	39.0%
210	settled solids density	gm/ml										gm/ml	1.3
211	volume of settled solids	liters										liters	4.39E+04
212		gallons										gallons	1.16E+04
213		inches										inches	4.2

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ATTACHMENT 9

AN-107 BATCH #4

	A	B	C	E	G	H	I	J	K	L	M	N	O	P
1	Supernatant - Batch 4		AN-107 Supernate	AN-107 Batch 3 Treated Waste Composition	AN-107 + AN-107 Batch 3 Heel	Dilution Water	Diluted AN-107 + AN-107 Batch 3 Heel		Diluted AN-107 + AN-107 Batch 3 Heel	3M $Sr(NO_3)_2$	40wt% $NaMnO_4$ (3.83M)	Percent Removal from Supernate	Treated Waste	Precipitate
2	Analyte	Units	Adjusted Concentration	Adjusted Concentration	Adjusted Concentration			Units	Unit Change					
3	106Ru	uCi/g	3.15E-09	2.15E-09	3.10E-09		2.18E-09	uCi/ml	2.75E-09			0.0%	2.72E-09	
4	113mCd	uCi/g	1.37E-02	9.37E-03	1.35E-02		9.47E-03	uCi/ml	1.20E-02			0.0%	1.18E-02	
5	125Sb	uCi/g	1.32E-03	9.20E-04	1.30E-03		9.13E-04	uCi/ml	1.15E-03			0.0%	1.14E-03	
6	126Sn	uCi/g	6.62E-03	4.46E-03	6.50E-03		4.57E-03	uCi/ml	5.77E-03			0.0%	5.70E-03	
7	129I	uCi/g	8.13E-05	5.55E-05	7.99E-05		5.62E-05	uCi/ml	7.09E-05			0.0%	7.01E-05	
8	134Cs	uCi/g	1.80E-03	1.23E-03	1.77E-03		1.24E-03	uCi/ml	1.57E-03			0.0%	1.55E-03	
9	137Cs	uCi/g	2.18E+02	1.49E+02	2.14E+02		1.51E+02	uCi/ml	1.90E+02			0.0%	1.88E+02	
10	137mBa	uCi/g	2.06E+02	1.41E+02	2.02E+02		1.42E+02	uCi/ml	1.80E+02			0.0%	1.78E+02	
11	14C	uCi/g	4.36E-04	2.98E-04	4.28E-04		3.01E-04	uCi/ml	3.80E-04			0.0%	3.76E-04	
12	151Sm	uCi/g	2.09E+00	1.43E+00	2.05E+00		1.44E+00	uCi/ml	1.82E+00			0.0%	1.80E+00	
13	152Eu	uCi/g	2.31E-04	2.29E-05	2.20E-04		1.54E-04	uCi/ml	1.95E-04			85.0%	2.89E-05	
14	154Eu	uCi/g	2.52E-01	2.49E-02	2.40E-01		1.69E-01	uCi/ml	2.13E-01			85.0%	3.15E-02	
15	155Eu	uCi/g	1.37E-01	1.35E-02	1.30E-01		9.16E-02	uCi/ml	1.16E-01			85.0%	1.71E-02	
16	226Ra	uCi/g	2.31E-08	1.58E-08	2.27E-08		1.60E-08	uCi/ml	2.02E-08			0.0%	1.99E-08	
17	227Ac	uCi/g	2.84E-06	1.94E-06	2.79E-06		1.96E-06	uCi/ml	2.48E-06			0.0%	2.45E-06	
18	228Ra	uCi/g	6.94E-06	4.74E-06	6.82E-06		4.80E-06	uCi/ml	6.05E-06			0.0%	5.98E-06	
19	229Th	uCi/g	1.14E-08	7.80E-09	1.12E-08		7.88E-09	uCi/ml	9.94E-09			0.0%	9.83E-09	
20	231Pa	uCi/g	2.98E-05	2.04E-05	2.93E-05		2.06E-05	uCi/ml	2.60E-05			0.0%	2.57E-05	
21	232Th	uCi/g	1.36E-06	8.97E-07	1.33E-06		9.39E-07	uCi/ml	1.18E-06			0.0%	1.17E-06	
22	232U	uCi/g	6.97E-07	4.61E-07	6.84E-07		4.81E-07	uCi/ml	6.07E-07			0.0%	6.00E-07	
23	233U	uCi/g	4.28E-05	2.83E-05	4.20E-05		2.95E-05	uCi/ml	3.73E-05			0.0%	3.68E-05	
24	234U	uCi/g	3.03E-05	2.00E-05	2.97E-05		2.09E-05	uCi/ml	2.64E-05			0.0%	2.61E-05	
25	235U	uCi/g	1.20E-06	7.94E-07	1.18E-06		8.28E-07	uCi/ml	1.05E-06			0.0%	1.03E-06	
26	236U	uCi/g	2.05E-06	1.36E-06	2.01E-06		1.41E-06	uCi/ml	1.79E-06			0.0%	1.76E-06	
27	237Np	uCi/g	4.00E-05	3.96E-06	3.80E-05		2.67E-05	uCi/ml	3.38E-05			85.0%	5.00E-06	
28	238Pu	uCi/g	2.31E-03	2.28E-04	2.20E-03		1.54E-03	uCi/ml	1.95E-03			85.0%	2.89E-04	
29	238U	uCi/g	2.37E-05	1.57E-05	2.33E-05		1.64E-05	uCi/ml	2.06E-05			0.0%	2.04E-05	
30	239Pu	uCi/g	3.18E-02	3.14E-03	3.02E-02		2.13E-02	uCi/ml	2.68E-02			85.0%	3.98E-03	
31	240Pu	uCi/g	8.27E-03	8.15E-04	7.86E-03		5.53E-03	uCi/ml	6.98E-03			85.0%	1.03E-03	
32	241Am	uCi/g	5.15E-01	5.08E-02	4.90E-01		3.44E-01	uCi/ml	4.35E-01			85.0%	6.44E-02	
33	241Pu	uCi/g	1.45E-01	1.43E-02	1.38E-01		9.70E-02	uCi/ml	1.22E-01			85.0%	1.81E-02	
34	242Cm	uCi/g	1.96E-03	1.93E-04	1.86E-03		1.31E-03	uCi/ml	1.65E-03			85.0%	2.45E-04	
35	242Pu	uCi/g	8.75E-07	8.63E-08	8.32E-07		5.85E-07	uCi/ml	7.39E-07			85.0%	1.09E-07	
36	243Am	uCi/g	3.38E-04	3.33E-05	3.21E-04		2.26E-04	uCi/ml	2.85E-04			85.0%	4.23E-05	
37	243Cm	uCi/g	5.56E-05	5.49E-06	5.29E-05		3.72E-05	uCi/ml	4.69E-05			85.0%	6.96E-06	
38	244Cm	uCi/g	1.32E-03	1.30E-04	1.26E-03		8.83E-04	uCi/ml	1.11E-03			85.0%	1.65E-04	
39	3H	uCi/g	4.51E-04	3.05E-04	4.43E-04		3.12E-04	uCi/ml	3.93E-04			0.0%	3.89E-04	
40	59Ni	uCi/g	1.49E-02	9.79E-03	1.46E-02		1.03E-02	uCi/ml	1.30E-02			0.0%	1.28E-02	
41	60Co	uCi/g	4.53E-02	3.06E-02	4.45E-02		3.13E-02	uCi/ml	3.95E-02			0.0%	3.90E-02	
42	63Ni	uCi/g	1.04E+00	6.84E-01	1.02E+00		7.18E-01	uCi/ml	9.06E-01			0.0%	8.95E-01	
43	79Se	uCi/g	5.65E-04	3.81E-04	5.55E-04		3.90E-04	uCi/ml	4.93E-04			0.0%	4.87E-04	
44	90Sr	uCi/g	5.40E+01	2.13E+00	5.12E+01		3.60E+01	uCi/ml	4.54E+01			94.0%	2.69E+00	
45	90Y	uCi/g	5.40E+01	3.67E+01	5.31E+01		3.73E+01	uCi/ml	4.71E+01			0.0%	4.65E+01	
46	93mNb	uCi/g	1.33E-02	9.10E-03	1.31E-02		9.19E-03	uCi/ml	1.16E-02			0.0%	1.15E-02	
47	93Zr	uCi/g	1.60E-02	1.09E-02	1.57E-02		1.11E-02	uCi/ml	1.40E-02			0.0%	1.38E-02	
48	99Tc	uCi/g	5.69E-02	3.97E-02	5.60E-02		3.93E-02	uCi/ml	4.97E-02			0.0%	4.91E-02	

	U	V	W	X	Y
1	AN-107		AN-107 Batch 3 Treated Waste	Unit Change	AN-107 Batch 3 Treated Waste
2	Analyte	Units		Units	
3	106Ru	uCi/ml	2.72E-09	uCi/g	2.15E-09
4	113mCd	uCi/ml	1.18E-02	uCi/g	9.37E-03
5	125Sb	uCi/ml	1.16E-03	uCi/g	9.20E-04
6	126Sn	uCi/ml	5.63E-03	uCi/g	4.46E-03
7	129I	uCi/ml	7.01E-05	uCi/g	5.55E-05
8	134Cs	uCi/ml	1.55E-03	uCi/g	1.23E-03
9	137Cs	uCi/ml	1.89E+02	uCi/g	1.49E+02
10	137mBa	uCi/ml	1.78E+02	uCi/g	1.41E+02
11	14C	uCi/ml	3.76E-04	uCi/g	2.98E-04
12	151Sm	uCi/ml	1.80E+00	uCi/g	1.43E+00
13	152Eu	uCi/ml	2.89E-05	uCi/g	2.29E-05
14	154Eu	uCi/ml	3.14E-02	uCi/g	2.49E-02
15	155Eu	uCi/ml	1.70E-02	uCi/g	1.35E-02
16	226Ra	uCi/ml	1.99E-08	uCi/g	1.58E-08
17	227Ac	uCi/ml	2.45E-06	uCi/g	1.94E-06
18	228Ra	uCi/ml	5.98E-06	uCi/g	4.74E-06
19	229Th	uCi/ml	9.85E-09	uCi/g	7.80E-09
20	231Pa	uCi/ml	2.57E-05	uCi/g	2.04E-05
21	232Th	uCi/ml	1.13E-06	uCi/g	8.97E-07
22	232U	uCi/ml	5.82E-07	uCi/g	4.61E-07
23	233U	uCi/ml	3.58E-05	uCi/g	2.83E-05
24	234U	uCi/ml	2.53E-05	uCi/g	2.00E-05
25	235U	uCi/ml	1.00E-06	uCi/g	7.94E-07
26	236U	uCi/ml	1.71E-06	uCi/g	1.36E-06
27	237Np	uCi/ml	5.00E-06	uCi/g	3.96E-06
28	238Pu	uCi/ml	2.88E-04	uCi/g	2.28E-04
29	238U	uCi/ml	1.98E-05	uCi/g	1.57E-05
30	239Pu	uCi/ml	3.96E-03	uCi/g	3.14E-03
31	240Pu	uCi/ml	1.03E-03	uCi/g	8.15E-04
32	241Am	uCi/ml	6.41E-02	uCi/g	5.08E-02
33	241Pu	uCi/ml	1.80E-02	uCi/g	1.43E-02
34	242Cm	uCi/ml	2.44E-04	uCi/g	1.93E-04
35	242Pu	uCi/ml	1.09E-07	uCi/g	8.63E-08
36	243Am	uCi/ml	4.21E-05	uCi/g	3.33E-05
37	243Cm	uCi/ml	6.92E-06	uCi/g	5.49E-06
38	244Cm	uCi/ml	1.64E-04	uCi/g	1.30E-04
39	3H	uCi/ml	3.85E-04	uCi/g	3.05E-04
40	59Ni	uCi/ml	1.24E-02	uCi/g	9.79E-03
41	60Co	uCi/ml	3.86E-02	uCi/g	3.06E-02
42	63Ni	uCi/ml	8.63E-01	uCi/g	6.84E-01
43	79Se	uCi/ml	4.81E-04	uCi/g	3.81E-04
44	90Sr	uCi/ml	2.69E+00	uCi/g	2.13E+00
45	90Y	uCi/ml	4.64E+01	uCi/g	3.67E+01
46	93mNb	uCi/ml	1.15E-02	uCi/g	9.10E-03
47	93Zr	uCi/ml	1.38E-02	uCi/g	1.09E-02
48	99Tc	uCi/ml	5.01E-02	uCi/g	3.97E-02

BEST AVAILABLE COPY

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
49	Ag	ug/g	1.34E+00		9.29E-01		1.32E+00		9.26E-01	M	1.08E-05			0.0%	1.07E-05					
50	Al	ug/g	7.85E+02		7.69E+02		7.84E+02		5.51E+02	M	2.56E-02			0.0%	2.55E-02					
51	Aroclors (Total PCB)	ug/g	2.80E-03				2.65E-03		1.86E-03											
52	As	ug/g	9.09E-01		1.09E+00		9.19E-01		6.46E-01	M	1.09E-05			0.0%	1.08E-05					
53	B	ug/g	1.57E+01		1.10E+01		1.54E+01		1.09E+01	M	1.27E-03			0.0%	1.25E-03					
54	Ba	ug/g	6.63E+00		3.64E+00		6.47E+00		4.55E+00	M	4.18E-05			19.0%	3.35E-05					
55	Be	ug/g	1.32E-01		9.90E-02		1.30E-01		9.15E-02	M	1.28E-05			0.0%	1.27E-05					
56	Bi	ug/g	5.83E+00		4.30E+00		5.75E+00		4.04E+00	M	2.44E-05			0.0%	2.41E-05					
57	Ca	ug/g	3.89E+02		2.11E+02		3.79E+02		2.67E+02	M	8.42E-03			19.0%	6.74E-03					
58	Cd	ug/g	4.38E+01		2.97E+01		4.30E+01		3.03E+01	M	3.40E-04			0.0%	3.36E-04					
59	Ce	ug/g	3.38E+01		3.32E+00		3.21E+01		2.26E+01	M	2.04E-04			85.0%	3.02E-05					
60	Cl	ug/g	1.24E+03		8.83E+02		1.22E+03		8.58E+02	M	3.06E-02			0.0%	3.02E-02					
61	Co	ug/g	2.92E+00		1.96E+00		2.87E+00		2.02E+00	M	4.32E-05			0.0%	4.27E-05					
62	Cr	ug/g	1.19E+02		6.43E+01		1.16E+02		8.16E+01	M	1.98E-03			21.0%	1.55E-03					
63	Cu	ug/g	2.01E+01		1.36E+01		1.97E+01		1.39E+01	M	2.76E-04			0.0%	2.73E-04					
64	F	ug/g	6.79E+01		4.55E+01		6.67E+01		4.69E+01	M	3.12E-03			0.0%	3.08E-03					
65	Fe	ug/g	1.15E+03		2.26E+01		1.09E+03		7.65E+02	M	1.73E-02			97.0%	5.13E-04					
66	Free OH	ug/g	1.26E+04		8.41E-03		1.24E+04		8.70E+03	M	6.46E-01			0.0%	6.38E-01					
67	Hg	ug/g	1.53E-01		1.01E-01		1.50E-01		1.06E-01	M	6.64E-07			0.0%	6.57E-07					
68	K	ug/g	1.21E+03		8.29E+02		1.19E+03		8.36E+02	M	2.70E-02			0.0%	2.67E-02					
69	La	ug/g	2.23E+01		2.19E+00		2.12E+01		1.49E+01	M	1.36E-04			85.0%	2.00842E-05					
70	Li	ug/g	2.04E+00		1.35E+00		2.00E+00		1.41E+00	M	2.56E-04			0.0%	2.53E-04					
71	Mg	ug/g	9.75E-01		1.14E+00		9.84E-01		6.92E-01	M	3.59E-05			0.0%	3.55E-05					
72	Mn	ug/g	3.41E+02		8.93E+00		3.23E+02		2.27E+02	M	5.22E-03		3.83	96.0%	2.06E-04					
73	Mo	ug/g	2.34E+01		1.62E+01		2.30E+01		1.62E+01	M	2.13E-04			0.0%	2.10E-04					
74	Na	ug/g	1.45E+05		9.94E+04		1.43E+05		1.00E+05	M	5.50E+00		3.83	0.0%	5.45E+00					
75	Nd	ug/g	6.42E+01		6.31E+00		6.11E+01		4.29E+01	M	3.76E-04			85.0%	5.57E-05					
76	NH3	ug/g	3.41E+01		2.47E+01		3.36E+01		2.36E+01	M	1.75E-03			0.0%	1.73E-03					
77	Ni	ug/g	3.66E+02		2.47E+02		3.60E+02		2.53E+02	M	5.44E-03			0.0%	5.37E-03					
78	NO2	ug/g	4.66E+04		3.21E+04		4.55E+04		3.22E+04	M	8.84E-01			0.0%	8.73E-01					
79	NO3	ug/g	1.46E+05		1.01E+05		1.44E+05		1.01E+05	M	2.06E+00	6.00		0.0%	2.07E+00					
80	Oxalate	ug/g	6.37E+02		4.32E+02		6.26E+02		4.40E+02	M	6.46E-03			0.0%	6.35E-03					
81	Pb	ug/g	2.62E+02		1.21E+02		2.54E+02		1.79E+02	M	1.09E-03			30.0%	7.54E-04					
82	PO4	ug/g	1.08E+03		8.03E+02		1.06E+03		7.49E+02	M	9.95E-03			0.0%	9.83E-03					
83	Rh	ug/g	1.75E+01				1.65E+01		1.16E+01	M	1.43E-04			0.0%	1.41E-04					
84	Sb	ug/g	2.24E-01		0.150283229		2.20E-01		1.55E-01	M	1.60E-06			0.0%	1.58E-06					
85	Se	ug/g	5.67E-01		0.864284243		5.83E-01		4.10E-01	M	6.56E-06			0.0%	6.48E-06					
86	Si	ug/g	9.16E+00		6.62E+00		9.05E+00		6.36E+00	M	2.86E-04			0.0%	2.63E-04					
87	SO4	ug/g	5.71E+03		4.01E+03		5.62E+03		3.95E+03	M	5.19E-02			0.0%	5.13E-02					
88	Sr	ug/g	1.32E+00		1.18E+02		7.66E+00		5.39E+00	M	7.76E-05	3.00		94.0%	1.20E-03		1.71E-03			
89	Ta	ug/g	1.70E+01				1.61E+01		1.13E+01	M	7.89E-05			0.0%	7.79E-05		Equilibrium Value			
90	Th	ug/g	1.24E+01		8.15E+00		1.22E+01		8.56E+00	M	4.65E-05			0.0%	4.60E-05					
91	Ti	ug/g	9.98E-01		0.664813266		9.80E-01		6.89E-01	M	1.82E-05			0.0%	1.79E-05					
92	TIC as CO3	ug/g	5.16E+04		3.42E+04		5.07E+04		3.56E+04	M	7.49E-01			2.7%	7.20E-01					
93	Tl	ug/g	8.73E-02		0.092112966		8.76E-02		6.16E-02	M	3.80E-07			0.0%	3.76E-07					
94	TOC	ug/g	2.26E+04		1.53E+04		2.22E+04		1.56E+04	M	1.64E+00			0.0%	1.62E+00					
95	UTOTAL	ug/g	7.12E+01		4.69E+01		6.99E+01		4.91E+01	M	2.61E-04			0.0%	2.57E-04					
96	V	ug/g	4.91E-01		0.370182213		4.84E-01		3.41E-01	M	8.44E-06			0.0%	8.34E-06					
97	Y	ug/g	6.02E+00		3.975634237		5.91E+00		4.15E+00	M	5.90E-05			0.0%	5.83E-05					
98	Zn	ug/g	1.32E+01		8.682280872		1.30E+01		9.11E+00	M	1.76E-04			0.0%	1.74E-04					
99	Zr	ug/g	4.19E+01		4.94E+00		3.99E+01		2.80E+01	M	3.88E-04			82.0%	6.90E-05					
100	Sum of TRU	uCi/g	5.59E-01		5.52E-02		5.32E-01		3.74E-01	uCi/ml	0.47				0.07					
101	Supernate density	gm/ml	1.43		1.26		1.42	1.00	1.26	gm/ml	1.26									
102	Sum of TRU	uCi/ml	6.00E-01		6.98E-02		7.55E-01		4.72E-01	uCi/ml					7.00E-02					
103	Sr-90	uCi/ml	77.22		2.69		72.66		45.43	uCi/ml	45.43				2.69E+00					
104																				
105	Na concentration	M	9.02		5.45		8.60		5.50						5.45					
106																				
107	wt% Na_2O in glass		15.0%		15.0%		15.0%		15.0%						15.0%					
108	wt% SO_3 in glass		0.4%		0.4%		0.4%		0.4%						0.4%					
109	MT/m3 glass density		2.76		2.76		2.76		2.76						2.76					
110	gm glass/liter of waste		1.86E+03		1.13E+03		1.82E+03		1.14E+03						1.13E+03					
111	m3 per liter of waste		6.75E-04		4.08E-04		6.59E-04		4.12E-04						4.06E-04					
112																				
113	TRU in glass	nCi/gm	429.15		61.74		415.22		415.2	nCi/gm					62.1					
114	TRU Removal Required to achieve	50 nCi/gm	88.3%		n/a		88.0%	n/a	88.0%											
115	Sr-90 in glass	Ci/m3	114.39		6.59		110.30		110.30	Ci/m3					6.59					
116	Sr-90 Removal Required to achieve	10 Ci/m^3	91.3%		n/a		90.9%	n/a	90.9%											
117	Batch Volume	Liters	[redacted]		1.04E+05		1.70E+06	1.02E+06	2.72E+06	Liters	2.72E+06	1.83E+04	1.44E+04	Liters	2.75E+06					
118		Gallons	4.22E+05		2.75E+04		4.50E+05	2.69E+05	7.19E+05	Gallons	7.19E+05	4.83E+03	3.82E+03	Gallons	7.28E+05					
119	Height of Supernatant	Inches	153.5		10.0		163.5		261.5		261.5				264.6					
120	Target Na M							[redacted]												
121	Sr M											3.00			0.02					
122	Moles Sr Added											5.49E+04								
123	MnO_4 M												3.83		0.02					
124	Mole Mn Added												5.54E+04							
125																				

AN-107 Batch 2 includes 10" of AN-107 Treated Waste Composition.

The percent removal is for the Mn present in the sample before addition of permanganate. All added permanganate precipitates. AN-107 averaged 96% removal. AN-102 averaged 30% removal.

Consistency check: Calculate the Sr-90 concentration using the equilibrium concentration of Sr-90 / total Sr equal to 0.018 µCi/µg.

The moles of carbonate removed are equal to the amount of Sr added.

U	V	W	X	Y
Ag	M	1.09E-05	ug/g	9.28E-01
Al	M	3.60E-02	ug/g	7.69E+02
Aroclors (Total PCB)			ug/g	
As	M	1.83E-05	ug/g	1.08E+00
B	M	1.28E-03	ug/g	1.10E+01
Ba	M	3.35E-05	ug/g	3.64E+00
Be	M	1.39E-05	ug/g	9.90E-02
Bi	M	2.60E-05	ug/g	4.30E+00
Ca	M	6.66E-03	ug/g	2.11E+02
Cd	M	3.34E-04	ug/g	2.97E+01
Ce	M	2.99E-05	ug/g	3.32E+00
Cl	M	3.14E-02	ug/g	8.83E+02
Co	M	4.19E-05	ug/g	1.96E+00
Cr	M	1.56E-03	ug/g	6.43E+01
Cu	M	2.71E-04	ug/g	1.36E+01
F	M	3.02E-03	ug/g	4.55E+01
Fe	M	5.10E-04	ug/g	2.26E+01
Free OH	M	6.24E-01	ug/g	8.40E+03
Hg	M	6.35E-07	ug/g	1.01E-01
K	M	2.68E-02	ug/g	8.29E+02
La	M	1.99217E-05	ug/g	2.19E+00
Li	M	2.46E-04	ug/g	1.35E+00
Mg	M	5.90E-05	ug/g	1.14E+00
Mn	M	2.05E-04	ug/g	8.93E+00
Mo	M	2.13E-04	ug/g	1.62E+01
Na	M	5.45E+00	ug/g	9.94E+04
Nd	M	5.52E-05	ug/g	6.30E+00
NH3	M	1.84E-03	ug/g	2.47E+01
Ni	M	5.30E-03	ug/g	2.47E+02
NO2	M	8.80E-01	ug/g	3.21E+04
NO3	M	2.06E+00	ug/g	1.01E+05
Oxalate	M	6.34E-03	ug/g	4.32E+02
Pb	M	7.39E-04	ug/g	1.21E+02
PO4	M	1.07E-02	ug/g	6.02E+02
Rh	M	1.40E-04	ug/g	
Sb	M	1.56E-06	ug/g	1.50E-01
Se	M	1.38E-05	ug/g	8.64E-01
Si	M	3.00E-04	ug/g	6.61E+00
SO4	M	5.27E-02	ug/g	4.01E+03
Sr	M	1.70E-03	ug/g	1.18E+02
Ta	M	7.75E-05	ug/g	
Th	M	4.43E-05	ug/g	8.14E+00
Ti	M	1.75E-05	ug/g	6.65E-01
TIC as CO3	M	7.19E-01	ug/g	3.42E+04
Tl	M	5.69E-07	ug/g	9.21E-02
TOC	M	1.61E+00	ug/g	1.53E+04
UTOTAL	M	2.49E-04	ug/g	4.69E+01
V	M	9.17E-06	ug/g	3.70E-01
Y	M	5.64E-05	ug/g	3.97E+00
Zn	M	1.68E-04	ug/g	8.68E+00
Zr	M	6.83E-05	ug/g	4.93E+00

