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Revision 3

Feed Composition For The Sodium-Bearing Waste Treatment Process

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Bechtel BWXT Idaho, LLC

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ABSTRACT

A settlement agreement between the State of Idaho and the United States Department of Energy mandates that all sodium-bearing waste at the Idaho Nuclear Technology and Engineering Center, within the Idaho National Engineering and Environmental Laboratory, be treated by December 31, 2012. Detailed feed compositions are needed to support design and development studies for the sodium-bearing waste treatment process that will be used to comply with the settlement agreement. This report presents the expected volumes and compositions of these feed streams and the sources and assumptions used in determining them. The report also discusses efforts to develop a simulant of the sodium-bearing waste tank solids.

SUMMARY

A sodium-bearing waste (SBW) treatment facility will treat liquids and solids contained in existing tanks at the Idaho Nuclear Technology and Engineering Center (INTEC). The treatment facility will also treat additional liquid waste, called Newly Generated Liquid Waste (NGLW) that will be generated after 2005 and stored in separate tanks from the SBW. Processes currently under consideration for treating this waste include cesium ion exchange followed by grouting, calcination using the New Waste Calcining Facility (NWCF) upgraded with additional air pollution control equipment, direct evaporation of the SBW to a solidified waste, and steam reforming.

This report presents the most recent compilation of volumes and compositions of the feed streams to these potential processes. As new characterization data are received and as changes are made in INTEC Tank Farm management plans, this report will be updated. This report also identifies the assumptions and source documents used in calculating the treatment process feed compositions. This report also discusses progress in developing a simulant for the SBW undissolved solids.

Tanks WM-180 and WM-189 presently contain volumes of waste near their administrative capacities and no additions to these tanks are expected. As of July 31, 2003, Tank WM-188 contained about 230,000 gallons of waste. Approximately 55,000 gallons of additional waste will be added to Tank WM-188 prior to the start of treatment. The compositions presented in this report for waste in Tanks WM-180 and WM-189 are based on sample analyses; the projected composition of waste in Tank WM-188 (when full) is based on analyses of the present tank waste and estimated compositions of wastes that will be added to the tank.

As tanks in the Tank Farm Facility (TFF) are flushed and closed, solids will accumulate in Tank WM-187. Tank WM-187 presently contains solids flushed from WM-182 and WM-183. In FY 2003 and 2004, Tanks WM-184, WM-185 and WM-186 will be flushed to WM-187; Tank WM-181 will be flushed the following year. The treatment process will process the solids collected in WM-187 tank as well as solids from the three SBW tanks (WM-180, WM-188, WM-189). Compositions are defined both for alternatives that process solids separately and together with SBW liquid.

A program to sample and analyze solids from each tank is in progress but has not been completed. Compositions of solids are presently available for five Tank Farm tanks (WM-180, WM-181, WM-182, WM-183, and WM-188), and these compositions are used to estimate compositions of solids in tanks at the time of treatment. Other analyses performed on solids from Tank WM-186 have been used to develop a simulant for tank solids.

Projections have been made of the volumes of NGLW streams generated prior to and during operation of the SBW treatment facility. For some of these NGLW streams, chemical composition data are available and have been used in generating treatment facility feed compositions. However, data for radionuclide concentrations in NGLW are extremely limited. Thus, radionuclide

concentrations in treatment facility feeds are based solely on data from existing tank waste. Starting in FY 2006, NGLW will be collected in tanks WM-100, WM-101 and WM-102. The accumulated NGLW will later be blended with SBW for treatment in the SBW treatment facility.

Progress has been made developing a simulant for the tank solids. Analysis of WM-186 solids has shown that the solids are largely amorphous and composed of nanometer-sized individual particles that agglomerate upon standing to particles that are mostly in the 1-200 µm range. Analysis also has shown that many of the cations are present as complex hydroxyl compounds – oxy-hydrates, hydroxyl-oxides and/or hydroxides rather than simple oxides. These results support preparation of a solids simulant by metathesis.

CONTENTS

FIGURES

TABLES

ACRONYMS

BSE	back scattered electron
CMACT	Calcination with MACT upgrade SBW treatment alternative
DEA	diethanolamine
DSC	differential scanning calorimetry
EDF	engineering design file
EDS	energy dispersive x-ray spectrometry
HLLWE	High-Level Liquid Waste Evaporator
ICP/AES	inductively coupled plasma/atomic emission spectroscopy
ICP/MS	inductively coupled plasma/mass spectroscopy
ICPP	Idaho Chemical Processing Plant
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LDUA	light-duty utility arm
LET&D	Liquid Effluent Treatment and Disposal (facility)
MACT	maximum achievable control technology
NGLW	newly generated liquid waste
NWCF	New Waste Calcining Facility
PEW	process equipment waste
PEWE	Process Equipment Waste Evaporator
PSD	particle size distribution
RCRA	Resource Conservation and Recovery Act
SAD	selected area electron diffraction
SBW	sodium-bearing waste
SE	secondary electron
SEM	scanning electron microscopy
SG	specific gravity
SRTC	Savannah River Technical Center
SVOCs	semi-volatile organic compounds
TEA	triethanolamine

TEM	transmission electrom microscopy
TFF	Tank Farm Facility
TGA	thermogravimetric analysis
TIC	total inorganic carbon
TOC	total organic carbon
TRU	transuranic
UDS	undissolved solids
VOCs	volatile organic compounds
WCF	Waste Calcining Facility
WDS	Wavelength dispersive spectrometry
WIR	Waste Incidental to Reprocessing
XAFS	x-ray absorption fine structure
XPS	x-ray photoelectron spectroscopy
XRD	powder x-ray diffraction
XRF	x-ray fluorescence

GLOSSARY

Alternative: A holistic solution for sodium-bearing waste (SBW) treatment, including the process/ tech nologies used, and in the larger context, the program/project and its cost, schedule, and regulatory and stakeholder environment.

Calcine/MACT or “CMACT”: An SBW treatment alternative that includes upgrades to the calciner in the NWCF, a new Maximum Achievable Control Technology (MACT) compliance facility, a scrub treatment process, and possibly a new calcine packaging facility.

CsIX or Cesium Ion Exchange/TRU Grout: An SBW treatment alternative that includes filtration of solids, cesium removal by ion exchange and one of several possible methods for stabilization of the cesium-free contact-handled transuranic (TRU) waste, namely, grouting, absorption on silica gel or absorption on another sorbent. The baseline process is grouting and the name would change if another stabilization method were chosen.

Direct Evaporation: An SBW treatment alternative involving concentration of SBW by evaporation to the extent that it solidifies upon cooling into a disposable waste.

Heels: The initial residual volume left in the Tank Farm tanks consisting of concentrated SBW liquid and tank solids.

Heels, cut: Tank solids in liquid ranging from diluted SBW to water; having been rinsed and diluted.

Newly Generated Liquid Waste: Liquid waste from a variety of sources that in the past has been evaporated and added to the liquid waste in the below-grade tanks at INTEC. Sources include leachates from treating contaminated high efficiency particulate air filters, decontamination liquids from INTEC operations that may or may not be associated with INTEC waste management activities, and liquid wastes from other INEEL facilities. INTEC has historically used this term to refer to liquid waste streams (past and future) that were not part of spent fuel reprocessing. It will be stored along with SBW in the TFF tanks until September 2005 whereupon present plans call for its segregated storage. Since it is mixed with the existing SBW in the TFF tanks it does not formally exist as a separate entity and will not until segregation starts in 2005.

Sludge: The mixture of tank solids and interstitial liquid.

Sodium-bearing waste: The term is non-specific and can range in meaning from SBW liquid +/- tank solids to all Tank Farm tank contents (SBW liquid and all tank solids). SBW is mixed hazardous, radioactive waste generated as a by-product of spent nuclear fuel reprocessing. It consists in minor part of second and third cycle extraction wastes but is mostly made up of decontamination solutions used over the years in support of operations. It is relatively high in sodium and potassium content from the solutions used for decontamination. Hence the name, SBW, and its separate tracking and management at INTEC. SBW is high in transuranics (TRU) and is best characterized as mixed transuranic waste.

Steam Reforming: An SBW treatment alternative involving heating SBW with additives and steam to form a solid particulate waste.

Tank solids: Any and all solids contained in the Tank Farm tanks.

Tank solids, settled: Heavier tank solids that lay at the bottom of the tanks.

Tank solids, entrained: Tank solids, both suspended and settled, that are sucked up by the steam jets and transported with the liquid SBW to further treatment.

Feed Composition for the Sodium-Bearing Waste Treatment Process

1. INTRODUCTION

Radioactive liquid waste has been generated over the last five decades at the Idaho Nuclear Technology and Engineering Center (INTEC), formerly called the Idaho Chemical Processing Plant, as a result of nuclear fuel reprocessing activities. From December 1963 until June 2000, the Waste Calcining Facility (WCF) and the New Waste Calcining Facility (NWCF) processed the liquid waste into a granular, solid form. As of July 31, 2003, approximately 880,000 gallons of waste remained in Tank Farm tanks at INTEC. Additional liquid waste will be generated in the future as a result of filter leach operations, equipment and building decontamination activities, Resource Conservation and Recovery Act (RCRA) closure activities, and other operations at INTEC.

Four processes are presently being evaluated for treating these wastes.

- Cesium ion exchange (CsIX)
- Calcination
- Steam reforming
- Direct evaporation.

Design and development activities are on going to select a single treatment process from these four alternatives or others that may be proposed in bids for the Idaho Completion Project contract. To support design studies for the treatment processes, detailed feed compositions are needed. This report presents the expected compositions of these feed streams and the sources and methods used in estimating them. This report also presents available physical property data for tank solids and discusses efforts to develop a simulant for the solids. A solid simulant may be needed to demonstrate proposed methods to handle, transport, mix and treat the tank solids.

1.1 Source Data and Documents

The primary sources of information used in generating projected feedstock compositions are described below.

<u>Historical and Present Tank Farm Liquid Composition</u>

1. M. D. Staiger, C. B. Millet, R. A. Nickelson, R. A. Wood, A. Chambers, "Tank Farm Facility, Tank and Waste Data*," Engineering Design File EDF-1598*, February 27, 2001.

Engineering Design File (EDF)1598 contains a brief review of previous documents containing Tank Farm composition data, a compilation of Tank Farm liquid composition analytical data up through January 2000, estimates of Tank Farm solids volume, and an estimate of newly generated liquid waste (NGLW) composition. The EDF compiles analytical results of samples taken from each of the Tank Farm tanks consistent with the liquid waste present in the tank as of late 2000. In addition, a waste composition for each tank is presented based on averages of analytical results, for those species for which data are available, and estimates for other chemical and radionuclide species. Estimates were based on calculations by Doug Wenzel using ORIGEN2 for a "typical" SBW composition and the assumption that concentrations of the estimated species for a given tank are equal to the concentration in the "typical" SBW times the ratio of ^{137}Cs in the tank waste to ^{137}Cs in the "typical" SBW. Wenzel's calculations are documented in the following reports:

D. R. Wenzel, "Evaluation of Radionuclide Inventory for Sodium-Bearing Waste," *Engineering Design File EDF-FDO-006/CPP-97080*, November 26, 1997.

D. R. Wenzel, "Calculation of July 1999 Inventories for INTEC Wastes," *INEEL Interoffice Memorandum*, Wen-27-99, originally issued November 7, 1999 and reissued with corrections August, 2000.

D. R. Wenzel, "Calculation of July 1999 Radionuclide Inventory for Sodium-Bearing Waste," *INEEL Interoffice Correspondence*, Wen-20-99, May 18, 1999.

2. C. B. Millet, "Composition of Tank Farm Waste as of October 2002," *INEEL Interoffice Memorandum* Mil-07-02, December 12, 2002 (consistent with Excel spreadsheet "Tank Farm Composition Database 10-02d.xls").

Clark Millet maintains a spreadsheet known as the "Tank Farm Composition Database" that includes sample analyses data as well as summary concentrations for each Tank Farm tank. The tables contained in Reference 1 of both analyses data and summary averages and estimates reflect the Tank Farm Composition Database spreadsheet that was current at the time EDF-1598 was being prepared. Updates to the Tank Farm Composition Database continued after publication of EDF-1598 as described in:

D. R. Tyson, "Validation of the Radionuclide Mass Balance Used in the INTEC SBW WIR Determination Report," *Engineering Design File EDF-1920*, Revision 4, August 29, 2002.

M. C. Swenson, "Validation of the Radionuclide Inventory and Mass Balance Used in the INTEC SBW and Tank Farm Residuals WIR Determination Reports," *Engineering Design File EDF-1920 INEEL/EXT-2001-534*, Revision 5, September 2003.

In early FY 2003 the Tank Farm Composition Database was again updated to:

- Incorporate analysis data from samples taken from Tank WM-180 in 2000
- Incorporate analysis data from samples taken from Tank WM-189 in 2002
- Update the waste volumes and radionuclide decay basis from July 1, 1999 to January 1, 2003
- Adjust the waste compositions in WM-182 and WM-183 due to water flushes of these tanks
- Adjust the WM-185 waste composition due to additions of water and waste from WM-183 transferred in 2000 and 2001
- Adjust the waste composition of WM-187 due to additions of waste to the tank in 2002
- Incorporate additional updates by Wenzel of ORIGEN2 calculations of SBW radionuclide inventories.

The Tank Farm Composition Database serves as the common source and control point for all estimates of present Tank Farm liquid waste composition.

3. J. D. Christian, *Composition and Simulation of Tank WM-180 Sodium-Bearing Waste at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-2001-00600, May 2001.

Jerry Christian evaluated data from samples taken in 2000 of Tank WM-180 waste and recommended a surrogate composition for waste from this tank. A comparison of the Tank WM-180 liquid composition based on 2000 sample analyses with analyses of samples taken in 1993 is given in Table 1 (See Section 2.1). Reference 3 also contains compositional data for the solids in WM-180, both analytical data and results of thermodynamic modeling, and a recommended composition of a simulant of WM-180 waste.

4. T. A. Batcheller, D. D. Taylor, *Characterization of Tank WM-189 Sodium-Bearing Waste at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-02-01171 Rev. 1, July 2003.

Tom Batcheller and Dean Taylor evaluated liquid and solids analytical data from FY 2002 WM-189 samples and present their results in Reference 4. In addition to a recommended composition for Tank WM-189 waste, Batcheller and Taylor present uncertainties associated with each component concentration.

5. V. J. Johnson, R. L. Demmer, T. A. Batcheller, *Characterization of Tank WM-188 Sodium-Bearing Waste at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-03-00478, June 2003.

Samples from Tank WM-188 were taken in late November 2002 and analyzed in 2003. Reference 5 contains the results of the analyses for both liquids and solids from the tank. In contrast to the procedure used for Tank WM-189 solids (Reference 4), the solids from WM-188 were washed with water prior to analysis.

<u>Tank Solids Compositions</u>

References 3 and 4 contain analyses of solids from Tanks WM-180 and WM-189. Waste from each of these tanks was separately transferred by steam jet to a tank in the NWCF blend and hold cell, where it was sampled. Solids contained in the samples were thus solids entrained with the liquid waste during jet transfer.

6. M. Patterson, *Light Duty Utility Arm Deployment in Tank WM-188*, INEEL/EXT-99-01302, December 1999.

Reference 6 contains compositional data for solids that were present in WM-188 in 1999, obtained by the Light Duty Utility Arm (LDUA) sample end effector.

7. *Idaho Hazardous Waste Management Act/Resource Conservation and Recovery Act Closure Plan for Idaho Nuclear Technology and Engineering Center Tanks WM-182 and WM-183*, DOE/IC-10802, Appendix B, "Data Summary for Tanks WM-182 and WM-183," DOE/ID-10802, November 2001.

8. A. Poloski, "Solids Characterization," *Engineering Design File EDF-TST-001*, September 20, 2000.

References 7 and 8 contain chemical and physical property data for solids that were present in the heels of Tanks WM-182 and WM-183 when sampled in 2000.

9. D. R. Tyson, "Validation of the Radionuclide Mass Balance Used in the INTEC SBW WIR Determination Report," *Engineering Design File EDF-1920*, Revision 4, August 29, 2002

Reference 9 contains summary of the inventory of radionuclides in each tank is contained in Reference 9, which includes a significant correction to the ^{137}Cs concentration of WM-182 solids reported in Reference 8. The radionuclide inventories shown in Reference 9 for tanks other than WM-182, WM-183 and WM-188 are estimates.