Row	A	B	C	E	G	I	J
126	Sludge			Inventory AP-102	AP-102 Heel	AN-107 Batch #3 Treated Waste	
127	Analyte	Units					Units
128	106Ru	Ci		2.42E-07	2.42E-07	2.42E-07	Ci
129	113mCd	Ci		1.53E+00	1.53E+00	1.53E+00	Ci
130	125Sb	Ci		7.30E-01	7.30E-01	7.30E-01	Ci
131	126Sn	Ci		5.71E-02	5.71E-02	5.71E-02	Ci
132	129I	Ci		1.77E-02	1.77E-02	1.77E-02	Ci
133	134Cs	Ci		7.13E-03	7.13E-03	7.13E-03	Ci
134	137Cs	Ci		1.25E+04	1.25E+04	1.25E+04	Ci
135	137mBa	Ci		1.18E+04	1.18E+04	1.18E+04	Ci
136	14C	Ci		7.41E-01	7.41E-01	7.41E-01	Ci
137	151Sm	Ci		3.08E+02	3.08E+02	3.08E+02	Ci
138	152Eu	Ci		7.34E-02	7.34E-02	1.74E+00	Ci
139	154Eu	Ci		6.16E+00	6.16E+00	1.02E+03	Ci
140	155Eu	Ci		1.37E+00	1.37E+00	2.99E+02	Ci
141	226Ra	Ci		3.82E-06	3.82E-06	3.82E-06	Ci
142	227Ac	Ci		4.04E-05	4.04E-05	4.04E-05	Ci
143	228Ra	Ci		4.70E-03	4.70E-03	4.70E-03	Ci
144	229Th	Ci		1.66E-04	1.66E-04	1.66E-04	Ci
145	231Pa	Ci		1.09E-04	1.09E-04	1.09E-04	Ci
146	232Th	Ci		7.70E-04	7.70E-04	7.70E-04	Ci
147	232U	Ci		2.22E-03	2.22E-03	2.22E-03	Ci
148	233U	Ci		9.38E-03	9.38E-03	9.38E-03	Ci
149	234U	Ci		1.63E-03	1.63E-03	1.63E-03	Ci
150	235U	Ci		6.47E-05	6.47E-05	6.47E-05	Ci
151	236U	Ci		5.22E-05	5.22E-05	5.22E-05	Ci
152	237Np	Ci		3.88E-02	3.88E-02	3.03E-01	Ci
153	238Pu	Ci		1.85E-03	1.85E-03	5.50E+00	Ci
154	238U	Ci		1.45E-03	1.45E-03	1.45E-03	Ci
155	239Pu	Ci		7.21E-02	7.21E-02	7.58E+01	Ci
156	240Pu	Ci		1.22E-02	1.22E-02	1.97E+01	Ci
157	241Am	Ci		1.07E-01	1.07E-01	1.47E+03	Ci
158	241Pu	Ci		8.58E-02	8.58E-02	3.48E+02	Ci
159	242Cm	Ci		2.77E-04	2.77E-04	4.73E+00	Ci
160	242Pu	Ci		7.41E-07	7.41E-07	2.09E-03	Ci
161	243Am	Ci		3.89E-06	3.89E-06	9.66E-01	Ci
162	243Cm	Ci		2.29E-05	2.29E-05	1.59E-01	Ci
163	244Cm	Ci		1.97E-04	1.97E-04	3.77E+00	Ci
164	3H	Ci		4.09E+00	4.09E+00	4.09E+00	Ci
165	59Ni	Ci		3.82E-02	3.82E-02	3.82E-02	Ci
166	60Co	Ci		2.13E-01	2.13E-01	2.13E-01	Ci
167	63Ni	Ci		3.51E+00	3.51E+00	3.51E+00	Ci
168	79Se	Ci		5.05E-03	5.05E-03	5.06E-03	Ci
169	90Sr	Ci		5.66E+01	5.66E+01	3.65E+05	Ci
170	90Y	Ci		5.66E+01	5.66E+01	5.66E+01	Ci
171	93mNb	Ci		3.99E-01	3.99E-01	3.99E-01	Ci
172	93Zr	Ci		4.62E-01	4.62E-01	4.62E-01	Ci
173	99Tc	Ci		1.06E+01	1.05E+01	1.05E+01	Ci
174	Al	kg		1.57E+04	1.57E+04	1.57E+04	kg
175	Arochlors (Total PCB)	kg		3.85E+00	3.85E+00		kg
176	Bi	kg		1.52E+00	1.52E+00	1.52E+00	kg
177	Ca	kg		1.65E+04	1.65E+04	1.70E+04	kg
178	Cl	kg		2.91E+02	2.91E+02	2.91E+02	kg
179	Cr	kg		2.59E+01	2.59E+01	3.10E+02	kg
180	F	kg		8.21E+00	8.21E+00	8.21E+00	kg
181	Fe	kg		9.07E-01	9.07E-01	2.68E+03	kg
182	Free OH	kg		1.20E+03	1.20E+03	1.20E+03	kg
183	Hg	kg		0.00E+00	0.00E+00		kg
184	K	kg		1.85E+02	1.85E+02	1.85E+02	kg
185	La	kg		4.80E-01	4.80E-01	8.36E+01	kg
186	Mn	kg		1.49E+00	1.49E+00	1.10E+04	kg
187	Na	kg		9.18E+03	9.18E+03	9.18E+03	kg
188	Ni	kg		1.28E+00	1.28E+00	1.28E+00	kg
189	NO2	kg		4.67E+03	4.67E+03	4.67E+03	kg
190	NO3	kg		7.58E+03	7.58E+03	7.58E+03	kg
191	Oxalate	kg		4.10E+01	4.10E+01	4.10E+01	kg
192	Pb	kg		2.65E+00	2.65E+00	3.51E+02	kg
193	PO4	kg		2.65E+04	2.65E+04	2.65E+04	kg
194	Si	kg		3.74E+00	3.74E+00	3.74E+00	kg
195	SO4	kg		1.51E+02	1.51E+02	1.51E+02	kg
196	Sr	kg		1.53E-01	1.53E-01	1.52E+04	kg
197	Th	kg		6.99E+00	6.99E+00	6.99E+00	kg
198	TIC as CO3	kg		1.10E+03	1.10E+03	1.21E+04	kg
199	TOC	kg		2.16E+02	2.16E+02	2.16E+02	kg
200	UTOTAL	kg		4.36E+00	4.36E+00	4.36E+00	kg
201	Zr	kg		8.25E-01	8.25E-01	9.98E+01	kg
202							
203	Density	gm/ml		1.75	1.75		
204	Volume	Liters	0	88,000	88,000		
205	Inches of sludge		0.0	8.5	8.5	19.5	
206							
207	Total	kgs					
208							
209	wt% settled solids	wt%					
210	settled solids density	gm/ml					
211	volume of settled solids	liters					
212		gallons					
213		inches					

Row	M	O	P	Q	R	S
126		Treated Waste	Precipitate	Species	M.W	Mass of Precipitated Solids
128		2.42E-07				
129		1.53E+00				
130		7.30E-01				
131		5.71E-02				
132		1.77E-02				
133		7.13E-03				
134		1.25E+04				
135		1.18E+04				
136		7.41E-01				
137		3.08E+02				
138		2.20E+00				
139		1.51E+03				
140		5.68E+02				
141		3.82E-06				
142		4.04E-05				
143		4.70E-03				
144		1.66E-04				
145		1.09E-04				
146		7.70E-04				
147		2.22E-03				
148		9.38E-03				
149		1.63E-03				
150		6.47E-05				
151		5.22E-05				
152		3.81E-01				
153		1.00E+01				
154		1.45E-03				
155		1.38E+02				
156		3.59E+01				
157		2.48E+03				
158		8.29E+02				
159		8.56E+00				
160		3.79E-03				
161		1.63E+00				
162		2.67E-01				
163		8.35E+00				
164		4.09E+00				
165		3.82E-02				
166		2.13E-01				
167		3.51E+00				
168		5.06E-03				
169		4.81E+06				
170		5.66E+01				
171		3.99E-01				
172		4.62E-01				
173		1.05E+01				
174		1.57E+04	0.00E+00		M.W	Mass of Precipitated Solids
175						
176		1.52E+00	0.00E+00			
177		1.71E+04	1.74E+02	CaCO3	100	4.35E+02
178		2.91E+02	0.00E+00			
179		3.77E+02	6.67E+01	Cr(OH)3	103	1.32E+02
180	Includes added Mn that precipitates.	8.21E+00	0.00E+00			
181		5.23E+03	2.55E+03	Fe(OH)3	106.85	4.88E+03
182		1.20E+03	0.00E+00			
183		-4.45E-17	-4.45E-17			
184		1.85E+02	0.00E+00			
185		1.27E+02	4.35E+01	La(OH)3	189.9	5.95E+01
186		1.48E+04	3.79E+03	NaMn(O)(OH)(O)	126.94	8.78E+03
187		9.18E+03	0.00E+00			
188		1.28E+00	0.00E+00			
189		4.67E+03	0.00E+00			
190	Includes added Sr that precipitates	7.58E+03	-2.00E-11			
191		4.10E+01	0.00E+00			
192		5.36E+02	1.84E+02	Pb(OH)4	275.2	2.45E+02
193		2.65E+04	0.00E+00			
194		3.74E+00	0.00E+00			
195		1.51E+02	0.00E+00			
196		1.96E+04	4.42E+03	SrCO3	147.62	7.44E+03
197		6.99E+00	0.00E+00			
198		1.54E+04	3.29E+03			
199		2.16E+02	0.00E+00			
200		4.36E+00	0.00E+00			
201		1.79E+02	7.90E+01	Zr(OH)4	159.22	1.38E+02
205		23.7				
207					kg	2.21E+04
209					wt%	39.0%
210					gm/ml	1.3
211					liters	4.36E+04
212					gallons	1.15E+04
213					inches	4.2

Total Solids in AP-102 After Final Treatment	
6.52E+04	gal
2.47E+06	L
3.21E+06	kg

Row	U	V	W	X
126	Sludge		Treated Waste	
127	Analyte	Units		Units
128	106Ru	Ci	2.42E-07	Ci
129	113mCd	Ci	1.53E+00	Ci
130	125Sb	Ci	7.30E-01	Ci
131	126Sn	Ci	5.71E-02	Ci
132	129I	Ci	1.77E-02	Ci
133	134Cs	Ci	7.13E-03	Ci
134	137Cs	Ci	1.25E+04	Ci
135	137mBa	Ci	1.18E+04	Ci
136	14C	Ci	7.41E-01	Ci
137	151Sm	Ci	3.08E+02	Ci
138	152Eu	Ci	5.26E-01	Ci
139	154Eu	Ci	4.97E+02	Ci
140	155Eu	Ci	2.87E+02	Ci
141	226Ra	Ci	3.82E-06	Ci
142	227Ac	Ci	4.04E-05	Ci
143	228Ra	Ci	4.70E-03	Ci
144	229Th	Ci	1.66E-04	Ci
145	231Pa	Ci	1.09E-04	Ci
146	232Th	Ci	7.70E-04	Ci
147	232U	Ci	2.22E-03	Ci
148	233U	Ci	9.38E-03	Ci
149	234U	Ci	1.63E-03	Ci
150	235U	Ci	6.47E-05	Ci
151	236U	Ci	5.22E-05	Ci
152	237Np	Ci	1.17E-01	Ci
153	238Pu	Ci	4.49E+00	Ci
154	238U	Ci	1.45E-03	Ci
155	239Pu	Ci	6.19E+01	Ci
156	240Pu	Ci	1.81E+01	Ci
157	241Am	Ci	1.00E+03	Ci
158	241Pu	Ci	2.82E+02	Ci
159	242Cm	Ci	3.61E+00	Ci
160	242Pu	Ci	1.70E-03	Ci
161	243Am	Ci	6.57E-01	Ci
162	243Cm	Ci	1.06E-01	Ci
163	244Cm	Ci	2.57E+00	Ci
164	3H	Ci	4.09E+00	Ci
165	59Ni	Ci	3.62E-02	Ci
166	60Co	Ci	2.13E-01	Ci
167	63Ni	Ci	3.51E+00	Ci
168	79Se	Ci	5.06E-03	Ci
169	90Sr	Ci	1.10E+05	Ci
170	90Y	Ci	5.66E+01	Ci
171	93mNb	Ci	3.99E-01	Ci
172	93Zr	Ci	4.62E-01	Ci
173	99Tc	Ci	1.06E+01	Ci
174	Al	kg	1.57E+04	kg
175	Arochlors (Tota	kg		kg
176	Bi	kg	1.52E+00	kg
177	Ca	kg	1.87E+04	kg
178	Cl	kg	2.91E+02	kg
179	Cr	kg	9.36E+01	kg
180	F	kg	8.21E+00	kg
181	Fe	kg	2.56E+03	kg
182	Free OH	kg	1.20E+03	kg
183	Hg	kg	-4.45E-17	kg
184	K	kg	1.85E+02	kg
185	La	kg	4.39E+01	kg
186	Mn	kg	3.81E+03	kg
187	Na	kg	9.18E+03	kg
188	Ni	kg	1.28E+00	kg
189	NO2	kg	4.67E+03	kg
190	NO3	kg	7.58E+03	kg
191	Oxalate	kg	4.10E+01	kg
192	Pb	kg	1.84E+02	kg
193	PO4	kg	2.65E+04	kg
194	Si	kg	3.74E+00	kg
195	SO4	kg	1.51E+02	kg
196	Sr	kg	4.44E+03	kg
197	Th	kg	6.99E+00	kg
198	TIC as CO3	kg	4.41E+03	kg
199	TOC	kg	2.16E+02	kg
200	UTOTAL	kg	4.36E+00	kg
201	Zr	kg	7.94E+01	kg
202				
203	Density			gm/ml
204	Volume			Liters
205	Inches of sludge		12.7	

Volume conversion to inches uses 2750 gal/in in the DSTs. Note this should not be used when working with the lower 6 inches of the tank. Use volume calculator from RPP-13019 (CH2M Hill).

APPENDIX B

HTWOS MODELING CONSTRAINTS, REQUIREMENTS, AND ASSUMPTIONS

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LIST OF TERMS

Terms

None

Abbreviations and Acronyms

BCR	Baseline Change Request
BBI	Best-Basis Inventory
BNI	Bechtel National, Inc.
BNI/WGI	Bechtel National-Washington Group
CH2M HILL	CH2M HILL Hanford Group, Inc.
CSB	Canister Storage Building
DOE	U.S. Department of Energy
DST	Double-shell tank
ETF	Effluent Treatment Facility
FY	Fiscal year
GPM	Glass Properties Model
HLW	High-level waste
HTWOS	Hanford Tank Waste Operations Simulator
ICD	Interface Control Document
IDF	Integrated Disposal Facility
IHLW	Immobilized high-level waste
ILAW	Immobilized low-activity waste
IMUST	Inactive miscellaneous underground storage tanks
LAW	Low-activity waste
LERF	Liquid Effluent Retention Facility
LLW	Low-level waste
MRS	Mobile Retrieval System
MSD	Mission Summary Diagram
ORP	U.S. Department of Energy, Office of River Protection
OSD	Operating Specification Document
PFP	Plutonium Finishing Plant
PUREX	Plutonium-Uranium Extraction Plant
RCRA	*Resource Conservation and Recovery Act of 1976*
RL	U.S. Department of Energy, Richland Operations Office
RPP	River Protection Project
SpG	Specific gravity
SST	Single-shell tank
STP	Supplemental Treatment Plant
SWL	Saltwell liquid
TFC	Tank Farm Contractor
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (or TPA)
TRU	transuranic
TWINS	Tank Waste Information Network System

Abbreviations and Acronyms, continued

VOC	Volatile organic carbon
WESF	Waste Encapsulation and Storage Facility
WSCF	Waste Sampling and Characterization Facility
WRF	Waste Retrieval Facility
WTP	Waste Treatment and Immobilization Plant
WVRF	Waste volume reduction factor

Units

Bq	Becquerels
Ci	Curies
ft	feet
ft^3	cubic feet
g	grams
g/mL	grams per milliliter
g-mol	gram mole
kg	kilograms
Kgal	kilogallons
L	liters
$\underline{M}$	molarity or moles per liter
m^2	square meters
m^3	cubic meters
Mgal	million gallons
MT	metric tons
MTG/d	metric tons of glass per day
nCi/g	nanocuries per gram
wt%	Weight percent

B1.0 INTRODUCTION

Appendix B presents a detailed discussion of the assumptions used in the Hanford Tank Waste Operations Simulator (HTWOS) model run performed to support one of a series of optimization studies. This appendix documents the assumptions and defines the major inputs for the HTWOS model that reflects the case (or cases) being examined by Optimization Study 2, *Strontium/Transuranic Separation Process in the Double-Shell Tank Systems.*

These technical assumptions address the major functions, processes, and interfaces that correspond with the River Protection Project (RPP) system. Only the subset specific to this study are shown in Figure B-1. The availability and capacities of the various systems and processes are defined in the HTWOS model to determine a processing schedule for waste retrieval, delivery, and treatment.

Tables B-1 and B-2 summarize the direction for the modeling and the key assumptions in a concise format to aid the reader.

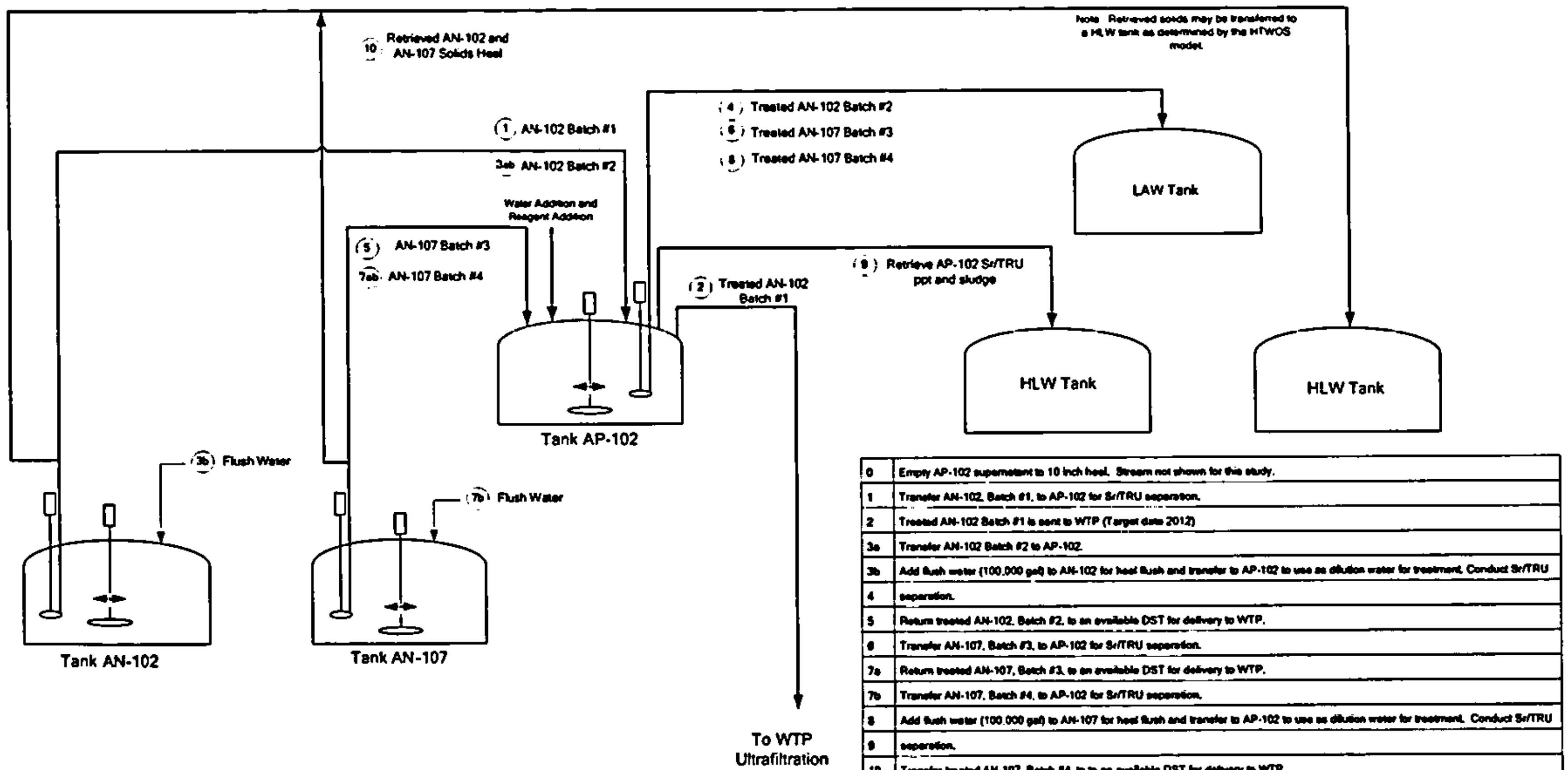
B1.1 BRIEF DESCRIPTION OF CASE AND ASSUMPTIONS

Text of Item: The Development Run for the Refined Target Case is being used as a reference case for an optimization study that will model the pretreatment of AN-102 and AN-107 tank supernatants by performing Sr/TRU separation in the double-shell tank system. The separation of Sr/TRU from the supernatant in tanks 241-AN-102 and 241-AN-107 is currently planned to be completed in the ultrafiltration system within the WTP. While the Sr/TRU precipitation process is conducted within the WTP, HLW sludge can not be pretreated because these two pretreatment processes use the same vessels and ultrafiltration system. The WTP is projected to experience a 6 to 24 month[1] interruption in HLW pretreatment processing along with a reduction in HLW melter throughput due to the process limitations when pretreating the-AN-102 and AN-107 supernatants. This optimization study will evaluate the separation of Sr^{90} and TRU in an existing double-shell tank prior to delivery to the WTP and evaluate the resulting change (i.e., expected reduction) in lifecycle or schedule for the completion of the overall waste treatment mission.

Discussion: The HTWOS model simulates the waste storage, retrieval, and treatment processes to provide an integrated flowsheet and mission scenario using the agreed upon modeling assumptions.

[1] ORP-11242, revision 2, 2003, *River Protection Project System Plan*, page 2-19, CH2M HILL Hanford Group Inc., Richland Washington

Figure B-1. Simplified Schematic of Process Flow Sequence for Sr/TRU Separation in the DST System



0	Empty AP-102 supernatant to 10 inch heel. Stream not shown for this study.
1	Transfer AN-102, Batch #1, to AP-102 for Sr/TRU separation.
2	Treated AN-102 Batch #1 is sent to WTP (Target date 2012)
3a	Transfer AN-102 Batch #2 to AP-102.
3b	Add flush water (100,000 gal) to AN-102 for heel flush and transfer to AP-102 to use as dilution water for treatment. Conduct Sr/TRU
4	separation.
5	Return treated AN-102, Batch #2, to an available DST for delivery to WTP.
6	Transfer AN-107, Batch #3, to AP-102 for Sr/TRU separation.
7a	Return treated AN-107, Batch #3, to an available DST for delivery to WTP.
7b	Transfer AN-107, Batch #4, to AP-102 for Sr/TRU separation.
8	Add flush water (100,000 gal) to AN-107 for heel flush and transfer to AP-102 to use as dilution water for treatment. Conduct Sr/TRU
9	separation.
10	Transfer treated AN-107, Batch #4, to to an available DST for delivery to WTP.

Retrieve AP-102 solids (Sr/TRU ppt and sludge) to an available HLW tank for blending and transfer to WTP.

Retrieve AN-102 and AN-107 solids heel to an available HLW.

Table B-1. HTWOS Model Change Summary Form

Case Name	Sr/TRU Separation in DSTs (Study 2)

Objective: Provide HTWOS model results to support an optimization study to conduct Sr/TRU separation in the DST system.

Scenario Change Summary - This section is focused on changes in key assumptions or key inputs to the model.

Revise model assumptions (from the "Development Run for the Refined Target Case" case documented in RPP-23412, *Hanford Tank Waste Operations Simulator Model Data Package for the Development Run for the Refined Target Case*, Rev. 0, DRAFT) to incorporate the configuration and key assumptions for the optimization study. Run the HTWOS model and provide results.

Software Change Summary - This section is focused on changes in the HTWOS model functionality and includes references to the Scenario Change Summary section where appropriate.

Revise the model as needed to implement the changes outlined in the Scenario Change Summary Section above and detailed in Table B-2.

Requestor or Point of Contact: - Paul Certa

For reporting modeling status and resolving issues.

Supplemental Information:

The following specific information is requested as an output from the model:

- Projected composition of treated AN-102 and AN-107 supernatants from each of the four specific batches to be treated. Compositions to include the treated supernatant and resulting solids phase for comparison to the mass balance tables prepared to perform Sr/TRU separation in tank AP-102. Negotiate level of detail and presentation format with the customer POC.
- Identify what waste staging actions had to be changed in order to accommodate in-tank separation.
- Feed Vector of delivered batches to the WTP.
- Identify impacts to SST Tank Retrieval Sequence and schedule by implementing the Sr/TRU separation in the DST System and compare to Developmental Run.
- Identify or indicate improvement to the project WTP outage or delays predicted by the Development Run compared to the Optimization Study 2 Run.
- Waste oxide loading and glass limit report for the HLW batch(es) containing the precipitated solids.
- Other figures and tables that may be easily produced after the HTWOS run and evaluation of impacts that can be used to support the Optimization Study 2 (i.e., glass plots for Sr/TRU separation compared to the Developmental Run , total waste volume plot, etc.)

Change Approval

Team Lead: R. A. Kirkbride Randy A. Kirkbride 3/1/05	Manager: N. W. Kirch N W Kirch 3/1/05
Customer Point of Contact: P. J. Certa P Certa 3/2/05	Customer: M. Thien M. Thien 3/2/05
Customer: Mike Johnson M E Johnson 3/2/2005	Concurrence: Lynn Swanson by phone PC

3/2/2005 3:51 pm

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
A1.1.[2] Brief Description of Case		
Provide HTWOS model results to support an optimization study to conduct Sr/TRU separation in the DST system. A simple schematic of the overall process is shown in Figure B-1.		No
A2.0. Major Facilities		
A2.1. New Waste Generation		
A2.1.1. New Waste Introduced Via 200 East Area		
PUREX – yearly rate for FYs 2010 through 2017	5 Kgal/year	No
B-Plant – yearly rate	No waste anticipated	No
WESF – yearly rate	No waste anticipated	No
300 Area – yearly rate for FYs 2006, 2007, and 2008. Flush for misc. waste	20 Kgal/year 44%	No
400 Area	No wastes anticipated	No
WSCF	No wastes anticipated	No
100 Area	No wastes anticipated from 100 N, 100-K Basin, 105-F Basin, or 105-H Basin	No
A2.1.2. New Waste Introduced Via 200 West Area		
222-S Laboratory – yearly rate Flush for misc. waste WVRF	10 Kgal/year 22% 99%	No
T-Plant Yearly rate (FYs 2018 through 2021) Flush for misc. waste	15 Kgal/year 22%	No
PFP stabilization – not calculated in yearly average dates Total volume Flush	2004-2005 15 Kgal total 22%	No
A2.1.3 Tank Farm Waste Generations		
Tank Farms Yearly Rate	120 Kgal/year	No
A2.2. Waste Treatment Plant		
Key features for modeling	Key features of the WTP that will be modeled for purposes of mission planning and estimation of secondary waste streams include:	No

[2] In this table, the Section numbers (A1.1, for example) refer to corresponding section in Appendix A of the Tank Farm Contractor Operation and Utilization Plan (TFCOUP). If no corresponding section exists, a placeholder (X) section name is assigned.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	• LAW Feed Receipt Tanks (simplified – 1.5 Mgal lumped capacity) • HLW Feed Receipt Tank • Front End Evaporator (simplified – no feed tanks) • Ultrafilter System (with modified [OH-] endpoint and oxidative leach) • Pretreated HLW Lag Storage and Blend Tanks (simplified – 81 Kgal lumped capacity) • Cesium Ion-Exchange (as a black-box) • Back End Evaporator / Pretreated LAW Storage (simplified and product routing modified to interface with STP) • HLW Melter Feed Preparation (simplified) • HLW Melter (model total capacity, not individual melters) • LAW Melter Feed Preparation (simplified) • LAW Melter (model total capacity, not individual melters) • Off-gas treatment systems (added NH4+ for proper stoichiometry). • Recycle of LAW SBS and WESP Condensate to back-end evaporator feed tank. • Recycle of HLW SBS and WESP to front-end evaporator feed tank. • Transfer of LAW Caustic Scrubber solution to LERF via WTP PT facility.	
Technical Basis for Modeling	The basis for modeled chemical reactions, extents and split factors for estimating primary and secondary waste streams will be the 24590-WTP-MDD-PR-01-002, Rev 6, with flowsheet and operating mode modifications as needed to implement the other assumptions for the System Plan.	No
A2.2.1. Low-Activity Waste Processing		
LAW feed delivery dates	Start delivery of the first LAW feed batch on 12/1/2009 and deliver remaining LAW feed as needed to keep the WTP operating within	No

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: *Sr/TRU Separation in the DSTs (Study 2)*		Involves Model Change That Needs to be Verified?
	model constraints. The first LAW feed batch will be provided by a decant transfer of all supernatant in AY-102 (less ten-inches above the HLW solids) to the LAW feed receipt tanks.	
LAW Pretreatment Ramp Up	From - To MT Na /year (net rate) 12/1/2009 – 1/31/2011 based on LAW melter[3] 2/1/2011 –12/31/2028 2950	No
LAW Vitrification Ramp Up[4]	From - To MTG/d (net rate) 3/1/2010 – 1/31/11 3.4[5] 2/1/2011 – 12/31/2011 18.0 1/1/2012 – 12/31/2012 24.0 1/1/2013 – 12/31/2014 28.8[6] 1/1/2015 – 12/31/2028 34.0[7]	No
Complete Waste Processing	Goal is to complete waste processing by12/31/2028.	No
A2.2.2. LAW Feed Receipt Tanks		
LAW Feed Receipt Tank Use	1.5 Mgal Total Capacity; be capable of receiving 1 Mgal without interruption while feeding out of the remaining 0.5 Mgal	No
A2.2.3. LAW Pre-Treatment Process		
LAW WTP Process Model	• There will be approximately 300 gallons (2005 lb_m air-dried) of spent cesium ion exchange resin generated for every 300,000 gallons of supernate treated through the	No

[3] LAW pretreatment will provide sufficient feed at the rate needed to operate the LAW melter.

[4] Melter ramp-up is based on ORP-22339, *River Protection Project Low-Activity Waste Supplemental Treatment Technologies Report*, Rev. A, 90% Draft.

[5] Melter rate is the average value that produces 188 immobilized low-activity waste packages during hot commissioning.

[6] This is based on a name-plate capacity of 36 MTG/d and a 0.80 TOE. The basis for the TOE is "Low Activity Waste Facility Operations Research Availability Assessment", (24590-LAW-RPT-PO-03-001, Rev. 0) and is driven by the 16 week bubbler life. It is assumed that the TOE stated in the reference (0.774) can be increased to an average of 0.80 until such time as the second-generation melters are available. The basis for the nameplate is the 5-day average goal stated in Table C.6-5.1 of Standard 5 of the BNI Contract for the LAW Facility.

[7] This capacity assumes the installation of second-generation LAW melters.

[8] This assumes that all supernate is Envelope A and is based on operating the system as four column carousel (lead, lag, polish, regeneration), with the columns swapping function every 100 column volumes, 300 gallons per column volume, resin change-out after the 10th regeneration cycle (24590-WTP-MDD-PR-01-002, Section 4.7.4). Using the air-dried bulk density of SuperLig resin from Flow Properties Test Report Sodium Form Resin Samples, 4716-1, Jenike & Johanson, 2003, summary page 2, the bulk density is about 50 pounds per cubic foot of resin

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		**Involves Model Change That Needs to be Verified?**
	cesium ion exchange system.[8] • Spent cesium ion exchange resin will contain the following constituents after being prepared for disposal[9]: o Cr – 670 μg/g o K – 220 μg/g o Na – 83,800 μg/g o ^{99}Tc – 6.74 μg/g[10] o ^{238}U – 14.8 μg/g[10] o ^{60}Co – 1.31 μCi/g o ^{137}Cs – 60 μCi/g	
A2.2.4. ILAW Formulation and Packaging		
ILAW Process	• During hot commissioning, the total sodium loading, sulfate volatilization and formulation of the LAW glass will be estimated using the Gimpel Model as described in 24590-WTP-MDD-PR-01-002.[11] • During hot operations, the total sodium loading of LAW glass from pretreated feed will be determined using the DOE Model (D-03-DESIGN-004), which maximizes the sodium oxide loading in the LAW glass subject to the following constraints: $[Na_2O] \leq 20wt\%$ $[SO_3] \leq 0.8wt\%$ • During hot operations, the composition of the LAW glass will be estimated using a glass recipe model similar to that described in 24590-WTP-MRQ-PO-04-0065 (DRAFT). Sulfate volatilization will be estimated using Equation 3.1-5f of 24590-WTP-RPT-PT-02-005. • Melter split factor for I-129: assume that *20% of the I-129 entering the melter is* retained in the LAW glass product; the	No

[9] These are the RCRA listed constituents detected at levels above the minimum reportable quantities during small-scale column testing per 24590-PTF-3PS-MWD0-T0003, Rev 1, Section 3.4.7.5, page 10.