10. V. J. Johnson, R. L. Demmer, *Characterization of Tank WM-181 Sodium-Bearing Waste Solids at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-03-00979, September 2003.

11. M. C. Swenson, "Historical Tank Farm Sample Results," *INEL Correspondence*, MCS-27-92, December 17, 1992.

Reference 11 contains some older analyses of tank solids as well as a description of sources of solids. Reference 11 also includes some data that shows how solids composition varies with particle size.

Tank Solids Mass Estimate

12. A. P. Poloski, "INTEC Tank Farm Sludge Density Measurements/Calculations," *Engineering Design File 15722-040*, July 12, 2000.

Reference 8 gives an estimate of the volume of "sludge" (the solids/liquid residual in a tank after removing liquid waste) by tank. Reference 9 uses the estimated tank sludge volumes of Reference 8 plus a solids concentration from Reference 12 to derive estimates of the mass of tank solids present in each tank. Estimates of the mass of tank solids (as shown in Table 12 of References 9 and 34) have been used in the INTEC Waste Incidental to Reprocessing (WIR Determination) documents and various SBW treatment mass balances made in previousyears. New estimates are proposed in Section 3.1 for use in Conceptual Designs for SBW treatment alternatives.

NGLW Stream Compositions

13. J. A. Nenni, "Balance-of-Plant Sample Data Compilation," *Engineering Design File,* EDF-2506, September 2002.

Joe Nenni compiled compositional data for NGLW streams based on analysis of samples taken from FY-1999 through FY-2002. Compositional data in Reference 13 includes metals, anions, pH or acidity, undissolved solids (UDS), total inorganic carbon (TIC), and total organic carbon (TOC), semi volatile organic compounds, and volatile organic compounds. No radionuclide compositional data are included.

14. J. L. Tripp, *Supporting Information for the INEEL Liquid Waste Management Plan*, Appendix B, INEEL/EXT-98-00730, July 1998.

Reference 14 contains NGLW compositional data from sample analysis prior to FY-1999. Compositions are provided by NGLW stream, and include, when available, radionuclide activities.

15. C. M. Barnes, "NGLW Volumes and Compositions for Treatment Study," *INEEL Interoffice Memorandum* CMB-07-02, Rev. 1, April 8, 2002.

Reference 15 contains estimates of the composition of several groups of NGLW streams, including streams that were thought to be high in TRU content, streams that are expected to be low in TRU content, and all NGLW streams combined. Since Reference 15 was issued, new estimates of NGLW generation volumes have been made (see Reference 16). NGLW compositions shown in Section 2.4 were recalculated based on the new projections of waste volumes. However, as discussed in Section 2.4, radionuclide compositions shown in this report have been estimated based on SBW concentrations rather than NGLW analysis. Although not used to prepare NGLW composition estimates for this report, use of Reference 15 in Conceptual Design may be warranted in calculations in which small changes in NGLW radionuclide content could have impacts on the process design. If small changes in radionuclide content are important to design of the SBW treatment facility or disposal of the final waste forms then review of the conservatism as described in EDF-1920 revision 5 (Reference 34) should be done.

Present and Future Liquid Volumes

16. C. M. Barnes, C. B. Millet, "INTEC Tank Farm Facility Management Plan," Plan-1112, September 30, 2002.

Present TFF volumes are based on tank level measurements. A web-based monthly update of TFF tank volumes is available at http://emhome.inel.gov/hlw/Tankdata/TankMap.htm. Reference 16 contains estimates of future tank volumes. The estimated volumes in Reference 16 do not include estimates for waste streams generated by any of the SBW treatment processes.

Tank Solids Properties and Simulants

Poloski (Reference 12) calculates the volume fraction of solids in WM-183 sludge and also the solids particle density from measurements of the mass and volume of the sludge sample, the weight fraction of water in the sludge and the density of water. Reference 8 includes particle size distribution data for solids from Tanks WM-182 and WM-183 and settling rate data for solids from Tank WM-182. Reference 3 contains particle size distribution data for Tank WM-180 solids. In Reference 4, Batcheller presents particle size distribution data for solids from WM-189 as well as other solids and sludge properties.

17. J. R. Harbour, R. F. Schumacher, A. Choi, A. K. Hansen, *Development of an Initial Simulant for the Idaho Tank Farm Solids*, WSRC-TR-2002-00436, November 11, 2002.

Harbour et al used analysis data from WM-182 and WM-183 solids to develop a tank solids simulant, and then measured shear stress versus shear rate for the simulant.

Tank Farm Background Information

18. W. B. Palmer, C. B. Millet, M. D. Staiger, M. C. Swenson, W. B. McNaught, F. S. Ward, *INTEC Waste Management Through 2070,* INEEL/EXT-2000-01005, December 2000.

Palmer et al document the history and discuss present operation of the INTEC Tank Farm, INTEC waste management equipment and operation, and SBW and NGLW management plans. While the plans and waste compositions in the report are no longer current, the history and discussion of equipment and INTEC operations is useful.

1.2 Feeds to the Alternative Treatment Processes

Waste to be treated by the SBW Treatment Facility includes:

1. SBW stored in Tank WM-180, including liquid and a relatively small amount of undissolved solids. Tank WM-180 is presently full (near its administrative limit) and no changes in waste composition are expected for this tank.

2. SBW stored in Tank WM-188, including liquid and a relatively small amount of undissolved solids. Tank WM-188 is presently about three-quarters full; waste will continue to be added through 2005.

3. SBW stored in Tank WM-189, including liquid and a relatively small amount of undissolved solids. Tank WM-189 is presently full (near its administrative limit) and no changes in waste composition are expected for this tank.

4. NGLW that will be collected in Tanks WM-100, WM-101 and WM-102 from 2006 through the end of SBW treatment. Transfers into and out of these tanks will be made up to and possibly during the period of SBW treatment.

5. Solids stored in Tank WM-187, collected from Tanks WM-182, WM-183, WM-184, WM-185, WM-186, and WM-181. Heels from these tanks will be flushed to WM-187 using water, thus the solids in Tank WM-187 will be contained in a dilute acid/salt solution.

The following sections discuss differences in the feeds to each of the treatment processes.

1.2.1 CsIX

For the CsIX treatment alternative, NGLW and SBW would be blended in Treatment Facility Receiving Tank. Slurried tank solids would be received in a separate tank and treated in equipment separate from equipment that treats the liquid waste. Solids from WM-187 would be the first solids treated, followed by solids from the Tanks WM-180, WM-188, and WM-189 after these tanks have been emptied of liquid.

Thus the feeds to the CsIX/TRU Grout process will consist of liquid containing a small amount of solids, ranging in composition from a WM-180/NGLW blend to a WM-188/NGLW blend to a WM-189/NGLW blend and a solid slurry varying in solids content and varying in composition from the composition of solids from WM-187 to the composition of solids from WM-180, WM-188, and WM-189.

The NGLW composition could change during SBW treatment. At the start of SBW treatment, the NGLW would consist of INTEC waste streams only. During SBW treatment, dilute aqueous wastes from the CsIX process would be sent to INTEC evaporators, and the concentrated waste added to the NGLW. Also, the NGLW generated from continued INTEC operation during the period of SBW treatment may not have the same composition as the composition of NGLW accumulated prior to treatment.

1.2.2 Calcination/MACT

If calcination were selected for SBW treatment, decontamination of NWCF cells could begin as early as 2004, resulting in waste not generated for the other options. This NWCF cell decontamination waste would be concentrated and added to WM-188 through FY 2005 or WM-100, WM-101, and WM-102 after 2005. Unlike the CsIX process, no dilute liquid wastes are expected to be generated continually during operation, but wastes would be generated intermittently during scheduled and unscheduled shutdowns, and also from decontamination activities after SBW processing is complete.

A separate study[19] has recommended that solids be mixed with liquid tank waste in TFF tanks and processed together (co-processed) in the calciner. In the same study several scenarios for blending solids from Tank WM-187 with wastes from the other tanks were proposed and one scenario was recommended in which solids collected in Tank WM-187 would be distributed between tanks WM-188, WM-189 and WM-187, while waste in WM-180 would not be blended. Data from additional tank sampling and analyses may result in revisions to the scenario for tank blending.

Based on present plans the waste feed will consist of Tank WM-180 waste and blends of wastes from Tanks WM-187, WM-188, WM-189, WM-100, WM-101, and WM-102. This will result in four distinct feeds to the treatment facility, and except for WM-180, more homogeneous in solids concentration and liquid composition than the waste presently in any of the individual tanks.

1.2.3 Steam Reforming

The waste feed to the Steam Reforming process would be nearly identical to the feed for the Calcination/MACT alternative. Minor differences in NGLW composition between these two alternatives would cause very minor differences in feed composition. Like calcination, solids would be co-processed and transfers would be made between Tank Farm Facility (TFF) tanks to evenly distribute solids among the various tanks.

1.2.4 Direct Evaporation

Co-processing of solids has also been recommended for the Direct Evaporation process.[20] Feeds to the process would essentially be the same as the feeds for the calcination and steam reforming alternatives, with only small differences due to differences in NGLW composition and volume between what would be generated for the direct evaporation alternative and the calcination or steam reforming alternative.

2. LIQUID WASTE COMPOSITION AND PROPERTIES

This section discusses the sources and amounts of wastes that will be in tanks fed to the treatment process. It also projects compositions of the liquid in these tanks and the basis for calculating these compositions.

2.1 WM-180 Liquid Composition

Tables 1 and 2 show the composition of liquid waste in Tank WM-180. Two compositions are shown in Table 1, one based on FY 2000 samples and the other based on the average of three samples taken in 1993. Approximately 278,900 gallons of waste were in WM-180 at the time of sampling in 1993. Since then, about 400 gallons of waste and 2000 gallons of water were added to WM-180, 3400 gallons were transferred from WM-180 to WM-182 in 1997, and 2600 gallons were transferred to the NWCF for sampling in 2000. Thus, at most 1% of the difference between the two analyses can be accounted for by additions to the tank; the remainder of the difference provides an estimate of the uncertainty in the composition. While the differences between the two sets of analyses are within ~10% for most major species, much larger differences are seen for some of the other species.

Table 2 presents a comprehensive composition for waste in Tank WM-180. The composition is based on averaging data from both 1993 and 2000 WM-180 samples and estimating other species. Estimates are shown by italics and are based on a 2002 update by Wenzel.[27] The method for estimating concentrations of unknown species is documented in Reference 1. Radionuclide concentrations in Table 2 are based on a decay date of January 1, 2003.

Table 1. Comparison of analyses of WM-180 samples.

	1993 Mol/liter	2000 Mol/liter	Ratio 2000/1993
H^+	1.14E+00	1.10E+00	0.96
Al^{+3}	5.90E-01	6.63E-01	1.12
Ba^{+2}	5.10E-05	5.58E-05	1.09
B^{+3}	1.02E-02	1.23E-02	1.20
Cd^{+2}	7.73E-04	7.54E-04	0.98
Ca^{+2}	3.39E-02	4.72E-02	1.39
Cl^-	3.11E-02	3.00E-02	0.96
Cr^{+3}	3.29E-03	3.35E-03	1.02
F^-	4.18E-02	4.74E-02	1.13
Fe^{+3}	1.75E-02	2.17E-02	1.24
Pb^{+2}	1.23E-03	1.31E-03	1.06
Hg^{+2}	9.89E-04	2.02E-03	2.04
Ni^{+2}	1.48E-03	1.47E-03	0.99
NO_3^-	4.56E+00	5.01E+00	1.10
K^+	1.83E-01	1.96E-01	1.07
Se^{+2}	1.04E-05	1.46E-04	14.0
Ag^+	4.43E-06	5.29E-06	1.19
Na^+	2.00E+00	2.06E+00	1.03
SO_4^{-2}	4.28E-02	6.98E-02	1.63

Table 2. WM-180 composition.

Specific Gravity		1.26	Dissolved species			Mol/liter
Undissolved Solids, g/liter		0.63	Mercury	Hg^{+2}		1.35E-03
Dissolved species		Mol/liter	Molybdenum	Mo^{+6}		1.82E-04
Acid	H+	1.12E+00	Neodymium	Nd^{+3}		*1.59E-05*
Actinium	Ac^{+2}	*1.22E-15*	Neptunium	Np^{+4}		*9.10E-06*
Aluminum	Al^{+3}	6.06E-01	Nickel	Ni^{+2}		1.44E-03
Americium	Am^{+4}	*3.14E-08*	Niobium	Nb^{+5}		*3.40E-08*
Antimony	Sb^{+5}	3.59E-08	Nitrate	NO_3^-		4.66E+00
Arsenic	As^{+5}	4.71E-04	Palladium	Pd^{+4}		*1.89E-06*
Astatine	At^-	*2.91E-28*	Phosphate	PO_4^{-3}		2.88E-03
Barium	Ba^{+2}	5.17E-05	Phosphorus	P^{+5}		1.29E-02
Beryllium	Be^{+2}	7.33E-06	Plutonium	Pu^{+4}		*2.03E-06*
Bismuth	Bi^{+3}	*4.41E-18*	Polonium	Po^{+4}		*1.45E-18*
Boron	B^{+3}	1.08E-02	Potassium	K^+		1.84E-01
Bromine	Br^-	*1.64E-07*	Praseodymium	Pr^{+4}		*4.49E-06*
Cadmium	Cd^{+2}	7.49E-04	Promethium	Pm^{+3}		*6.57E-10*
Calcium	Ca^{+2}	3.85E-02	Protactinium	Pa^{+4}		*4.57E-12*
Californium	Cf^{+4}	*9.42E-21*	Radium	Ra^{+2}		*1.91E-14*
Carbon	C^{+4}	*1.90E-06*	Rhodium	Rh^{+4}		*1.94E-06*
Cerium	Ce^{+4}	4.46E-05	Rubidium	Rb^+		*2.98E-06*
Cesium	Cs^+	*9.97E-06*	Ruthenium	Ru^{+3}		1.18E-04
Chloride	Cl^-	3.00E-02	Samarium	Sm^{+3}		*2.95E-06*
Chromium	Cr^{+3}	3.49E-03	Selenium	Se^{+4}		1.04E-05
Cobalt	Co^{+2}	1.82E-05	Silicon	Si^{+4}	<	2.80E-04
Copper	Cu^{+2}	6.57E-04	Silver	Ag^+		4.43E-06
Curium	Cm^{+4}	*5.11E-11*	Sodium	Na^+		1.98E+00
Dysprosium	Dy^{+3}	*3.38E-10*	Strontium	Sr^{+2}		1.12E-04
Erbium	Er^{+3}	*5.58E-12*	Sulfate	SO_4^{-2}		5.17E-02
Europium	Eu^{+3}	*2.72E-07*	Sulfur	S^{+6}		6.59E-02
Fluoride	F^-	4.24E-02	Technetium	Tc^{+7}		*3.16E-06*
Francium	Fr^+	*3.45E-23*	Tellurium	Te^{+4}		*1.55E-06*
Gadolinium	Gd^{+3}	1.67E-04	Terbium	Tb^{+4}		*1.14E-09*
Gallium	Ga^{+3}	*1.01E-14*	Thallium	Tl^{+3}		*1.05E-20*
Germanium	Ge^{+4}	*4.73E-09*	Thorium	Th^{+4}		*1.06E-10*
Holmium	Ho^{+3}	*1.41E-11*	Thulium	Tm^{+3}		*2.64E-15*
Indium	In^{+3}	*7.34E-08*	Tin	Sn^{+4}		*6.33E-08*
Iodine	I^-	*1.36E-06*	Titanium	Ti^{+4}		5.45E-05
Iron	Fe^{+3}	1.87E-02	Uranium	U^{+4}		3.39E-04
Lanthanum	La^{+3}	*4.94E-06*	Vanadium	V^{+5}	<	8.60E-06
Lead	Pb^{+2}	1.32E-03	Ytterbium	Yb^{+3}		4.93E-16
Lithium	Li^+	3.68E-04	Yttrium	Y^{+3}		*3.68E-06*
Magnesium	Mg^{+2}	1.13E-02	Zinc	Zn^{+2}		*9.90E-04*
Manganese	Mn^{+4}	1.33E-02	Zirconium	Zr^{+4}		5.97E-05

Table 2. (continued).