[10] The reference states μg/g, not μCi/g.

[11] This is an updated reference from 24590-WTP-MCR-PT-02-002, which was used in SP2.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	remaining 80% will report to the melter off-gas system.[12] • One spent LAW Melter is assumed every 2.5 years and contains 6900 gallons of glass,[13] not to exceed 9 spent LAW melters.[14]	
ILAW Glass Density	2.6 MT/m^3	No
ILAW Package Net Mass	5.92 MT	No
A2.2.5. ILAW Interim Storage Capacity		
ILAW Interim Storage Capacity	No lag storage of ILAW in WTP.	No
A2.2.6. High-Level Waste Processing		
HLW feed delivery dates	Start delivery of the first batch group of HLW feed on 12/15/2009 and deliver remaining HLW feed as needed to keep the WTP operating within model constraints. The first batch group of HLW feed will be provided from AY-102 by adding sufficient water to the decanted solids to yield a solids loading between 10 and 200 grams solids per liter of slurry (150 g/liter nominal).	No
HLW Vitrification Ramp-up[15]	From - To HLW MTG/d (net rate) 5/17/2010 – 1/31/2011 0.69[16] 2/1/2011 – 12/31/2011 3.0 1/1/2012 – 12/31/2012 4.0 1/1/2013 – 9/30/2027 5.0[17,18]	No

[12] BNI is in the progress of updating the model design document for the WTP dynamic model. One of the parameters being updated is the melter splits for I-129. The Configuration Management Group (DOE 2004) has concurred with ORP's recommendation that we adopt the preliminary splits for I-129 since this is a significant change (72.973 % retention, reduced to 20% retention) in a component important to performance of the disposed waste.

[13] Melter failures (spent melters) are already accounted for in the assumed net production capacity assumptions. Assumes two melters, each with a 5-year minimum design life per 24590-LAW-3PS-AE00-T0001. Volume of glass in the melter does not include an allowance for increased volume due corrosion of refractory and reflects the set point of 6891 gallons per 24590-WTP-MDD-PR-01-002, Appendix D; other contributions to source term such as plenum deposits are neglected.

[14] Per 24590-WTP-ICD-MG-01-003, Section 4.2.1.2.

[15] Melter ramp-up is based on ORP-22339, *River Protection Project Low-Activity Waste Supplemental Treatment Technologies Report*, Rev. A, 90% Draft.

[16] Melter rate is the average needed to produce 56 canisters of immobilized high-level waste (glass) during Hot Commissioning.

[17] This is based on a nameplate capacity of 6 MTG/d and a 0.84 TOE. The basis for the TOE is "High Level Waste Facility Operations Research Availability Assessment," (24590-HLW-RPT-PT-02-001, Rev. 0). The basis for the nameplate is the goal stated in Table C.6-5.1 of Standard 5 of the BNI Contract.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
A2.2.7. HLW Feed Receipt Tanks		
HLW Feed Receipt Tank Usage	• Sufficient space to receive 160,000 gallons (600 m^3) without interruption. • All HLW batches must be at least 130,000 gallons total volume and contain more than 2 wt% solids.	Yes
A2.2.8. HLW Pre-Treatment Process		
HLW WTP Process Model	• HLW pretreatment can provide sufficient pretreated HLW solids to produce up to 571 canisters of IHLW per year.[19] • The water wash factors in the TWINS on 8/24/2004 will be used for partitioning waste into solid and liquid phases during retrieval and staging. • The caustic leach factors in the TWINS on 8/24/2004 will be used as the basis for computing the caustic leach factors associated with each delivered batch of HLW solids and for the entrained solids. • One spent HLW Melter is assumed every 2.5 years and contains 1800 gallons of glass,[20] not to exceed 9 spent HLW melters. • For planning purposes, all solids delivered with the HLW feed and entrained solids delivered with the LAW feed, will undergo caustic and oxidative leaching with the insoluble fraction incorporated into HLW glass. • An oxidative leach process that removes Cr from the HLW sludge without impact on	Yes

[18] This rate can be increased not-to-exceed 6 MTG/d if needed to finish waste treatment by 2028, with a commensurate increase in programmatic risk.

[19] This is based on 5.0 MTG/d per ORP-22339, 365.24 d/yr and 3.2 MTG/canister (thin-walled canisters). Section C.7(b)(1)(ii) of the BNI contract requires HLW pretreatment to be sized to support 480 canisters of HLW glass per year. This also assumes that issues with ultrafilter performance identified in D-03-DESIGN-005 have been successfully resolved.

[20] Melter failures (spent melters) are already accounted for in the assumed net production capacity assumptions. Assumes two melters, each with a 5-year minimum design life per 24590-HLW-3PS-AE00-T0001. Volume of glass in the melter includes an allowance for increased volume due corrosion of refractory per 24590-HLW-M5C-HMP-00002, Table 2; other contributions to source term such as plenum deposits are neglected. This will probably be a conservative (high) estimate of the content of the melter since the current plans are to purge HLW from the melter if there is advance indication of impending failure and empty the melter as much as possible using the airlift.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	cycle time or other species will be implemented in the ultrafilters. Reaction stoichiometry and endpoint (5,000 μg Cr / g dried solids) are described in RPP-15552.	
A2.2.9. HLW Formulation and Packaging		
Method for Estimating HLW Waste Oxide Loading	Glass Properties Model modified as follows. • Increase the maximum spinel liquidus temperature constraint from 1050 °C to 1100 °C. • Increase the maximum viscosity constraint from 5.5 Pa•s to 10 Pa•s. • Increase the maximum Cr_2O_3 constraint from 0.5 wt% to 1.0 wt%. • Use a maximum zircon liquidus temperature limit of 1050 °C. • Use a Product Consistency Test (PCT) upper limit of 2 g/m^2.	No
Melter split factor for I-129	Assume that 20% of the I-129 entering the melter is retained in the HLW glass product; the remaining 80% will report to the melter off-gas system.[12]	No
IHLW Glass Density	2.7 MT/m^3	No
IHLW Canister Net Mass	3.2 MT (thin-walled canister)	No
A2.2.10. IHLW Interim Storage		
IHLW Interim Storage Capacity	22 canisters of IHLW can be stored in the WTP before having to ship canisters to an interim storage site on the Hanford Site.	No
A2.3. Supplemental Treatment		
A2.3.1. TRU/LLW Sludge Packaging		
Contact-Handled Sludge Packaging	• The contact-handled Supplemental TRU Treatment and Packaging process will be available on February 28, 2006 and treat a maximum of 2,880 gallons of undiluted TRU tank waste per day.[21] • The system will first be located near B-Farm and then moved to T-Farm. There will be a 10-day outage between tanks and 60-day outage to move equipment between farms. • The SSTs assumed to provide contact-	No

[21] *The stated rate is based on planning assumptions for a single retrieval system and does not fully utilize the TRU treatment system capacity.*

[22] These are operational considerations.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	handled sludge are [B-201, B-202, B-203, B-204], [T-201, T-202, T-203, T-204], T-111, T-110, and T-104, in the stated order except that the tank order within the [brackets] can be changed.[22] • The waste from the B-200 and T-200 series SSTS, T-104, T-110, and T-111 will be retrieved without impact to DST space. • It is assumed that this waste can be treated and packaged as contact-handled TRU and disposed of at WIPP. • There will be no water or waste sent to the DST system. • The process assumptions for the contact-handled sludge treatment system are discussed in the remote-handled section.	
Remote-Handled Sludge Packaging	• The remote-handled Supplemental TRU Treatment and Packaging process will be available on 7/1/2012 and treat 2,880 gallons of undiluted tank waste per day. It is assumed to be located near AW-Farm.[23] • All remote handled sludge will be water-washed prior to treatment to remove soluble waste constituents. The East Area DSTs will be water washed in their respective tanks; the SSTs and SY-102 waste will be retrieved, transferred to a 200E area DST and then water-washed. No attempt will be made to segregate the remote-handled SST TRU sludge from the remote-handled DST TRU sludge. • Supernatant liquid will be decanted from tank AW-103 in August 2011. The waste	No

[23] The remote-handled Supplemental TRU Treatment and Packaging process is expected to be a re-deployment of the contact-handled system with additional shielding.

[24] "Dry batch mode" is a continuous process.

[25] This assumes that only 4 of the 5 feed tanks are used; the 5th tank is kept in reserve.

[26] "Carrier" refers to the material added to the waste in the dryer to form a stable mixture with appropriate handling properties.

[27] The final package has not been established; 55-gallon drums may also be used.

[28] The final package configuration has not been established; the dried waste may also be directly loaded into the RH 72B canister.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	solids in tank AW-103 will be washed four times over a nine month period starting 9/1/2011 using 273,000 gallons of 0.01 M NaOH solution each time. After each wash, the solids are settled to 40 wt% before decanting the wash solution for feed to the evaporator. The first wash of AW-103 waste solids is assumed to dissolve the saltcake portion. Existing water wash factors and the Sr solubility model will be applied to estimate the overall wash effectiveness. • Supernatant liquid will be decanted from tank AW-105 in September 2012. The waste solids in tank AW-105 will be washed four times over a nine-month period starting 10/1/2012 using 263,000 gallons of 0.01 M NaOH solution each time. After each wash, the solids are settled to 40 wt% before decanting the wash solution for feed to the evaporator. The first wash of AW-105 waste solids is assumed to dissolve the saltcake portion. Existing water wash factors and the Sr solubility model will be applied to estimate the overall wash effectiveness. • Supernatant liquid will be decanted from tank SY-102 by 10/30/2013. The SY-102 solids will be washed three times over a nine month period starting by 11/1/2013 using 290,000 gallons of 0.01 M NaOH solution each time. After each wash, the solids are settled to 40 wt% before decanting the wash solution for feed to the evaporator. The first wash of SY-102 waste solids is assumed to dissolve the saltcake portion. Existing water wash factors and the Sr solubility model will be applied to estimate the overall wash effectiveness. (Note: The solids in SY-102 may be moved to AW-103 for washing, after the washed AW-103 solids are delivered for packaging, if the cross-site transfer does not delay operation of the packaging facility.) • The SSTs assumed to provide remote-handled sludge are T-105, T-107, T-112, B-107, B-110, and B-111; the DSTs assumed to provide remote-handled sludge	

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	are SY-102, AW-103 and AW-105. • The overall process for both contact-handled and remote-handled TRU sludge treatment is assumed to use the "dry batch mode"[24] as described in the System Design Description (RPP-20499) and summarized as follows: o As the CH-TRU sludge is retrieved and transferred, a total of 1 part water by volume is added per original in-tank sludge bulk volume. o The slurry (either direct from the SSTs for CH-TRU or via a DST for water washed RH-TRU) will be transferred to the Feed Receipt Process System modeled as a single tank with a working volume of 28,800 gallons.[25] o The slurry, carrier[26] and heat are continuously added to the dryer, while dried product is withdrawn to maintain a product with 20-wt% water and 80-wt% waste loading (both relative to waste, water and carrier). o The CH-TRU dried waste product is packaged in standard waste boxes (SWB)[27], each SWB holding approximately 2,760 lb_m waste. o The RH-TRU dried waste product is assumed to be packaged in 55-gallon drums containing 700 lb_m of product per drum, which are loaded three drums to a RH-72B canister[28]. • Secondary waste will be estimated using the dryer retention factors as stated in 20843.PCAL.001, Assumption 8 and by applying the DFs for the 242-A Evaporator condenser. The dryer retention factors (and equivalent splits for modeling) are presented in Table B-3 the gaseous effluent split factors are presented in Table B-4. • Liquid effluent will either be transferred to the LERF via Tank Truck or recycled to the Retrieval project. For planning purposes, it	

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	will be assumed that the liquid effluent is transferred only to LERF (no recycle) and modeled as a continuous transfer. • The washed solids are assumed to be remote handled for packaging. • It is assumed that this waste can be treated and packaged as remote-handled TRU and disposed of at WIPP.	
A2.3.2. Supplemental LAW Processing		
Supplemental Treatment Demonstration	• A demonstration facility will be located in the 200 West Area (west of S-Farm) and be operated at a net rate of 3.92 MTG/d starting on 5/31/2005 to process 260 MT Na from the low-curie waste from tank S-109. • The demonstration facility will be fed directly from S-109 with no solids entrained out of S-109. The feed will be delivered at 5 M Na. The S-109 waste retrieval will be controlled to limit the total activity in the retrieved waste to 0.0062 Ci per liter (at the 5 M Na feed concentration) for the demonstration.[29] Retrieval of the low-Cs waste from S-109 will generate about 100 Kgal of Cs-rich wastes that will be sent to tank SY-102.[30] • The Supplemental Treatment Demonstration process assumptions (other than process rate) will be the same as that used for the full-scale Supplemental Treatment Process.	No
Supplemental Treatment Process	• A production process facility will be located in the 200 East Area. • The production facility, consisting of eight melter lines, starts operating on 1/31/2011 at a combined net rate of 31.4 MTG/day[31].	No

[29] The demonstration project will probably target a lower Cs-137 concentration in the low-curie feed from S-109 for shielding considerations.

[30] The demonstration project is expected to increase the estimated amount of Cs-rich waste from S-109 to about 250 Kgal.

[31] If necessary, the treatment rate may be ramped up by two additional melter lines (for an increase of 7.84 MTG/day) on a date agreed to by the requestor.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	• The feed to the Supplemental Treatment process includes: o Low-curie feed from the selective dissolution and solid/liquid separation of SST waste.[32] o "Excess" pretreated LAW from the WTP[33] - this feed source should be preferentially used. • Low-Cs waste in the 200 West Area will be moved cross-site to feed the process when dedicated DST space is available to transfer low-Cs waste without contamination (through SY-101 in to an East Area DST used as a feed tank).	
WTP Process Considerations	The WTP pretreatment facility will be configured so that a portion of concentrated pretreated LAW from the Treated LAW Concentrate Tank can be transferred to the Supplemental Treatment Plant (STP) as feed. This is downstream of the point to which LAW SBS and WESP condensate is recycled, so the STP feed will include a proportional fraction of the SBS and WESP condensate.	No
STP Process Basis	The process will be modeled using a simple lumped flowsheet that implements the overall mass balances (elemental, NOX, and activity) as shown in Section 3.2 of the process flowsheet (RPP-20528) using the process design criteria provided in 145579-A-DC-002, with the following exceptions: • The Tri-mer scrubber (provides backup off-gas treatment) is assumed to not be operated. • The splits for the dryer will be set equal to the splits used for the WTP evaporators.[34]	No

[32] The amount of low-curie feed may be increased if needed to finish waste treatment by 12/31/2028, not to exceed the available amount of low-curie feed. The estimated amount of low-curie feed required is about 3,500 MT Na.

[33] The amount of "excess" pretreated LAW that is available is the difference between the assumed LAW pretreatment capacity of 2,950 MT Na/year and the demand from the WTP LAW Vitrification facility expressed in MT Na/year and depends on the glass formulation for each specific LAW melter batch.

[34] The referenced flowsheet assumes that 50% of the I-129 in the dryer feed reports to dryer offgas stream – this is an overly conservative value. Additionally, only I-129 is partitioned (not conservative). Since the dryer operates in a similar temperature and pressure regime as both the 242-A Evaporator and the WTP evaporators, it is assumed that using the evaporator splits will provide a better estimate of the partitioning that will take place until

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	• 20 wt% waste Na_2O loading.[35] These mass balances cover both primary and major secondary waste streams from the process which will be modeled as a single lumped process train comprising the following unit operations: • Feed Tank • Dryer • Condenser for Dryer Offgas • Melter • Sintered Metal Filter with recycle to dryer (modeled as to dryer feed tank) • Hydrosonic Scrubber • HEPA Filter • Carbon Filter • NOx Removal	
Feed Staging[36] and Solids Return	• The low-Cs tanks that are candidates for feed are: B-105, T-109, B-103, B-101, S-109, B-108, S-105, TY-102, TX-117, BY-112, BY-105, BY-102, BY-111, BY-108, TX-118, BY-109 BX-111, BY-103, and TX-114. • The following tanks can be considered candidate Low-Cs Tanks after 1/1/2011: TX-112, TX-111, and TX-110. • The following tanks can be considered candidate Low-Cs Tanks after 1/1/2018: TX-105, TX-115, U-107, TX-108, and TX-103. • Selective dissolution will be used during the retrieval of candidate feed tanks using the planning assumptions in Table B-5 for splits – use average values when ranges are provided. First, the "higher" curie fraction	No

the flowsheet is updated or supplanted. The Configuration Management Team provided verbal concurrence with this change on December 27, 2004 with the understanding that approval will be indicated by ORP's concurrence with these assumptions. For simplicity, the HTWOS model will use the published WTP Evaporator splits rather than the more complicated 242-A Evaporator partitioning coefficients.

[35] It is assumed that the target waste sodium oxide loading of 17.6-wt% in 145579-A-DC-002 is increased by flowsheet refinements such as low-sodium soil to the nominal value of 20-wt% assumed in ORP-22339. No allowance is made for potentially lower oxide loadings during the supplemental treatment system demonstration.

[36] The list of candidate SSTs and selective dissolution assumptions are provided by 7F300-04-RER-001 R1.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	will be retrieved from the SST and stored in the DST system for later delivery to the WTP. Then, the remainder of the waste (the low-curie fraction) will be retrieved and staged in a separate 200E area DST for delivery to the Supplemental Treatment Process.	
Product and Packaging	Bulk vitrification is used as the supplemental treatment process to immobilize LAW. The following will be used to estimate bulk vitrification product volume and package count. • Glass density is 2.7 MT/m^3. • Packaged in 35 m^3 roll-off boxes, each filled with 43.8 MT glass. External volume of box is 1,920 ft^3 (8 ft by 10 ft by 24 ft, ~ 54.4 m^3).	No
A2.4. Waste Disposal Sites		
ILAW Facility Need Dates (Integrated Disposal Facility; IDF)	The IDF is assumed to be operational on 2/28/2006. The ILAW produced by the Supplemental Treatment demonstration can be safely stored until the IDF is available.	No
IHLW Facility Need Dates (Project W-464)	The need date for IHLW interim storage facility (the Canister Storage Building) will be the date on which the 1st IHLW is produced (5/17/2010). The demand for interim storage space will be established assuming that 22 canisters of WTP-provided IHLW is used. The shipping date of IHLW to Yucca will be the date on which the Canister Storage Building is full (880 canisters + 22 canisters in WTP-provided lag storage), but no earlier than 1/1/2012. Canisters will be shipped to Yucca at a rate of 2 canisters per day, first priority given to shipping the newly created IHLW from the WTP – any excess shipping capacity will be used to empty the IHLW stored in the CSB.	No
A2.5. Cesium and Strontium Capsule Processing		
Cesium and Strontium Capsules	Cesium and strontium capsules are disposed separately by RL and not incorporated into HLW glass in the WTP.	No
A2.X. Sr/TRU Precipitation Process for AN-102 and AN-107 Supernatants in Tank AP-102		
Tank Selection	Supernate from AN-102 and AN-107 will be treated in AP-102, based on the availability of a central riser that is fitted for a mixer pump.	Yes

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
Remove AP-102 Supernatant	AP-102 Supernatant must be removed before transfer and treatment of AN-102 supernatant in AP-102. • Assume that current pumping practices will leave 10 inches of supernatant in AP-102 to avoid disturbing the existing solids during supernatant removal. • The 10 inches of waste remaining in AP-102 will be combined and treated with the first batch of AN-102 supernatant.	Yes
Tank Treatment Sequence	Assume AN-102 supernatant is treated first followed by transfer and treatment of AN-107 supernatant.	Yes
Start Date for Sr/TRU Separation	Sr/TRU separation of AN-102 supernatant will be initiated based on the space availability predicted by HTWOS and not constrained to the start date for WTP processing of AN-102 and AN-107 supernatant used in the Development Run. The delivery of AN-102 and AN-107 feeds to the WTP is considered to be flexible. • Include a 16 month outage for AP-102. This is the estimated time required to install a replacement 150-hp mixer pump in AP-102. Assume the replacement mixer pump is installed 16 months prior to the start of Sr/TRU processing in tank AP-102. Basis: Personal communications between Mike Johnson, John Van Beek, and Curtis Rieck (January 2005). • Target a delivery date of treated AN-102, Batch #1 for 2012, however, as noted, the delivery date to WTP is flexible.	Yes
Number of Batches	Four batches are assumed for conducting the Sr/TRU precipitation in Tank AP-102. • Tank AN-102 supernate will be treated in two equal batches and the AN-107 supernate will also be treated in two equal batches. • Residual AN-102 supernate in tank AP-102 can be mixed with the AN-107 supernate.	Yes
Supernatant Heels	Following the transfer of the last batch of supernate from tank AN-102 (or AN-107) to tank AP-102, add ~100,000 gallons of water to the heel of supernatant in tank AN-102 (or AN-	Yes

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		**Involves Model Change That Needs to be Verified?**
	107) and transfer to tank AP-102. Assume no mixing of the liquids with the existing solids.	
Sr/TRU Processing Sequence	See Figure 1, *Process Flow Sequence for Sr/TRU Separation in Tank AP-102.* 1) Transfer, the first batch of AN-102 into AP-102 and conduct the Sr/TRU separation process. 2) Transfer the first batch of treated AN-102 supernate to WTP in 2012, or as determined by the HTWOS modeler. 3) a) Transfer the second batch of AN-102 supernatant to tank AP-102. b) Add flush water to AN-102 to dilute residual supernate heel and transfer to AP-102 for treatment with AN-102 Batch #2. Treat. 4) Transfer treated AN-102 supernatant from tank AP-102 to available DST for eventual delivery to WTP. 5) Transfer the first batch of AN-107 (Batch #3) supernatant to tank AP-102 and conduct the Sr/TRU removal process. 6) Transfer the treated AN-107 Batch #3 supernate to an available DST for eventual delivery to the WTP. 7) a) Transfer the second batch volume of AN-107 (Batch #4) supernate from tank AN-107 to tank AP-102. b) Add flush water to tank AN-107 to dilute remaining supernate heel and transfer to AP-102 for treatment with the AN-107 Batch #4. 8) Transfer the treated AN-107 Batch #4 supernate to available DST for eventual delivery to WTP. 9) Retrieve AP-102 solids (Sr/TRU ppt and sludge) to any available HLW tanks at the discretion of the modeler. Solids should be blended with other HLW solids for delivery to the WTP. 10) Retrieve AN-102 and AN-107 solids heel to any available HLW tanks at the discretion of the modeler. Solids shall be blended with other HLW solids for delivery to the WTP.	Yes
Disposition of Sr/TRU Precipitate	Solids shall be blended with other HLW solids for delivery to the WTP.	Yes
Disposition of tanks AN-102 and AN-107	Retrieve AN-102 and AN-107 solids heel to	Yes

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		**Involves Model Change That Needs to be Verified?**
Solids	any available HLW tanks at the discretion of the modeler. Solids may be blended with other HLW solids for delivery to the WTP.	
A2.X1 Sr/TRU Process Conditions		
Sr/TRU Precipitation Process Basis	Process Dilution water: Water is added to AN-102 and AN-107 supernatant liquids to achieve a 5.5 M sodium concentration. Water addition is performed in Tank AP-102 on a batch basis. <u>Sodium permanganate ($NaMnO_4$) addition</u>: 5.308 gallons of 3.83M $NaMnO_4$ are to be added per <u>1,000 gallon</u> of diluted supernatant (Basis: RPP-24809, Appendix A) <u>Strontium nitrate $Sr(NO_3)_2$ addition</u>: 6.723 gallons of 3M $Sr(NO_3)_2$ are to be added per <u>1,000 gallon</u> of diluted tank supernatant (Basis: RPP-24809, Appendix A). Reaction Time: minimum of 4 hours (PNWD-3340, Section 3.1) (Assume mixer pump installed in AP-102). Reaction temperature: 26 to 28° C, ambient conditions (PNWD-3340, Section 3.1).	Yes
Percent Removals from Supernatants	Eu^{152} = 85% Eu^{154} = 85% Eu^{155} = 85% Np^{237} = 85% Pu^{238} = 85% Pu^{239} = 85% Pu^{240} = 85% Am^{241} = 85% Pu^{241} = 85% Cm^{242} = 85% Pu^{242} = 85% Am^{243} = 85% Cm^{243}= 85% Cm^{244} = 85% Sr^{90} = 94% Sr total = 94% Ba = 19% Ca = 19% Ce = 85% Cr = 21% Fe = 97% La = 85% Mn = 96%, AN-102 Mn = 30%, AN-107 Nd = 85% Pb = 30% TIC as CO_3 = 3.9% Zr = 82% TOC = 0%	Yes
A2.X2. Sr/TRU Precipitation Chemistry		
Strontium Removal	The addition of strontium nitrate ($Sr(NO_3)_2$) to tank AN-102 and AN-107 supernatants results in isotopic dilution of (Sr^{90}) and precipitation of strontium carbonate ($SrCO_3$) Isotopic Dilution Reactions: $Sr(NO_3)_2 + {}^{90}Sr{\cdot}Chelant + Na_2CO_3 \leftrightarrow$ $Sr{\cdot}Chelant + {}^{90}SrCO_3 + 2NaNO_3$ $Sr(NO_3)_2 + Na_2CO_3 \leftrightarrow SrCO_3 + 2NaNO_3$ The reaction above implements the percent	Yes

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	removals listed in previous assumption. Upon adding $Sr(NO_3)_2$ to the AN-102 (or AN-107) supernate, 94% of the total Sr is precipitated. This assumption applies only to the treated AN-102 and AN-107 supernate only and does not apply to other LAW supernate. The existing Sr-90 solubility correlation applies to all other LAW supernate.	
3.0. Retrieval and Closure		
A3.1. SST Interim Stabilization		
Saltwell liquid pumping	None; saltwell pumping was completed in March 2004.	No
A3.2. SST Tri-Party Agreement Milestones		
SST TPA Milestone Dates	Retrieve S-112 per TPA Milestone M-045-03C by 3/31/2005. Retrieve S-102 per TPA Milestone M-045-05A by 3/31/2005. Retrieve C-Farm (Waste Management Area – C) per TPA Milestone M-045-00B by 9/30/2006.	No
A3.3. SST Retrieval Sequence Basis		
Retrieval sequence basis	Give priority to the SST milestones listed above, then: • Retrieve the remaining Pool tanks, balancing logistics, tanks space and feed to the various treatment processes. • Retrieve the remaining SSTs, risk-based, balancing logistics, tank space and feed to the various treatment processes. Table B-6 provides the list of SSTs in the SST retrieval pool. Table B-7 provides starting assumptions for sequence and retrieved waste volumes for near term SST retrievals.	No
A3.4. Waste Retrieval Facilities		
Waste Retrieval Facility (WRF) Availability Dates	B-Complex WRF: 6/1/2018 T-Complex WRF: 6/1/2018 *Wastes retrieved from tanks in the B or T* complexes before the WRFs are available will be at lower insoluble solids loadings as defined	No

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	in the Retrieved Waste Composition assumptions (see Section A3.8 of HNF-SD-WM-SP-012). Compliant transfer lines will be constructed to support retrievals from B and T complex before the WRFs are made available; one line for each complex.	
A3.5. SST Farm Upgrades		
Availability Dates for Tank Farms Upgrades	Any SST farm upgrades needed to support the retrieval of SST waste will be completed before the retrieval dates projected by the HTWOS model.	No

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
A3.6. Constraints on Simultaneous Retrievals		
Simultaneous retrieval	• The most limiting condition(s) resulting from application of the following constraints:[37] Retrieval and transfer systems in the NE and NW quadrants can support a maximum of 6 *simultaneous retrievals in each tank farm* and a total of six simultaneous retrievals in each quadrant (after the WRFs are constructed). Retrieval and transfer systems in the SE and SW quadrants can support a maximum of 2 simultaneous retrievals in each tank farm and a total of two simultaneous retrievals in that quadrant. SE - A, AX, and C farms NE - B, BX, and BY farms SW - S, SX, and U farms NW - T, TX, and TY farms A maximum of 7 total simultaneous retrievals can be performed at one time. (This assumes that labor resources are available.) The waste from up to two SSTs may be retrieved to one DST at one time. The waste from one only SST may be retrieved into one WRF tank at a time. Constraints also apply to retrievals going directly from SSTs to supplemental treatment processes.	No
A3.7. Retrieval Rates		
SST Waste Retrieval Rates	Minimum retrieval durations are given in Section A3.7 of HNF-SD-WM-SP-012 and based on proposed project schedules or technologies to be used to retrieve the waste.	No
SST Waste Residuals	• 200 Series SSTs: 30 ft^3 of "selected phase" as defined in DOE/ORP-2003-02, *Inventory and Source Term Data Package - Environmental Impact Statement for Retrieval, Treatment and Disposal of Tank Waste, and Closure of Single-Shell Tank Waste at the Hanford Site Richland WA*,	No

[37] These constraints may be lifted by retrieving several source SSTs into one receiver tank if the modeling indicates that they create a bottleneck in the system.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	Rev. 0; re-estimated using the current BBI. • 100 Series SSTs: 360 ft^3 of 35-wt% water-washed solids with ½ concentration of bulk as-retrieved supernate for all tanks; except C-106 will use the BBI.	
A3.8. Retrieved Waste Composition		
Retrieval Solution Requirements	• The amount of retrieval solution needed to retrieve the waste from SSTs listed in Table A-14 in Section A3.3 of HNF-SD-WM-SP-012 will be determined as the amount need to achieve the total retrieved volume given in the table after the application of water wash factors. • The amount of retrieval solution needed to retrieve wastes from the S, SX, and U farm SSTs not listed in Table A-14 will be determined as the amount needed to result in a Na concentration ≤ 5 M and an insoluble solids concentration ≤ 5 wt% (3.5 volume %) after the application of wash factors. • The amount of retrieval solution needed to retrieve wastes from SSTs in the B or T farm complex before the WRFs are available will be determined as the amount needed to result in a Na concentration ≤ 5 M and an insoluble solids concentration ≤ 5 wt% after the application of wash factors. • The amount of retrieval solution needed to retrieve wastes from SSTs in the B or T farm complex after the WRFs are available will be determined as the amount needed to result in a Na concentration ≤ 5 M and an insoluble solids concentration ≤ 10 wt% after the application of wash factors. • The amount of retrieval solution needed to retrieve wastes from all other SSTs will be determined as the amount needed to result in a Na concentration ≤ 5 M and an insoluble solids concentration ≤ 10 wt% after the application of wash factors.	No
A3.9. Retrieval System Reuse		
Retrieval System Availability	• A sufficient number of retrieval systems are available. • Retrieval systems will be reused when cost effective.	No

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
A3.X. SST Closure		
SST Closure	• SSTs will be interim closed in the 10-month period immediately after retrieval has been completed. • Closure activities for each tank farm can begin after all tanks in that farm are interim closed.[38]	No
A3.X. SST Waste Leaks		
SST Waste Leaks During Retrieval	No waste is assumed to leak from the SSTs during retrieval.	No
A4.0. Waste Feed Operations		
A4.1. Waste Inventory		
A4.1.1. Initial Inventory		
Date that BBI quarterly update was issued	Starting tank inventories represents the contents of the tanks as of April 2004 per RPP-22760. This is identified as the "FY 2004a" inventory and is based on Best Basis Inventory (BBI) downloaded from TWINS circa 8/10/2004. Adjustments were made in the HTWOS model for historical transfers through December 31, 2004.	Yes
IMUST waste total volume (2011-15)	500 Kgal total	No
A4.2. DST Operations		
A4.2.1. Sodium Hydroxide Additions		
Caustic addition • Planned Additions • Caustic Rules for SST Retrievals	• No near-term additions are planned. Future evaluations may show the need for caustic additions. • Liquids associated with sludge retrievals need to have at least 0.05 M free OH. Saltcake retrievals do not require NaOH addition because waste in DSTs contains sufficient OH⁻ as a buffer.	No
A4.2.2. Flush Volumes		
	Table A-16 in Section A4.2.2 of HNF-SD-WM-SP-012 provides the flush volumes used in the HTWOS model.	No
A4.2.3. Minimum DST Level		
	• Liquids or slurries can be removed down to	No

[38] This is an enabling assumption that may need to be refined as closure strategies are developed.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	within 12 inches above the bottom of a DST. • Wastes can be removed down to the bottom of a DST during final cleanout. • Supernatants can be pumped down to within 10 inches of a settled solids layer • SY-101 can only be pumped down to 100 inches (275 Kgal) between now and 10/1/2013. After that date, the transfer pump will be replaced and the waste can be pumped down to 12 inches. • SY-102 can only be pumped down to 200 inches (550 Kgal) until the solids are washed before delivery for TRU packaging. After the solids are washed the waste can be pumped down to within 12 inches. • The AZ/AY farm tanks can be pumped down below 64 inches if the annulus ventilation is shut down. The annulus ventilation will be shut down when necessary to deliver feed to the WTP allowing the waste to be pumped down within 12 inches of the bottom.	
A4.2.4. Maximum DST Level		
Maximum DST Levels	Design evaluation, records evaluation, and Ultrasonic Testing will confirm that AP farm is appropriate for increased fill height by 11/1/2004. Actual use of the increased fill will be managed through "In-Process Tests" during transfers.[39] No transfers that use the increased operating level are scheduled for calendar year 2004. See Table B-8 for a list of the maximum levels for each DST.	No

[39] The dates proposed for increasing the DST fill levels may be revised after evaluating results from the model run.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
A4.2.5. Tank Solids Level		
Solids Settling Endpoint	Insoluble solids retrieved from C-Farm SSTs can be settled to a solids loading comparable to that in the source SSTs within 2 days of transferring to a DST. This is accomplished in the model by settling to the same bulk solids volume observed in the SSTs or to an adjusted bulk volume based on mass dissolved during retrieval. Insoluble solids retrieved from other SSTs and currently in the DST system can be settled to 40 wt% solids within 30 days.[40]	No
Solids Management Strategy	Assume that the solids management strategy for the DSTs will allow, on the average: • DSTs supporting C-Farm retrieval will be operated with a minimal supernate layer so that they do not become Group A tanks even though they will be filled with significant quantities of solids. • DSTs not supporting C-Farm retrieval are assumed to hold up to 10-wt% bulk solids based on the maximum operating level of each DST.	No

[40] The modelers will seek to apply the "wet sludge volume" approach used for the C-Farm retrievals to insoluble solids retrieved from other SSTs if it can be implemented. If it cannot be implemented due to model logic issues, the current approach of settling to 40 wt% solids will be used.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
A4.2.6. Tank Space Allocation		
Space Allocation Categories	Use the categories and reasoning given in Table A-19 in Section A4.2.6 of HNF-SD-WM-SP-012 to allocate and track head space above the waste in the DSTs.	No
DST Usage	**WTP Feed Staging tanks:** [41] AN-101, AN-102, AN-103, AN-104, AN-105, AN-107, AP-101, AP-102, AP-103, AP-104, AP-105, AP-106, AP-108, AW-101, AY-101, AY-102, AZ-101, and AZ-102 **WTP Alternative (Back-up) HLW Feed Staging tanks:** AN-103, AN-104 (cross-site receiver), and AN-105. At the modelers' discretion, other DSTs equipped with dual mixer pumps can be used to store and stage HLW feed. **Slurry Transfer Limitations:** Use AZ, AY, and AN farms, primarily for staging HLW solids. Try to avoid staging solids through AP or AW farms after retrieving the solids currently in those farms. **Supplemental Sludge Treatment Process Feed Staging Tanks:** AW-103, AW-105, and SY-102 **Supplemental LAW Treatment DST Usage:** Provide feed directly from S-109 to the Demonstration Bulk Vitrification System. Transfer low-Cs wastes from the West Area and from East Area SSTs when sufficient DST space is available to transfer cross-site without contamination and to provide a dedicated feed tank in the East Area. Retrievals and transfers are managed to prevent the entrainment of solids in the feed. **Sludge Transfer for Waste Feed Staging:** AN-101 and AN-106 will acquire solids from C-Farm retrieval and require additional equipment to transfer a portion of those solids into other DSTs for waste feed staging into the WTP. Issue: This is emerging work scope and not	No

[41] See Section A5.2 for information on project scopes regarding equipment needs.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	currently covered by current project scope or baseline plans.	
Emergency Space and LAW or HLW Waste Return Space • TFC Emergency Space and Emergency Returns from WTP • LAW or HLW Non-Emergency Process Returns from WTP • Contingency space	Emergency Space and Emergency Returns will be raised from 1.14 Mgal to 1.235 Mgal on 11/1/2004, and will be allocated as shown below: • 1.235 Mgal total • None • None	No
WTP Returns (to the DST system)	*No waste streams or wastewaters are returned* to DST system from the WTP.	No
DST Space Allocation Categories • Evaporator Operational Space • Restricted TRU Head Space • Restricted WTP Feed Tank Space • Safety Basis Head Space	• Supports 242-A operation (AW-102, bottoms receiver, and dilute waste receivers, when used) • TRU solids (AW-103 & AW-105) • Early WTP feed sources or DSTs used to stage WTP feed • Waste has an associated safety issue	No
A4.2.7. Waste Segregation or Blending		
Feed Controls • Blend off high-sulfate supernate (FCL Issue # 1) • Blend off high ^{233}U solids (FCL Issue # 2) • Prepare and protect hot	The feed controls (which specify specific blending and waste segregation requirements) from HNF-SD-WM-OCD-015, Rev 13, are modified as needed to support the other mission assumptions and summarized below: • A portion of supernate from AZ-102 will be decanted and blended with lower [SO_4] supernate, so that the final [SO_4]:[Na] ratio in AZ-102 and in any other tank receiving significant quantities of the high [SO_4] supernate will be less than a target level of 0.048 mole SO_4/mole Na after blending and any evaporator campaigns are completed. Constrain the blending of AZ-102 supernate to start after 4/1/2007. • The solids from C-104 will be blended with the solids in AY-101 so that the resulting [233U] is less than a target level of 2.0E-04 Ci/100 grams equivalent of waste oxides. The two source tanks and the resulting blend will be kept segregated from other sources of solids. • The supernate in AY-102 will be removed	Yes

Table B-2. *Assumptions Matrix.* (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
commissioning feed (FCL Issue # 3)	and replaced with supernate from AP-101, *without concentration. It is assumed that* the TFC will successfully demonstrate the supernate in AP-101 should be consolidated with the solids in AY-102 using the stipulated "Special process to release controls". No other waste, other than process condensate, will be mixed *with the hot commissioning feed staged in* AY-102.	
• Segregate Envelope C (FCL Issue # 4)	• The AN-102 and AN-107 supernatants must be segregated from all other waste until it has been pretreated to remove Sr/TRU components. Do not store this pretreated supernate with any other HLW or TRU solids.	
• Segregate TRU sludge from complexed waste (FCL Issue # 5)	• Envelope C waste or other waste capable of complexing TRU shall not be stored with the insoluble solids currently in AW-103, AW-105 or SY-102. For purposes of this control, waste will be considered to be Envelope C if the [TRU]:[Na] ration exceeds 13 μCi/mole or the [90Sr]:[Na] ratio exceeds 1.19E+03 μCi/mole in the liquid phase.	
• Segregate waste destined for TRU or LLW packaging (FCL Issue # 6)	• No additional waste shall be added or stored with the insoluble solids currently in AW-103 and AW-105, except that the addition of remote-handled TRU from SSTs or SY-102 is permitted. Avoid mixing the waste in SY-102 with additional solids (other than remote-handled TRU). Do not transfer contact-handled TRU waste into the DST system. Keep the remote-handled TRU waste segregated from insoluble non-TRU solids.	
• Segregate low-cesium SST waste for supplemental treatment (FCL Issue # 7)	• Waste from the candidate SSTs containing low-curie waste should be managed to maximize the amount of low-curie (less than 0.05 Ci/liter ^{137}Cs). The low-cesium fraction designated for feed to supplemental LAW treatment should be kept segregated from any high-cesium waste.	
Blending	There is no deliberate blending of waste to optimize WTP feeds other than the specific blending described in the feed controls. Incidental blending that occurs as waste is moved through the system is relied on to	No

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	provide benefits such as a significant reduction in HLW glass quantities.	
A4.2.8. Availability of DST Space		
DST Integrity	No DST failures or replacements are assumed.	No
A4.2.9. Space Optimization		
Tank Space Options Incorporated (M-46-21 options)	• Concentrate waste to save space (to 1.44 SpG). • Release the ORP restriction on the use of the WTP feed restricted space. • Allocate only 1.235 Mgal as emergency space. • Implement tank level increases detailed in Table B-8.	No
A4.2.10. Aging Waste Farm Condensates		
	HTWOS does not account for in-tank evaporation from or the recycle back to the aging waste tanks.	No
A4.2.11. Common Use of Transfer Lines		
	There are no restrictions on the subsequent use of transfer lines based on waste types (HLW, LAW, TRU, and LLW) and chemistries.	No
A4.2.12. Waste Transfer Routes		
Essential Drawings for DST Waste Transfer System	Transfer system constraints are imposed through the near-term SST retrieval plans.	No
A4.2.13. Waste Transfers		
Cross-site Transfer Rate	• Wastes transferred cross-site through the supernatant line can be transferred at rates between 50 and 60 gallons per minute. • Wastes transferred cross-site through the slurry line can be transferred at rates between 100 and 120 gallons per minute.	No
SST Retrievals	Wastes retrieved from the SSTs will be retrieved at the capacity of the retrieval system as defined by the minimum durations when DST space is available.	No
DST Transfer Rate	Wastes can be transferred between DSTs or to the WTP at a rate of 140 gallons per minute (excluding cross-site transfers).	No
Transfer Durations	Waste transfer durations will be calculated by dividing the total volume being transferred by the transfer rate.	No
Transfer System Set-up Time	There is a 5-day delay between subsequent uses of transfer routes having common components starting on 11/1/2007 to account for the	No

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		**Involves Model Change That Needs to be Verified?**
	closeout of one transfer route and the establishment of another route.	
DST Waste Residuals	100 gallons having the composition of the last waste contained in the tank.	No
A4.3. 242-A Evaporator		
A4.3.1. Evaporator Availability		
242-A Evaporator Shutdown & New Evaporator Availability	• 242-A Evaporator is available until 9/30/2018 • No tank farm evaporator is available after 10/1/2018 to support DST space management.	No
A4.3.2. Evaporator Operation		
• Training Volume • Average Evaporation Rate • Maximum Evaporation Rate • Bottoms Set Point (g/mL) • Feed Staging Duration • Yearly Evaporation of Waste • SST wastes evaporated	• 82 Kgal of water is evaporated to train personnel if the evaporator has not been operated for 11 months.[42] Each training run adds 50 Kgal of water to AW-102. • 500 Kgal/month[43] • The lesser of 50 gpm boil-off or 140 gpm feed • 1.44[44]. • *3 months minimum;*[45] • Yes • Evaporate retrieved waste as needed to manage DST space until the WTP starts.	No
A4.3.3. Evaporator Process Chemistry		
Waste Volume Reduction	• Water is removed until the specific gravity set point is reached (as calculated by algorithms within the model). Recent *issues with solids formation in the* evaporator are handled as part of the historical transfer data.	No

[42] The period between evaporator campaigns must be less than 12 months to maintain operator qualifications and avoid the need for a full readiness review. An eleven month period was chosen in the model to make sure training runs occurred within a 12 month period. About 50 Kgal of water is sent to AW-102 is from seal water (during the run) and emptying the evaporator vessel after the training run. This will be modeled as a 50 Kgal addition after each training run.

[43] This is an operational constraint to avoid over committing evaporator campaigns.

[44] This density is expected to be the average density selected for future evaporator campaigns – it is not an inherent limitation of the evaporator. The feed for each evaporator campaign will be evaluated and a target density for specific for that feed will be determined considering the ability of the transfer system to maintain solids in suspension and the DSTs ability to stay within buoyant displacement gas release event (BDGRE) controls. In the future, a lower value may be used for waste containing high concentrations of phosphates.

[45] The evaporator feed may be sampled and staged in one or more DSTs, including AW-102, during the three-month period prior to being run through the evaporator.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	• The waste volume reduction factor can be calculated using the following equation: $$WVR = \frac{(\rho_B - \rho_F)}{(\rho_B - 1)}$$ Where: ρ_B = Evaporator set point (bottoms SpG) ρ_F = Specific gravity of evaporator feed	
Process Condensate Composition	• The volume of process condensate will be 1.15 times the waste volume boiled off the feed to account for seal water and the vacuum system steam jets. • The composition of process condensate from the 242-A Evaporator will be estimated using the split factors calculated using the following equation: $$SF_i = \frac{1}{\left[1 + \frac{Kp_i}{21{,}579}\left(\frac{(1 - WVR)}{WVR}\right)\right]}$$ Where: SF_i = split factor for component i; the split factor is the mass or activity of component i in the process condensate to the mass or activity of i in the feed WVR = waste volume reduction factor Kp_i = 242-A evaporator partition coefficients from HNF-14755 and RPP-17239; in the case of tritium and water the Kp_i values are equal to the WVR because they partition equally with water. The partition coefficients are provided in Table B-9. 21,579 = a numerical factor accounting for the 15% volume increase and for the ratio of the volume of condensate as a vapor to the volume of condensate as a liquid.	No
Gaseous Effluent	The contributions of the waste to the gaseous effluent stream will be estimated by applying split factors (the reciprocal of decontamination factors) to the process condensate stream. The split factors are derived from decontamination factors that come from a condenser in the WTP evaporator model, which is based on the 242-A evaporator. The split factors are reported in	No

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	Table B-4.	
A4.3.4. ETF and LERF		
• Effluent Treatment Facility • LERF Capacity	• ETF (nor the downstream facilities TEDF/SALDS) capacity does not constrain Tank Farm, supplemental treatment, or WTP operations. The processing rate may be varied at the discretion of the modeler. • The ETF will be modeled as a black-box. Overall partitioning of feed into solid waste and treated effluent will be approximated using overall removal efficiencies for the polisher.[46] The values used are reported in Table B-10. • The LERF will be modeled as two basins[47], each with a 7.8 Mgal volume, used to provide lag storage of liquid effluents from the 242-A Evaporator and the various treatment processes. One will be used to accumulate effluents while the other is used to feed the ETF.	No
A4.4. Waste Feed Delivery		
A4.4.1. LAW Feed Delivery Plans		
LAW Feed Delivery Sequence and Envelope Designation[48].	<u>Source Tank (Envelope)</u> AY-102 (containing concentrated AP-101; A/D) 1-3 tanks from AP-Farm (A) AN-104 (A) AN-102 (C) **Treat as Envelope A for model assumption AN-105 (A) AN-107 (C) **Treat as Envelope A for model assumption SY-101 (A) AN-103 (A) AW-101(A) Continue with liquid wastes made available from SST retrieval. Actual sequence and timing for delivery of pretreated AN-102 (107) supernatants can be changed at the modeler's discretion.	Yes

[46] Removal efficiencies reported in Table B-7 are taken from HNF-4573, *Liquid Effluent Retention Facility Basin 44 Process Test Post-Report*, Rev. 0A.

[47] Two of the three LERF basins are allocated to support the waste treatment mission; the other basis is set aside for potential use with CERCLA waste.

[48] The LAW feed sequence may be modified to support accelerated SST retrieval or to improve the availability of feed for the WTP at the discretion of the modeler.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
A4.4.2. LAW Feed Specifications		
	BNI contract Specification 7 will be used to assess envelope compliance.	No
A4.4.3. LAW Entrained Solids		
Entrained Solids Quantity	• 0.5 wt% solids are entrained in decanted supernatants. • Supernatant liquids from dissolving salts will entrain the same solids concentration as exists in the tank after dissolution up to a maximum of 2 wt%.	No
Entrained Solids Composition	Entrained solids have the same composition as the average composition of solids in the tank.	No
A4.4.4. HLW Feed Delivery Plans		
HLW Feed Delivery Sequence and Retrieval Efficiency[49]	Source Tank — Retrieval Efficiency AY-102 (AP-101)[50] — 90% AZ-101 — 90% AZ-102 — 80% C-104/AY-101 — 100%/100% Continue with HLW solids made available from SST retrieval.	No
A4.4.5. HLW Feed Specifications		
	BNI contract Specification 8 will be used to assess envelope compliance.	No
A4.4.6. Feed Compliance Verification		
Compliance Verification Sampling	Allow 210 days to complete feed compliance verification starting from when each staging tank (DST) is first filled with feed.	No
A5.0. Project Delivery		
A5.1. Project Impacts on DST System Availability[51]		
AN-101-01A Pit work (W-314)	9/23/2004 – 4/7/2005	No
241-A-A Pit work outage (W-314)	9/23/2004 – 4/7/2005	No
AN Farm Outage (W-314)	9/23/2004 – 4/7/2005	No
AP Farm Outage (W-314)	9/23/2004 – 4/7/2005	No
AP 102 Outage	Mixer pump installation will require a 16 month outage	Yes
Cross-site line outage connects	9/23/2004 – 4/7/2005	No

[49] The HLW feed sequence may be modified to support accelerated SST retrieval or to improve the availability of feed for the WTP at the discretion of the modeler.

[50] Consolidation of AP-101 waste into tank AY-102 introduces a risk that there will be insufficient space to receive aging waste farm ventilation condensates from 702-AZ. AY-102 solids are anticipated to be delivered with water for WTP Hot Commissioning feed.

[51] These dates are not considered hard constraints because of current efforts to re-plan field schedules. The modeling will be managed to use the latest available schedule data and still meet the completion date.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
cross-site to AN farm (W-314)		
Cross-site to AP farm (W-211)	6/1/2004 – 11/1/2004	No
AW Farm Outage (W-314)	7/1/2004 – 11/1/2004	No
SY Farm Outage (W-314)	7/1/2004 – 11/1/2004	No
244-S Outage (W-314)	4/10/2003 – 8/1/2004 222-S direct routed to SY farm after 6/30/2005 PFP can no longer use 244-TX after 3/30/2005	No
AY Farm Electrical Upgrades to support C-104 retrieval	12/1/2005 – 12/1/2006	No
AZ Farm Electrical Upgrades	9/23/2004 – 12/31/2005	No
A5.2. Feed Staging Tank Upgrades		
	• The necessary equipment will be available in time to support all planned waste transfers. • The DSTs will need a mixer pump, and, a decant/transfer pump (if solids entrainment is a concern) or a fixed intake transfer pump (if solids entrainment is not a problem). Solids retrieval equipment will be installed in AN-101 and AN-106 to move C-Farm solids into WTP waste feed staging tanks. • The following DSTs have been identified as requiring expense or capital project work before use as feed staging tanks; AN-101, AN-102, AN-103, AN-104, AN-105, AN-107, AP-101, AP-102, AP-104, AW-101, AY-101, AY-102, AZ-101, and AZ-102	No
A6.0. HTWOS Model or Data Analysis Assumptions		
A6.1. Estimating Waste Compositions		
	Wastes are homogenized when mixed.	No
A6.2. Water Content of Initial Inventory		
	The water content of initial inventory is determined by calculating a stream density and total stream mass (including water), the total stream mass excluding water, and then obtaining water content by difference.	No
A6.3. Volume of In-Process Streams		
	Volumes of waste streams are calculated from mass using density correlations for liquids and a solid density of 3 g/mL.	No
A6.4. Transuranic Content Accounting		
	TRU quantities for LAW and ILAW are based on Specification 2 and 7 definitions.	No
A6.5. Radionuclide Decay		

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)		Involves Model Change That Needs to be Verified?
	• The BBI reference decay date of 1/1/2004 is used as the reference decay date in the model. • Radionuclides are decayed to the date of delivery for feed specification compliance assessment. • Half-life values for decay calculations are taken from the Chart of Nuclides, 15th Edition.	No
A6.6. Waste Chemistry and Mass Balances		
	• Dissolution of solids is predicted by the application of water-wash factors from TWINS and by use of the Sr solubility model documented in RPP-21807.[52] • Chemical charges are balanced when washing solids by the adjustment of bound OH^- and then by adjustment of CO_3^{2-}. • TOC (less oxalate) shall be treated as C. • HTWOS does not account for solids formation.	No
A6.7. ILAW Package Production		
	ILAW package production rates are based on the glass production rates, glass density, and package fill assumptions.	No
A6.8. IHLW Canister Production		
	IHLW canister production rates are based on the glass production rates, glass density, and package fill assumptions.	No
A6.9. Mission Summary Diagram		
Mission Summary Diagram • Schedule float • Transfer window	• Handled external to the model. When possible, allocate 6 months float on either side of feed compliance verification activities for the 1st batch of LAW and the 1st batch of HLW. All other schedule float and project strategy will be developed with guidance from Projects. • Two months	No
Terms: BBI = Best Basis Inventory BNI = Bechtel National, Inc. BNI/WGI = Bechtel National-Washington Group		

[52] The strontium solubility model does not apply to AN-102 and AN-107 supernatant treatment where specific strontium percent removals were provided.