Radionuclides	Ci/liter	Radionuclides	Ci/liter	Radionuclides	Ci/liter
Tl-207	*2.00E-11*	U-233	*4.15E-11*	Ru-106	*4.83E-07*
Tl-208	*5.99E-10*	U-234	1.07E-06	Rh-102	*4.47E-10*
Tl-209	*2.13E-15*	U-235	3.95E-08	Rh-106	*4.83E-07*
Pb-209	*9.86E-14*	U-236	5.84E-08	Pd-107	*8.57E-09*
Pb-210	*1.43E-12*	U-237	*3.34E-09*	Ag-108m	*2.21E-13*
Pb-211	*2.01E-11*	U-238	2.34E-08	Ag-108	*1.97E-14*
Pb-212	*1.67E-09*	U-240	*3.51E-16*	Ag-109m	*6.62E-17*
Pb-214	*4.25E-12*	Np-235	NA	Ag-110m	*1.28E-14*
Bi-210m	*1.14E-25*	Np-236	*1.59E-12*	Ag-110	*1.70E-16*
Bi-210	*1.44E-12*	Np-237	1.22E-06	Cd-109	*6.62E-17*
Bi-211	*2.01E-11*	Np-238	*3.95E-11*	Cd-113m	*1.72E-06*
Bi-212	*1.67E-09*	Np-239	*1.11E-08*	In-115	*5.23E-17*
Bi-213	*9.86E-14*	Np-240m	*3.51E-16*	Sn-119m	*2.60E-15*
Bi-214	*4.25E-12*	Pu-236	*1.42E-09*	Sn-121m	*3.47E-08*
Po-210	*1.37E-12*	Pu-238	5.71E-04	Sn-126	*2.13E-07*
Po-211	*5.62E-14*	Pu-239	8.27E-05	Sb-125	*6.70E-06*
Po-212	*1.07E-09*	Pu-240	*5.26E-06*	Sb-126m	*2.13E-07*
Po-213	*9.65E-14*	Pu-241	*1.36E-04*	Sb-126	*2.99E-08*
Po-214	*4.25E-12*	Pu-242	*4.10E-09*	Te-123	*1.99E-19*
Po-215	*2.01E-11*	Pu-243	*1.13E-17*	Te-125m	*1.63E-06*
Po-216	*1.67E-09*	Pu-244	*3.52E-16*	I-129	2.39E-08
Po-218	*4.25E-12*	Am-241	7.07E-05	Cs-134	5.36E-06
At-217	*9.86E-14*	Am-242m	*7.89E-09*	Cs-135	*4.46E-07*
Rn-219	*2.01E-11*	Am-242	*7.86E-09*	Cs-137	2.62E-02
Rn-220	*1.67E-09*	Am-243	*1.11E-08*	Ba-137m	*2.48E-02*
Rn-222	*4.25E-12*	Cm-242	*6.51E-09*	La-138	*9.91E-17*
Fr-221	*9.86E-14*	Cm-243	*1.47E-08*	Ce-142	*1.55E-11*
Fr-223	*2.76E-13*	Cm-244	*9.15E-07*	Ce-144	*3.25E-07*
Ra-223	*2.01E-11*	Cm-245	*1.55E-10*	Pr-144m	*3.90E-09*
Ra-224	*1.67E-09*	Cm-246	*1.02E-11*	Pr-144	*3.25E-07*
Ra-225	*9.86E-14*	Cm-247	*1.13E-17*	Nd-144	*8.34E-16*
Ra-226	*4.25E-12*	Cm-248	*1.20E-17*	Pm-146	*2.64E-08*
Ra-228	*2.77E-16*	Cf-249	*8.97E-18*	Pm-147	*8.84E-05*
Ac-225	*9.86E-14*	Cf-250	*7.33E-18*	Sm-146	*1.43E-13*
Ac-227	*2.00E-11*	Cf-251	*1.41E-19*	Sm-147	*3.82E-12*
Ac-228	*2.77E-16*			Sm-148	*1.96E-17*
Th-227	*1.98E-11*	H-3	1.82E-05	Sm-149	*1.74E-18*
Th-228	*1.66E-09*	Be-10	*1.56E-12*	Sm-151	*1.74E-04*
Th-229	*9.86E-14*	C-14	*6.23E-11*	Eu-150	*7.46E-12*
Th-230	*4.27E-10*	Se-79	*2.27E-07*	Eu-152	*1.31E-06*
Th-231	*1.09E-08*	Rb-87	*1.52E-11*	Eu-154	4.64E-05
Th-232	*3.68E-16*	Sr-90	2.03E-02	Eu-155	*8.52E-05*
Th-234	*1.07E-08*	Y-90	*2.03E-02*	Gd-152	*7.38E-19*
Pa-231	*4.64E-11*	Zr-93	*1.15E-06*	Gd-153	*3.85E-16*
Pa-233	*1.52E-06*	Nb-93m	*8.86E-07*	Ho-166m	*2.39E-11*
Pa-234m	*1.07E-08*	Nb-94	*5.91E-07*	Tm-171	*2.61E-16*
Pa-234	*1.40E-11*	Tc-98	*1.34E-12*	Co-60	4.14E-06
U-232	*1.03E-09*	Tc-99	9.38E-06	Ni-63	2.46E-05

2.2 WM-188 Liquid Composition

Table 3 shows four compositions for the chemical species in Tank WM-188 waste.

1. An estimated composition of waste presently in the tank.
2. A projected composition after filling for the calcination/MACT or steam reforming alternative.
3. A projected composition after filling for the Direct Evaporation treatment alternative.
4. A projected composition after filling for the CsIX treatment alternative.

Table 3. WM-188 composition.

	2003	Future Composition		
	Composition	CMACT	DE	CsIX
	WM-188	WM-188a	WM-188b	WM-188c
Volume, gallons	211,100	285,000	285,000	285,000
SG	1.32	1.32	1.32	1.32
TOC, g/l	0.44	1.08	1.03	0.85
UDS, g/l	1.04	0.70	0.69	0.45
Heel solids, g/l	6.3	4.6	4.6	4.6
	mol/liter	mol/liter	mol/liter	mol/liter
H^{+}	2.83E+00	2.61E+00	2.62E+00	2.84E+00
Al^{+3}	7.38E-01	5.79E-01	5.81E-01	5.58E-01
Am^{+4}	9.17E-08	6.81E-08	6.81E-08	6.81E-08
Sb^{+5}	5.28E-06	6.05E-06	6.05E-06	4.80E-06
As^{+5}	5.62E-06	1.27E-05	1.33E-05	5.62E-06
Ba^{+2}	8.52E-05	6.85E-05	6.86E-05	6.52E-05
Be^{+2}	2.00E-05	1.53E-05	1.52E-05	1.50E-05
B^{+3}	2.33E-02	1.82E-02	1.82E-02	1.75E-02
Br^{-}	4.79E-07	3.56E-07	3.56E-07	3.56E-07
Cd^{+2}	3.40E-03	2.69E-03	2.70E-03	2.54E-03
Ca^{+2}	7.04E-02	5.50E-02	5.51E-02	5.37E-02
Ce^{+4}	3.73E-05	2.77E-05	2.77E-05	2.77E-05
Cs^{+}	3.91E-05	2.90E-05	2.90E-05	2.90E-05
Cl^{-}	3.47E-02	2.75E-02	2.76E-02	2.66E-02
Cr^{+3}	5.83E-03	4.93E-03	4.89E-03	4.74E-03
Co^{+2}	5.41E-05	4.36E-05	4.39E-05	7.30E-05
Cu^{+2}	8.62E-04	6.78E-04	6.80E-04	6.50E-04
Eu^{+3}	7.95E-07	5.90E-07	5.90E-07	5.90E-07
F^{-}	1.92E-02	1.99E-02	2.00E-02	1.75E-02
Gd^{+3}	2.07E-04	1.54E-04	1.54E-04	1.54E-04
Ge^{+4}	1.38E-08	1.03E-08	1.03E-08	1.03E-08

Table 3. (continued.)

	2003	CMACT	DE	CsIX
	mol/liter	mol/liter	mol/liter	mol/liter
In^{+3}	2.14E-07	1.83E-06	1.83E-06	1.83E-06
I^{-}	3.98E-06	2.96E-06	2.96E-06	2.96E-06
Fe^{+3}	2.74E-02	2.15E-02	2.15E-02	2.11E-02
La^{+3}	1.44E-05	1.07E-05	1.07E-05	1.07E-05
Pb^{+2}	1.09E-03	8.87E-04	8.94E-04	9.81E-04
Li^{+}	3.93E-04	2.91E-04	2.91E-04	2.91E-04
Mg^{+2}	2.77E-02	2.06E-02	2.06E-02	2.06E-02
Mn^{+4}	1.82E-02	1.71E-02	1.69E-02	1.55E-02
Hg^{+2}	7.73E-03	6.18E-03	6.22E-03	6.04E-03
Mo^{+6}	3.00E-04	2.23E-04	2.23E-04	2.23E-04
Nd^{+3}	4.66E-05	3.46E-05	3.46E-05	3.46E-05
Np^{+4}	2.66E-05	2.64E-06	2.64E-06	2.64E-06
Ni^{+2}	2.42E-03	1.92E-03	1.93E-03	1.84E-03
Nb^{+5}	3.32E-05	2.46E-05	2.46E-05	2.46E-05
NO_3^-	7.29E+00	6.42E+00	6.42E+00	6.57E+00
Pd^{+4}	4.26E-04	3.15E-04	3.15E-04	3.15E-04
PO_4^{-3}	9.07E-05	3.99E-04	3.99E-04	3.99E-04
Pu^{+4}	5.92E-06	4.66E-06	4.66E-06	4.66E-06
K^{+}	1.93E-01	2.09E-01	2.05E-01	3.49E-01
Pr^{+4}	1.31E-05	9.75E-06	9.75E-06	9.75E-06
Rh^{+4}	5.66E-06	4.21E-06	4.21E-06	4.21E-06
Rb^{+}	8.72E-06	6.47E-06	6.47E-06	6.47E-06
Ru^{+3}	1.91E-04	1.42E-04	1.42E-04	1.42E-04
Sm^{+3}	8.63E-06	6.41E-06	6.41E-06	6.41E-06
Se^{+4}	4.80E-06	5.90E-06	6.03E-06	4.22E-06
Si^{+4}	7.98E-04	5.95E-04	5.95E-04	5.95E-04
Ag^{+}	4.27E-06	3.99E-06	4.02E-06	3.44E-06
Na^{+}	1.68E+00	1.58E+00	1.56E+00	1.43E+00
Sr^{+2}	1.09E-04	8.04E-05	8.04E-05	8.04E-05
SO_4^{-2}	3.63E-02	2.99E-02	3.00E-02	2.79E-02
Tc^{+7}	9.24E-06	1.33E-05	1.33E-05	1.33E-05
Te^{+4}	5.12E-06	3.80E-06	3.80E-06	3.80E-06
Tb^{+4}	3.32E-09	2.47E-09	2.47E-09	2.47E-09
Th^{+4}	3.69E-05	2.74E-05	2.74E-05	2.74E-05
Sn^{+4}	5.30E-05	3.93E-05	3.93E-05	3.93E-05
Ti^{+4}	7.04E-05	5.23E-05	5.23E-05	5.23E-05
U^{+4}	4.13E-04	3.50E-04	3.50E-04	3.50E-04
V^{+5}	2.61E-05	3.39E-05	3.50E-05	2.19E-05
Y^{+3}	1.08E-05	7.99E-06	7.99E-06	7.99E-06
Zn^{+2}	1.05E-03	8.65E-04	8.67E-04	8.07E-04
Zr^{+4}	3.39E-03	2.89E-03	2.93E-03	2.54E-03
H2O	4.38E+01	4.73E+01	4.73E+01	4.67E+01

Table 3. (continued.)

	Present Composition	Future Composition		Present Composition	Future Composition
	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)		Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)
Ra-226	1.24E-11	1.05E-11	Zr-93	3.36E-06	2.83E-06
Ac-227	5.85E-11	4.93E-11	Nb-93m	2.59E-06	2.18E-06
Th-228	4.86E-09	4.09E-09	Nb-94	1.73E-06	1.46E-06
Th-230	1.25E-09	1.05E-09	Tc-98	3.91E-12	3.29E-12
Th-232	1.07E-15	9.05E-16	Tc-99	2.66E-05	2.24E-05
Pa-231	1.36E-10	1.14E-10	Ru-106	1.41E-06	1.19E-06
Pa-233	4.45E-06	3.74E-06	Rh-102	1.31E-09	1.10E-09
U-232	3.02E-09	2.54E-09	Pd-107	2.51E-08	2.11E-08
U-233	1.21E-10	1.02E-10	Cd-113m	5.04E-06	4.24E-06
U-234	1.32E-06	1.11E-06	In-115	1.53E-16	1.29E-16
U-235	1.13E-07	9.49E-08	Sn-121m	1.01E-07	8.54E-08
U-236	5.06E-08	4.26E-08	Sn-126	6.23E-07	5.25E-07
U-237	9.76E-09	8.22E-09	Sb-125	1.96E-05	1.65E-05
U-238	1.49E-08	1.28E-08	Sb-126	8.72E-08	7.34E-08
Np-236	4.66E-12	3.92E-12	Te-123	5.81E-19	4.89E-19
Np-237	5.15E-07	4.41E-07	Te-125m	4.78E-06	4.02E-06
Pu-236	4.15E-09	3.50E-09	I-129	8.09E-08	6.81E-08
Pu-238	6.36E-04	5.36E-04	Cs-134	4.41E-06	3.88E-06
Pu-239	7.53E-05	6.34E-05	Cs-135	1.30E-06	1.10E-06
Pu-240	1.54E-05	1.29E-05	Cs-137	7.40E-03	6.39E-03
Pu-241	3.98E-04	3.36E-04	Ba-137m	7.00E-03	6.04E-03
Pu-242	1.20E-08	1.01E-08	La-138	2.90E-16	2.44E-16
Pu-244	1.03E-15	8.65E-16	Ce-142	4.53E-11	3.82E-11
Am-241	6.44E-05	5.58E-05	Ce-144	9.51E-07	8.00E-07
Am-242m	2.31E-08	2.00E-08	Nd-144	2.44E-15	2.05E-15
Am-243	3.25E-08	2.82E-08	Pm-146	7.72E-08	6.50E-08
Cm-242	5.23E-08	4.40E-08	Pm-147	2.58E-04	2.17E-04
Cm-243	4.31E-08	3.63E-08	Sm-146	4.18E-13	3.52E-13
Cm-244	1.15E-06	9.72E-07	Sm-147	1.12E-11	9.41E-12
Cm-245	4.53E-10	3.81E-10	Sm-148	5.74E-17	4.83E-17
Cm-246	2.98E-11	2.51E-11	Sm-149	5.10E-18	4.29E-18
			Sm-151	5.09E-04	4.29E-04
H-3	1.73E-05	1.46E-05	Eu-150	3.82E-06	3.21E-06
Be-10	4.55E-12	3.83E-12	Eu-154	2.46E-05	2.12E-05
C-14	1.82E-10	1.53E-10	Eu-155	5.57E-06	4.89E-05
Se-79	6.63E-07	5.58E-07	Gd-152	2.16E-18	1.82E-18
Rb-87	4.45E-11	3.74E-11	Ho-166m	6.98E-11	5.88E-11
Sr-90	5.73E-02	4.83E-02	Co-60	5.03E-06	4.34E-06
Y-90	5.73E-02	4.83E-02	Ni-63	4.80E-05	4.04E-05

Since radionuclide concentrations in NGLW, after concentration, are assumed equal to those in SBW, Table 3 shows only two sets of radionuclide concentrations – the present composition and the future composition.

The INTEC Tank Farm Facility Management Plan (Reference 16, PLN-1112) indicates four High Level Liquid Waste Evaporator (HLLWE) campaigns in the period 2003-2005 that will fill Tank WM-188 by late 2005. Each of these campaigns will concentrate waste from Tank WM-187. Volumes of HLLWE concentrate shown in PLN-1112 were calculated using assumed concentration factors. To predict the composition of the evaporator concentrates, the process simulation program ASPEN Plus was used to model each evaporator campaign. Table 4 shows the predicted volumes using ASPEN as well as the estimates from PLN-1112.

New waste generated during this period (called "SBW" until 2005, "NGLW" after 2005) was excluded from the process simulations (and the volumes shown in the HLLWE concentrates below) because the composition of the generated waste will vary depending on the treatment alternative and depending on how the evaporators are operated. Section 2.4 discusses these variations of NGLW composition.

Table 4. Sources of waste projected to be in Tank WM-188.