Table B-2. Assumptions Matrix. (20 Sheets)

Case name: Sr/TRU Separation in the DSTs (Study 2)	Involves Model Change That Needs to be Verified?
DST = Double-Shell Tank ETF = Effluent Treatment Facility FY = fiscal year HLW = high-level waste IDF = Integrated Disposal Facility IHLW = immobilized high-level waste ILAW = immobilized low-activity waste IMUST = inactive miscellaneous underground storage tanks LAW = low-activity waste LERF = Liquid Effluent Retention Facility LLW = low-level waste MSD = Mission Summary Diagram NCAW = neutralized current acid waste NCRW = neutralized cladding removal waste ORP = U.S. Department of Energy, Office of River Protection PFP = Plutonium Finishing Plant PUREX = Plutonium-Uranium Extraction Plant RL = U.S. Department of Energy, Richland Operations Office SST = Single-Shell Tank TPA = Tri-Party Agreement (*Hanford Federal Facility Agreement and Consent Order*) TRU = transuranic TWINS = Tank Waste Information Network System WSCF = Waste Sampling and Characterization Facility WESF = Waste Encapsulation and Storage Facility WRF = Waste Retrieval Facility WTP = Waste Treatment and Immobilization Plant WVRF = waste volume reduction factor	

Table B-3. Transuranic Waste Dryer Retention Factors. (2 Sheets)					
Analyte	Fraction Retained	Split Factor[2]	Analyte	Fraction Retained	Split Factor
106-Ru	99.999640%	3.600E-06	Cd+2	99.899690%	1.003E-03
113m-Cd	99.899690%	1.003E-03	Ce+3	99.999988%	1.250E-07
125-Sb	99.999988%	1.250E-07	Cl-	99.806490%	1.935E-03
126-Sn	99.999988%	1.250E-07	CN-	99.719600%	2.804E-03
129-I	26.214580%	7.379E-01	Co+3	99.899700%	1.003E-03
134-Cs	100.000000%	0.000E+00	CO3-2	99.899700%	1.003E-03
137-Cs	100.000000%	0.000E+00	Cr(OH)4-	99.999988%	1.250E-07
137m-Ba	100.000000%	0.000E+00	Cr(TOTAL)	99.997130%	2.870E-05
14-C	99.899680%	1.003E-03	Cs+	100.000000%	0.000E+00
151-Sm	99.999988%	1.250E-07	Cu+2	99.892270%	1.077E-03
152-Eu	99.999988%	1.250E-07	F-	99.994300%	5.700E-05
154-Eu	99.999988%	1.250E-07	Fe+3	99.890000%	1.100E-03
155-Eu	99.999988%	1.250E-07	H2O	Calculated[1]	Calculated[1]
226-Ra	99.999988%	1.250E-07	Hg+2	99.899640%	1.004E-03
227-Ac	99.999988%	1.250E-07	K+	99.971130%	2.887E-04
228-Ra	99.999988%	1.250E-07	La+3	99.999988%	1.250E-07
229-Th	99.999988%	1.250E-07	Li+	99.999988%	1.250E-07
231-Pa	99.999988%	1.250E-07	Mg+2	99.187720%	8.123E-03
232-Th	99.999988%	1.250E-07	Mn+4	99.897470%	1.025E-03
232-U	99.899660%	1.003E-03	Mo+6	99.899700%	1.003E-03
233-U	99.899660%	1.003E-03	Na+	99.996610%	3.390E-05
234-U	99.899660%	1.003E-03	Nd+3	99.999988%	1.250E-07
235-U	99.899660%	1.003E-03	NH3	11.001890%	8.900E-01
236-U	99.899660%	1.003E-03	Ni+2	99.899690%	1.003E-03
237-Np	99.899700%	1.003E-03	NO2-	99.958180%	4.182E-04
238-Pu	99.999970%	3.000E-07	NO3-	99.883090%	1.169E-03
238-U	99.899660%	1.003E-03	OH (Bound)	99.999988%	1.250E-07
239-Pu	99.999970%	3.000E-07	OH-	99.899700%	1.003E-03
240-Pu	99.999970%	3.000E-07	Pb+2	96.760970%	3.239E-02
241-Am	99.999930%	7.000E-07	Pd+2	99.999988%	1.250E-07
241-Pu	99.999970%	3.000E-07	PO4-3	99.899700%	1.003E-03
242-Cm	99.899700%	1.003E-03	Pr+3	99.999988%	1.250E-07
242-Pu	99.999970%	3.000E-07	Pu+4	99.999970%	3.000E-07
243-Am	99.999930%	7.000E-07	Rb+	99.999988%	1.250E-07
243-Cm	99.899700%	1.003E-03	Rh+3	99.999988%	1.250E-07
244-Cm	99.899700%	1.003E-03	Ru+3	99.999640%	3.600E-06
3-H	Calculated[1]	Calculated[1]	Sb+5	99.999988%	1.250E-07

Table B-3. Transuranic Waste Dryer Retention Factors. (2 Sheets)					
Analyte	Fraction Retained	Split Factor[2]	Analyte	Fraction Retained	Split Factor
59-Ni	99.899690%	1.003E-03	Se+6	99.999988%	1.250E-07
60-Co	99.899700%	1.003E-03	Si+4	99.840100%	1.599E-03
63-Ni	99.899690%	1.003E-03	SO4-2	99.911820%	8.818E-04
79-Se	99.899700%	1.003E-03	Sr+2	99.999980%	2.000E-07
90-Sr	99.999980%	2.000E-07	Ta+5	99.999988%	1.250E-07
90-Y	99.999980%	2.000E-07	Tc+7	99.899700%	1.003E-03
93-Zr	99.999988%	1.250E-07	Te+6	99.999988%	1.250E-07
93m-Nb	99.899700%	1.003E-03	Th+4	99.999988%	1.250E-07
99-Tc	99.899700%	1.003E-03	Ti+4	99.999988%	1.250E-07
Ag+	99.999988%	1.250E-07	Tl+3	99.999988%	1.250E-07
Al(OH)4-	99.933110%	6.689E-04	TOC	97.130510%	2.869E-02
Al+3	99.933110%	6.689E-04	U(TOTAL)	99.899690%	1.003E-03
As+5	99.999988%	1.250E-07	V+5	99.999988%	1.250E-07
B+3	99.894770%	1.052E-03	W+6	99.899700%	1.003E-03
Ba+2	99.889560%	1.104E-03	Y+3	99.999980%	2.000E-07
Be+2	99.999988%	1.250E-07	Zn+2	99.897910%	1.021E-03
Bi+3	99.999988%	1.250E-07	Zr+4	99.999988%	1.250E-07
Ca+2	98.691590%	1.308E-02	NA	NA	NA

Notes:

1. Water and tritium retention in the dried solids and partitioning to the condensate is based on the water content of the dried solids with tritium partitioning in the same proportion as water.
2. $$SFi = \left(1 - \frac{RFi}{100}\right)$$

Where,

SFi = The split factor or component i,
RFi = The dryer retention factor for component i expressed as a percent,
i = Index for the component list,
/100 = Converts the value from a percentage to a fraction

Table B-4. Gaseous Effluent Split Factors for Generic Condenser. (2 Sheets)

Analyte	Split Factor	Analyte	Split Factor
^{106}Ru	No Value	Ba+2	0.002016
^{113m}Cd	0.00154	Bi+3	0.0000358
^{125}Sb	0.0000358	C2O4-2	1.53E-06
^{126}Sn	0.0000358	Ca+2	0.05814
^{129}I	0.0011	Cd+2	0.00154
^{134}Cs	0.0000427	Ce+3	0.00154
^{137}Cs	0.0000427	Cl-	0.0001299
^{137m}Ba	0.002	Co+3	0.00154

Table B-4. Gaseous Effluent Split Factors for Generic Condenser. (2 Sheets)

Analyte	Split Factor	Analyte	Split Factor
^{14}C	0.00154	CO3-2	0.00154
^{151}Sm	0.00032	Cr(OH)4-	0.000188
^{152}Eu	0.00032	Cr(TOTAL)	0.000188
^{154}Eu	0.00032	Cs+	0.0000427
^{155}Eu	0.00032	Cu+2	0.000188
^{229}Th	0.00154	F-	0.00053
^{232}Th	0.00154	Fe+3	0.002
^{232}U	0.00154	H+	0.01
^{233}U	0.00154	Hg+2	0.00154
^{234}U	0.00154	K+	0.00157
^{235}U	0.00154	La+3	0.00154
^{236}U	0.00154	Li+	0.0016
^{237}Np	0.00154	Mg+2	0.035
^{238}Pu	0.00032	Mn+4	0.001642
^{238}U	0.00154	Mo+6	0.001642
^{239}Pu	0.00032	Na+	0.0016
^{240}Pu	0.00032	NH3	0.0806
^{241}Am	0.00032	Ni+2	0.00154
^{241}Pu	0.00032	NO2-	0.0000962
^{242}Cm	0.00154	NO3-	0.0000962
^{242}Pu	0.00032	OH (Bound)	0.00154
^{243}Am	0.00032	OH-	0.00154
^{243}Cm	0.00154	Pb+2	0.0000358
^{244}Cm	0.00154	Pd+2	0.00154
^{3}H	0.014	PO4-3	0.00154
^{59}Ni	0.00154	Pu+4	0.00032
^{60}Co	0.00154	Sb+5	0.0000358
^{63}Ni	0.00154	Si+4	0.00435
^{90}Sr	0.0000855	SO4-2	0.0002375
^{93}Zr	0.002	Sr+2	0.0000855
^{99}Tc	0.00154	Tc+7	0.00154
Ag+	0.00188	Th+4	0.00154
Al(OH)4-	0.00154	Ti+4	0.002
Al+3	0.00154	U(TOTAL)	0.00154
As+5	0.00154	Zn+2	0.001621
B+3	0.00177	Zr+4	0.002

Table B-5. Selective Dissolution Separation Assumptions.

Specie	Percentage of Tank Waste Low Curie Feed to Bulk Vitrification	Percentage of Waste Feed to Waste Treatment Plant
Chemical		
Aluminum (Al)	40	60
Calcium (Ca)	100	0
Chromate (CrO4)	45	55
Potassium (K)	80	20
Sodium (Na)	70	30
Nitrate (NO3)	65	35
Nitrite (NO2)	40	60
Hydroxide (OH)	40	60
Chloride (Cl)	40	60
Fluoride (F)	100	0
Phosphate (PO4)	75	25
Sulfate (SO4)	90	10
Total Inorganic Carbon (TIC)	85	15
Total Organic Carbon (TOC)	90	10
Radionuclide		
^{90}Sr (soluble)[2]	100	0
^{99}Tc	40	60
^{129}I	40	60
^{137}Cs [1]	20 to 40	80 to 60
^{241}Am (soluble)[2]	100	0
Pu (soluble)[2]	100	0

Table B-6. Single-Shell Tank Retrieval Pool Tank List.

A-102	C-108	SX-108
A-106	C-109	SX-110
AX-101	C-110	SX-115
AX-102	C-111	T-104
AX-103	C-112	T-110
AX-104	C-201	T-111
B-201	C-202	T-112
B-202	C-203	T-201
B-203	C-204	T-202
B-204	S-102	T-203
C-101	S-103	T-204
C-102	S-105	U-112
C-103	S-107	U-201
C-104	S-112	U-202
C-105	SX-101	U-203
C-106	SX-105	U-204
C-107	SX-106	-

Table B-7. Single-Shell Tank Retrieval Modeling Assumptions. (2 Sheets)

Order in Sequence[1,2]	Single-Shell Tank	Target Destination	Estimated As-Retrieved Volume to DSTs (Kgal)[3]	Estimated Retrieval Duration (days)
1	C-106	AN-106	485	134
2	S-112	SY-101	2,000	294
3	C-203	AN-106	37	12
4	C-202	AN-106	12	4
5	S-102	SY-102	1,500	184
6	C-201	AN-106	12	4
7	C-204	AN-106	24	8
	S-109[4]	SY-102/ Supp Demo	100/ 592	7/ TBD
8	U-201	SY-102	40	5
9	U-202	SY-102	40	5
10	U-203	SY-102	40	5
11	U-204	SY-102	30	4
12	C-103	AN-106	230	38
13	C-102	AN-101	445	164
14	C-105	AN-106	276	38
15	B-201	TRU	[30]	10
16	B-202	TRU	[29]	10
17	B-203	TRU	[51]	17
18	B-204	TRU	[50]	17
19	T-201	TRU	[31]	10
20	C-109	AN-106	280	34
21	T-202	TRU	[21]	7
22	T-203	TRU	[37]	12
23	C-101	AN-101	332	56
24	C-112	AN-106	316	55
25	T-204	TRU	[37]	12
26	T-110	TRU	[370]	128
27	C-110	AY-101	374	40
28	C-107	AN-106	420	32
29	C-104	AY-101	1,700	134
30	C-111	AN-101	229	42
31	T-111	TRU	[447]	155
32	C-108	AN-106	279	35
33	U-112	SY-102	555	47
34	SX-115	SY-102	35	7
35	SX-108	SY-102	178	26
36	A-102	AN-101	68	6
37	A-106	AN-101	384	26
38	T-104	TRU	[441]	153
39	SX-110	SY-102	478	25
40	AX-102	AN-101	53	4
41	AX-104	AN-101	97	2
42	AX-103	AN-101	235	14
43	AX-101	AN-101	999	125
44	SX-106	SY-102	979	131

Table B-7. Single-Shell Tank Retrieval Modeling Assumptions. (2 Sheets)

Order in Sequence[1,2]	Single-Shell Tank	Target Destination	Estimated As-Retrieved Volume to DSTs (Kgal)[3]	Estimated Retrieval Duration (days)
45	SX-105	TBD	984	13
46	SX-101	TBD	1,170	16
47	S-103	TBD	1,300	97
48	S-105	TBD	2,200	239
49	S-107	TBD	2,963	70
50	T-112	TBD	67	23

Notes:

1. Retrieval of waste from tank C-106 has been completed.
2. Sequence numbering applied to SST retrieval pool tanks.
3. Volumes given are net impact to the DST system. The waste in the C-Farm SSTs and tank S-102 will be retrieved using recirculation involving larger volumes. Volumes in brackets [ ] represent CH-TRU waste that is retrieved directly to the Supplemental TRU Sludge Treatment System without impact to DST tank space.
4. Tank S-109 is not in the single-shell tank retrieval pool but some waste is being retrieved from tank S-109 to demonstrate supplementary low-activity waste treatment technologies to support other RRP mission requirements. The impact of the S-109 retrieval to the DST system was modeled as 100 Kgal with the bulk of the as-retrieved volume being fed to a supplemental treatment process.

Table B-8. Maximum DST Fill Levels

DSTs	Current Fill Height Limit (inches)	New Fill Height Limit (inches)	Level Increase (Date)	Current Fill Volume[1] (Kgal)	New Fill Volume[1,2] (Kgal)
AP-101	416	449	11/1/04	1,144	1,235
AP-102	416	449	11/1/04	1,144	1,235
AP-103	416	449	11/1/04	1,144	1,235
AP-104	416	449	11/1/04	1,144	1,235
AP-105	416	449	11/1/04	1,144	1,235
AP-106	416	449	11/1/04	1,144	1,235
AP-107	416	449	11/1/04	1,144	1,235
AP-108	416	449	11/1/04	1,144	1,235
SY-101	416	416	NA	1,144	1,144
SY-102	421	421	NA	1,158	1,158
SY-103	416	416	NA	1,144	1,144
AN-101	416	416	NA	1,144	1,144
AN-102	416	416	NA	1,144	1,144
AN-106	416	416	NA	1,144	1,144
AN-107	416	416	NA	1,144	1,144
AN-103	416	416	NA	1,144	1,144
AN-104	416	416	NA	1,144	1,144
AN-105	416	416	NA	1,144	1,144
AW-105	416	416	NA	1,144	1,144
AW-106	416	416	NA	1,144	1,144
AW-101	416	416	NA	1,144	1,144
AW-102	409	409	NA	1,125	1,125
AW-103	416	416	NA	1,144	1,144
AW-104	416	416	NA	1,144	1,144
AY-101	364	364	NA	1,001	1,001
AY-102	364	364	NA	1,001	1,001
AZ-101	364	364	NA	1,001	1,001
AZ-102	364	364	NA	1,001	1,001
-	-	-	Total	31,455	32,183

Notes:

1. Fill volumes are calculated from fill heights and are rounded to the nearest 1,000 gallons
2. Existing space and new available space from increasing levels in some DSTs may not be used immediately because of other constraints, such as safety basis constraints, for example.

Table B-9. Partition Coefficients for the 242-A Evaporator. (3 Sheets)

Component Name	Partition Coefficient[1]	Reference
106-Ru	6.70E+07	HNF-14755, Rev. 0
113m-Cd	1.00E+07	RPP-17239, Rev. 0
125-Sb	1.00E+07	HNF-14755, Rev. 0
126-Sn	1.00E+07	HNF-14755, Rev. 0
129-I	4.00E+08	RPP-17239, Rev. 0
134-Cs	1.00E+07	RPP-17239, Rev. 0
137-Cs	9.30E+11	RPP-17239, Rev. 0
137m-Ba	1.00E+07	RPP-17239, Rev. 0
14-C	1.00E+07	HNF-14755, Rev. 0
151-Sm	1.00E+07	HNF-14755, Rev. 0
152-Eu	1.00E+07	RPP-17239, Rev. 0
154-Eu	1.00E+07	RPP-17239, Rev. 0
155-Eu	1.00E+07	HNF-14755, Rev. 0
226-Ra	1.00E+07	HNF-14755, Rev. 0
227-Ac	1.00E+07	RPP-17239, Rev. 0
228-Ra	1.00E+07	RPP-17239, Rev. 0
229-Th	1.00E+07	RPP-17239, Rev. 0
231-Pa	1.00E+07	RPP-17239, Rev. 0
232-Th	1.00E+07	RPP-17239, Rev. 0
232-U	1.00E+07	RPP-17239, Rev. 0
233-U	1.00E+07	HNF-14755, Rev. 0
234-U	1.00E+07	HNF-14755, Rev. 0
235-U	1.00E+07	HNF-14755, Rev. 0
236-U	1.00E+07	RPP-17239, Rev. 0
237-Np	3.70E+10	RPP-17239, Rev. 0
238-Pu	3.70E+10	HNF-14755, Rev. 0
238-U	1.00E+07	HNF-14755, Rev. 0
239-Pu	3.70E+10	HNF-14755, Rev. 0
240-Pu	1.00E+07	HNF-14755, Rev. 0
241-Am	1.40E+10	HNF-14755, Rev. 0
241-Pu	1.00E+07	HNF-14755, Rev. 0
242-Cm	1.00E+07	RPP-17239, Rev. 0
242-Pu	1.00E+07	RPP-17239, Rev. 0
243-Am	1.40E+10	HNF-14755, Rev. 0
243-Cm	1.00E+07	RPP-17239, Rev. 0
244-Cm	1.00E+07	HNF-14755, Rev. 0
3-H	=WVR[2]	RPP-17239, Rev. 0
59-Ni	1.00E+07	RPP-17239, Rev. 0
60-Co	7.00E+10	RPP-17239, Rev. 0
63-Ni	1.00E+07	HNF-14755, Rev. 0
79-Se	1.00E+07	HNF-14755, Rev. 0
90-Sr	2.30E+09	RPP-17239, Rev. 0
90-Y	1.00E+07	RPP-17239, Rev. 0
93-Zr	1.00E+07	HNF-14755, Rev. 0
93m-Nb	1.00E+07	RPP-17239, Rev. 0
99-Tc	1.10E+11	RPP-17239, Rev. 0
Ag+	1.00E+07	HNF-14755, Rev. 0
Al(OH)4-	1.00E+07	RPP-17239, Rev. 0
Al+3	1.50E+07	HNF-14755, Rev. 0
As+5	1.00E+07	HNF-14755, Rev. 0

Table B-9. Partition Coefficients for the 242-A Evaporator. (3 Sheets)

Component Name	Partition Coefficient[1]	Reference
B+3	1.00E+07	HNF-14755, Rev. 0
Ba+2	1.00E+07	HNF-14755, Rev. 0
Be+2	1.00E+07	HNF-14755, Rev. 0
Bi+3	1.00E+07	HNF-14755, Rev. 0
Ca+2	1.00E+07	HNF-14755, Rev. 0
Cd+2	1.00E+07	HNF-14755, Rev. 0
Ce+3	1.00E+07	RPP-17239, Rev. 0
Cl-	5.20E+06	HNF-14755, Rev. 0
CN-	1.00E+07	HNF-14755, Rev. 0
Co+3	1.00E+07	RPP-17239, Rev. 0
CO3-2	1.00E+07	HNF-14755, Rev. 0
Cr(OH)4-	1.00E+07	RPP-17239, Rev. 0
Cr(TOTAL)	3.50E+08	HNF-14755, Rev. 0
Cs+	1.00E+07	RPP-17239, Rev. 0
Cu+2	1.00E+07	RPP-17239, Rev. 0
F-	2.40E+08	HNF-14755, Rev. 0
Fe+3	1.00E+07	HNF-14755, Rev. 0
H+	=WVR[2]	RPP-17239, Rev. 0
H2O	=WVR[2]	RPP-17239, Rev. 0
Hg+2	1.00E+07	HNF-14755, Rev. 0
K+	3.50E+07	HNF-14755, Rev. 0
La+3	1.00E+07	RPP-17239, Rev. 0
Li+	1.00E+07	RPP-17239, Rev. 0
Mg+2	1.00E+07	HNF-14755, Rev. 0
Mn+4	1.00E+07	HNF-14755, Rev. 0
MnO2	1.00E+07	RPP-17239, Rev. 0
MnO4-	1.00E+07	RPP-17239, Rev. 0
Mo+6	1.00E+07	HNF-14755, Rev. 0
Na+	3.00E+08	HNF-14755, Rev. 0
Nd+3	1.00E+07	RPP-17239, Rev. 0
NH3	1.10E+03	HNF-14755, Rev. 0
Ni+2	1.00E+07	HNF-14755, Rev. 0
NO2-	2.40E+07	HNF-14755, Rev. 0
NO3-	5.70E+06	HNF-14755, Rev. 0
OH-	1.00E+07	HNF-14755, Rev. 0
Pb+2	3.00E+05	HNF-14755, Rev. 0
Pd+2	1.00E+07	RPP-17239, Rev. 0
PO4-3	1.00E+07	HNF-14755, Rev. 0
Pr+3	1.00E+07	RPP-17239, Rev. 0
Pu+4	1.00E+07	RPP-17239, Rev. 0
Rb+	1.00E+07	RPP-17239, Rev. 0
Rh+3	1.00E+07	RPP-17239, Rev. 0
Ru+3	1.00E+07	RPP-17239, Rev. 0
Sb+5	1.00E+07	HNF-14755, Rev. 0
Se+6	1.00E+07	HNF-14755, Rev. 0
Si+4	1.00E+07	HNF-14755, Rev. 0
SO4-2	1.40E+07	HNF-14755, Rev. 0
Sr+2	1.00E+07	RPP-17239, Rev. 0
Ta+5	1.00E+07	RPP-17239, Rev. 0
Tc+7	1.00E+07	RPP-17239, Rev. 0
Te+6	1.00E+07	RPP-17239, Rev. 0

Table B-9. Partition Coefficients for the 242-A Evaporator. (3 Sheets)

Component Name	Partition Coefficient[1]	Reference
Th+4	1.00E+07	RPP-17239, Rev. 0
Ti+4	1.00E+07	HNF-14755, Rev. 0
Tl+3	1.00E+07	RPP-17239, Rev. 0
TOC	1.00E+07	RPP-17239, Rev. 0
U(TOTAL)	1.00E+07	HNF-14755, Rev. 0
V+5	1.00E+07	HNF-14755, Rev. 0
W+6	1.00E+07	RPP-17239, Rev. 0
Y+3	1.00E+07	RPP-17239, Rev. 0
Zn+2	1.00E+07	HNF-14755, Rev. 0
Zr+4	1.00E+07	HNF-14755, Rev. 0

Notes;

1. The partition coefficient represents the vapor-liquid equilibrium behavior of a component, and is defined as the ratio of the concentration of a component in the concentrated bottoms to the concentration of that same component in the vapor.
2. The entry "=WVR" means "equals the waste volume reduction factor." The use of "=WVR" indicates that the affected component is split in the same proportions as water.

Table B-10. Liquid Effluent Retention Facility Powder Split Factors. (2 Sheets)

Analyte	Split Factor	Analyte	Split Factor
^{106}Ru	0.99999	Be+3	0.999
^{113m}Cd	0.99999	Bi+3	0.999
^{125}Sb	0.99999	C2O4-2	0.999
^{126}Sn	0.99999	Ca+2	0.999
^{129}I	0.99999	Cd+2	0.999
^{134}Cs	0.99999	Ce+3	0.999
^{137}Cs	0.99999	Cl-	0.999
^{137m}Ba	0.99999	Co+3	0.999
^{14}C	0.99999	CO3-2	0.999
^{151}Sm	0.99999	Cr(OH)4-	0.999
^{152}Eu	0.99999	Cr(TOTAL)	0.999
^{154}Eu	0.99999	Cs+	0.999
^{155}Eu	0.99999	Cu+2	0.999
^{226}Ra	0.99999	F-	0.999
^{227}Ac	0.99999	Fe+3	0.999
^{228}Ra	0.99999	Hg+2	0.999
^{231}Pa	0.999	K+	0.999
^{229}Th	0.999	La+3	0.999
^{232}Th	0.999	Li+	0.999
^{232}U	0.999	Mg+2	0.999
^{233}U	0.999	Mn+4	0.999
^{234}U	0.999	Mo+6	0.999
^{235}U	0.999	Na+	0.999

Table B-10. Liquid Effluent Retention Facility Powder Split Factors. (2 Sheets)

Analyte	Split Factor	Analyte	Split Factor
^{236}U	0.999	Nd+3	0.999
^{237}Np	0.999	NH3	0.999
^{238}Pu	0.999	Ni+2	0.999
^{238}U	0.999	NO2-	0.999
^{239}Pu	0.999	NO3-	0.999
^{240}Pu	0.999	OH (Bound)	0.999
^{241}Am	0.999	OH-	0.999
^{241}Pu	0.999	Pb+2	0.999
^{242}Cm	0.999	Pd+2	0.999
^{242}Pu	0.999	PO4-3	0.999
^{243}Am	0.999	Pu+4	0.999
^{243}Cm	0.999	Rb+	0.999
^{244}Cm	0.999	Rh+3	0.999
^{3}H	0.00	Ru+3	0.999
^{59}Ni	0.999	Sb+5	0.999
^{60}Co	0.99999	Se+6	0.999
^{63}Ni	0.99999	Si+4	0.999
^{79}Se	0.99999	SO4-2	0.999
^{90}Sr	0.999999	Sr+2	0.999
^{90}Y	0.999999	Ta+5	0.999
^{93}Zr	0.99999	Tc+7	0.999
^{93m}Nb	0.999999	Te+6	0.999
^{99}Tc	0.99999	Th+4	0.999
Ag+	0.999	Ti+4	0.999
Al(OH)4-	0.999	Tl+3	0.999
Al+3	0.999	TOC	0.930
As+5	0.999	U(TOTAL)	0.999
B+3	0.999	Zn+2	0.999
Ba+2	0.999	Zr+4	0.999

Note: Split factor values are based on Polisher removal efficiencies taken from HNF-4573, *Liquid Effluent Retention Facility Basin 44 Process Test Post-Report*, Rev. 0A.

B1.2 EXCEPTIONS TO ASSUMPTIONS

Text of Item: A deviation in the percent removal of the carbonate (CO_3) was identified between the HTWOS model run and mass balance presented in this study. The HTWOS models removal of total inorganic carbon (TIC) as CO_3 at 100%, whereas the mass balance modeled removal of TIC as CO_3 as equal to the amount of Sr removal (results are 3.9% removal). The impact of this exception is taken to be negligible.

No other discrepancies were identified.

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APPENDIX C

HTWOS RESULTS

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HTWOS Output for Sr/TRU Separation Process in the Double-Shell Tank System. The HTWOS model output provides the LAW delivery dates to WTP for the tank AN-102 and tank AN-107 supernatants.

March 16 HTWOS Output for Task 2 Optimization Study - Sr/ TRU Separation Process in the Double-Shell Tank System

Source	Receipt	Start	End	Liq(gal)	Sol(gal)	In-line(gal)	Liq(SpG)	Water(kg)	Activity(Ci)	
AY-102	WTP-LAW-RECEIPT	12/2/2009	12/2/2009	7.08E+05	6622.45	0	1.409	2.34E+06	2.24E+06	
AP-101	WTP-LAW-RECEIPT	4/25/2011	4/25/2011	1.21E+06	33.69	0	1.467	3.71E+06	1.49E+06	
AP-103	WTP-LAW-RECEIPT	9/30/2011	9/30/2011	1.21E+06	4.304	0	1.375	3.54E+06	1.76E+06	
AN-104	WTP-LAW-RECEIPT	3/3/2012	3/3/2012	6.88E+05	6295.227	0	1.386	2.27E+06	1.27E+06	
AN-101	WTP-LAW-RECEIPT	6/17/2012	6/17/2012	7.71E+05	2818.084	0	1.375	2.53E+06	1.33E+06	
AP-102	WTP-LAW-RECEIPT	10/4/2012	10/5/2012	1.18E+06	0	0	1.399	3.42E+06	1.70E+06	AP-102 Supernatant
AP-102	WTP-LAW-RECEIPT	4/23/2013	4/23/2013	9.70E+05	0	0	1.251	3.18E+06	1.15E+06	AN-102 Batch #1
AP-102	WTP-LAW-RECEIPT	8/12/2013	8/12/2013	7.92E+05	0	0	1.238	2.59E+06	9.50E+05	AN-102 Batch #2
AP-105	WTP-LAW-RECEIPT	12/10/2013	12/10/2013	1.21E+06	1177.584	0	1.479	3.71E+06	1.73E+06	
AP-103	WTP-LAW-RECEIPT	6/4/2014	6/5/2014	7.53E+05	1130.324	0	1.318	2.37E+06	8.49E+05	
AN-105	WTP-LAW-RECEIPT	8/23/2014	8/23/2014	7.53E+05	7258.539	0	1.46	2.63E+06	1.07E+06	
AP-102	WTP-LAW-RECEIPT	11/24/2014	11/24/2014	7.52E+05	0	0	1.255	2.50E+06	8.05E+05	AN-107 Batch #3
AP-102	WTP-LAW-RECEIPT	3/11/2015	3/11/2015	6.56E+05	0	0	1.257	2.18E+06	6.84E+05	AN-107 Batch #4
AP-107	WTP-LAW-RECEIPT	5/24/2015	5/24/2015	1.14E+06	6.884	0	1.41	3.43E+06	1.64E+06	
AP-103	WTP-LAW-RECEIPT	11/29/2015	11/29/2015	8.54E+05	868.397	0	1.371	2.85E+06	1.51E+06	
AN-103	WTP-LAW-RECEIPT	3/17/2016	3/18/2016	8.55E+05	1972.805	0	1.503	3.15E+06	1.07E+06	
AN-105	WTP-LAW-RECEIPT	7/19/2016	7/19/2016	7.15E+05	6567.079	0	1.392	2.37E+06	1.07E+06	
AW-101	WTP-LAW-RECEIPT	11/16/2016	11/16/2016	9.50E+05	3426.373	0	1.403	3.18E+06	1.34E+06	
AP-101	WTP-LAW-RECEIPT	5/5/2017	5/10/2017	1.00E+06	0.62	0	1.44	3.30E+06	2.05E+06	
AP-106	WTP-LAW-RECEIPT	11/10/2017	11/15/2017	1.00E+06	4.54E-05	0	1.229	3.37E+06	9.48E+05	
AW-101	WTP-LAW-RECEIPT	3/10/2018	3/16/2018	1.00E+06	0	0	1.243	3.72E+06	2.54E+05	
AP-104	WTP-LAW-RECEIPT	6/6/2018	6/12/2018	1.00E+06	0	0	1.414	3.35E+06	4.96E+05	
AP-101	WTP-LAW-RECEIPT	4/28/2019	5/2/2019	7.92E+05	0	0	1.347	2.65E+06	8.15E+05	
AN-107	WTP-LAW-RECEIPT	5/2/2019	5/3/2019	2.08E+05	0	0	1.278	7.29E+05	59828.141	
AP-102	WTP-LAW-RECEIPT	9/29/2019	10/4/2019	1.00E+06	0	0	1.157	3.63E+06	2.16E+05	Not Applicable
AP-105	WTP-LAW-RECEIPT	8/26/2024	8/31/2024	1.00E+06	2.27E-10	0	1.149	3.61E+06	1.07E+05	
AW-103	WTP-LAW-RECEIPT	1/19/2025	1/25/2025	1.00E+06	9.98E-08	0	1.187	3.53E+06	59034.558	
AW-102	WTP-LAW-RECEIPT	5/29/2025	6/2/2025	5.70E+05	4.00E-09	0	1.197	2.00E+06	22312.925	
AW-101	WTP-LAW-RECEIPT	6/2/2025	6/4/2025	4.30E+05	4.48E-10	0	1.058	1.60E+06	12667.479	
AP-101	WTP-LAW-RECEIPT	9/2/2025	9/16/2025	1.00E+06	6.80E-09	0	1.22	3.56E+06	1.85E+05	
AP-108	WTP-LAW-RECEIPT	1/24/2027	1/31/2027	1.00E+06	5.156	0	1.468	2.85E+06	1.05E+06	
AP-108	WTP-LAW-RECEIPT	9/25/2027	9/26/2027	2.02E+05	1.04	0	1.467	5.78E+05	2.12E+05	
AP-107	WTP-LAW-RECEIPT	9/26/2027	9/30/2027	7.67E+05	16.383	0	1.017	2.90E+06	18593.914	
AN-104	WTP-LAW-RECEIPT	9/30/2027	9/30/2027	499.947	0.053	0	1.058	1862.847	3.057	