	PLN-1112 gallons	Evap Simulation gallons
Volume 10/31/2002	211,100	211,100
HLLWE Campaign		
#1, 2003	24,341	13,921
#2, 2003-4	9,656	10,687
#3, 2004	12,392	7,466
#4, 2005	15,388	10,762
Subtotal	272,877	253,936
SBW Generated through 2005	11,783	31,064
Volume August, 2005	284,660	285,000

The first HLLWE campaign, in 2003, will evaporate waste from WM-187 that primarily consists of flush waters from WM-182 and WM-183. Following this campaign, Tank WM-187 will receive flush waters from WM-184 and WM-186, and this will be sent to the HLLWE in 2004. The third HLLWE campaign will evaporate waste collected in WM-187 in 2004 or 2005, primarily the flush water from cleaning Tank WM-185, along with the cut heels (see glossary) removed from WM-182, WM-183, WM-184 and WM-186 during closure activities. The fourth HLLWE campaign will evaporate flush waters collected in WM-187 from WM-181, possibly WM-103, WM-104, WM-105, and WM-106, and cut heel from WM-185 and WM-181.

2.3 WM-189 Liquid Composition

Table 5 shows the composition of waste in WM-189. Tank WM-189 is presently near its administrative capacity limit, and no additions to the tank or changes to the composition are expected in the future. Estimates are shown in italics.

Table 5. WM-189 composition.

Gallons	280,100		mol/liter		Ci/liter		Ci/liter		Ci/liter
SG	1.317	Np^{+4}	*1.74E-05*	Pb-211	*3.84E-11*	U-236	7.81E-08	Rh-106	*9.24E-07*
		Ni^{+2}	2.32E-03	Pb-212	*3.19E-09*	U-237	*6.39E-09*	Pd-107	*1.64E-08*
	mol/liter	Nb^{+5}	*6.52E-08*	Pb-214	*8.14E-12*	U-238	4.35E-08	Ag-108m	*4.24E-13*
H+	2.90	NO_3^-	6.52E+00	Bi-210m	*2.19E-25*	U-240	*6.72E-16*	Ag-108	*3.77E-14*
Ac^{+2}	*2.33E-15*	Pd^{+4}	*3.61E-06*	Bi-210	*2.75E-12*	Np-236	*3.05E-12*	Ag-109m	*1.27E-16*
Al^{+3}	7.12E-01	PO_4^{-3}	< 3.05E-04	Bi-211	*3.84E-11*	Np-237	4.59E-07	Ag-110m	*2.44E-14*
Am^{+4}	*6.00E-08*	P^{+5}	2.07E-03	Bi-212	*3.19E-09*	Np-238	*7.55E-11*	Ag-110	*3.25E-16*
Sb^{+5}	7.52E-06	Pu^{+4}	*3.88E-06*	Bi-213	*1.89E-13*	Np-239	*2.13E-08*	Cd-109	*1.27E-16*
As^{+5}	*2.42E-09*	Po^{+4}	*2.78E-18*	Bi-214	*8.14E-12*	Np-240m	*6.72E-16*	Cd-113m	*3.30E-06*
At^-	*5.58E-28*	K^+	2.25E-01	Po-210	*2.62E-12*	Pu-236	*2.72E-09*	In-115	*1.00E-16*
Ba^{+2}	5.62E-05	Pr^{+4}	*8.60E-06*	Po-211	*1.07E-13*	Pu-238	3.87E-04	Sn-119m	*4.97E-15*
Be^{+2}	2.02E-05	Pm^{+3}	*1.26E-09*	Po-212	*2.05E-09*	Pu-239	4.35E-05	Sn-121m	*6.64E-08*
Bi^{+3}	*8.43E-18*	Pa^{+4}	*8.74E-12*	Po-213	*1.85E-13*	Pu-240	*1.01E-05*	Sn-126	*4.08E-07*
B^{+3}	2.12E-02	Ra^{+2}	*3.65E-14*	Po-214	*8.14E-12*	Pu-241	*3.98E-01*	Sb-125	*1.28E-05*
Br^-	*3.14E-07*	Rh^{+4}	*3.71E-06*	Po-215	*3.84E-11*	Pu-242	*7.85E-09*	Sb-126m	*4.08E-07*
Cd^{+2}	3.91E-03	Rb^+	*5.71E-06*	Po-216	*3.19E-09*	Pu-243	*2.15E-17*	Sb-126	*5.71E-08*
Ca^{+2}	7.31E-02	Ru^{+3}	1.72E-04	Po-218	*8.14E-12*	Pu-244	*6.73E-16*	Te-123	*3.81E-19*
Cf^{+4}	*1.80E-20*	Sm^{+3}	*5.65E-06*	At-217	*1.89E-13*	Am-241	7.34E-05	Te-125m	*3.13E-06*
C^{+4}	*3.64E-06*	Se^{+4}	*8.24E-07*	Rn-219	*3.84E-11*	Am-242m	*1.51E-08*	I-129	*5.30E-08*
Ce^{+4}	3.51E-05	Si^{+4}	3.08E-04	Rn-220	*3.19E-09*	Am-242	*1.50E-08*	Cs-134	4.03E-05
Cs^+	2.68E-05	Ag^+	*6.54E-08*	Rn-222	*8.14E-12*	Am-243	*2.13E-08*	Cs-135	*8.54E-07*
Cl^-	2.06E-02	Na^+	2.04E+00	Fr-221	*1.89E-13*	Cm-242	2.98E-08	Cs-137	5.01E-02
Cr^{+3}	5.64E-03	Sr^{+2}	1.42E-04	Fr-223	*5.29E-13*	Cm-243	*2.82E-08*	Ba-137m	*4.74E-02*
Co^{+2}	4.63E-05	SO_4^{-2}	1.07E-01	Ra-223	*3.84E-11*	Cm-244	1.05E-06	La-138	*1.90E-16*
Cu^{+2}	9.54E-04	S^{+6}	8.58E-02	Ra-224	*3.19E-09*	Cm-245	*2.96E-10*	Ce-142	*2.97E-11*
Cm^{+4}	*9.78E-11*	Tc^{+7}	*6.05E-06*	Ra-225	*1.89E-13*	Cm-246	*1.95E-11*	Ce-144	*6.23E-07*
Dy^{+3}	*6.46E-10*	Te^{+4}	7.26E-06	Ra-226	*8.14E-12*	Cm-247	*2.15E-17*	Pr-144m	*7.47E-09*
Er^{+3}	*1.07E-11*	Tb^{+4}	*2.18E-09*	Ra-228	*5.31E-16*	Cm-248	*2.30E-17*	Pr-144	*6.23E-07*
Eu^{+3}	*5.20E-07*	Tl^{+3}	*2.00E-20*	Ac-225	*1.89E-13*	Cf-249	*1.72E-17*	Nd-144	*1.60E-15*
F^-	1.37E-02	Th^{+4}	3.50E-05	Ac-227	*3.83E-11*	Cf-250	*1.40E-17*	Pm-146	*5.05E-08*
Fr^+	*6.60E-23*	Tm^{+3}	5.05E-15	Ac-228	*5.31E-16*	Cf-251	*2.70E-19*	Pm-147	*1.69E-04*
Gd^{+3}	1.35E-04	Sn^{+4}	4.14E-05	Th-227	*3.79E-11*		Ci/liter	Sm-146	*2.74E-13*
Ga^{+3}	*1.94E-14*	Ti^{+4}	7.29E-05	Th-228	*3.18E-09*	H-3	9.66E-06	Sm-147	*7.32E-12*
Ge^{+4}	*9.05E-09*	U^{+4}	5.08E-04	Th-229	*1.89E-13*	Be-10	*2.98E-12*	Sm-148	*3.76E-17*
Ho^{+3}	*2.71E-11*	V^{+5}	2.51E-05	Th-230	*8.17E-10*	C-14	*1.19E-10*	Sm-149	*3.34E-18*
In^{+3}	*1.40E-07*	Yb^{+3}	*9.44E-16*	Th-231	*2.08E-08*	Se-79	*4.34E-07*	Sm-151	*3.33E-04*
I^-	*2.61E-06*	Y^{+3}	*7.05E-06*	Th-232	*7.04E-16*	Rb-87	*2.91E-11*	Eu-150	*1.43E-11*
Fe^{+3}	2.69E-02	Zn^{+2}	1.07E-03	Th-234	*2.06E-08*	Sr-90	3.88E-02	Eu-152	*2.50E-06*
La^{+3}	*9.45E-06*	Zr^{+4}	3.56E-04	Pa-231	*8.88E-11*	Y-90	*5.11E-02*	Eu-154	1.84E-04
Pb^{+2}	1.16E-03		Ci/liter	Pa-233	*2.91E-06*	Zr-93	*2.20E-06*	Eu-155	*1.63E-04*
Li^+	3.83E-04		(Jan, 2003)	Pa-234m	*2.06E-08*	Nb-93m	*1.70E-06*	Gd-152	*1.41E-18*
Mg^{+2}	2.21E-02	Tl-207	*3.83E-11*	Pa-234	*2.67E-11*	Nb-94	*1.13E-06*	Gd-153	*7.38E-16*
Mn^{+4}	1.95E-02	Tl-208	*1.15E-09*	U-232	*1.97E-09*	Tc-98	*2.56E-12*	Ho-166m	*4.57E-11*
Hg^{+2}	6.48E-03	Tl-209	*4.07E-15*	U-233	*7.94E-11*	Tc-99	*9.96E-06*	Tm-171	*4.99E-16*
Mo^{+6}	2.80E-04	Pb-209	*1.89E-13*	U-234	1.74E-06	Ru-106	*9.24E-07*	Co-60	*3.62E-05*
Nd^{+3}	*3.05E-05*	Pb-210	*2.74E-12*	U-235	6.01E-08	Rh-102	*8.56E-10*	Ni-63	*3.14E-05*

2.4 Liquid Waste Generation

The Tank Farm Management Plan (PLN-1112, Reference 16) contains projected volumes of new wastes that are expected to be generated in the future at INTEC or that could be sent to INTEC for treatment. In addition to the wastes listed in PLN-1112, a few additional wastes will be generated by a specific treatment alternative, either prior to operations or during operations. The chemical compositions of these wastes were estimated as follows:

1. The 30 expected waste streams were divided into two groups–those that made significant contributions to the total and those that did not. A significant waste stream was defined as a stream contributing more than 1% to the total volume after concentration by evaporation.

2. A composition for each significant waste stream was obtained either from analyses or by estimation.

3. A set of waste streams and corresponding volumes was defined for each of two time periods (2003 through 2005 and 2006 through 2011) and each of the four treatment alternatives. These eight sets of waste streams were reduced to four unique sets.

4. For each unique set, a combined dilute waste composition was calculated based on projected dilute generation volumes and compositions.

5. Evaporation of the dilute wastes was simulated using ASPEN Plus. An endpoint of 1.3 specific gravity (SG) for the concentrate was specified in each evaporation simulation. Simulations were made with and without water dilution, in order to evaluate the benefits of removing additional acid from the dilute wastes by adding water during evaporation.

6. An estimated concentrated volume was calculated for streams that contribute less than 1% to the total generated waste volume by dividing the total dilute volume of these streams by 2000. The concentration factor of 2000 was the same as assumed in PLN-1112. The concentrated composition of these streams was assumed the same as that of the wastes obtained in Step 5.

7. A single composition was calculated for each set of waste streams by adding the concentrate, as predicted by the evaporator simulation, to compositions/volumes of NWCF Turnaround, NWCF Bed Dissolution and NWCF Adsorber Wash wastes.

8. Simulation of evaporation of the waste of the composition obtained in step 7 was performed again using ASPEN Plus to obtain a concentrate with a specific gravity of 1.3 for each of the 4 sets of waste streams.

9. The remainder of the waste streams (streams that are not evaporated) were added to the concentrated waste obtained in step 8 to obtain a single combined generated waste composition for each of the four sets. Because treatment alternatives may or may not recycle bottoms from the Liquid Effluent Treatment and Disposal (LET&D) facility, compositions were calculated both with and without the LET&D bottoms.

Concentrations of radionuclides in generated wastes were assumed the same as SBW. As discussed in Revision 1 of this report,[25] radionuclide analyses are available for only 9 to 22 vol % of the waste generated in a given year. Applying the limited amount of radionuclide concentration data to the total generated waste could introduce significant errors, because (1) radionuclide concentrations are unknown for ~80-90% of the total concentrated waste, (2) the wastes streams are generated from different processes and sources and hence not expected to be similar, and (3) many of the waste streams are very dilute as generated and analytical errors would be multiplied for the concentrated waste, by factors as high as 2000 for some of the waste streams.

2.4.1 Significant Waste Streams

Table 6 identifies the relative importance of the different waste streams. The values shown in Table 6 were calculated by:

- Summing annual generation rates for each stream over the period 2003 through 2011
- Including additional wastes generated by a specific treatment process
- Estimating the volume of concentrated waste for each waste stream by using the concentration factors assumed in PLN-1112
- Summing the concentrated waste volumes and ranking the streams by concentrated volume.

Table 6. Breakdown of 2003-2011 wastes by stream.

Rank	Percent of Total Concentrated Volume	Cumulative Percent	Stream Name	Basis for Composition
1	15.94%	15.94%	LET&D Bottoms	Nenni, 2002
2	15.54%	31.48%	Tank Farm Line Flushes	Estimated
3	13.95%	45.43%	NWCF Bed Dissolution	Estimated
4	13.33%	58.76%	Filter Leach	Nenni, 2002
5	12.95%	71.71%	NWCF Decon Facility	Tripp, 1998
6	6.38%	78.08%	NWCF Ops-Adsorber Washes	Nenni, 2002
7	5.98%	84.06%	NWCF Turnaround Conc.	Estimated
8	3.19%	87.25%	PEW Descale	Tripp, 1998
9	2.28%	89.52%	CPP-601 (Lab Drains)	Nenni, 2002
10	1.99%	91.52%	NWCF Ops-Deep Recycle	Nenni, 2002
11	1.79%	93.31%	CPP-601/627/640 Deactivation	Tripp, 1998
12	1.72%	95.03%	Vault Flush	Estimated
13	1.00%	96.03%	NWCF cell decon	
14	0.80%	96.82%	TRA-689 Decon Solution	
15	0.80%	97.62%	Misc. Balance of Plant	
16	0.70%	98.32%	NWCF Turnaround Dilute	
17	0.60%	98.92%	CPP-603 Basin Water	
18	0.30%	99.21%	TAN Pool Water	
19	0.24%	99.45%	Misc. Deactivation Rinses	
20	0.15%	99.60%	LET&D	
21	0.14%	99.74%	FAST Operations	
22	0.11%	99.85%	Tank Farm Sumps	
23	0.05%	99.90%	MTR Canal Water	
24	0.03%	99.92%	CsIX Dilute Aqueous Waste	
25	0.04%	99.96%	CPP-604 Sumps	
26	0.01%	99.96%	NWCF Utility Tunnel	
27	0.01%	99.98%	CPP-603 Operations	
28	0.01%	99.99%	PBF Canal	
29	0.01%	99.998%	PBF D&D	
30	0.00%	100.00%	TAN V-Tank	

Table 6 shows that 12 streams account for 95% of the total waste after concentration. Only the compositions of these 12 streams were used to estimate the combined generated waste composition.

2.4.2 Compositions of Individual Waste Streams

Compositions of individual waste streams are presented in this section.

2.4.2.1 LET&D Bottoms. Table 7 shows the estimated composition of bottoms from the LET&D facility..

Table 7. Estimated LET&D bottoms composition.

	Mol/liter	
H+	1.21E+01	
Al^{+3}	5.61E-02	
Sb^{+5}	6.92E-07	1
As^{+5}	1.62E-06	1
Ba^{+2}	9.77E-07	
Be^{+2}	8.65E-07	
B^{+3}	2.10E-04	2
Cd^{+2}	1.89E-07	1
Ca^{+2}	7.44E-04	2
Cl^{-}	6.57E-03	2
Cr^{+3}	1.70E-03	
Co^{+2}	1.75E-04	
Cu^{+2}	8.54E-05	
F^{-}	7.16E-03	1
Fe^{+3}	2.92E-04	2
Pb^{+2}	4.62E-07	1
Mn^{+4}	5.83E-05	
Hg^{+2}	2.34E-04	
Ni^{+2}	1.94E-03	
NO_3^{-}	1.23E+01	3
P^{+5}	7.49E-05	2
K^{+}	2.51E-03	2
Se^{+4}	1.27E-06	1
Ag^{+}	1.91E-07	1
Na^{+}	2.40E-02	2
S^{+6}	1.09E-03	2
Tl^{+3}	5.75E-07	1
U^{+4}	5.68E-07	1
V^{+5}	1.67E-06	
Zn^{+2}	1.50E-05	
Zr^{+4}	2.91E-06	2
	g/liter	
UDS	2.22E-02	
TIC	4.47E-02	
TOC	1.41E-02	

1. Gray shading indicates data contains flags, typically below detection limits or detected in blank

2. Red shading indicates value was estimated based on concentrations of other known species and the concentration of the unknown species in SBW

3. Blue shading indicates that value was obtained by charge balance

No shading indicates the average of analytical data for three samples. Data points with qualifying flags were excluded from the averages.

Estimates of species that were not analyzed were obtained by multiplying the ratio of the concentration of a given species in SBW by the average ratio of a representative species in the LET&D bottoms to the concentration of these same species in SBW. To estimate the concentration of chloride, the fluoride ratio was used. The other estimated species are all nonvolatile and the average ratio for barium, manganese, and zinc was used to estimate the nonvolatile species.

Samples of LET&D bottoms were taken from the LET&D bottoms tank, WLL-195, and were taken in 1999 and 2000. Analyses of these samples are reported in Reference 13.

2.4.2.2 Tank Farm Line Flushes. The composition of Tank Farm line flushes was assumed equal to the average SBW composition, as shown in Reference 26.

2.4.2.3 NWCF Bed Dissolution. The NWCF bed dissolution composition shown in Table 8 was calculated based on the following assumptions.

- Dissolution of calcine with 10 volumes of 6 molar nitric acid per volume of calcine
- Calcine composition as shown in the mass balance for the calcination with MACT Upgrade alternative in Reference 23
- 96% calcine dissolution, the remainder of calcine present in the waste as undissolved solids.

Table 8. NWCF bed dissolution composition.

	Mol/liter		Mol/liter
H+	4.95E+00	Ni^{+2}	1.07E-04
Al^{+3}	1.50E-01	NO_3^-	5.47E+00
Sb^{+5}	9.68E-07	P^{+5}	1.38E-03
As^{+5}	8.79E-06	K^+	5.22E-03
Ba^{+2}	2.80E-05	Se^{+4}	8.80E-06
Be^{+2}	1.85E-07	Ag^+	1.21E-06
B^{+3}	5.80E-04	Na^+	4.74E-02
Cd^{+2}	1.44E-04	S^{+6}	1.75E-03
Ca^{+2}	3.97E-03	Tl^{+3}	2.10E-06
Cl^-	5.97E-04	U^{+4}	1.27E-05
Cr^{+3}	1.60E-04	V^{+5}	5.50E-06
Co^{+2}	2.81E-06	Zn^{+2}	4.47E-05
Cu^{+2}	2.78E-05	Zr^{+4}	9.69E-04
F^-	2.84E-03	Ni^{+2}	1.07E-04
Fe^{+3}	8.20E-04		g/liter
Pb^{+2}	6.79E-05	UDS	4.36
Mn^{+4}	2.34E-04	TIC	0
Hg^{+2}	5.71E-06	TOC	0

2.4.2.4 Filter Leach. The filter leach composition, shown in Table 9, is based on the analyses of five samples from NWCF Decontamination Tanks NCD-123 and NCD-129 taken in 1999 and 2001. The data for these samples is compiled in Reference 13. Concentrations shown in Table 9 are averages of data and estimates for species not analyzed. The ratio of concentration of a species in the filter leach waste to the concentration of the same species in SBW, averaged for all species measured in filter leach samples, was used to estimate concentrations of non-analyzed species.

Table 9. Estimated filter leach composition.

	Mol/liter	
H^+	5.45E-01	
Al^{+3}	1.83E-03	
Sb^{+5}	5.54E-06	
As^{+5}	1.49E-06	1
Ba^{+2}	8.49E-06	
Be^{+2}	1.33E-07	1
B^{+3}	6.35E-04	2
Cd^{+2}	1.34E-06	
Ca^{+2}	2.25E-03	2
Cl^-	8.54E-04	2
Cr^{+3}	6.08E-05	
Co^{+2}	3.75E-07	1
Cu^{+2}	1.96E-05	
F^-	2.15E-03	1
Fe^{+3}	8.84E-04	2
Pb^{+2}	8.45E-06	
Mn^{+4}	2.11E-04	
Hg^{+2}	4.13E-06	
Ni^{+2}	2.86E-05	
NO_3^-	6.57E-01	3
P^{+5}	2.26E-04	2
K^+	7.60E-03	2
Se^{+4}	1.33E-06	1
Ag^+	7.12E-07	1
Na^+	7.26E-02	2
S^{+6}	3.31E-03	2
Tl^{+3}	5.79E-07	1
U^{+4}	1.16E-06	1
V^{+5}	8.42E-07	1
Zn^{+2}	1.38E-04	
Zr^{+4}	8.79E-06	2
	g/liter	
UDS	1.50E-02	
TIC	5.88E-02	
TOC	7.03E-01	

1. Gray shading indicates data contains flags, typically below detection limits or detected in blank

2. Red shading indicates value was estimated based on concentrations of other known species and the concentration of the unknown species in SBW

3. Blue shading indicates that value was obtained by charge balance

No shading indicates the average of analytical data for five samples. Data points with qualifying flags were excluded from the averages.

2.4.2.5 *NWCF Decon Facility.*

Compositional data from 1997 for the NWCF Decon Facility Waste is contained in Reference 14. The data includes low, average and high concentration values for six chemical species plus TIC, TOC and UDS. Averages were based on from 6 to 20 data points depending on the specie. Table 10 shows these averages plus estimates for other species. Estimates were based either on the SBW or the PEWE descale composition. Estimates based on SBW were calculated by multiplying the SBW concentration for that specie by the average ratio of decon facility Al and U concentration to SBW Al and U concentration. Since the makeup NWCF Decon solution uses the same chemicals as the PEWE descale (see Section 2.4.2.8), concentrations of the major metal species in the chemicals (Na, K, Cr, and Mn) were assumed the same for the NWCF Decon Facility waste as for the PEWE Descale waste. Table 10 shows the estimated composition of the NWCF Decon Facility waste.

Table 10. Estimated NWCF Decon Facility composition.

	Mol/liter	
H^+	7.41E-01	
Al^{+3}	1.23E-02	
Sb^{+5}	4.29E-07	2
As^{+5}	2.80E-06	2
Ba^{+2}	8.47E-07	2
Be^{+2}	2.36E-07	2
B^{+3}	2.71E-04	2
Cd^{+2}	4.14E-05	2
Ca^{+2}	9.59E-04	2
Cl^-	1.34E-03	
Cr^{+3}	1.16E-03	1
Co^{+2}	5.48E-07	2
Cu^{+2}	1.30E-05	2
F^-	6.21E-03	
Fe^{+3}	3.77E-04	2
Pb^{+2}	1.84E-05	2
Mn^{+4}	6.12E-03	1
Hg^{+2}	2.17E-05	
Ni^{+2}	3.03E-05	2
NO_3^-	1.45E+00	3
P^{+5}	9.65E-05	
K^+	1.17E-01	1
Se^{+4}	8.19E-07	2
Ag^+	2.97E-08	2
Na^+	5.25E-01	1
S^{+6}	9.99E-04	
Tl^{+3}	2.29E-07	2
U^{+4}	5.55E-06	
V^{+5}	5.42E-06	2
Zn^{+2}	1.61E-05	2
Zr^{+4}	3.75E-06	2
	g/liter	
UDS	0.79	
TIC		
TOC	0.67	

1. Green shading indicates estimate based on PEWE descale makeup formulation.

2. Red shading indicates value was estimated based on concentrations of other known species and the concentration of the unknown species in SBW

3. Blue shading indicates that value was obtained by charge balance

No shading indicates the average of analytical data.

2.4.2.6 *NWCF Operations - Adsorber Flushes.* The NWCF adsorbers are typically flushed with 2-4 molar nitric acid. The composition of the adsorber flush was assumed to be related to that of the NWCF Non-Fluoride Hot Sump Tank, NCC-122, as sampled in 1999 and 2000. NCC-122 collects cell waste from cell floor drains, off-gas compressor intercoolers, and other dilute NWCF wastes. A composition for the adsorber waste was estimated by multiplying concentrations of NCC-122 contents by the ratio of expected acid concentration for the adsorber waste (3 molar) to the acid concentration of NCC-122 samples. As for previous wastes, concentrations of some species for which there were no analyses were estimated based on SBW. Table 11 shows the estimated adsorber flush composition.

Table 11. Estimated NWCF operations – adsorber flush composition

	Mol/liter	
H+	3.0	
Al^{+3}	9.68E-02	
Sb^{+5}	1.96E-05	1
As^{+5}	3.27E-05	1
Ba^{+2}	1.38E-05	1
Be^{+2}	2.21E-06	1
B^{+3}	4.22E-03	2
Cd^{+2}	2.49E-05	1
Ca^{+2}	1.49E-02	2
Cl^{-}	5.68E-03	2
Cr^{+3}	4.45E-04	1
Co^{+2}	5.77E-06	1
Cu^{+2}	8.72E-05	1
F^{-}	1.21E-02	1
Fe^{+3}	5.87E-03	2
Pb^{+2}	4.51E-05	
Mn^{+4}	7.18E-04	
Hg^{+2}	9.69E-03	
Ni^{+2}	2.18E-04	
NO_3^{-}	4.02E+00	3
P^{+5}	1.51E-03	2
K^{+}	5.05E-02	2
Se^{+4}	2.54E-05	1
Ag^{+}	5.91E-06	1
Na^{+}	4.82E-01	2
S^{+6}	2.20E-02	2
Tl^{+3}	1.26E-05	1
U^{+4}	7.92E-06	
V^{+5}	1.43E-05	1
Zn^{+2}	5.10E-04	
Zr^{+4}	5.85E-05	2
UDS		
TIC	7.61E-01	1
TOC	7.40E-01	1

1. Gray shading indicates data contains flags, typically below detection limits or detected in blank

2. Red shading indicates value was estimated based on concentrations of other known species and the concentration of the unknown species in SBW

3. Blue shading indicates that value was obtained by charge balance

No shading indicates the average of analytical data for three samples from Tank NCC-119, multiplied by the ratio of 3 divided by the acid molarity of NCC-119 samples.

2.4.2.7 NWCF Turnaround Concentrated Waste. The composition of the NWCF turnaround concentrated waste is assumed to be equal to, after concentrating the volume to one-half the original, the composition of the NWCF bed dissolution waste.

2.4.2.8 PEWE Descale. The PEWE descale waste composition is based on the following make-up formulation given in Reference 14:

- 300 gallons TURCO ARR diluted with water to 2 lb/gal (TURCO ARR assumed to be 70 wt % NaOH, 15 wt % triethanolamine, 5 wt % diethanolamine and 5 wt % kerosene)

- 300 gallons TURCO 4502 diluted with water to 0.5 lb/gal (TURCO 4502 assumed to be 77 wt % KOH, 20 wt % $KMnO_4$, 3 wt % K_2CrO_3)

- 300 gal oxalic acid solution at 0.5 lb oxalic acid per gallon

- 300 gal 6 N HNO_3.

Table 12 lists the composition calculated using the above formulation.

Table 12. PEWE descale composition.

	mol/liter
H^+	1.22E-01
NO_3^-	7.92E-01
K^+	1.17E-01
Mn^{+7}	6.12E-03
Cr^{+6}	1.16E-03
Na^+	5.25E-01
	g/liter
Oxalic acid	7.50
Kerosene	1.50
TEA	4.50
DEA	1.50
TOC	14.99

2.4.2.9 CPP-601 – Lab Drains. Nenni (Reference 13) reports analytical data for sixteen samples from the CPP-601 Deep Tanks, and averages of these data are shown in Table 13. Additional data from earlier samples are available in Reference 14 but were not used. Table 13 also shows the composition range of this waste stream.

Table 13. CPP-601 Deep Tank waste composition.

		Range of concentration Relative to average		
	Mol/liter	Max/Ave	Min/Ave	
H^+	3.57E-01	+96%	-63%	1
Al^{+3}	4.28E-03	+340%	-81%	
Sb^{+5}	3.30E-07	+159%	-90%	1
As^{+5}	2.61E-07	+205%	-80%	1
Ba^{+2}	1.35E-06	+270%	-62%	
Be^{+2}	5.89E-07	+354%	-81%	
B^{+3}	1.15E-04			2
Cd^{+2}	1.54E-06	+323%	-77%	
Ca^{+2}	4.08E-04			2
Cl^-	2.97E-03	+20%	-20%	
Cr^{+3}	1.77E-05	+111%	-53%	
Co^{+2}	1.13E-06	+173%	-47%	
Cu^{+2}	1.11E-05	+60%	-59%	
F^-	1.15E-03	+111%	-40%	1
Fe^{+3}	1.60E-04			2
Pb^{+2}	3.28E-06	+306%	-80%	
Mn^{+4}	1.46E-05	+103%	-54%	
Hg^{+2}	1.14E-05	+206%	-89%	
Ni^{+2}	9.09E-06	+60%	-44%	
NO_3^-	3.86E-01			3
P^{+5}	4.11E-05			2
K^+	1.38E-03			2
Se^{+4}	1.73E-07	+96%	-77%	1
Ag^+	5.15E-07	+640%	-92%	1
Na^+	1.32E-02			2
S^{+6}	5.99E-04			2
Tl^{+3}	7.87E-08	+77%	-72%	1
U^{+4}	1.06E-06	+97%	-44%	
V^{+5}	1.92E-07	+139%	-79%	1
Zn^{+2}	2.99E-05	+382%	-68%	
Zr^{+4}	1.59E-06			2
	g/liter			
UDS	1.05E-01	+185%	-97%	
TIC	1.90E-02	+145%	-82%	1
TOC	1.24E-01	+113%	-65%	

1. Gray shading indicates data contains flags, typically below detection limits or detected in blank

2. Red shading indicates value was estimated based on concentrations of other known species and the concentration of the unknown species in SBW

3. Blue shading indicates that value was obtained by charge balance

No shading indicates the average of analytical data for sixteen samples. Data points with qualifying flags were excluded from the averages.

2.4.2.10 NWCF Operations – Deep Recycle. Table 14 shows an estimated composition of the Deep Recycle. The composition is based on analysis of 13 samples from the NWCF Fluoride Hot Sump Tank, NCC-119, taken from December 1998 to March 2000, plus daily logs of NWCF scrub composition from May 14, 1998 to April 8, 1999 and from March 7, 2000 to May 28, 2000. For concentrations derived solely from NCC-119 analyses, Table 14 shows the standard deviation of the data points.

Table 14. Estimated NWCF Operation – deep recycle waste composition.

	Mol/liter	Standard deviation Mol/liter	
H+	2.74		4
Al^{+3}	8.41E-01		4
Sb^{+5}	6.12E-06		2
As^{+5}	5.17E-05	4.8E-05	1
Ba^{+2}	6.63E-06	5.5E-06	1
Be^{+2}	7.73E-06	6.7E-06	1
B^{+3}	3.86E-03		2
Cd^{+2}	3.84E-04	4.3E-04	
Ca^{+2}	1.37E-02		2
Cl^{-}	0.0615		4
Cr^{+3}	9.24E-04	8.3E-04	
Co^{+2}	9.33E-06	9.2E-06	1
Cu^{+2}	5.16E-05	4.0E-05	1
F^{-}	6.11E-02	6.4E-02	1
Fe^{+3}	5.37E-03		2
Pb^{+2}	1.38E-04	1.7E-04	
Mn^{+4}	1.48E-03	1.4E-03	
Hg^{+2}	8.74E-02	4.9E-02	4
Ni^{+2}	2.30E-04	1.5E-04	
NO_3^{-}	6.39		3
P^{+5}	1.38E-03		2
K^{+}	4.62E-02		2
Se^{+4}	1.17E-05		2
Ag^{+}	1.48E-06	1.0E-06	1
Na^{+}	4.41E-01		2
S^{+6}	2.01E-02		2
Tl^{+3}	3.27E-06		2
U^{+4}	2.91E-05	2.5E-05	
V^{+5}	2.75E-06	7.9E-07	
Zn^{+2}	1.32E-04	1.0E-04	1
Zr^{+4}	5.34E-05		2
UDS	6.31		
TIC			
TOC	0.13		

1. Gray shading indicates data contains flags, typically below detection limits or detected in blank

2. Red shading indicates value was estimated based on concentrations of other known species and the concentration of the unknown species in SBW

3. Blue shading indicates that value was obtained by charge balance

4. Green shading indicates value is an average based on logs of scrub composition.

No shading indicates the average of analytical data for thirteen samples.