March 16 HTWOS Results for AN-107 Batch #4										
AP-102:	HTWOS Projected Composition for Supernatant			1/3/2015						
					Sludge:					
	Liquid	Liquid	Liquid	Solid	Liquid	Liquid	Liquid	Solid	Solid	Solid
	Vol(gal)	Vol(L)	(Spg)	(Spg)	Vol(gal)	Vol(L)	(Spg)	Vol(gal)	Vol(L)	(Spg)
	6.83E+05	2.59E+06	1.26E+00	3.00E+00	4.16E+04	1.58E+05	1.26E+00	1.16E+04	4.41E+04	3.00E+00
	Liquid	Liquid	Liquid	Solid	Liquid	Liquid	Liquid	Solid	Solid	Solid
Comp	(kg-mol)	(kg)	(Ci)	(Ci)	(kg-mol)	(kg)	(Ci)	(kg-mol)	(kg)	(Ci)
106-Ru	1.33E-17	1.41E-15	4.66E-09	0	8.16E-19	8.64E-17	2.86E-10	2.81E-16	2.98E-14	9.85E-08
113m-Cd	7.08E-07	7.96E-05	1.79E+01	0	4.35E-08	4.88E-06	1.10E+00	3.19E-08	3.58E-06	8.04E-01
125-Sb	1.45E-09	1.77E-07	1.83E-01	0	8.90E-11	1.08E-08	1.12E-02	3.15E-10	3.84E-08	3.98E-02
126-Sn	9.75E-03	1.23E+00	1.39E+01	0	5.98E-04	7.54E-02	8.56E-01	4.09E-05	5.16E-03	5.85E-02
129-I	7.54E-03	9.73E-01	1.72E-01	0	4.63E-04	5.97E-02	1.05E-02	2.53E-04	3.26E-02	5.75E-03
134-Cs	5.68E-10	7.78E-08	1.00E-01	0	3.48E-11	4.77E-09	6.16E-03	8.08E-13	1.11E-10	1.43E-04
137-Cs	3.01E-02	4.12E+00	3.58E+05	0	1.85E-03	2.53E-01	2.19E+04	2.20E-04	3.01E-02	2.61E+03
137m-Ba	4.59E-09	6.29E-07	3.38E+05	0	2.82E-10	3.86E-08	2.08E+04	3.36E-11	4.60E-09	2.47E+03
14-C	1.79E-05	2.15E-04	9.58E-01	0	1.10E-06	1.32E-05	5.88E-02	2.84E-08	3.41E-07	1.52E-03
151-Sm	1.08E-03	1.63E-01	4.28E+03	0	6.64E-05	9.99E-03	2.63E+02	8.56E-05	1.29E-02	3.39E+02
152-Eu	1.58E-09	2.43E-07	4.23E-02	0	5.84E-10	9.00E-08	1.56E-02	4.69E-08	7.22E-06	1.25E+00
154-Eu	7.83E-07	1.21E-04	3.26E+01	0	2.90E-07	4.46E-05	1.21E+01	1.47E-05	2.26E-03	6.10E+02
155-Eu	1.15E-07	1.78E-05	8.62E+00	0	4.27E-08	6.57E-06	3.19E+00	1.48E-06	2.28E-04	1.11E+02
226-Ra	2.29E-10	5.18E-08	5.13E-05	0	1.41E-11	3.18E-09	3.15E-06	1.48E-11	3.35E-09	3.31E-06
227-Ac	1.47E-09	3.34E-07	2.42E-02	0	9.03E-11	2.05E-08	1.48E-03	7.65E-12	1.74E-09	1.26E-04
228-Ra	1.02E-10	2.31E-08	6.27E-03	0	6.26E-12	1.41E-09	3.85E-04	2.75E-11	6.21E-09	1.69E-03
229-Th	5.15E-10	1.19E-07	2.56E-05	0	3.16E-11	7.33E-09	1.57E-06	3.33E-09	7.73E-07	1.65E-04
231-Pa	6.12E-06	1.41E-03	6.67E-02	0	3.75E-07	8.67E-05	4.09E-03	2.53E-08	5.83E-06	2.75E-04

March 16 HTWOS Results for AN-107 Batch #4										
AP-102:	HTWOS Projected Composition for Supernatant			1/3/2015						
232-Th	1.16E-01	2.69E+01	2.96E-03	0	7.10E-03	1.65E+00	1.81E-04	3.38E-02	7.84E+00	8.63E-04
232-U	2.61E-10	6.21E-08	1.37E-03	0	1.60E-11	3.81E-09	8.41E-05	3.85E-10	9.17E-08	2.02E-03
233-U	4.09E-05	9.74E-03	9.39E-02	0	2.51E-06	5.98E-04	5.76E-03	5.58E-06	1.33E-03	1.28E-02
234-U	4.49E-05	1.07E-02	6.64E-02	0	2.76E-06	6.56E-04	4.07E-03	2.78E-06	6.61E-04	4.11E-03
235-U	5.11E-03	1.22E+00	2.63E-03	0	3.13E-04	7.46E-02	1.61E-04	3.16E-04	7.52E-02	1.62E-04
236-U	2.92E-04	6.95E-02	4.50E-03	0	1.79E-05	4.27E-03	2.76E-04	1.43E-05	3.40E-03	2.20E-04
237-Np	7.53E-05	1.79E-02	1.26E-02	0	2.79E-05	6.61E-03	4.66E-03	2.26E-03	5.35E-01	3.77E-01
238-Pu	1.62E-07	3.88E-05	6.65E-01	0	6.01E-08	1.44E-05	2.46E-01	2.18E-06	5.20E-04	8.91E+00
238-U	6.50E-01	1.55E+02	5.20E-02	0	3.99E-02	9.49E+00	3.19E-03	4.24E-02	1.01E+01	3.39E-03
239-Pu	6.73E-04	1.61E-01	9.99E+00	0	2.49E-04	5.95E-02	3.69E+00	9.02E-03	2.16E+00	1.34E+02
240-Pu	4.78E-05	1.14E-02	2.60E+00	0	1.77E-05	4.23E-03	9.60E-01	6.41E-04	1.53E-01	3.48E+01
241-Am	1.93E-04	4.66E-02	1.60E+02	0	7.15E-05	1.72E-02	5.91E+01	2.88E-03	6.95E-01	2.38E+03
241-Pu	1.09E-06	2.61E-04	2.69E+01	0	4.04E-07	9.66E-05	9.95E+00	1.46E-05	3.50E-03	3.60E+02
242-Cm	7.23E-10	1.76E-07	5.85E-01	0	2.67E-10	6.52E-08	2.16E-01	9.74E-09	2.38E-06	7.88E+00
242-Pu	2.92E-07	6.99E-05	2.75E-04	0	1.08E-07	2.58E-05	1.02E-04	3.92E-06	9.36E-04	3.69E-03
243-Am	2.21E-06	5.32E-04	1.06E-01	0	8.16E-07	1.97E-04	3.93E-02	3.29E-05	7.93E-03	1.58E+00
243-Cm	1.09E-09	2.66E-07	1.35E-02	0	4.03E-10	9.85E-08	4.98E-03	1.62E-08	3.96E-06	2.00E-01
244-Cm	1.37E-08	3.35E-06	2.72E-01	0	5.08E-09	1.24E-06	1.00E-01	2.05E-07	4.99E-05	4.04E+00
3-H	1.76E-08	5.33E-08	5.16E-01	0	1.08E-09	3.27E-09	3.17E-02	0	0	0
59-Ni	6.94E-03	4.08E-01	3.25E+01	0	4.26E-04	2.50E-02	1.99E+00	1.31E-05	7.70E-04	6.14E-02
60-Co	3.50E-07	2.06E-05	2.33E+01	0	2.15E-08	1.27E-06	1.43E+00	1.70E-09	1.00E-07	1.13E-01
63-Ni	6.30E-04	3.70E-02	2.10E+03	0	3.86E-05	2.27E-03	1.29E+02	1.58E-06	9.28E-05	5.27E+00
79-Se	2.17E-03	1.71E-01	1.19E+00	0	1.33E-04	1.05E-02	7.31E-02	1.74E-06	1.38E-04	9.57E-04
90-Sr	4.08E-04	3.57E-02	4.93E+03	0	3.73E-04	3.27E-02	4.51E+03	5.05E-02	4.42E+00	6.11E+05
90-Y	1.01E-07	9.07E-06	4.93E+03	0	9.21E-08	8.29E-06	4.51E+03	1.25E-05	1.12E-03	6.11E+05

March 16 HTWOS Results for AN-107 Batch #4										
AP-102:	HTWOS Projected Composition for Supernatant			1/3/2015						
93-Zr	1.53E-01	1.40E+01	3.58E+01	0	9.40E-03	8.57E-01	2.20E+00	2.28E-03	2.08E-01	5.32E-01
93m-Nb	1.45E-06	1.35E-04	3.23E+01	0	8.92E-08	8.29E-06	1.98E+00	2.11E-08	1.96E-06	4.68E-01
99-Tc	7.20E-02	7.12E+00	1.21E+02	0	4.42E-03	4.37E-01	7.41E+00	9.81E-04	9.71E-02	1.65E+00
Ag+	2.72E-02	2.93E+00	0	0	1.67E-03	1.80E-01	0	2.97E-04	3.21E-02	0
Al(OH)4-	0	0	0	0	0	0	0	0	0	0
Al+3	6.88E+01	1.86E+03	0	0	4.22E+00	1.14E+02	0	4.73E+02	1.28E+04	0
As+5	2.93E-02	2.20E+00	0	0	1.80E-03	1.35E-01	0	4.21E-03	3.15E-01	0
B+3	3.20E+00	3.46E+01	0	0	1.96E-01	2.12E+00	0	2.26E-02	2.44E-01	0
Ba+2	8.50E-02	1.16E+01	0	0	6.30E-03	8.63E-01	0	9.46E-02	1.30E+01	0
Be+2	3.25E-02	2.93E-01	0	0	1.99E-03	1.80E-02	0	6.09E-04	5.48E-03	0
Bi+3	6.18E-02	1.29E+01	0	0	3.79E-03	7.92E-01	0	5.81E-03	1.21E+00	0
C10H12N2O8-4	0	0	0	0	0	0	0	0	0	0
C10H15N2O7-3	0	0	0	0	0	0	0	0	0	0
C12H27O4P	0	0	0	0	0	0	0	0	0	0
C13H28	0	0	0	0	0	0	0	0	0	0
C2Cl4	0	0	0	0	0	0	0	0	0	0
C2H3O2-	0	0	0	0	0	0	0	0	0	0
C2H3O3-	0	0	0	0	0	0	0	0	0	0
C2HCl3	0	0	0	0	0	0	0	0	0	0
C2O4-2	1.59E+01	1.40E+03	0	0	9.75E-01	8.58E+01	0	1.00E+00	8.82E+01	0
C3H6O	0	0	0	0	0	0	0	0	0	0
C4H10O	0	0	0	0	0	0	0	0	0	0
C4H8O	0	0	0	0	0	0	0	0	0	0
C5H5N	0	0	0	0	0	0	0	0	0	0
C6H5NO2	0	0	0	0	0	0	0	0	0	0

March 16 HTWOS Results for AN-107 Batch #4										
AP-102:	HTWOS Projected Composition for Supernatant			1/3/2015						
C6H5O7-3	0	0	0	0	0	0	0	0	0	0
C6H6	0	0	0	0	0	0	0	0	0	0
C7H6N2O4	0	0	0	0	0	0	0	0	0	0
C7H8O	0	0	0	0	0	0	0	0	0	0
Ca+2	1.71E+01	6.87E+02	0	0	1.27E+00	5.09E+01	0	4.27E+02	1.71E+04	0
Cd+2	8.59E-01	9.65E+01	0	0	5.27E-02	5.92E+00	0	2.18E-03	2.45E-01	0
Ce+3	7.64E-02	1.07E+01	0	0	2.83E-02	3.96E+00	0	1.14E+00	1.60E+02	0
CH2Cl2	0	0	0	0	0	0	0	0	0	0
CHCl3	0	0	0	0	0	0	0	0	0	0
CHO2-	0	0	0	0	0	0	0	0	0	0
Cl-	7.73E+01	2.74E+03	0	0	4.74E+00	1.68E+02	0	3.22E-03	1.14E-01	0
CN-	0	0	0	0	0	0	0	0	0	0
Co+3	1.08E-01	6.36E+00	0	0	6.63E-03	3.91E-01	0	6.29E-04	3.70E-02	0
CO3-2	1.90E+03	1.14E+05	0	0	1.16E+02	6.97E+03	0	2.57E+02	1.54E+04	0
Cr(OH)4-	0	0	0	0	0	0	0	0	0	0
Cr(TOTAL)	5.06E+00	2.63E+02	0	0	3.10E-01	1.61E+01	0	5.75E-01	2.99E+01	0
Cs+	1.38E-01	1.89E+01	0	0	8.48E-03	1.16E+00	0	1.01E-03	1.38E-01	0
Cu+2	6.97E-01	4.43E+01	0	0	4.28E-02	2.72E+00	0	2.04E-03	1.30E-01	0
F-	7.53E+00	1.43E+02	0	0	4.62E-01	8.78E+00	0	1.18E-02	2.25E-01	0
Fe+3	1.30E+00	7.26E+01	0	0	2.37E+00	1.32E+02	0	9.19E+01	5.13E+03	0
H+	0	0	0	0	0	0	0	0	0	0
H2O	1.26E+05	2.27E+06	0	0	7.68E+03	1.38E+05	0	0	0	0
H2O2	0	0	0	0	0	0	0	0	0	0
Hg+2	1.70E-03	3.41E-01	0	0	1.04E-04	2.09E-02	0	1.12E-05	2.25E-03	0
K+	6.82E+01	2.66E+03	0	0	4.18E+00	1.63E+02	0	1.82E+00	7.12E+01	0

March 16 HTWOS Results for AN-107 Batch #4										
AP-102:	HTWOS Projected Composition for Supernatant			1/3/2015						
La+3	5.08E-02	7.06E+00	0	0	1.88E-02	2.61E+00	0	8.93E-01	1.24E+02	0
Li+	6.45E-01	4.47E+00	0	0	3.95E-02	2.74E-01	0	1.54E-02	1.07E-01	0
Mg+2	9.66E-02	2.35E+00	0	0	5.93E-03	1.44E-01	0	1.07E-02	2.60E-01	0
Mn+4	9.13E+00	5.02E+02	0	0	7.73E-01	4.25E+01	0	1.83E+01	1.01E+03	0
MnO2	0	0	0	0	0	0	0	2.52E+02	2.19E+04	0
MnO4-	0	0	0	0	0	0	0	0	0	0
Mo+6	5.38E-01	5.16E+01	0	0	3.30E-02	3.17E+00	0	1.98E-03	1.90E-01	0
Na+	1.42E+04	3.26E+05	0	0	8.68E+02	2.00E+04	0	4.60E+01	1.06E+03	0
Nd+3	1.41E-01	2.03E+01	0	0	5.21E-02	7.52E+00	0	2.10E+00	3.03E+02	0
NH3	4.27E+00	7.27E+01	0	0	2.62E-01	4.46E+00	0	1.54E-02	2.62E-01	0
NH4+	0	0	0	0	0	0	0	0	0	0
Ni+2	1.37E+01	8.05E+02	0	0	8.41E-01	4.94E+01	0	4.10E-02	2.41E+00	0
NO2-	2.34E+03	1.08E+05	0	0	1.44E+02	6.60E+03	0	4.75E-01	2.18E+01	0
NO3-	5.30E+03	3.29E+05	0	0	3.20E+02	1.98E+04	0	2.34E-01	1.45E+01	0
OH(BOUND)	1.94E+01	3.31E+02	0	0	1.19E+00	2.03E+01	0	1.87E+03	3.19E+04	0
OH-	1.63E+03	2.77E+04	0	0	1.06E+02	1.80E+03	0	0	0	0
Pb+2	1.92E+00	3.98E+02	0	0	1.63E-01	3.37E+01	0	2.54E+00	5.26E+02	0
Pd+2	0	0	0	0	0	0	0	0	0	0
PO4-3	2.54E+01	2.42E+03	0	0	1.56E+00	1.48E+02	0	3.82E+01	3.63E+03	0
Pr+3	0	0	0	0	0	0	0	0	0	0
Pu+4	0	0	0	0	0	0	0	0	0	0
Rb+	0	0	0	0	0	0	0	0	0	0
Rh+3	3.70E-01	3.80E+01	0	0	2.27E-02	2.33E+00	0	7.53E-04	7.75E-02	0
Ru+3	0	0	0	0	0	0	0	0	0	0
Sb+5	3.92E-03	4.78E-01	0	0	2.41E-04	2.93E-02	0	1.25E-03	1.52E-01	0

March 16 HTWOS Results for AN-107 Batch #4										
AP-102:	HTWOS Projected Composition for Supernatant			1/3/2015						
Se+6	1.66E-02	1.31E+00	0	0	1.02E-03	8.06E-02	0	5.03E-04	3.97E-02	0
Si+4	7.25E-01	2.04E+01	0	0	4.45E-02	1.25E+00	0	1.42E-01	3.98E+00	0
SO4-2	1.32E+02	1.26E+04	0	0	8.07E+00	7.75E+02	0	1.32E-01	1.27E+01	0
Sr+2	3.11E+00	2.73E+02	0	0	2.78E-02	2.44E+00	0	2.35E+02	2.06E+04	0
Ta+5	1.97E-01	3.56E+01	0	0	1.21E-02	2.19E+00	0	2.92E-06	5.29E-04	0
Tc+7	0	0	0	0	0	0	0	0	0	0
Te+6	0	0	0	0	0	0	0	0	0	0
Th+4	4.49E-04	1.04E-01	0	0	2.76E-05	6.40E-03	0	1.12E-05	2.60E-03	0
Ti+4	4.54E-02	2.18E+00	0	0	2.79E-03	1.34E-01	0	6.16E-04	2.95E-02	0
Tl+3	9.76E-04	1.99E-01	0	0	5.99E-05	1.22E-02	0	2.74E-03	5.59E-01	0
TOC	4.05E+03	4.87E+04	0	0	2.52E+02	3.02E+03	0	1.87E+01	2.25E+02	0
U(TOTAL)	0	0	0	0	0	0	0	0	0	0
V+5	2.14E-02	1.09E+00	0	0	1.31E-03	6.69E-02	0	9.48E-04	4.83E-02	0
W+6	0	0	0	0	0	0	0	0	0	0
Y+3	1.47E-01	1.32E+01	0	0	9.00E-03	8.10E-01	0	1.19E-03	1.07E-01	0
Zn+2	4.42E-01	2.89E+01	0	0	2.71E-02	1.77E+00	0	3.12E-03	2.04E-01	0
Zr+4	1.48E-01	1.35E+01	0	0	4.59E-02	4.18E+00	0	1.46E+00	1.33E+02	0

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APPENDIX D

DETAILED COST ESTIMATE

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APPENDIX D - COST SUMMARY
Study # 2 - Strontium and TRU Separation Process in DST System

DESCRIPTION	COST
CAPITAL COSTS	
Management	
Project Management	40,800
Construction Management	39,000
Subtotal:	79,800
Engineering, Design & Inspection	
Title I	98,100
Title II	215,300
Title III	120,000
Engineering Support	66,750
Subtotal:	500,150
Construction	
General Conditions	58,064
Site Work & Demo	4,499
Concrete	23,075
Mechanical	249,264
Electrical	26,675
General Labor Support	31,676
Other Costs	294,334
Subtotal:	687,587
Construction Support	90,518
Startup	303,120
Contingency	627,574
Total Captital Costs	2,288,748

Rate
40%

Estimate Type:	Pre-Conceptual Study
Lead Estimator:	Randy Ohrt
Project Manager:	Kishor Shah
Revision:	0
Date Issued:	
Remarks:	

NON-CAPITAL COSTS

Other Project Costs	171,255
Operations	0
Closure	137,517
Contingency on Non-Capital Costs	0
Escalation	0
TOTAL PROJECT COSTS	2,597,521

Project: CH2M Hill Engineering Optimization Studies
Estimate Title: Study # 2- Separate within TF Strontium and TRU Elements from AN-102, AN-107 Supernate

Description	Quan	Unit	Labor Unit Hrs	Labor Rate	Labor Dollars	Material Equip Unit Cost	Material Equip Dollars	Subcontract Dollars	Total Dollars	Comments
Management										
Project Management	1	LS	480	85.00	40,800	0	0		40,800	Includes PM and support (3 people 160 hr each = 480 hr @ $85/hr = $40,800)
Construction Management	1	LS	600 HOW TO	65.00	39,000		0		39,000	Includes CM , HPT support, IH support, Safety and field work supervisor. (6 people 100 hr each = 600 hr @ $65/hr = $39,000)

Total:	79,800

APPENDIX D - COST SUMMARY
Study # 2 - Strontium and TRU Separation Process in DST System

Description	Quan	Unit	Labor Unit Hrs	Labor Hrs Total	Labor Rate	Labor Dollars	Material Unit Cost	Equipment Dollars	Subcontract Dollars	Total Dollars	Comments
Engineering, Design and Inspection											
Title I										98,100	
Drawings	6	Dwgs	80	480	90.00	43,200		0		43,200	
Equipment Outline Specifications	3	Specs	40	120	90.00	10,800		0		10,800	
Estimate	1		60	60	85.00	5,100		0		5,100	
Safety Analysis	1		160	160	90.00	14,400		0		14,400	
Calcs.	1		200	200	90.00	18,000		0		18,000	
Design Mgmt	1		60	60	110.00	6,600		0		6,600	
Total:				1080							
TitleII										215,300	
Drawings	12	Dwgs	100	1200	90.00	108,000		0		108,000	
Equipment Procurement Specifications	5	Specs	80	400	90.00	36,000		0		36,000	
Estimate	1		100	100	85.00	8,500		0		8,500	
Safety Analysis	1		300	300	90.00	27,000		0		27,000	
Calcs.	1		300	300	90.00	27,000		0		27,000	Includes AB modification support
Design Mgmt	1		80	80	110.00	8,800		0		8,800	
				2380							
Total:											
Title III										120,000	
Inspection, submittal review, etc.	1		1500	1500	80.00	120,000		0		120,000	Approx. 17% of construction costs. Includes ORR support
Total:											
Engineering Support										66,750	
ECN	1	lot	250	250	85.00	21,250				21,250	
Work Package Preparation Support	2	ea		700	65.00	45,500				45,500	

APPENDIX D - COST SUMMARY
Study # 2 - Strontium and TRU Separation Process in DST System

Description	Quan	Unit	Labor Unit Hrs	Labor Hours	Labor Rate	Labor Dollars	Material Unit Cost	Total Equipment Cost	Total Material Equip Dollars	Subcontract Dollars	Total Dollars	Comments
Construction												
General Conditions											58,064	
Training	16	ea	60	960	52.15	50,064	500	8,000			58,064	Allowance for Training - HGET, Rad Worker II, Medical, mask fit, Haz Mat, etcetera, assume 16 men
Site Work & Demo											4,499	
CLEAN WORK												
Prepare areas for pad/containment, assume excavation of 16x20x2'deep(2pl)	50	cy	1.15	57.5	52.15	2,999		0	1,500		4,499	
Concrete											23,075	
CLEAN WORK												
forms	600	sf	0.25	150	49.88	7,482	1	600			8,082	
rebar	2500	lb	0.02	50	52.15	2,608	1	1,250			3,858	
pour, 2 places	20	cy	1	20	52.15	1,043	70	1,400	1,500		3,943	
finish	700	sf		8	52.15	417	0	175			592	
apply special coating	1360	sf								2,720	2,720	
allowance for handrailing	144	lf								2,880	2,880	
allowance for steps and landings	2	sets								1,000	1,000	
Mechanical											249,264	
CLEAN WORK												
SR (NO3)2 Addition Tank* 4,000 gal, 100ppm, Strotium Nitrate Transfer System	1	ea	80	80	52.15	4,172	83,584	83,584	2,500		90,256	* Quote #050314PE1 from Precision Pumping Systems, Inc. Paul Ellegood (360) 425-4545, 03-14-05
NaMnO4 Addition Tank* 3,200 gal, 100ppm, Sodium Permanganate Transfer System	1	ea	80	80	52.15	4,172	79,613	79,613	2,500		86,285	
ZONE WORK												
Greenhouse for tie-in	1	ea	828	828	52.15	43,180	1,890	1,890	2,000		47,070	
Furnish and install dispersion nozzle with flanged valve into tank,	2	ea	100	200	52.15	10,430	3,000	6,000			16,430	
Install Flex hose/flanged connector to above flanged fitting, 4 inch dia (furnished w/studs)	2	ea	24	48	52.15	2,503					2,503	
Acceptance Testing	1	ls	96	96	70.00	6,720					6,720	ATP - 3 men for 4 days to perform in-field testing
Electrical											26,675	
CLEAN WORK												
Allowance for 200 ft of above ground armored cable, 220v	200	lf	0.64	128	52.15	6,675 0	100	20,000			26,675	

Description	Quan	Unit	Labor Unit Hrs	Labor Hours	Labor Rate	Labor Dollars	Material Unit Cost	Total Equipment Cost	Total Material/Equip Dollars	Subcontract Dollars	Total Dollars	Comments
power for 7.5 HP pumps, includes						0						
necessary J-boxes and connections						0						
						0						
General Labor Support											31,676	
LABOR SUPPORT/SUPPLIED AIR,	1	LS		293	36.99	10,838		0	5,000		15,838	
2 MEN FOR DURATION												
LABOR SUPPORT/STEPOFF PAD,	1	LS		293	36 99	10,838		0	5,000		15,838	
ALLOWANCE FOR 2 MAN RULE												
allow 25% of MH's												
SUBTOTAL				3292		164,141		168,759	15,000	6,600	393,253	
Other Costs											294,334	
Mask 100%				1758		164,141					164,141	
GENERAL FOREMAN 3%				151		9,848					9,848	
GENERAL REQUIREMENTS 18 4%				957		62,216					62,216	
CONSUMABLES 3 5%								5,745			5,745	
SALES TAX 8 3%								14,484			14,484	
Profit 6%											37,900	
TOTAL			0			400,347		391,499	35,000		687,587	
Construction Support											90,518	
HPT Coverage				1000	51.67	51,670					51,670	
IH Coverage				500	50.63	25,315					25,315	
Craft Planning Support				250	54.13	13,533					13,533	

APPENDIX D - COST SUMMARY
Study # 2 - Strontium and TRU Separation Process in DST System

Description	Dollars	Contigency %	Contingency $
CAPITAL COSTS			
Management			
Project Management	40,800	25%	10,200
Construction Management	39,000	25%	9,750
Subtotal:	79,800	25%	19,950
Engineering, Design & Inspection			
Title I	98,100	40%	39,240
Title II	215,300	40%	86,120
Title III	120,000	40%	48,000
Engineering Support	66,750	40%	26,700
Subtotal:	500,150	40%	200,060
Construction			
General Conditions	58,064	40%	23,226
Site Work & Demo	4,499	40%	1,799
Concrete	23,075	40%	9,230
Mechanical	249,264	30%	74,779
Electrical	26,675	40%	10,670
General Labor Suppprt	31,676	40%	12,670
Other Costs	294,334	40%	117,734
Subtotal:	687,587	36%	250,109
Construction Support	90,518	40%	36,207
Startup	303,120	40%	121,248
Total Contingency on Capital Costs	1,570,657	40%	627,574
NON-CAPITAL COSTS			
Other Project Costs	171,255	0%	0
Operations	0	0%	0
Closure	137,517	0%	0
Total Contingency on OPC's	308,773	0%	0

APPENDIX D - COST SUMMARY
Study # 2 - Strontium and TRU Separation Process in DST System

Other Project Costs	**171,255**	
Design / Environmental	30,000	
Conceptual Design	30,000	Subcontract
Regulatory Permitting/Approval	0	None required for this activity
Management	141,255	
Program Management	6,876	1% of Infrastructure & facilities and process systems
Technical Support	13,752	2% of Infrastructure & facilities and process systems
ESH&Q	20,628	3% of Infrastructure & facilities and process systems
AB Modification	100,000	Allowance
Start Up	**303,120**	
Procedures	100,000	Allowance
Training	3,120	8 hrs per person specific training for this system only (6 people @ 8 hours each = 48 hours @ $65/hr = $3,120. Overall tank farm training is not included in this estimate.
Hot Start	200,000	System start (ORR) and initial fill of chemical feed tanks
Operations	0	Will be done as part of existing Tank Farm Operations
Training	0	
Operations	0	
Consumables	0	
Closure	137,517	Approximatly 20% of Construction Cost

Project: CH2M Hill Engineering Optimization Studies
Estimate Title: Study # 2- Separate within TF Strontium and TRU Elements from AN-102, AN-107 Supernate

Estimate Basis

1) ESTIMATE PURPOSE
This estimate was produced in support of CH2M Hill Subcontract No.:21843 to COGEMA Engineering "Engineering Studies Support.
This cost estimate is for Study # 2 - Separate with the Tank Farm Stronium and TRU Elements From AN-102, AN-107 Supernate

2) ESTIMATE TECHNICAL BASIS
A. This estimate is based upon the process flowsheets and equipment/construction needs developed under this study by COGEMA Engineering and subcontractors, Lucas EMS, Inc and DMJM Technologies.