2.4.2.11 CPP-601/627/640 Deactivation Waste. Table 15 shows the composition of deactivation wastes from CPP-601, CPP-627, and CPP-640. Concentrations are taken from Reference 14 and are averages of 4 to 26 data points, depending on the chemical specie.

Table 15. CPP-601/627/640 deactivation waste composition.

	Mol/liter	
H^+	4.58E-02	
Al^{+3}	7.18E-04	
Sb^{+5}	4.27E-08	Red shading indicates value was
As^{+5}	2.02E-08	estimated based on concentrations
Ba^{+2}	2.92E-08	of other known species and the concentration
Be^{+2}	1.28E-08	of the unknown species in SBW
B^{+3}	2.69E-05	
Cd^{+2}	3.85E-07	No shading indicates the average of
Ca^{+2}	9.53E-05	analytical data for 4-26 samples.
Cl^-	1.24E-04	
Cr^{+3}	1.06E-06	
Co^{+2}	5.45E-08	
Cu^{+2}	1.29E-06	
F^-	7.53E-05	
Fe^{+3}	3.75E-05	
Pb^{+2}	1.51E-07	
Mn^{+4}	2.63E-05	
Hg^{+2}	6.48E-07	
Ni^{+2}	3.12E-06	
NO_3^-	4.84E-02	
P^{+5}	9.60E-06	
K^+	9.44E-05	
Se^{+4}	2.18E-08	
Ag^+	2.19E-08	
Na^+	6.26E-04	
S^{+6}	5.62E-05	
Tl^{+3}	2.28E-08	
U^{+4}	2.24E-09	
V^{+5}	5.39E-07	
Zn^{+2}	1.60E-06	
Zr^{+4}	3.73E-07	
UDS	1.75E-02	
TIC		
TOC	8.51E-03	

2.4.2.12 Vault Flush. The composition of vault flush waste, after concentration by a factor of 40, was assumed equal to the composition of SBW.

2.4.3 Composition of Combined Newly Generated Waste

Table 16 shows the estimated composition of combined wastes generated from 2003-5 and 2006-11 for different treatment alternatives. The composition of generated waste for the steam reforming alternative should be very similar to the calcination/MACT alternative (CMACT). Note that LET&D bottoms is included in the combined waste for the CsIX alternative, but not for the others. CMACT can use the LET&D acid for decon. If a direct evaporation process scheme is selected that does not recover and grout LET&D acid, the composition shown in Table 16 for CsIX would apply. If a direct evaporation scheme is selected that does grout LET&D acid, the volume of acid produced from generated wastes should be added to that produced from SBW to obtain the total volume fed to the grout facility. The volumes of 2003-5 waste shown in Table 16 includes only the amount that will exceed the capacity of WM-188 and hence need to be stored in WM-100, WM-101, or WM-102.

Table 16. Estimated combined generated waste.

	Combined Waste 2003-2005 CMACT	Combined Waste 2006-2011 CMACT	Combined Waste 2003-2005 CsIX	Combined Waste 2006-2011 CsIX
Gallons	10,900	69,400	18,500	66,400
	Mol/liter	Mol/liter	Mol/liter	Mol/liter
H+	1.86E+00	2.92E+00	3.78E+00	4.19E+00
Al^{+3}	2.65E-01	2.22E-01	9.42E-02	1.57E-01
Sb^{+5}	1.81E-05	2.09E-05	7.49E-06	1.30E-05
As^{+5}	7.21E-05	5.73E-05	1.23E-05	4.36E-05
Ba^{+2}	4.48E-05	3.98E-05	1.70E-05	2.78E-05
Be^{+2}	3.84E-06	3.71E-06	2.07E-06	2.94E-06
B^{+3}	7.43E-03	6.48E-03	1.73E-03	4.76E-03
Cd^{+2}	1.42E-03	8.50E-04	1.44E-04	8.33E-04
Ca^{+2}	2.31E-02	2.15E-02	1.22E-02	1.48E-02
Cl^{-}	1.51E-02	1.21E-02	7.21E-03	1.17E-02
Cr^{+3}	5.10E-03	4.32E-03	3.51E-03	4.42E-03
Co^{+2}	2.97E-05	2.04E-05	2.79E-04	4.60E-05
Cu^{+2}	3.32E-04	2.51E-04	8.77E-05	2.27E-04
F^{-}	4.61E-02	3.57E-02	2.64E-02	3.76E-02
Fe^{+3}	9.37E-03	8.47E-03	6.67E-03	6.08E-03
Pb^{+2}	6.86E-04	4.26E-04	1.48E-03	4.05E-04
Mn^{+4}	3.03E-02	2.38E-02	1.69E-02	2.38E-02
Hg^{+2}	3.80E-03	5.62E-03	2.62E-03	1.89E-03
Ni^{+2}	1.09E-03	7.51E-04	3.99E-04	9.67E-04
NO_3^{-}	6.35E+00	6.71E+00	7.69E+00	7.52E+00
P^{+5}	3.08E-03	2.73E-03	7.85E-04	1.83E-03
K^{+}	5.58E-01	4.61E-01	1.74E+00	4.45E-01
Se^{+4}	1.98E-05	2.38E-05	5.65E-06	1.21E-05
Ag^{+}	6.48E-06	6.77E-06	1.86E-06	4.21E-06
Na^{+}	2.79E+00	2.35E+00	1.54E+00	2.17E+00
S^{+6}	2.50E-02	2.56E-02	7.79E-03	1.67E-02
Tl^{+3}	7.65E-06	1.01E-05	1.83E-06	4.74E-06
U^{+4}	1.41E-04	8.83E-05	4.88E-02	8.52E-05
V^{+5}	1.19E-04	7.79E-05	1.65E-05	7.30E-05
Zn^{+2}	7.32E-04	7.07E-04	2.37E-04	5.00E-04
Zr^{+4}	3.15E-03	1.89E-03	1.62E-04	1.69E-03
	g/liter	g/liter	g/liter	g/liter
UDS	5.15E+00	4.47E+00	3.08E+00	3.37E+00
TIC	1.96E-01	4.19E-01	1.32E-01	1.67E-01
TOC	5.88E+00	4.35E+00	4.00E+00	4.78E+00
	gallons	gallons	gallons	gallons
LET&D btms	13,600	20,500	0	0

Table 16. Estimated combined generated waste (continued).

	Combined Waste 2003-2005 Direct Evaporation	Combined Waste 2006-2011 Direct Evaporation
Gallons	6,400	44,100
	Mol/liter	Mol/liter
H^+	1.99E+00	1.07E+00
Al^{+3}	2.83E-01	2.28E-01
Sb^{+5}	1.81E-05	2.00E-05
As^{+5}	7.75E-05	6.58E-05
Ba^{+2}	4.62E-05	4.26E-05
Be^{+2}	3.79E-06	4.37E-06
B^{+3}	7.83E-03	7.28E-03
Cd^{+2}	1.55E-03	1.26E-03
Ca^{+2}	2.41E-02	2.28E-02
Cl^-	1.56E-02	1.51E-02
Cr^{+3}	4.75E-03	6.45E-03
Co^{+2}	3.20E-05	2.73E-05
Cu^{+2}	3.49E-04	3.28E-04
F^-	4.72E-02	4.75E-02
Fe^{+3}	9.81E-03	9.27E-03
Pb^{+2}	7.45E-04	6.15E-04
Mn^{+4}	2.89E-02	3.69E-02
Hg^{+2}	4.22E-03	2.73E-03
Ni^{+2}	1.18E-03	1.00E-03
NO_3^-	6.39E+00	6.18E+00
P^{+5}	3.27E-03	2.79E-03
K^+	5.27E-01	6.91E-01
Se^{+4}	2.09E-05	1.79E-05
Ag^+	6.74E-06	6.41E-06
Na^+	2.67E+00	3.37E+00
S^{+6}	2.59E-02	2.56E-02
Tl^{+3}	8.12E-06	7.00E-06
U^{+4}	1.51E-04	1.29E-04
V^{+5}	1.28E-04	1.11E-04
Zn^{+2}	7.49E-04	7.70E-04
Zr^{+4}	3.50E-03	2.55E-03
	g/liter	g/liter
UDS	5.08E+00	5.29E+00
TIC	1.82E-01	1.76E-01
TOC	5.50E+00	6.37E+00
	gallons	gallons
LET&D btms	11,700	19,300

2.5 Tank WM-187 Liquid Composition

Tank WM-187 has been and will continue to be used as a collection tank for solids and dilute wastes until the time of SBW treatment. Table 17 shows the estimated composition of the liquid that will be in Tank WM-187 at the time of SBW treatment.

Table 17. Estimated liquid composition of Tank WM-187 at time of SBW treatment.

	mol/liter		mol/liter		Ci/liter
H+	2.29E-01	Sm	5.87E-07	Cm-246	2.03E-12
Al	3.58E-02	Se	1.28E-06	H-3	2.87E-06
Am	6.23E-09	Ag	4.34E-06	Be-10	3.09E-13
Sb	4.35E-08	Na	1.13E-01	C-14	6.62E-12
As	3.85E-06	Sr	1.53E-06	Se-79	4.50E-08
Ba	3.85E-06	SO4	4.67E-03	Rb-87	3.02E-12
Be	7.09E-08	Tc	6.28E-07	Sr-90	4.89E-03
B	2.07E-03	Te	3.08E-07	Y-90	5.30E-03
Br	3.26E-08	Tb	2.26E-10	Zr-93	2.28E-07
Cd	5.52E-04	Tl	4.00E-08	Nb-93m	1.76E-07
Ca	5.83E-03	Sn	1.13E-07	Nb-94	1.17E-07
C	3.77E-07	U	4.16E-05	Zr-95	2.96E-06
Ce	1.78E-06	V	1.31E-07	Tc-98	2.66E-13
Cs	1.94E-06	Y	7.32E-07	Tc-99	1.15E-06
Cl	1.58E-03	Zn	1.10E-05	Ru-106	6.17E-07
Cr	4.41E-04	Zr	8.38E-04	Pd-107	1.70E-09
Co	8.50E-07		Ci/liter	Cd-113m	3.42E-07
Cu	1.11E-05		(Jan, 2003)	In-115	1.04E-17
Eu	5.40E-08	Ra-226	8.45E-13	Sn-121m	6.89E-09
F	1.11E-02	Th-228	3.30E-10	Sn-126	4.24E-08
Gd	6.81E-06	Th-230	8.48E-11	Sb-125	3.46E-06
Ge	9.39E-10	Th-232	7.30E-17	Te-123	3.95E-20
In	1.46E-08	Pa-231	9.21E-12	Te-125m	3.25E-07
I	2.71E-07	Pa-233	3.02E-07	I-129	2.99E-09
Fe	1.89E-03	U-232	2.05E-10	Cs-134	6.21E-06
La	9.81E-07	U-233	8.25E-12	Cs-135	8.86E-08
Pb	1.22E-04	U-234	4.34E-08	Cs-137	5.20E-03
Li	2.43E-06	U-235	1.78E-09	Ba-137m	4.92E-03
Mg	1.67E-04	U-236	1.82E-09	La-138	1.97E-17
Mn	1.55E-03	U-238	3.15E-09	Ce-142	3.08E-12
Hg	1.22E-04	Np-236	3.16E-13	Ce-144	3.42E-07
Mo	2.60E-06	Np-237	2.03E-07	Nd-144	1.66E-16
Nd	3.17E-06	Pu-236	2.82E-10	Pm-146	5.25E-09
Np	1.81E-06	Pu-238	8.01E-05	Pm-147	1.76E-05
Ni	2.07E-04	Pu-239	4.19E-06	Sm-146	2.84E-14
Nb	4.66E-07	Pu-240	9.08E-07	Sm-147	7.60E-13
NO3	4.57E-01	Pu-241	6.58E-05	Sm-148	3.90E-18
Pd	3.74E-07	Pu-242	1.36E-09	Sm-149	3.46E-19
PO4	1.11E-04	Pu-244	6.98E-17	Sm-151	3.46E-05
Pu	5.70E-07	Am-241	6.11E-06	Eu-152	2.59E-07
K	1.58E-02	Am-242m	1.57E-09	Eu-154	2.68E-05
Pr	8.92E-07	Am-243	2.21E-09	Eu-155	7.44E-06
Pm	1.31E-10	Cm-242	1.29E-09	Gd-152	1.47E-19
Rh	3.85E-07	Cm-243	2.93E-09	Ho-166m	4.75E-12
Rb	5.93E-07	Cm-244	1.82E-07	Co-60	7.00E-06
Ru	2.35E-06	Cm-245	3.08E-11	Ni-63	6.94E-06

2.6 Summary of Liquid Waste Compositions

This section presents feed compositions recommended for use in SBW Treatment Facility design studies. For alternatives in which solids are processed separately from the liquid, the feed compositions are equivalent to the tank waste compositions, diluted by steam used to jet waste out of the tanks. For alternatives in which solids are co-processed with liquids, transfers between tanks will result in some degree of blending the liquid compositions.

2.6.1 Tank Waste Compositions

The compositions of wastes in Tanks WM-180 and WM-189 are not expected to change from their present composition and hence are the same for all treatment alternatives. The composition of WM-188 and NGLW are expected to vary with treatment alternative. Table 18 presents the composition of liquid waste in Tanks WM-180, WM-188, and WM-189 and WM-187 at the time of treatment. Table 18 also shows the total NGLW that will be a fed to the SBW treatment facility.

Concentrations shown in Table 18 have been adjusted to ensure charge balance and consistency between radionuclide activities and chemical concentrations. Nitrate concentrations were adjusted to obtain charge balance. To check for consistency between radionuclide activities and chemical concentrations, activities of radionuclides were converted to molar concentrations and compared to concentrations measured or estimated for the chemical species. If the sum of the concentrations of all isotopes of an element, converted from activities, was greater than the chemical concentration for that element, the chemical concentration was replaced by that sum.[a] For example, if the concentration of Americium, as calculated by converting ^{241}Am, ^{242m}Am, ^{242}Am, and ^{243}Am concentrations in curies per liter to moles per liter and summing was greater than the molar concentration of Am reported as a chemical species, then the sum of the isotopes was used as the concentration. With these adjustments, values in Table 18 are consistent with those shown in previous tables of compositions for the individual tanks. Chemical species with concentrations less than 10^{-10} mol/liter and isotopes with concentrations less than 10^{-15} mol/liter were not included in Table 18. For the generated waste, concentrations of species for which no analytical data or other estimates were available were assumed equal to the average concentration in the SBW tanks for that species.

The entrained solids (often called UDS – solids that are carried with liquid transferred out of a tank) concentration shown for WM-180 in Table 18 is based on analysis of a sample taken from the tank in 2000. Christian[3] reported a value of UDS for an agitated sample of 0.234 g/liter; the value shown in Table 18 is corrected for steam jet dilution contained in the sample. The UDS concentration in Tank WM-188 is similarly based on a sample analyzed in FY 2003.[5] No comparable measurement is available for Tank WM-189. The value shown in Table 18 for this tank is the average of UDS concentrations measured in samples from five tanks of SBW sampled between 1988 and 1993. The range of UDS in the historical data for these five SBW tanks was 0.17 g/liter to 5.05 g/liter. An estimated concentration of settled solids (as if averaged in the entire volume of liquid) is also shown for each tank.

The TOC concentration in WM-189 is based on analysis of the 2002 sample from WM-189.[4] The TOC concentration for WM-188 is based on analysis of a sample taken in late 2002 (from Reference 5) plus estimates of UDS in waste added to WM-188. The UDS concentration in WM-189 was assumed to be the same as the measured concentration in WM-188. The TOC concentration in WM-180 and WM-187 was assumed to be the average of TOC analysis of historical samples from the three other tanks.

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[a] In most cases, the chemical concentration is greater than that of the same species calculated from isotopic concentrations because of nonradioactive isotopes.

Table 18. Composition of tank wastes.

	WM-180	WM-187	WM-188a CMACT, SR	WM-188b DE	WM-188c CsIX
Gallons	276,000	88,000	285,000	285,000	285,000
	mol/liter	mol/liter	mol/liter	mol/liter	mol/liter
H^{+}	1.12E+00	2.29E-01	2.61E+00	2.62E+00	2.84E+00
Al^{+3}	6.06E-01	3.58E-02	5.79E-01	5.81E-01	5.58E-01
Am^{+4}	3.14E-08	6.23E-09	6.81E-08	6.81E-08	6.81E-08
Sb^{+5}	3.59E-08	4.34E-08	6.05E-06	6.05E-06	4.80E-06
As^{+5}	4.71E-04	8.78E-08	1.27E-05	1.33E-05	5.62E-06
Ba^{+2}	5.17E-05	4.57E-06	6.85E-05	6.86E-05	6.52E-05
Be^{+2}	7.33E-06	7.09E-08	1.53E-05	1.52E-05	1.50E-05
B^{+3}	1.08E-02	2.06E-03	1.82E-02	1.82E-02	1.75E-02
Br^{-}	1.64E-07	3.26E-08	3.56E-07	3.56E-07	3.56E-07
Cd^{+2}	7.49E-04	5.07E-04	2.69E-03	2.70E-03	2.54E-03
Ca^{+2}	3.85E-02	5.83E-03	5.50E-02	5.51E-02	5.37E-02
Ce^{+4}	4.46E-05	1.78E-06	2.77E-05	2.77E-05	2.77E-05
Cs^{+}	9.97E-06	1.94E-06	2.90E-05	2.90E-05	2.90E-05
Cl^{-}	3.00E-02	1.58E-03	2.75E-02	2.76E-02	2.66E-02
Cr^{+3}	3.49E-03	4.41E-04	4.93E-03	4.89E-03	4.74E-03
Co^{+2}	1.82E-05	8.50E-07	4.36E-05	4.39E-05	7.30E-05
Cu^{+2}	6.57E-04	1.11E-05	6.78E-04	6.80E-04	6.50E-04
Eu^{+3}	2.72E-07	5.40E-08	5.90E-07	5.90E-07	5.90E-07
F^{-}	4.24E-02	1.11E-02	1.99E-02	2.00E-02	1.75E-02
Gd^{+3}	1.67E-04	6.81E-06	1.54E-04	1.54E-04	1.54E-04
Ge^{+4}	4.73E-09	9.39E-10	1.03E-08	1.03E-08	1.03E-08
In^{+3}	7.44E-07	1.48E-07	1.83E-06	1.83E-06	1.83E-06
I^{-}	1.36E-06	2.71E-07	2.96E-06	2.96E-06	2.96E-06
Fe^{+3}	1.87E-02	1.89E-03	2.15E-02	2.15E-02	2.11E-02
La^{+3}	4.94E-06	9.81E-07	1.07E-05	1.07E-05	1.07E-05
Pb^{+2}	1.32E-03	1.22E-04	8.87E-04	8.94E-04	9.81E-04
Li^{+}	3.68E-04	2.43E-06	2.91E-04	2.91E-04	2.91E-04
Mg^{+2}	1.13E-02	2.22E-03	2.06E-02	2.06E-02	2.06E-02
Mn^{+4}	1.33E-02	1.55E-03	1.71E-02	1.69E-02	1.55E-02
Hg^{+2}	1.35E-03	1.22E-04	6.18E-03	6.22E-03	6.04E-03
Mo^{+6}	1.82E-04	8.08E-06	2.23E-04	2.23E-04	2.23E-04
Nd^{+3}	1.59E-05	3.17E-06	3.46E-05	3.46E-05	3.46E-05
Np^{+4}	9.10E-06	1.81E-06	2.64E-06	2.64E-06	2.64E-06
Ni^{+2}	1.44E-03	1.67E-04	1.92E-03	1.93E-03	1.84E-03
Nb^{+5}	3.40E-08	4.66E-07	2.46E-05	2.46E-05	2.46E-05
NO_3^{-}	5.16E+00	4.83E-01	6.42E+00	6.42E+00	6.57E+00
Pd^{+4}	1.89E-06	3.74E-07	3.15E-04	3.15E-04	3.15E-04
PO_4^{-3}	1.29E-02	5.73E-04	3.99E-04	3.99E-04	3.99E-04
Pu^{+4}	5.82E-06	5.70E-07	4.66E-06	4.66E-06	4.66E-06
K^{+}	1.84E-01	1.58E-02	2.09E-01	2.05E-01	3.49E-01
Pr^{+4}	4.49E-06	8.92E-07	9.75E-06	9.75E-06	9.75E-06
Rh^{+4}	1.94E-06	3.85E-07	4.21E-06	4.21E-06	4.21E-06
Rb^{+}	2.98E-06	5.93E-07	6.47E-06	6.47E-06	6.47E-06
Ru^{+3}	1.18E-04	2.35E-06	1.42E-04	1.42E-04	1.42E-04
Sm^{+3}	2.95E-06	5.87E-07	6.41E-06	6.41E-06	6.41E-06
Se^{+4}	1.04E-05	1.34E-07	5.90E-06	6.03E-06	4.22E-06
Si^{+4}	3.02E-07	1.62E-04	5.95E-04	5.95E-04	5.95E-04

Table 18 (continued).

	WM-180	WM-187	WM-188a CMACT, SR	WM-188b DE	WM-188c CsIX
	mol/liter	mol/liter	mol/liter	mol/liter	mol/liter
Na^{+}	1.98E+00	1.13E-01	1.58E+00	1.56E+00	1.43E+00
Sr^{+2}	1.12E-04	1.53E-06	8.04E-05	8.04E-05	8.04E-05
SO_4^{-2}	5.17E-02	4.67E-03	2.99E-02	3.00E-02	2.79E-02
Tc^{+7}	5.59E-06	6.88E-07	1.33E-05	1.33E-05	1.33E-05
Te^{+4}	1.55E-06	3.08E-07	3.80E-06	3.80E-06	3.80E-06
Tb^{+4}	1.14E-09	2.26E-10	2.47E-09	2.47E-09	2.47E-09
Th^{+4}	1.06E-10	2.10E-11	2.74E-05	2.74E-05	2.74E-05
Sn^{+4}	6.33E-08	1.13E-07	3.93E-05	3.93E-05	3.93E-05
Ti^{+4}	5.45E-05	7.75E-06	5.23E-05	5.23E-05	5.23E-05
U^{+4}	3.75E-04	4.32E-05	3.50E-04	3.50E-04	3.50E-04
V^{+5}	9.23E-04	2.62E-05	3.39E-05	3.50E-05	2.19E-05
Y^{+3}	3.68E-06	7.32E-07	7.99E-06	7.99E-06	7.99E-06
Zn^{+2}	9.90E-04	1.10E-05	8.65E-04	8.67E-04	8.07E-04
Zr^{+4}	5.97E-05	7.14E-04	2.89E-03	2.93E-03	2.54E-03
H_2O	4.75E+01	5.49E+01	4.73E+01	4.73E+01	4.67E+01
	g/liter	g/liter	g/liter	g/liter	g/liter
Density	1259	1025	1324	1324	1324
TOC	0.225	0.225	1.08	1.03	0.85
UDS	0.23	NA	0.70	0.69	0.45
Heel solids	4.79	300	4.64	4.64	4.64
Radionuclides	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)
Ra-226	4.25E-12	8.45E-13	1.05E-11	1.05E-11	1.05E-11
Ac-227	2.00E-11	3.98E-12	4.93E-11	4.93E-11	4.93E-11
Th-228	1.66E-09	3.30E-10	4.09E-09	4.09E-09	4.09E-09
Th-230	4.27E-10	8.48E-11	1.05E-09	1.05E-09	1.05E-09
Th-232	3.68E-16	7.30E-17	9.05E-16	9.05E-16	9.05E-16
Pa-231	4.64E-11	9.21E-12	1.14E-10	1.14E-10	1.14E-10
Pa-233	1.52E-06	3.02E-07	3.74E-06	3.74E-06	3.74E-06
U-232	1.03E-09	2.05E-10	2.54E-09	2.54E-09	2.54E-09
U-233	4.15E-11	8.25E-12	1.02E-10	1.02E-10	1.02E-10
U-234	1.07E-06	8.22E-08	1.11E-06	1.11E-06	1.11E-06
U-235	3.95E-08	1.78E-09	9.49E-08	9.49E-08	9.49E-08
U-236	5.84E-08	3.42E-09	4.26E-08	4.26E-08	4.26E-08
U-237	3.34E-09	6.64E-10	8.22E-09	8.22E-09	8.22E-09
U-238	2.34E-08	3.15E-09	1.28E-08	1.28E-08	1.28E-08
Np-236	1.98E-12	4.71E-13	3.92E-12	3.92E-12	3.92E-12
Np-237	1.52E-06	3.02E-07	4.41E-07	4.41E-07	4.41E-07
Pu-236	1.42E-09	5.00E-10	3.50E-09	3.50E-09	3.50E-09
Pu-238	5.71E-04	1.42E-04	5.36E-04	5.36E-04	5.36E-04
Pu-239	8.27E-05	7.41E-06	6.34E-05	6.34E-05	6.34E-05
Pu-240	5.26E-06	1.61E-06	1.29E-05	1.29E-05	1.29E-05
Pu-241	1.36E-04	1.16E-04	3.36E-04	3.36E-04	3.36E-04
Pu-242	4.10E-09	2.40E-09	1.01E-08	1.01E-08	1.01E-08
Pu-244	3.52E-16	3.96E-18	8.65E-16	8.65E-16	8.65E-16
Am-241	7.07E-05	6.11E-06	5.58E-05	5.58E-05	5.58E-05
Am-242m	7.89E-09	1.57E-09	2.00E-08	2.00E-08	2.00E-08
Am-243	1.11E-08	2.21E-09	2.82E-08	2.82E-08	2.82E-08
Cm-242	6.51E-09	1.29E-09	4.40E-08	4.40E-08	4.40E-08

Table 18 (continued).

	WM-180	WM-187	WM-188a CMACT, SR	WM-188b DE	WM-188c CsIX
	Ci/liter	Ci/liter	Ci/liter	Ci/liter	Ci/liter
Cm-244	9.15E-07	1.82E-07	9.72E-07	9.72E-07	9.72E-07
Cm-245	1.55E-10	3.08E-11	3.81E-10	3.81E-10	3.81E-10
Cm-246	1.02E-11	2.03E-12	2.51E-11	2.51E-11	2.51E-11
H-3	1.82E-05	2.87E-06	1.46E-05	1.46E-05	1.46E-05
Be-10	1.56E-12	3.09E-13	3.83E-12	3.83E-12	3.83E-12
C-14	6.23E-11	1.24E-11	1.53E-10	1.53E-10	1.53E-10
Se-79	2.27E-07	4.50E-08	5.58E-07	5.58E-07	5.58E-07
Rb-87	1.52E-11	3.02E-12	3.74E-11	3.74E-11	3.74E-11
Sr-90	2.03E-02	4.89E-03	4.83E-02	4.83E-02	4.83E-02
Y-90	2.03E-02	4.89E-03	4.83E-02	4.83E-02	4.83E-02
Zr-93	1.15E-06	2.28E-07	2.83E-06	2.83E-06	2.83E-06
Nb-93m	8.86E-07	1.76E-07	2.18E-06	2.18E-06	2.18E-06
Nb-94	5.91E-07	1.17E-07	1.46E-06	1.46E-06	1.46E-06
Tc-98	1.34E-12	2.66E-13	3.29E-12	3.29E-12	3.29E-12
Tc-99	9.38E-06	1.15E-06	2.24E-05	2.24E-05	2.24E-05
Ru-106	4.83E-07	9.59E-08	1.19E-06	1.19E-06	1.19E-06
Rh-102	4.47E-10	8.89E-11	1.10E-09	1.10E-09	1.10E-09
Pd-107	8.57E-09	1.70E-09	2.11E-08	2.11E-08	2.11E-08
Cd-113m	1.72E-06	3.42E-07	4.24E-06	4.24E-06	4.24E-06
In-115	5.23E-17	1.04E-17	1.29E-16	1.29E-16	1.29E-16
Sn-121m	3.47E-08	6.89E-09	8.54E-08	8.54E-08	8.54E-08
Sn-126	2.13E-07	4.24E-08	5.25E-07	5.25E-07	5.25E-07
Sb-125	6.70E-06	3.46E-06	1.65E-05	1.65E-05	1.65E-05
Sb-126	2.99E-08	5.93E-09	7.34E-08	7.34E-08	7.34E-08
Te-123	1.99E-19	3.95E-20	4.89E-19	4.89E-19	4.89E-19
Te-125m	1.63E-06	3.25E-07	4.02E-06	4.02E-06	4.02E-06
I-129	2.39E-08	5.60E-09	6.81E-08	6.81E-08	6.81E-08
Cs-134	5.36E-06	6.21E-06	3.88E-06	3.88E-06	3.88E-06
Cs-135	4.46E-07	8.86E-08	1.10E-06	1.10E-06	1.10E-06
Cs-137	2.62E-02	5.20E-03	6.39E-03	6.39E-03	6.39E-03
Ba-137m	2.48E-02	4.92E-03	6.04E-03	6.04E-03	6.04E-03
La-138	9.91E-17	1.97E-17	2.44E-16	2.44E-16	2.44E-16
Ce-142	1.55E-11	3.08E-12	3.82E-11	3.82E-11	3.82E-11
Ce-144	3.25E-07	6.46E-08	8.00E-07	8.00E-07	8.00E-07
Nd-144	8.34E-16	1.66E-16	2.05E-15	2.05E-15	2.05E-15
Pm-146	2.64E-08	5.25E-09	6.50E-08	6.50E-08	6.50E-08
Pm-147	8.84E-05	1.76E-05	2.17E-04	2.17E-04	2.17E-04
Sm-146	1.43E-13	2.84E-14	3.52E-13	3.52E-13	3.52E-13
Sm-147	3.82E-12	7.60E-13	9.41E-12	9.41E-12	9.41E-12
Sm-148	1.96E-17	3.90E-18	4.83E-17	4.83E-17	4.83E-17
Sm-149	1.74E-18	3.46E-19	4.29E-18	4.29E-18	4.29E-18
Sm-151	1.74E-04	3.46E-05	4.29E-04	4.29E-04	4.29E-04
Eu-152	1.31E-06	2.59E-07	3.21E-06	3.21E-06	3.21E-06
Eu-154	4.64E-05	2.68E-05	2.12E-05	2.12E-05	2.12E-05
Eu-155	8.52E-05	7.44E-06	4.89E-06	4.89E-06	4.89E-06
Gd-152	7.38E-19	1.47E-19	1.82E-18	1.82E-18	1.82E-18
Ho-166m	2.39E-11	4.75E-12	5.88E-11	5.88E-11	5.88E-11
Co-60	4.14E-06	7.00E-06	4.34E-06	4.34E-06	4.34E-06

Table 18 (continued).