3) METHODOLOGY
A. Estimate is a combination of ROM material takeoffs,bottom's up estimating and a vendor estimate for the chemical addition skids.
B. CH2M Hill Project W-211 cost estimate was used as a basis for cost elements where equivelent costs could be identified.

4) ESCALATION
A. Cost estimate uses 2005 costs. Where elements of costs were pulled from the Project W-211 cost estimate, these costs were escalated as appropriate to 2005 costs using a 2 1/2 % annual escalation rate.

5) CONTINGENCY
A. As this is a preconceptual level estimate a contingency factor or 40% was applied to most captital cost elements. A 30% contingency level was applied to the mechanical construction portion of the construction cost estimate recognizing that we have vendor quotes for the major equipment components (Chemical Addition Skids). A 25% contingency rate was applied to the project management and construction management costs. No contingency was applied to the non-capital cost elements per direction from CH2M Hill.

6) REMARKS
A. GENERAL
1. Basis for Project Management and Construction Management Costs in Worksheets.

B. TITLE I DESIGN
1. ROM estimate based upon preliminary estimate of 4 drawings (PFD, Equipment Arrangements, Site Plan), Preliminary safety analysis, process and material balance calcs., and updated cost estimate.

C. TITLE II DESIGN

1. ROM Estimate based upon preliminary estimate of 6 drawings (PFD, P&ID, Site, equipment arrangements, structural, tank riser interface details, etc.), Procurement specifications, safety analysis, misc. calcs, detailed cost estimate and work package development support.

D. TITLE III ENGINEERING

1. ROM estimate based upon Tittle III inspection running about 15% of procurement and construction costs.

E. ENGINEERING SUPPORT

1. ECN's to mod Hanford drawings. Task Includes: Initial walkdown, Field photos, Field walkdown with Crafts, Tank Reference Level Calculation, Identify affected drawings, Identify all active ECNs against the affected drawings, Retrieve/review all active ECNs against each of the drawings, Determine affected procedures, Obtain work package number from planner, Obtain disciplined review of the ECN, Distribute ECN for review, Provide planner with advance copy of ECN, Obtain approval signatures on ECN, Release ECN through Document Control, Distribute released ECN to planner.
2. Work packages prepared in compliance with current requirements including MD-38. Work packages related to this type of work will be complex and require significant expenditure of time for preparation, review and approval. The resources required to plan and write the work package are estimated on a task basis. Radcon, system engineering and operations organizations provide planning for the work package. Developing this work package was estimated to require 24 hours each for RadCon, System Engineering and Operations support and 100 hours for a planner to plan and write the work package. Additional tasks included: Preparing work instruction, Identify Materials: spare parts, miscellaneous consumables, Identify and approve Lockout/Tagout, Prepare and approve work permits, Enhanced Work Planning Session, Perform field walkdown, Refine Work Instructions, Identify and mitigate hazards (RWP, AJHA). (1st package estimated at 500 hours and 2nd package at 200 hours because it can use part of the first.

E. CONSTRUCTION

1. Greenhouse hours, material and equipment costs were based on W211WADB - 5L410B, dated 1/16/03.
2. Site Specific Training costs are an allowance only.
3. The Strotium Nitrate tank and the Soduim Permanganate tank each come mounted on an 8 ft x 12 ft skid as complete systems from Precision Pumping Systems Inc. , Kent WA,
4. The dispersion nozzle and valve have no design available and are an allowance only.
5. It is assumed that the flex hose with a 4" flange will come as part of the tank skid.
6. All in farm work is assumed to be done on supplied air in masks and an 85% factor has been added to cover this, plus another 15% to cover protective clothing.
7. Two concrete pads have been included for the skids to rest on.
8. It has been assumed that access will be available for crane to offload the two skids and that equipment will be released back to the subcontractor.
9. Adequate power is assumed to be available within 50 ft of each skid.
10. No radiological burn-out has been factored in this estimate.
11. No costs have been included for PPE clothing or laundering.
12. No burial or disposal costs have been included.
13. Material costs taken from W211 have been escalated at 2-1/2% per year (5%) to reflect 2005 dollars.
14. Labor rates are in current FY05 dollars.

F. STARTUP

1. Allowance includes ORR and initial fill of chemicals

G. OTHER PROJECT COSTS (NON-CAPITAL COSTS)

1. Includes allowance for tank AB modification

APPENDIX E

HTWOS MODEL ASSUMPTION VALIDATION

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APPENDIX E

ASSUMPTION VALIDATION

Appendix E contains the completed Hanford Tank Waste Operations Simulator (HTWOS) Model Modification Record forms along with any necessary supporting data. These forms were prepared in accordance with "HTWOS Model Assumption Validation" (TFC-ENG-CHEM-D-39) to verify that the approved assumptions were incorporated into the model. Any assumptions not incorporated are identified as deviations in the "Result of Checking Modification" section of the form and are summarized in Appendix A Table A-12.

The CH2M HILL Hanford Group, Inc. personnel who changed the model to incorporate the assumptions or who verified the model changes are listed below. Their signatures are recorded below and apply to all of the forms documented on pages E-5 through E-14.

Modelers Names
R. S. Wittman   Date: 4/21/05

Verifier Name
S. L. Orcutt   Date: 4/25/2005

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HTWOS Model Modification Form

Modification Title: Check HLW Feed Receipt Tank Usage
Description of Modification: Sufficient space to receive 160,000 gallons (600 m3) without interruption. All HLW batches must be at least 130,000 gallons total volume and contain more than 2 wt% solids.
Method Used to Check Modification: HLW liquid and solid volumes delivered to WTP are in the file hlw-deliver.csv. Weight fraction of solids can be calculated.
Result of Checking Modification: Other than end of mission DST heal removals, all HLW batches are > 130 kgal. Verified that the total volumes are greater than 130 kgal for all batches (hlw-deliver.csv). The exception in the batch volumes is for the heals and the tank cleanouts.
Modeler Name: RS Wittman **Verifier Name:** SL Orcutt

HTWOS Model Modification Form

Modification Title: Check HLW Pre-Treatment Process.
Description of Modification: HLW WTP Process Model: HLW pretreatment can provide sufficient pretreated HLW solids to produce up to 571 canisters of IHLW per year. The water wash factors in the TWINS on 8/24/2004 will be used for partitioning waste into solid and liquid phases during retrieval and staging. The caustic leach factors in the TWINS on 8/24/2004 will be used as the basis for computing the caustic leach factors associated with each delivered batch of HLW solids and for the entrained solids. One spent HLW Melter is assumed every 2.5 years and contains 1800 gallons of glass, not to exceed 9 spent HLW melters. For planning purposes, all solids delivered with the HLW feed and entrained solids delivered with the LAW feed, will undergo caustic and oxidative leaching with the insoluble fraction incorporated into HLW glass.

An oxidative leach process that removes Cr from the HLW sludge without impact on cycle time or other species will be implemented in the ultrafilters. Reaction stoichiometry and endpoint (5,000 ug Cr/g dried solids) are described in RPP-15552.
Method Used to Check Modification: HLW WTP Process Model: The file study2-hlw-canisters-histoy.his shows that (5 MTG/day) or 571 canisters of IHLW per year is supported. Wash_Factors_08-24-2004-test.dat and Leach_Factors_08-24-2004-test.dat are the input wash and caustic leach factors used by HTWOS. One spent HLW Melter is assumed every 2.5 years and contains 1800 gallons of glass, not to exceed 9 spent HLW melters. All solids (from LAW and HLW batches) are combined in the ultrafilters as in the development run. An oxidative leach process that removes Cr from the HLW is applied in procedure htwos-oxidative-leach-cr.
Result of Checking Modification: Verified that the IHLW canister count does not exceed the 571 cans/year in the procedure study2-hlw-canisters-history.his. Verified that Cr is removed when the total Cr mass > 0.005* (total solid mass)
Modeler Name: RS Wittman **Verifier Name:** SL Orcutt

HTWOS Model Modification Form

Modification Title: Implement Sr/TRU Precipitation Process for AN-102 and AN-107 Supernatants in Tank AP-102.
Description of Modification: Tank Selection: Supernate from AN-102 and AN-107 will be treated in AP-102, based on the availability of a central riser that is fitted for a mixer pump. Remove AP-102 Supernatant: AP-102 Supernatant must be removed before transfer and treatment of AN-102 supernatant in AP-102. * Assume that current pumping practices will leave 10 inches of supernatant in AP-102 to avoid disturbing the existing solids during supernatant removal.

* The 10 inches of waste remaining in AP-102 will be combined and treated with the first batch of AN-102 supernatant.

Tank Treatment Sequence:
Assume AN-102 supernatant is treated first followed by transfer and treatment of AN-107 supernatant.

Start Date for Sr/TRU Separation:
Sr/TRU separation of AN-102 supernatant will be initiated based on the space availability predicted by HTWOS and not constrained to the start date for WTP processing of AN-102 and AN-107 supernatant used in the Development Run. The delivery of AN-102 and AN-107 feeds to the WTP is considered to be flexible.
* Include a 16 month outage for AP-102. This is the estimated time required to install a replacement 150-hp mixer pump in AP-102. Assume the replacement mixer pump is installed 16 months prior to the start of Sr/TRU processing in tank AP-102. Basis: Personal communications between Mike Johnson, John Van Beek, and Curtis Rieck (January 2005).
* Target a delivery date of treated AN-102, Batch #1 for 2012, however, as noted, the delivery date to WTP is flexible.

Number of Batches:
Four batches are assumed for conducting the Sr/TRU precipitation in Tank AP-102.
* Tank AN-102 supernate will be treated in two equal batches and the AN-107 supernate will also be treated in two equal batches.
* Residual AN-102 supernate in tank AP-102 can be mixed with the AN-107 supernate.

Supernatant Heels:
Following the transfer of the last batch of supernate from tank AN-102 (or AN-107) to tank AP-102, add ~100,000 gallons of water to the heel of supernatant in tank AN-102 (or AN-107) and transfer to tank AP-102. Assume no mixing of the liquids with the existing solids.

Sr/TRU Processing Sequence:
See Figure 1, Process Flow Sequence for Sr/TRU Separation in Tank AP-102.

1) Transfer, the first batch of AN-102 into AP-102 and conduct the Sr/TRU separation process.
2) Transfer the first batch of treated AN-102 supernate to WTP in 2012, or as determined by the HTWOS modeler.
3) a) Transfer the second batch of AN-102 supernatant to tank AP-102.
   b) Add flush water to AN-102 to dilute residual supernate heel and transfer to AP-102 for treatment with AN-102 Batch #2. Treat.
4) Transfer treated AN-102 supernatant from tank AP-102 to available DST for eventual delivery to WTP.
5) Transfer the first batch of AN-107 (Batch #3) supernatant to tank AP-102 and conduct the Sr/TRU removal process.

6) Transfer the treated AN-107 Batch #3 supernate to an available DST for eventual delivery to the WTP.
7) a) Transfer the second batch volume of AN-107 (Batch #4) supernate from tank AN-107 to tank AP-102.
   b) Add flush water to tank AN-107 to dilute remaining supernate heel and transfer to AP-102 for treatment with the AN-107 Batch #4.
8) Transfer the treated AN-107 Batch #4 supernate to available DST for eventual delivery to WTP.
9) Retrieve AP-102 solids (Sr/TRU ppt and sludge) to any available HLW tanks at the discretion of the modeler. Solids should be blended with other HLW solids for delivery to the WTP.
10) Retrieve AN-102 and AN-107 solids heel to any available HLW tanks at the discretion of the modeler. Solids shall be blended with other HLW solids for delivery to the WTP.

Disposition of Sr/TRU Precipitate:
Solids shall be blended with other HLW solids for delivery to the WTP.

Disposition of tanks AN-102 and AN-107 Solids:

Retrieve AN-102 and AN-107 solids heel to any available HLW tanks at the discretion of the modeler. Solids may be blended with other HLW solids for delivery to the WTP.

Method Used to Check Modification:
The HTWOS related assumptions are only the transfer process and timing assumptions. They can be checked from the transfer file wvp-taf-file, law-deliver.csv, and:
comp-AN-102_10-5-2012.csv
comp-AN-107_8-12-2013.csv
comp-AP-102_b1f.csv
comp-AP-102_b1i.csv
comp-AP-102_b2f.csv
comp-AP-102_b2i.csv
comp-AP-102_b3f.csv
comp-AP-102_b3i.csv
comp-AP-102_b4f.csv
comp-AP-102_b4i.csv
which contain the staged batches before (i) and after (f) Sr/TRU precipitation.

Result of Checking Modification:
Verified that the desired outputs were obtained in the above files located on /common_samwise/results/OP-Case2_3-17-2005. There were four total batches (2 from AN-102 and 2 from AN-107).

Modeler Name: RS Wittman
Verifier Name: SL Orcutt

HTWOS Model Modification Form

Modification Title: Sr/TRU Process Conditions.

Description of Modification:

Sr/TRU Precipitation Process Basis:

Process Dilution water: Water is added to AN-102 and AN-107 supernatant liquids to achieve a 5.5 M sodium concentration. Water addition is performed in Tank AP-102 on a batch basis.

Sodium permanganate ($NaMnO_4$) addition: 5.308 gallons of 3.83M $NaMnO_4$ are to be added per 1,000 gallon of diluted supernatant (Basis: RPP-24809, Appendix A)

Strontium nitrate $Sr(NO_3)_2$ addition: 6.723 gallons of 3M $Sr(NO_3)_2$ are to be added per 1,000 gallon of diluted tank supernatant (Basis: RPP-24809, Appendix A).

Reaction Time: minimum of 4 hours (PNWD-3340, Section 3.1) (Assume mixer pump installed in AP-102).

Reaction temperature: 26 to 28° C, ambient conditions (PNWD-3340, Section 3.1).

Percent Removals from Supernatants:
Eu152 = 85%
Eu154 = 85%
Eu155 = 85%
Np237 = 85%
Pu238 = 85%
Pu239 = 85%
Pu240 = 85%
Am241 = 85%
Pu241 = 85%
Cm242 = 85%
Pu242 = 85%
Am243 = 85%
Cm243= 85%
Cm244 = 85%
Sr90 = 94%
Sr total = 94%
Ba = 19%
Ca = 19%
Ce = 85%
Cr = 21%
Fe = 97%
La = 85%

Mn = 96%, AN-107 Mn = 30%, AN-102 Nd = 85% Pb = 30% TIC as CO3 = 3.9% Zr = 82% TOC = 0%
Method Used to Check Modification: The splits can be found in the data objects an-102-in-tank-tru-precip-fractions and an-107-in-tank-tru-precip-fractions. The reactions are referred to in sr-tru-precip-reactions and do-in-tank-sr-tru-precip.
Result of Checking Modification: Verified NaMnO4 and Sr(NO3)2 additions in the procedure named d-in-tank-sr-tru-precip. All Splits listed are correct except the following: Mn for AN-102 = 30% and AN-107 = 96%. TIC as C03 = 100%. The impact of these exceptions was taken to be negligible.
Modeler Name: RS Wittman **Verifier Name:** SL Orcutt

HTWOS Model Modification Form

Modification Title: Sr/TRU Precipitation Chemistry.
Description of Modification: Strontium Removal: The addition of strontium nitrate (Sr(NO3)2) to tank AN-102 and AN-107 supernatants results in isotopic dilution of (Sr90) and precipitation of strontium carbonate (SrCO3) Isotopic Dilution Reactions: Sr(NO3)2 + 90Sr*Chelant + Na2CO3 <--> Sr*Chelant + 90SrCO3 + 2NaNO3 Sr(NO3)2 + Na2CO3 <--> SrCO3 + 2NaNO3 The reaction above implements the percent removals listed in previous assumption. Upon adding Sr(NO3)2 to the AN-102 (or AN-107) supernate, 94% of the total Sr is precipitated. This assumption applies only to the treated AN-102 and AN-107 supernates only and does not apply to other LAW supernates. The existing Sr-90 solubility correlation applies to all other LAW supernates.
Method Used to Check Modification: The all-reactions.txt file shows that HTWOS has the above reaction. They are referred to in sr-tru-precip-reactions and do-in-tank-sr-tru-precip.

Result of Checking Modification: Verified that the reactions listed in the all-reactions.txt as an output from the model contains the correct reactions	
Modeler Name: RS Wittman **Verifier Name:** SL Orcutt	

HTWOS Model Modification Form

Modification Title: Initial Inventory	
Description of Modification: Date that BBI quarterly update was issued: Starting tank inventories represents the contents of the tanks as of April 2004 per RPP-22760. This is identified as the "FY 2004a" inventory and is based on Best Basis Inventory (BBI) downloaded from TWINS circa 8/10/2004. Adjustments were made in the HTWOS model for historical transfers through 12/31/04.	
Method Used to Check Modification: Check historical transfer file to ensure that it begins after 4/2004.	
Result of Checking Modification: Historical transfers begin in 6/2004.	
Modeler Name: RS Wittman **Verifier Name:** SL Orcutt	

HTWOS Model Modification Form

Modification Title: Waste Segregation or Blending.	
Description of Modification: Feed Controls: The feed controls (which specify specific blending and waste segregation requirements) from HNF SD WM OCD-015, Rev 13, are modified as needed to support the other mission assumptions and summarized below: * Blend off high-sulfate supernate (FCL Issue # 1): A portion of supernate from AZ-102 will be decanted and blended with lower [SO4] supernate, so that the final [SO4]:[Na] ratio in AZ-102 and in any other tank receiving significant quantities of the high [SO4] supernate will be less than a target level of 0.048 mole SO4/mole Na after blending and any evaporator campaigns are completed. Constrain the blending of AZ-102 supernate to start after 4/1/2007.	

* Blend off high 233U solids (FCL Issue # 2): The solids from C-104 will be blended with the solids in AY-101 so that the resulting [233U] is less than a target level of 2.0E-04 Ci/100 grams equivalent of waste oxides. The two source tanks and the resulting blend will be kept segregated from other sources of solids. * Prepare and protect hot commissioning feed (FCL Issue # 3): The supernate in AY-102 will be removed and replaced with supernate from AP-101, without concentration. It is assumed that the TFC will successfully demonstrate the supernate in AP-101 should be consolidated with the solids in AY-102 using the stipulated "Special process to release controls. No other waste, other than process condensate, will be mixed with the hot commissioning feed staged in AY-102. * Segregate Envelope C (FCL Issue # 4): The AN-102 and AN-107 supernatants must be segregated from all other waste until it has been pretreated to remove Sr/TRU components. Do not store this pretreated supernate with any other HLW or TRU solids. * Segregate TRU sludge from complexed waste (FCL Issue # 5): Envelope C waste or other waste capable of complexing TRU shall not be stored with the insoluble solids currently in AW-103, AW-105 or SY-102. For purposes of this control, waste will be considered to be Envelope C if the [TRU]:[Na] ration exceeds 13 µCi/mole or the [90Sr]:[Na] ratio exceeds 1.19E+03 µCi/mole in the liquid phase. * Segregate waste destined for TRU or LLW packaging (FCL Issue # 6): No additional waste shall be added or stored with the insoluble solids currently in AW-103 and AW-105, except that the addition of remote-handled TRU from SSTs or SY-102 is permitted. Avoid mixing the waste in SY-102 with additional solids (other than remote-handled TRU). Do not transfer contact-handled TRU waste into the DST system. Keep the remote-handled TRU waste segregated from insoluble non-TRU solids. * Segregate low-cesium SST waste for supplemental treatment (FCL Issue # 7): Waste from the candidate SSTs containing low-curie waste should be managed to maximize the amount of low-curie (less than 0.05 Ci/liter 137Cs). The low-cesium fraction designated for feed to supplemental LAW treatment should be kept segregated from any high-cesium waste.
Method Used to Check Modification: The above assumption was confirmed for the development run. OP-Case 2 transfer file is identical with the development run through 5/2/2011. Additionally, the RH-TRU and low Cs-137 staging occurs as in the development run.

Result of Checking Modification: Verified that there are no differences in transfer file through 5/2/2011 in comparison to the Development Run.
Modeler Name: RS Wittman **Verifier Name:** SL Orcutt

HTWOS Model Modification Form

Modification Title: LAW Feed Delivery Plans
Description of Modification: LAW Feed Delivery Sequence and Envelope Designation: <u>Source Tank (Envelope)</u> AY-102 (containing concentrated AP-101; A/D) 1-3 tanks from AP-Farm (A) AN-104 (A) AN-102 (C) **Treat as Envelope A for model assumption AN-105 (A) AN-107 (C) **Treat as Envelope A for model assumption SY-101 (A) AN-103 (A) AW-101 (A) Continue with liquid wastes made available from SST retrieval. Actual sequence and timing for delivery of pretreated AN-102 (107) supernatants can be changed at the modeler's discretion.
Method Used to Check Modification: The batches-delivered-to-wtp file shows the processing envelope to be A for all LAW deliveries. The source of the delivered feed in law-deliver.csv.
Result of Checking Modification: LAW Sequence in law-deliver.csv AY-102 AP-101 AP-103 AN-104 AN-101 AP-102 AP-102 AP-102 AP-105 AP-103 AN-105 AP-102 AP-102

AP-107 AP-103 AN-103 AN-105 AW-101
Modeler Name: RS Wittman **Verifier Name:** SL Orcutt

HTWOS Model Modification Form

Modification Title: Project Impacts on DST System Availability
Description of Modification: AP 102 Outage Mixer pump installation will require a 16 month outage.
Method Used to Check Modification: Verify outage in AP-102 from transfer file
Result of Checking Modification: Verified outage, and verified with Curtis Reick that tank AP-102 does not have to be emptied prior to installing the 150hp mixer pump in our modeling assumptions.
Modeler Name: RS Wittman **Verifier Name:** SL Orcutt

APPENDIX F

PROCESS DETAILS

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F1.0 PRECIPTIATION CHEMISTRY

F1.1 STRONTIUM REMOVAL

The addition of $Sr(NO_3)_2$ to tank AN-102 and AN-107 supernatants results in isotopic dilution of strontium (^{90}Sr) and precipitation of strontium carbonate ($SrCO_3$) (PNWD-3340). The addition of permanganate (MnO_4) increases ^{90}Sr decontamination, likely as a result of oxidation of the chelating agents and precipitation of additional $SrCO_3$ (PNWD-3264, Section 3.1.1 and PNWD-3340, *Section* 3.1). However, complexant oxidation is not the primary ^{90}Sr removal mechanism. Permanganate addition alone is not sufficient to reach the desired ^{90}Sr decontamination. Isotopic dilution and $SrCO_3$ precipitation are the primary mechanisms for ^{90}Sr decontamination (PNWD-3340, Section 3.1).

Isotopic Dilution Reactions:

$$Sr(NO_3)_2 + {}^{90}Sr{\cdot}Chelant + Na_2CO_3 \leftrightarrow Sr{\cdot}Chelant + {}^{90}SrCO_3 + 2NaNO_3$$

$$Sr(NO_3)_2 + Na_2CO_3 \leftrightarrow SrCO_3 + 2NaNO_3$$

Since the tank AN-102 and AN-107 supernatants contain significant carbonate concentrations (>1.0 M at present storage conditions), the forward reaction is favored. Adding $Sr(NO_3)_2$ to these wastes will increase the amount of soluble Sr, but ~94% of the added Sr does precipitate (PNWD-3340, Section 3.1).

F1.2 TRU REMOVAL

Permanganate treatment is most effective for removing the +3 valance TRU elements (PNWD-3340, Section 3.6). The removal of transuranic (TRU) (primarily americium (Am), plutonium (Pu) and curium (Cm)) occurs by addition of permanganate (MnO_4) with a stepwise manganese reduction: Mn(VII) to Mn(VI) to Mn(IV); precipitation of MnO_2, and concomitant TRU precipitation. Manganese dioxide is present in a hydrated form as $NaMn(O)(OH)(O){\cdot}xH_2O$. An example of the manganese reactions with formate (PNWD-3263, Section 3.1) are as follows:

$$2Mn^{VII}O_4^- + HCO_2^- + 3OH^- \rightarrow 2Mn^{VI}O_4^{-2} + CO_3^{-2} + 2H_2O$$

$$3Mn^{VI}O_4^{-2} + 2H_2O \leftrightarrow 2Mn^{VII}O_4^- + Mn^{IV}O_2 + 4OH^-$$

Permanganate will react with other organic compounds. However, nitrite and oxalate have been shown not to react with permanganate (PNWD-3263, Section 3.1).

Some TRU decontamination occurs when $Sr(NO_3)_2$ is added to tank AN-102 or AN-107 supernatants. For example, during a test conducted with AN-102 supernatant mixed with C-104 sludge leachate, a TRU decontamination factor (DF) of ~1.6 was achieved after adding $Sr(NO_3)_2$ to a final concentration of 0.02 M Sr (PNWD-3264, Section 3.1.2). The added Sr likely displaces some of the TRU elements from complexants present in these wastes. Addition of $Sr(NO_3)_2$ alone is insufficient to achieve the desired TRU decontamination.

F1.3 CO-PRECIPITATION OF ANALYTES

Based on the reaction chemistry, partial displacement from ligands (chelating agents) and co-precipitation of $BaCO_3$ and $CaCO_3$ during addition of $Sr(NO_3)_2$ are expected and have been observed during testing with actual tank AN-102 and AN-107 supernatant samples (PNWD 3340, Section 3.2). Addition of MnO_4 causes decomposition of ligands and precipitation of MnO_2. Displacement of iron (Fe), chromium (Cr), Cm, and lanthanides (e.g., cerium (Ce), neodymium (Nd), lanthanum (La) and europium (Eu)) from ligands and adsorption / co-precipitation on MnO_2 are expected based on similar chemical behavior of these cations and ^{241}Am. The removal of these cations from tank AN-102 and AN-107 supernatant has been observed after addition of MnO_4, as noted in Table F-1 and Table F-2. Curium precipitation has been measured to mirror that of ^{241}Am during the MnO_4 precipitation reaction (PNWD-3141, Section 3.1 and PNWD-3338, Section 3.2). The aluminum (Al) removal noted in Table F-1 and Table F-2 is likely due to entrained solids being captured by the precipitates and not due to co-precipitation. The degree to which these analytes are separated from tanks AN-102 and AN-107 supernatants is dependent on the concentration of reagents added to the waste.

F1.4 EFFECT OF EXCESS REAGENT ADDITIONS

The most notable effects of adding excess $Sr(NO_3)_2$ is the increased volume of precipitate that will form and the slight increase in ^{90}Sr decontamination. Adding excess $NaMnO_4$ will also increase the volume of precipitate formed and further reduce the total organic concentration in these wastes.

F1.5 AMMONIA EVOLUTION

Ammonium ion is present in tank AN-102 and AN-107 supernatants and could potentially be oxidized by MnO_4 to ammonia gas. Ammonium ion concentration in the tank AN-102 supernatant was found not to be effected by addition of MnO_4 to precipitate TRU elements (PNWD-3338, Section 3.8), providing evidence that ammonia does not volatilize from the reaction mixture. Gases are evolved from these supernatants due primarily to radiolysis and organic decomposition.

F2.0 TIME DEPENDENCE OF REACTION

In testing with tank AN-102 and AN-107 supernatant samples, the TRU removal reactions were found to be independent of time. Transuranics decontamination was not significantly impacted by reaction time or temperature (22 to 31°C) for a mixture of AN-102 supernatant and C-104 sludge leachate (PNWD-3264, Section 3.1.2). Also TRU decontamination was significantly greater once permanganate was added. The permanganate reactions and TRU decontamination were complete when first sample was removed at 18 minutes of reagent addition and mixing.

Strontium-90 decontamination increases significantly with time due to continued $SrCO_3$ precipitation. A reaction time of more than 4-hours has been shown to be necessary to approach the final Sr concentration in tank AN-102 supernatant[1] and AN-102 supernatant mixed with tank C-104 sludge leachate[2] samples. Similar results were found during testing of a tank AN-107 supernatant sample (PNWD-3340, Appendix B). The isotopic dilution of ^{90}Sr has been shown to be very rapid and complete within 18-minutes after reagent addition and sample mixing (PNWD-3264, Section 3.1). However, the precipitation of $SrCO_3$ was shown to be incomplete after 4-hours of reagent addition and mixing of the sample. Precipitation of $SrCO_3$ was completed by 24-hours after reagent addition if the sample was mixed. If the sample was not mixed, additional contact time is needed for $SrCO_3$ precipitation process completion. (PNWD-3338, Section 3.1).

F2.1 EQUILIBRIUM 90SR / SR CONCENTRATION

Table F-3 and Table F-4 provide the initial concentrations (RX-01-24 and SS-01-04) and final concentrations of ^{90}Sr, total Sr, total alpha emitting TRU elements and other analytes measured in the AN-102 samples (sample numbers RX-02-24 and RX-11-24) and AN-107 samples (sample numbers SS-02-24 and SS-08-24) 24-hours after reagent additions. Upon adding $Sr(NO_3)_2$ and $NaMnO_4$ to the AN-102 sample, the ratio of ^{90}Sr to total Sr reached an equilibrium value of ~0.018 microcuries per microgram, (μCi/μg) after 24-hours (PNWD-3340, Section 3.1). Similar results were obtained by treating a sample of AN-107 supernatant (PNWD-3340, Appendix B).

---

[1] The AN-102 supernatant was ~5.5 M Na before addition of reagents. After adding reagents, the treated sample contained 0.02M MnO_4 and 0.02 M Sr. The samples were reacted at a temperature of 26 to 28°C (PNWD-3340, section 3.1).

[2] The AN-102 supernatant / C-104 leachate sample was ~5.5M Na before addition of reagents. After adding reagents, the treated sample contained 0.02M MnO_4 and 0.02M Sr. The sample was reacted at a temperature of 31°C and cooled to 22 to 25°C for cell-unit filter (CUF) testing. The maximum ^{90}Sr DF was ~12. When the reacted slurry was cooled to 22 to 25°C for CUF testing, the ^{90}Sr DF decreased to 6. After about 15 hours of mixing and reaction at 22 to 25°C, the ^{90}Sr DF increased to ~10. The Sr/TRU precipitate was removed from the CUF, returned to 31°C and dead-end filtered to measure final ^{90}Sr decontamination. The ^{90}Sr DF for the dead-end filtered sample was ~14, approximately 55.5 hours after addition of reagents to the AN-102 / C-104 sample (PNWD-3264, section 3.1.1).

F3.0 REACTION TEMPERATURE

The Sr/TRU precipitation reaction has been successfully conducted at 15 to 50 ± 5°C (PNWD-3033, PNWD-3035, PNWD-3141, PNWD-3189, PNWD-3263, PNWD-3264, PNWD-3338, PNWD-3340, WSRC-TR-2000-00341, and WSRC-TR-2000-00506). The removal of TRU elements from tanks AN-102 and AN-107 supernatants is not temperature dependent. However, strontium precipitation is temperature and reagent concentration dependent.

At 50 ± 5°C, less strontium is soluble in the tanks AN-102 and AN-107 supernatants due to the retrograde solubility of $SrCO_3$, thus increasing ^{90}Sr decontamination (PNWD-3035, Section 3.1 and PNWD-3141, Section 3.1). However, if the Sr precipitation reaction is conducted at an elevated temperature and the slurry is then cooled, some $SrCO_3$ will re-dissolve, thus reducing the overall ^{90}Sr decontamination. Similarly, if the precipitation reaction is conducted at 15°C, more strontium remains soluble and the ^{90}Sr decontamination is reduced (PNWD-3338, Section 3.1). If the slurry is then heated from 15°C to 25°C, additional strontium will precipitate and the ^{90}Sr decontamination will increase.

Heating and cooling tank AN-102 and AN-107 supernatants requires time and energy. Given that these supernatants can not be maintained at an elevated temperature throughout storage and processing, it is better to conduct the Sr/TRU precipitation reaction at ambient temperature and allow sufficient time for the $SrCO_3$ precipitation reaction to be completed. Additionally, the quantity of $Sr(NO_3)_2$ added to these supernatants can be adjusted to achieve the desired ^{90}Sr decontamination at ambient temperature. These results show good decontamination of both wastes at low levels of reagent addition, 0.02 M $Sr(NO_3)_2$ and 0.02 M $NaMnO_4$.

Table F-1. Analytes Separated from AN-107 Supernatant During Sr/TRU Precipitation

	Archived AN-107[(a)] (PNWD-3033; 4.7 M Na, 0.74 M OH, 0.075 M Sr and 0.05 M MnO_4; after reagent addition, sample heated to 50°C for 4-hours, then cooled for filtration)	AN-107 (PNWD-3035; ~6 M Na, 1.0 M OH, 0.075 M Sr and 0.05 M MnO_4; sample mixed for 30-minutes after reagent additions and then heated to 50°C for 4-hours, cooled to ambient and filtered)	AN-107[(b)] (PNWD-3047; 6.9 M Na, 0.60 M OH, 0.05 M Sr and 0.03 M MnO_4; after each reagent addition, sample heated to 50°C for 2-hours)	AN-107[(C)] (PNWD-3047; 6.6 M Na, 0.62 M OH, 0.075 M Sr and 0.05 M MnO_4; after each reagent addition, sample heated to 50°C for 2-hours)	AN-107[(d)] (PNWD-3340; 5.5M Na, 0.32 M OH, 0.02 M Sr and 0.02 M MnO_4; 26-28°C, 24-hour mixing)
Analyte	Percentage Removed				
^{154}Eu	89%	90%	Not measured	Not measured	Not measured
^{90}Sr	95%	77%	64%	77.8%	94.5%
^{241}Am	94%	37%	69%	88%	85%
Al	13%	7%	0%	0%	0%
Ca	35%	37%	20%	30%	19%
Cr	33%	51%	31%	45%	21%
Fe	98%	98%	73%	91%	97%
Mn	90%	99%	65%	71%	96%
Pb	45%	60%	33%	44%	30%
Zr	93%	57%	Not measured	Not measured	82%
Carbonate	Not measured	13%	1%	12%	Not measured
Nitrite	Not measured	9%	Not measured	Not measured	Not measured
TOC	Not measured	6% (± 3%)	Not measured	Not measured	Not measured

Notes:

(a) The archived AN-107 sample was AN-107 supernatant diluted with 0.53 M NaOH solution to 5 M Na and 0.53 M free hydroxide. The diluted supernatant was decanted from settled solids and used in a cesium ion exchange column test in 1997. The free OH concentration in the diluted AN-107 sample was measured at 0.124 M after cesium ion exchange treatment. Sodium hydroxide pellets were added to the archived AN-107 sample in June 1999 to achieve a calculated target free OH concentration of 1.0 M (PNWD-3033, Section 2.1; sample MN-22)

(b) The AN-107 sample was diluted to 7.5 M and adjusted to 0.71 M before reagent additions for this test (samples RW-09 and RW-10).

(c) The AN-107 sample was diluted to 7.5 M and adjusted to 0.71 M before reagent additions for this test (sample RW-11).

(d) The AN-107 sample was diluted to 5.5 M and adjusted to 0.35 M before reagent additions for this test (sample SS-02 and SS-08)

Table F-2. Analytes Separated from AN-102 during Sr/TRU Precipitation

Analyte	AN-102 [a] (WSRC-TR-2000-00506; ~6 M Na, ~1.0 M OH, ~0.075 M Sr and ~0.05 M MnO_4; sample heated to 50°C before reagent addition and filtered hot after 4-hour digest)	AN-102 / C-104 Leachate (PNWD-3189, ~5 M Na, 0.2 M OH, 0.02 M Sr and 0.02 M MnO_4; treated at 26°C and digested for 4-hours)	AN-102[b] (PNWD-3340; 5.5 M Na, 0.14 M OH, 0.02 M Sr and 0.02 M MnO_4; treated at 26 - 28°C and digested for 24-hours)	AN-102[c] (PNWD-3338; 4.9 M Na, 0.4 M OH, 0.03 M Sr and 0.03 M MnO_4; treated at 26 to 28°C and digested for 24-hours)
^{90}Sr	84%	88%	94.2%	94%
^{241}Am	82%	63%	75.9%	75%
Al	Not removed	-2%	0%	5%
Ba	~81%	Not measured	Below quantification limit	Below detection limit
Ca	~48%	16%	19%	35%
Cr	~33%	8%	21%	20%
Fe	~83%	67%	97%	77%
Mn		30%	37%	24%
Pb	~17%	2%	30%	24%
Zn	~71%	46%	Below detection limit	Below detection limit
Zr	Not removed	47%	82%	76%

Notes:

(a) The AN-102 sample was contaminated with $^{243/244}Cm$ in the SRTC hot cells. Therefore, a higher concentration of MnO_4 was used to achieve ^{241}Am removal than would normally be necessary.

(b) The as-received AN-102 sample (0.25 M free OH) was diluted with 0.01 M NaOH solution to 5.5 M Na and 0.14 M free hydroxide. No additional NaOH added for this test (samples RX-02 and RX-11).

(c) The as-received AN-102 sample (0.25 M free OH) was diluted with 0.3 M NaOH solution to 5.5 M Na and 0.4 M free hydroxide (sample AC-05). Other tests conditions with tank AN-102 samples are reported in PNWD-3338.

Table F-3. Precipitation of Sr/TRU from Tank AN-102 Sample

Source of Sample Data: PNWD-3340, pages B.5, B.6, B.11	*AN-102 Waste Sample* (Diluted with 0.01M NaOH to ~5.5 M Na prior to reagent addition) (0.14 M free OH, measured value)			*AN-102 Waste Sample* (After precipitation with 0.02 M Mn and 0.02 M Sr)	
	RX-01-24 (pg. B.5)	RX-01-24 dup (pg. B.5)	Average	RX-02-2 (pg B.6)	RX-11-24 (pg B.11)
Mass Dilution Factor (b)	1	1	1	1.0803	1.0830
Volume Dilution Factor	1.0	1.0	1.0	1.1	1.1
	µg/ml	µg/ml	µg/ml	µg/ml	µg/ml
Al	6,160	6,190	6,175	5,300	5,740
Ca	253	256	254.5	185	183
Cd	33.4	33.8	33.6	29.1	30.7
Ce	-- (c)	[5.5]	[2.8]	-- (c)	-- (c)
Cr	106	106	106	74	73.5
Eu	-- (c)	-- (c)	--	-- (c)	-- (c)
Fe	10.7	10.8	10.8	[2.6]	[2.5]
K	1,180	1,190	1,185	1,030	1,140
La	[8.4]	[8.6]	[8.5]	[2.2]	[1.7]
Mg	-- (c)	-- (c)	--	-- (c)	--
Mn	[2.8]	[2.9]	[2.9]	-- (c)	[1.6]
Na	124,000 (f)	126,000 (f)	125,000	108,000 (f)	119,000
Nd	[18.0]	[19.0]	[18.5]	[6.1]	[4.6]
Ni	229	232	230.5	201.0	205.0
P	1,040	1,050	1,045	897	928
Pb	104	106	105	84.1	83.6
Sr	[1.4]	[1.4]	[1.4]	104	108
Zr	[4.3]	[4.4]	[4.4]	[1.5]	[1.4]
Density, gm/ml (calculated) (d)	1.270	1.270	1.270	1.224	1.227
^{90}Sr, µCi/g	27.10	29.10	28.10	1.50	1.55
Sum of Alpha, µCi/g	7.72E-02	8.33E-02	8.03E-02	1.79E-02	1.78E-02
^{90}Sr / Sr, µCi/µg	25.3	26.4	25.5	0.0177	0.0176
Percentage ^{90}Sr Removed (e)				94.2%	94.0%

Notes:

(a) Values in brackets [ ] are > method detection limit, (MDL) but < estimated quantitation limit with errors likely to exceed 15%.
(b) Mass dilution factor = Final mass solution/initial mass solution. Source of data, page A.1, PNWD-3340.
(c) "--"indicates the value is < IDL, instrument detection limit.
(d) Calculated density value from page B.23, PNWD 3340.
(e) Precipitation reaction conducted at 26 to 29°C. Final Sr and MnO_4 concentrations were each 0.02 M.
(f) Values listed were identified as over range.

Table F-4. Precipitation of Sr/TRU from Tank AN-107 Sample

Source of Sample Data: PNWD-3340, pages B.31, B.32, B.35	*AN-107 Waste Sample* (Diluted with 1.1 M NaOH to 8.6 M Na and then with 0.01 M NaOH to ~5.5 M Na and 0.55 M free OH)			*AN-107 Waste Sample* (After precipitation with 0.02 M Mn and 0.02 M Sr, stirred sample)		
	SS-01-04	SS-01-04 dup	Average	SS-02-24	SS-08-24	SS-08-24 dup
Mass Dilution Factor	1	1	1	1.0823	1.0848	1.0848
Volume Dilution Factor	1.0	1.0	1.0	1.1	1.1	1.1
	µg/ml	µg/ml	µg/ml	µg/ml	µg/ml	µg/mL
Al	2,180	2,170	2,175	1,990	1,920	Sample was not analyzed
Ca	420	418	419	311	306	
Cd	34.1	34.0	34.1	31.1	30.4	
Ce	[8.8]	[8.5]	8.7	(c)	(c)	
Cr	53.8	53.5	53.7	38.9	38.5	
Eu	(c)	(c)	--	(c)	(c)	
Fe	300	299	299.5	7.25	7.76	
K	9170	914	915.5	870	815	
La	[7.2]	[7.1]	7.2	[1.4]	[1.3]	
Mg	(c)	(c)	--	(c)	(c)	
Mn	64.3	63.9	64.1	[1.7]	[2.0]	
Na	124,000	124,000	124,000	112,000	111,000	
Nd	[23]	[23]	[23]	[4.9]	[4.9]	
Ni	278	275	276.5	249	250	
P	378	376	377.0	343	334	
Pb	128	126	127.0	81.7	85.6	
Sr	[3.5]	[3.5]	[3.5]	93.8	105	
Zr	18.6	18.5	18.6	[3.0]	[3.0]	
Density, gm/ml (calculated)	1.270	1.270	1.270	1.24	1.22	1.22
^{90}Sr, µCi/g	31.1	29.4	30.3	1.55	1.71	1.66
Sum of Alpha, µCi/g	1.25E-01	1.19E-01	1.22E-01	1.69E-02	1.64E-02	1.50E-02
^{90}Sr / Sr, µCi/µg	11.3	10.7	11	0.020	0.0199	
Percentage ^{90}Sr Removed				94.5%	93.9%	94.1%

(a) Values in brackets [ ] are > MDL but < estimated quantitation limit with errors likely to exceed 15%.
(b) Mass dilution factor = Final mass solution/initial mass solution. Source of data, page A.1, PNWD-3340.
(c) "--" indicates the value is < IDL, instrument detection limit.
(d) Calculated density value from page B.23, PNWD 3340.
(e) Precipitation reaction conducted at 26 to 29 °C. Final Sr and MnO_4 concentrations were each 0.02 M.
(f) Values listed were identified as "over range".

F4.0 SR/TRU PRECIPITATE PHYSICAL PROPERTIES

F4.1 PARTICLE SIZE

The particle size distribution was determined for the Sr/TRU precipitate formed from an archived sample of tank AN-107 supernatant reacted at 50° C with sodium hydroxide, sodium permanganate and strontium nitrate. Testing of the Sr/TRU precipitate was performed for crossflow filtration tests to demonstrate the performance of a 0.1 μm filter element. Cesium had previously been removed from the archived tank AN-107 sample during a cesium ion exchange test. The starting sodium and hydroxide concentrations in the archived AN-107 sample were 5 M and 0.126 M. After chemical additions, the sodium, hydroxide, sodium permanganate and strontium nitrate concentrations in the archived sample were 5.68 M Na, 0.87 M OH, 0.05 M $NaMnO_4$ and 0.075 M $Sr(NO_3)_2$. The tank AN-107 sample also contained entrained solids. The sample was sonicated after completion of the precipitation reaction to simulate a high shear environment. The particle size distribution ranged from 0.1 μm to ~3 μm (PNWD-3033). It is believed that the shearing of the pump breaks apart the precipitate and reduces the particle size.

The Sr/TRU precipitate particle size distribution was also measured for treated tank AN-102 supernatant mixed with C-104 sludge leachate. The AN-102 / C-104 sludge leachate *composition was ~5 M Na, 0.2 M OH, 0.02 M Sr and 0.02 M* MnO_4*; following addition of all* reagents. The slurry was reacted at 31°C and digested for 4-hours, cooled to 22 to 25°C and filtered, then returned to 31°C for dead-end filtration, washing and sampling. For the washed Sr/TRU precipitate, the number based mean particle size was 1.79 μm, ranging from 0.6 μm to ~10 μm (PNWD-3264, Section 3.4.4). The washed Sr/TRU precipitate was sonicated to simulate shearing and the number based mean particle size was measured to be 1.13 μm, ranging from 0.5 μm to ~10 μm (PNWD-3264, Section 3.4.4).

Based on this data, the number based particle size distribution for the Sr/TRU precipitation is expected to range from 0.1 μm to ~10 μm.

F4.2 SOLIDS VOLUME AND DENSITY

A diluted and caustic adjusted tank AN-107 supernatant sample (7.54 M Na and 0.717 M OH) was reacted with sodium hydroxide, sodium permanganate and strontium nitrate to yield final treated waste concentrations of 6 M Na, 1.0 M OH, 0.075 M Sr and 0.05 M MnO_4. After 30-minutes of mixing at ambient temperature, the sample was heated to 50°C and digested for 4-hours, cooled to ambient and processed in a cells unit filter (CUF) to measure filtration flux rates. Samples of the Sr/TRU precipitate slurry were extracted from the CUF and analyzed for physical properties (PNWD-3035, Section 3.5).

After settling for 3-days, the volume percent settled solids (includes interstitial liquid) in the Sr/TRU precipitate slurry was 39 ± 1 volume percent. The weight percent settle solids in this sample was 42 ± 3 weight percent. The density of the settled solids was calculated to be between 1.23 to 1.37 g/mL. Centrifuging the Sr/TRU precipitate slurry was conducted and the centrifuged solids volume percent and density were calculated to be 12 volume percent and 1.36 ± 0.01 gm/ml.

F4.3 VISCOSITY

A diluted and caustic adjusted tank AN-107 supernatant sample (7.54 M Na and 0.717 M OH) was reacted with sodium hydroxide, sodium permanganate and strontium nitrate to yield final treated waste concentrations of 6M Na, 1.0 M OH, 0.075 M Sr and 0.05 M MnO_4. After 30-minutes of mixing at ambient temperature, the sample was heated to 50°C and digested for 4-hours, cooled to ambient and processed in a CUF to measure filtration flux rates. Samples of the Sr/TRU precipitate slurry were extracted from the CUF and analyzed for physical properties (PNWD-3035, Section 3.5).

The viscosity of the Sr/TRU precipitate slurry (39 ± 1 volume percent settled solids) was between 7 to 18cP for shear rates between 50 to 300 per second (PNWD-3035, Section 3.6).

F4.4 GAS GENERATION RATE AND ENERGETICS

The thermal activation parameters for gas generation from water washed Sr/TRU precipitate were measured to be 64 (±62) kJ/mole for hydrogen, 79 (±26) kJ/mole for nitrous oxide, 14 (±7) kJ/mole for nitrogen, 147 (±82) kJ/mole for methane, and 60 (± 32) kJ/mole for total gas generated. The radiolytic G-values, in molecules per 100eV, were determined to be 0.18 (±0.02) for hydrogen, 0.0041 (±0.004) for nitrous oxide, 0.0006 (±0.001) for methane, and 0.19 (±0.023) for total gas generated. The scatter in the nitrogen data precluded an accurate assessment for the nitrogen G-value (PNWD-3257).

To assess the potential reactivity hazards of wasted Sr/TRU solids, energetics testing was conducted and reported in PNWD-3257. Exothermic conditions (i.e., energetics) is a requirement outlined in the safety screening Data Quality Objectives (DQO) (Dukelow et al. 1995) and is to ensure that there is not enough fuel to cause a safety hazard. The threshold limit for energetics is 480 J/g on a dry weight basis.

The water washed Sr/TRU precipitate exhibited only endothermic thermal reactivity and thus the Sr/TRU washed solids did not exhibit exothermic behavior exceeding the Hanford reactive waste criterion of an exothermic waste as measured by differential scanning colorimeter (DSC), and therefore would not be classified as reactive waste (PNWD-3257).

F5.0 SR/TRU PRECIPITATION TEST REPORTS SUMMARY

A series of test reports have been prepared by Savannah River National Laboratory and Battelle-Pacific Northwest Division and published for BNI[3] which demonstrate the effectiveness of the ^{90}Sr and TRU precipitation process. Many of these studies were conducted with actual tank waste samples of tanks AN-102 and AN-107 supernatants, using a range of experimental conditions, and are cited below as they apply to each specific Sr/TRU process condition (i.e., precipitation chemistry, sodium concentration, reaction time and temperature, etc.).

a) <u>PNWD-3141 (WTP-RPT-029), *Optimization of Sr/TRU Removal Conditions with Samples of AN-102 Tank Waste*</u>

This test report includes the results of testing performed to determine the effects of temperature and low levels of reagent on Tank AN-102 waste liquids. Decontamination factors were determined by comparing the ^{90}Sr and ^{241}Am concentrations ^{241}Am represents greater than 90% of the TRU content in the AN-102 sample in the filtered, treated supernatant with the concentration of these isotopes in the starting diluted waste. The recommended Sr/TRU removal process conditions for waste from Tank AN-102 are:

- Dilute to a final target sodium concentration of 5M and do not add additional sodium hydroxide.
- Conduct process at a temperature of 25± 5° C, with stirring, add 0.02M strontium nitrate followed by 0.02M sodium permanganate.
- Stir/digest precipitate at 25± 5° C for 4 hours.
- The DFs[4] for precipitation of ^{90}Sr varied between 5 and 7 at 26° C. The DFs for ^{241}Am were relatively independent of temperature and ranged between 5 and 6 with permanganate addition.

b) <u>PNWD-3338 (WTP-RPT-091, Rev. 0), *Assessment of Abnormal Process Conditions for Sr/TRU Removal Using AN-102 Tank Waste Samples*</u>

The PNWD-3338 test report provides the results of experiments conducted to assess the impact of abnormal process conditions on Sr/TRU removal. A primary focus was to assess the impact of temperature, time, and reagent concentrations, since these conditions have been shown to have significant impact in earlier studies. These studies were conducted with AN-102 waste samples that were adjusted to approximately 5.5 <u>M</u> Na with the addition of 0.3 <u>M</u> NaOH.

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[3] Test plans and studies identified in Bechtel National, Inc. (BNI), 2002. *Research and Technology Plan*, 24590-WTP-PL-RT-01-002, Rev. 1, U.S. Department of Energy, Office of River Protection, Richland, WA.

[4] Treated waste must meet Specification 2 of the Bechtel National, Inc. contract (WTP 2001) for removing ^{90}Sr and TRU elements from the LAW solution, i.e., 20 Ci/m^3 for ^{90}Sr and 100 ηCi/gm for TRU. Target decontamination levels were established at 50% below the LAW requirements, which corresponds to a ^{90}Sr DF of 10 and a TRU DF of 2 for AN-102 waste.

- Strontium is greatly affected by temperature. The removal of ^{90}Sr for the supernatant is more sensitive to process conditions, reagent level, temperature, and reaction time.
- The permanganate treatment for TRU removal is quite robust, with variation in process conditions having little impact on meeting the ILAW requirement.
- The non-radioactive Sr addition should be 0.02 M or higher to ensure low levels of ^{90}Sr in the ILAW.

- PNWD-3340 (WPT-RPT-082, Rev. 0), *Assessment of Sr/TRU Removal Mechanisms Using AN-102 and AN-107 Waste Samples*
  - This report discusses investigations into the mechanism of the Sr/permanganate treatment process for removal of ^{90}Sr and TRU using actual waste samples from AN-102 and AN-107. Conclusions reported include:
  - Oxidation is important for TRU decontamination in AN-102 supernatant (AN-102 has significantly more Ethylenediaminetetraacetic acid/Hydroxyethylethylenediaminetriacetic acid -type complexants than AN-107).
  - TRU removal process is most effective for removing tri-valent actinide ions, Am and Cm. These elements make up approximately 95% of the TRU in the waste.
  - Ligand exchange, precipitation, and sorption appear to be most important for TRU removal from AN-107.
  - Time dependence of ^{90}Sr and TRU removal: TRU precipitation is independent of time and ^{90}Sr precipitation is shown to be time dependent with an increased ^{90}Sr DF at 24 hours versus 4 hours.

d) PNWD-3264 Rev. 1 (WTP-RPT-044 Rev. 1), *Combined Entrained Solids and Sr/TRU Removal from AN-102 Waste Blended with C-104 Sludge Pretreatment Solutions*

The PNWD-3264 test report conducted studies to determine if low levels of reagent provide adequate decontamination conditions for integrated process testing with a mixture of Tank AN-102 waste and HLW sludge pretreatment streams (supernatant, wash, caustic leach, and rinse solutions from HLW pretreatment of Tank C-104 wastes). The mixture is referred to as "AN-102/C-104 waste blend." Studies with the AN-102/C-104 waste blend include demonstrating that reduced levels of strontium and permanganate addition provide decontamination of the liquid waste (supernatant) to meet LAW requirements for vitrification. See Tables below excerpted from PNWD-3264 showing the decontamination of ^{90}Sr and TRU resulting from the experiments with the AN-102/C-104 waste blend.

Small-Scale Tests data in Table 3.2 is from an earlier test report and is cited in Table 3.2, Section 3.0 of this document.

Table 3.2. Comparison of Sr-90 DFs and Total Sr Solubility for Treated Samples of AN-102/C-104 Waste Blend

	Small-Scale Tests[(a)]		This Study[(b)]	
Test Condition	Sr-90 DF	[Sr] μg/g	Sr-90 DF	[Sr] μg/g
Sr-Only	6.9	197	5.9	165
Sr + MnO_4^-	8.8	172	10.2	101

(a) 26°C and 4 hours after reagent addition.
(b) 31°C and 18 minutes after reagent addition.

Table 3.3. Comparison of Am-241 and Cm-243+244 DFs for Treated Samples of AN-102/C-104 Waste Blend

Test	Small-scale Tests		This Study	
Condition	Am-241 DF	Cm[(a)] DF	Am[(b)] DF	Cm[(a)] DF
Sr-Only	1.2	1	1.4	0.8
Sr + MnO_4^-	2.7	1.7	4.9	2.9

(a) Cm = Cm-243+244.
(b) Am = Am-241+Pu-238.

Table 3.7 from PNWD-3264 shows that the treated supernatant from all samples taken was below the contract limits for ILAW glass.

Table 3.7. Sr-90 and TRU ILAW Glass Loading for 15 wt% Waste Na_2O

Sample	Sr-90 (Ci/m^3)	TRU (nCi/g)
ILAW Limits:	20	100
Initial Waste Blend, LS-01	61	66
Treated Samples (Average)	4-10 (7)	10-21 (16)

Other test reports, as cited in Section 3.0, confirm the process conditions identified in these test reports and provide the basis for process conditions used in the material balance for this study.

F6.0 REFERENCES

PNWD-3033, 2000, *Demonstration of the Sr/TRU Removal Process with Archived AN-107 Waste*, (BNFL-RPT-026), Battelle, Pacific Northwest Division, Richland, Washington.

PNWD-3035, 2000, *Combined Entrained Solids and Sr/TRU Removal from AN-107 Diluted Feed*, (BNFL-RPT-027), Battelle, Pacific Northwest Division, Richland, Washington.

PNWD-3047, 2000, *Development of an Alternate Treatment Scheme for Sr/TRU Removal: Permanganate Treatment of Archived AN-107 Waste*, Battelle, Pacific Northwest Division, Richland, Washington.

PNWD-3141, 2002, *Optimization of Sr/TRU Removal Conditions with Samples of AN-102 Tank Waste*, Battelle, Pacific Northwest Division, Richland, Washington.

PNWD-3189, 2002, *Verification of Process Conditions for Sr/TRU Removal from AN-102/C104 Waste Blend*, Battelle, Pacific Northwest Division, Richland, Washington.

PNWD-3257, 2003, *Gas Generation and Energetics Studies of an Envelope C Waste Treated by the Sr/TRU Precipitation Process*, Battelle, Pacific Northwest Division, Richland, Washington.

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WHC-SD-WM-TRP-168, 1994, *Tank 241-AP-102 Characterization and Grout Product Test Results*, Westinghouse Hanford Company, Richland Washington.

WSRC-TR-2000-00341, 2000, *Entrained Solids, Strontium – Transuranic Precipitation and Crossflow Filtration of AN102 Small C*, (SRT-RPP-2000-00003), Westinghouse Savannah River Company, Aiken South Carolina.

WSRC-TR-2000-00506, 2000, *Strontium – Transuranic Precipitation and Crossflow Filtration of 241-AN-102 Large C*, (SRT-RPP-2001-00006), Westinghouse Savannah River Company, Aiken, South Carolina.