	WM-189	NGLW CMACT, SR	NGLW DE	NGLW CsIX
Gallons	280,100	80,300	50,500	84,900
	mol/liter	mol/liter	mol/liter	mol/liter
H^+	2.90E+00	2.8E+00	1.2E+00	4.1E+00
Al^{+3}	7.12E-01	2.3E-01	2.3E-01	1.4E-01
Am^{+4}	6.00E-08	5.3E-08	5.3E-08	5.3E-08
Sb^{+5}	7.52E-06	2.0E-05	2.0E-05	1.2E-05
As^{+5}	2.42E-09	5.9E-05	6.7E-05	3.7E-05
Ba^{+2}	5.62E-05	4.0E-05	4.3E-05	2.5E-05
Be^{+2}	2.02E-05	3.7E-06	4.3E-06	2.7E-06
B^{+3}	2.12E-02	6.6E-03	7.4E-03	4.1E-03
Br^-	3.14E-07	2.8E-07	2.8E-07	2.8E-07
Cd^{+2}	3.91E-03	9.3E-04	1.3E-03	6.8E-04
Ca^{+2}	7.31E-02	2.2E-02	2.3E-02	1.4E-02
Ce^{+4}	3.51E-05	3.6E-05	3.6E-05	3.6E-05
Cs^+	2.68E-05	2.2E-05	2.2E-05	2.2E-05
Cl^-	2.06E-02	1.2E-02	1.5E-02	1.1E-02
Cr^{+3}	5.64E-03	4.4E-03	6.2E-03	4.2E-03
Co^{+2}	4.63E-05	4.4E-03	6.2E-03	4.2E-03
Cu^{+2}	9.54E-04	2.2E-05	2.8E-05	9.7E-05
Eu^{+3}	5.20E-07	4.6E-07	4.6E-07	4.6E-07
F^-	1.37E-02	3.7E-02	4.7E-02	3.5E-02
Gd^{+3}	1.35E-04	1.5E-04	1.5E-04	1.5E-04
Ge^{+4}	9.05E-09	8.0E-09	8.0E-09	8.0E-09
In^{+3}	1.42E-06	1.3E-06	1.3E-06	1.3E-06
I^-	2.61E-06	2.3E-06	2.3E-06	2.3E-06
Fe^{+3}	2.69E-02	8.6E-03	9.3E-03	6.2E-03
La^{+3}	9.45E-06	8.4E-06	8.4E-06	8.4E-06
Pb^{+2}	1.16E-03	4.6E-04	6.3E-04	6.4E-04
Li^+	3.83E-04	3.5E-04	3.5E-04	3.5E-04
Mg^{+2}	2.21E-02	1.8E-02	1.8E-02	1.8E-02
Mn^{+4}	1.95E-02	2.5E-02	3.6E-02	2.2E-02
Hg^{+2}	6.48E-03	5.4E-03	2.9E-03	2.1E-03
Mo^{+6}	2.80E-04	2.3E-04	2.3E-04	2.3E-04
Nd^{+3}	3.05E-05	2.7E-05	2.7E-05	2.7E-05
Np^{+4}	2.75E-06	4.8E-06	4.8E-06	4.8E-06
Ni^{+2}	2.32E-03	8.0E-04	1.0E-03	8.4E-04
Nb^{+5}	6.52E-08	8.4E-06	8.4E-06	8.4E-06
NO_3^-	7.52E+00	6.5E+00	6.1E+00	7.5E+00
Pd^{+4}	3.61E-06	1.1E-04	1.1E-04	1.1E-04
PO_4^{-3}	2.07E-03	2.8E-03	2.9E-03	1.6E-03
Pu^{+4}	3.88E-06	4.8E-06	4.8E-06	4.8E-06
K^+	2.25E-01	4.7E-01	6.7E-01	7.3E-01
Pr^{+4}	8.60E-06	7.6E-06	7.6E-06	7.6E-06
Rh^{+4}	3.71E-06	3.3E-06	3.3E-06	3.3E-06
Rb^+	5.71E-06	5.1E-06	5.1E-06	5.1E-06
Ru^{+3}	1.72E-04	1.4E-04	1.4E-04	1.4E-04
Sm^{+3}	5.65E-06	5.0E-06	5.0E-06	5.0E-06
Se^{+4}	8.24E-07	2.3E-05	1.8E-05	1.1E-05
Si^{+4}	3.08E-04	3.0E-04	3.0E-04	3.0E-04
Ag^+	6.54E-08	6.7E-06	6.5E-06	3.7E-06

Table 18 (continued).

	WM-189	NGLW CMACT, SR	NGLW DE	NGLW CsIX
	mol/liter	mol/liter	mol/liter	mol/liter
Na^{+}	2.04E+00	2.4E+00	3.3E+00	2.0E+00
Sr^{+2}	1.42E-04	1.1E-04	1.1E-04	1.1E-04
SO_4^{-2}	1.07E-01	2.5E-02	2.6E-02	1.5E-02
Tc^{+7}	5.94E-06	8.3E-06	8.3E-06	8.3E-06
Te^{+4}	7.26E-06	4.2E-06	4.2E-06	4.2E-06
Tb^{+4}	2.18E-09	1.9E-09	1.9E-09	1.9E-09
Th^{+4}	3.50E-05	2.1E-05	2.1E-05	2.1E-05
Sn^{+4}	4.14E-05	2.7E-05	2.7E-05	2.7E-05
Ti^{+4}	7.29E-05	6.0E-05	6.0E-05	6.0E-05
U^{+4}	6.68E-04	9.5E-05	1.3E-04	1.1E-02
V^{+5}	2.51E-05	8.3E-05	1.1E-04	6.1E-05
Y^{+3}	7.05E-06	6.3E-06	6.3E-06	6.3E-06
Zn^{+2}	1.07E-03	7.1E-04	7.7E-04	4.4E-04
Zr^{+4}	3.56E-04	2.1E-03	2.7E-03	1.4E-03
H_2O	4.25E+01	4.58E+01	4.29E+01	4.58E+01
	g/liter	g/liter	g/liter	g/liter
Density	1331	1320	1320	1330
TOC	0.59	4.56	6.26	4.61
UDS	0.10	4.56	5.27	3.30
Heel solids	9.43	0	0	0
Radionuclides	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)
Ra-226	8.14E-12	7.6E-12	7.6E-12	7.6E-12
Ac-227	3.83E-11	3.6E-11	3.6E-11	3.6E-11
Th-228	3.18E-09	3.0E-09	3.0E-09	3.0E-09
Th-230	8.17E-10	7.7E-10	7.7E-10	7.7E-10
Th-232	7.04E-16	6.6E-16	6.6E-16	6.6E-16
Pa-231	8.88E-11	8.3E-11	8.3E-11	8.3E-11
Pa-233	2.91E-06	2.7E-06	2.7E-06	2.7E-06
U-232	1.97E-09	1.9E-09	1.9E-09	1.9E-09
U-233	7.94E-11	7.5E-11	7.5E-11	7.5E-11
U-234	1.74E-06	1.3E-06	1.3E-06	1.3E-06
U-235	6.01E-08	6.5E-08	6.5E-08	6.5E-08
U-236	7.81E-08	6.0E-08	6.0E-08	6.0E-08
U-237	6.39E-09	6.0E-09	6.0E-09	6.0E-09
U-238	4.35E-08	2.6E-08	2.6E-08	2.6E-08
Np-236	3.05E-12	3.0E-12	3.0E-12	3.0E-12
Np-237	4.59E-07	8.0E-07	8.0E-07	8.0E-07
Pu-236	3.26E-09	2.6E-09	2.6E-09	2.6E-09
Pu-238	4.64E-04	5.0E-04	5.0E-04	5.0E-04
Pu-239	5.22E-05	6.4E-05	6.4E-05	6.4E-05
Pu-240	1.21E-05	9.6E-06	9.6E-06	9.6E-06
Pu-241	4.77E-04	4.7E-03	4.7E-03	4.7E-03
Pu-242	9.42E-09	7.5E-09	7.5E-09	7.5E-09
Pu-244	2.58E-17	4.2E-16	4.2E-16	4.2E-16
Am-241	7.34E-05	6.7E-05	6.7E-05	6.7E-05
Am-242m	1.51E-08	1.4E-08	1.4E-08	1.4E-08
Am-243	2.13E-08	2.0E-08	2.0E-08	2.0E-08
Cm-242	2.98E-08	2.7E-08	2.7E-08	2.7E-08

Table 18 (Continued)

	WM-189	NGLW CMACT, SR	NGLW DE	NGLW CsIX
	Ci/liter	Ci/liter	Ci/liter	Ci/liter
Cm-244	1.05E-06	9.8E-07	9.8E-07	9.8E-07
Cm-245	2.96E-10	2.8E-10	2.8E-10	2.8E-10
Cm-246	1.95E-11	1.8E-11	1.8E-11	1.8E-11
H-3	9.66E-06	1.4E-05	1.4E-05	1.4E-05
Be-10	2.98E-12	2.8E-12	2.8E-12	2.8E-12
C-14	1.19E-10	1.1E-10	1.1E-10	1.1E-10
Se-79	4.34E-07	4.1E-07	4.1E-07	4.1E-07
Rb-87	2.91E-11	2.7E-11	2.7E-11	2.7E-11
Sr-90	3.88E-02	3.6E-02	3.6E-02	3.6E-02
Y-90	3.88E-02	3.6E-02	3.6E-02	3.6E-02
Zr-93	2.20E-06	2.1E-06	2.1E-06	2.1E-06
Nb-93m	1.70E-06	1.6E-06	1.6E-06	1.6E-06
Nb-94	1.13E-06	1.1E-06	1.1E-06	1.1E-06
Tc-98	2.56E-12	2.4E-12	2.4E-12	2.4E-12
Tc-99	9.96E-06	1.4E-05	1.4E-05	1.4E-05
Ru-106	9.24E-07	8.7E-07	8.7E-07	8.7E-07
Rh-102	8.56E-10	8.0E-10	8.0E-10	8.0E-10
Pd-107	1.64E-08	1.5E-08	1.5E-08	1.5E-08
Cd-113m	3.30E-06	3.1E-06	3.1E-06	3.1E-06
In-115	1.00E-16	9.4E-17	9.4E-17	9.4E-17
Sn-121m	6.64E-08	6.2E-08	6.2E-08	6.2E-08
Sn-126	4.08E-07	3.8E-07	3.8E-07	3.8E-07
Sb-125	1.28E-05	1.2E-05	1.2E-05	1.2E-05
Sb-126	5.71E-08	5.4E-08	5.4E-08	5.4E-08
Te-123	3.81E-19	3.6E-19	3.6E-19	3.6E-19
Te-125m	3.13E-06	2.9E-06	2.9E-06	2.9E-06
I-129	5.30E-08	4.9E-08	4.9E-08	4.9E-08
Cs-134	4.03E-05	1.6E-05	1.6E-05	1.6E-05
Cs-135	8.54E-07	8.0E-07	8.0E-07	8.0E-07
Cs-137	5.01E-02	2.7E-02	2.7E-02	2.7E-02
Ba-137m	4.74E-02	2.6E-02	2.6E-02	2.6E-02
La-138	1.90E-16	1.8E-16	1.8E-16	1.8E-16
Ce-142	2.97E-11	2.8E-11	2.8E-11	2.8E-11
Ce-144	6.23E-07	5.9E-07	5.9E-07	5.9E-07
Nd-144	1.60E-15	1.5E-15	1.5E-15	1.5E-15
Pm-146	5.05E-08	4.8E-08	4.8E-08	4.8E-08
Pm-147	1.69E-04	1.6E-04	1.6E-04	1.6E-04
Sm-146	2.74E-13	2.6E-13	2.6E-13	2.6E-13
Sm-147	7.32E-12	6.9E-12	6.9E-12	6.9E-12
Sm-148	3.76E-17	3.5E-17	3.5E-17	3.5E-17
Sm-149	3.34E-18	3.1E-18	3.1E-18	3.1E-18
Sm-151	3.33E-04	3.1E-04	3.1E-04	3.1E-04
Eu-152	2.50E-06	2.3E-06	2.3E-06	2.3E-06
Eu-154	1.84E-04	8.4E-05	8.4E-05	8.4E-05
Eu-155	1.63E-04	8.4E-05	8.4E-05	8.4E-05
Gd-152	1.41E-18	1.3E-18	1.3E-18	1.3E-18
Ho-166m	4.57E-11	4.3E-11	4.3E-11	4.3E-11
Co-60	3.62E-05	1.5E-05	1.5E-05	1.5E-05
Ni-63	3.14E-05	3.2E-05	3.2E-05	3.2E-05

2.6.2 Liquid Composition for Solids Co-processing Feeds

For treatment alternatives that co-process tank solids with SBW liquid, one method of preparing the mixed solids/liquid feed is to transfer a portion of the solids collected in Tank WM-187 to tanks of SBW liquid.[19] Several scenarios for accomplishing this have been suggested (see Reference 19) and evaluated based on criteria of:

- Obtaining as similar a concentration of solids as possible in the different tanks
- Minimizing the number of tank transfers
- Keeping the solids concentration in transfers below the level at which solids would settle in transfer piping
- Keeping one tank available for receiving dilute wastes from tank closure activities and SBW treatment processes
- Minimizing the number of different compositions fed to the treatment process
- Avoiding transfers to WM-180.

The recommended scenario[19] involves transferring liquid waste from Tanks WM-188 and WM-189 into WM-187, and then transferring mixed WM-187 solids/liquid waste back to WM-188 and WM-189. Based on tank volumes determined in this report, the recommended scenarios are shown in Tables 19a and 19b. Except for Tank WM-189, transfers between tanks assume 3% dilution from steam jets and transfers to treatment assume 5% dilution. An existing air-lift is assumed to be used to transfer waste from WM-189 to the 30,000 gal level, and steams jets to lower levels. Liquid compositions for this scenario are given in Table 20 for the CMACT and steam reforming alternative and in Table 21 for the direct evaporation alternative.

Table 19a. Tank mixing scenario, CMACT or SR.

	Initial volume gallons	Fill WM-187	Transfer solids from WM-187	add NGLW to WM-187	Volume transferred to treatment	Rounded, gallons	Average solids, g/liter
WM-180	276,000				289,800	290,000	5
WM-188	285,000	-96,300	96,300		299,250	299,000	34
WM-189	280,100	-95,000	99,900		286,500	287,000	39
Gen'd waste	80,300			-80,300			
WM-187	88,000	197,040	-190,490	82,710	186,120	186,000	52
Total	1,009,400				1,061,670	1,062,000	

Table 19b. Tank mixing scenario, Direct Evaporation.

	Initial volume gallons	Fill WM-187	Transfer solids from WM-187	add NGLW to WM-187	Volume transferred to treatment	Rounded, gallons	Average solids, g/liter
WM-180	276,000				289,800	290,000	5
WM-188	285,000	-96,300	96,300		299,250	299,000	34
WM-189	280,100	-95,000	99,900		286,500	287,000	39
Gen'd waste	50,500			-50,500			
WM-187	88,000	197,040	-190,490	52,020	153,900	154,000	62
Total	979,600				1,029,450	1,030,000	

Volumes and concentrations shown in Tables 20 (for CMACT and Steam Reforming) and 21 (for Direct Evaporation) are of the waste as received at the treatment facility, and include dilution from steam jet transfer and a concentration correction due to the volume of solids.

Table 20. Coprocessing feeds, CMACT or Steam Reforming.

	WM-180	WM-187	WM-188	WM-189
Gallons	290,000	186,000	299,000	287,000
	Mol/liter	Mol/liter	Mol/liter	Mol/liter
H^+	1.07E+00	2.12E+00	2.21E+00	2.47E+00
Al^{+3}	5.75E-01	3.15E-01	4.95E-01	5.98E-01
Am^{+4}	2.98E-08	4.47E-08	5.60E-08	5.29E-08
Sb^{+5}	3.41E-08	1.09E-05	5.15E-06	6.28E-06
As^{+5}	4.48E-04	2.70E-05	9.16E-06	1.43E-06
Ba^{+2}	4.91E-05	3.84E-05	5.57E-05	5.00E-05
Be^{+2}	6.96E-06	7.46E-06	1.31E-05	1.67E-05
B^{+3}	1.02E-02	9.62E-03	1.55E-02	1.80E-02
Br^-	1.56E-07	2.33E-07	2.93E-07	2.77E-07
Cd^{+2}	7.11E-04	1.56E-03	2.39E-03	3.26E-03
Ca^{+2}	3.66E-02	3.13E-02	4.78E-02	6.12E-02
Ce^{+4}	4.24E-05	2.57E-05	2.38E-05	2.94E-05
Cs^+	9.47E-06	1.88E-05	2.39E-05	2.34E-05
Cl^-	2.85E-02	1.35E-02	2.22E-02	1.85E-02
Cr^{+3}	3.32E-03	3.68E-03	4.18E-03	4.79E-03
Co^{+2}	1.73E-05	1.87E-03	3.64E-05	3.94E-05
Cu^{+2}	6.25E-04	2.81E-04	5.89E-04	7.87E-04
Eu^{+3}	2.58E-07	3.87E-07	4.85E-07	4.59E-07
F^-	4.03E-02	2.29E-02	1.68E-02	1.36E-02
Gd^{+3}	1.59E-04	1.13E-04	1.26E-04	1.18E-04
Ge^{+4}	4.49E-09	6.73E-09	8.44E-09	7.98E-09
In^{+3}	7.07E-07	1.13E-06	1.48E-06	1.28E-06
I^-	1.29E-06	1.94E-06	2.43E-06	2.30E-06
Fe^{+3}	1.78E-02	1.19E-02	1.84E-02	2.26E-02
La^{+3}	4.69E-06	7.03E-06	8.82E-06	8.34E-06
Pb^{+2}	1.25E-03	5.53E-04	7.72E-04	9.77E-04
Li^+	3.50E-04	2.58E-04	2.50E-04	3.18E-04
Mg^{+2}	1.08E-02	1.50E-02	1.74E-02	1.90E-02
Mn^{+4}	1.26E-02	1.67E-02	1.45E-02	1.66E-02
Hg^{+2}	1.28E-03	4.38E-03	5.14E-03	5.53E-03
Mo^{+6}	1.73E-04	1.81E-04	1.90E-04	2.34E-04
Nd^{+3}	1.51E-05	2.27E-05	2.84E-05	2.69E-05
Np^{+4}	8.65E-06	3.19E-06	2.36E-06	2.53E-06
Ni^{+2}	1.37E-03	1.06E-03	1.64E-03	1.96E-03
Nb^{+5}	3.23E-08	7.70E-06	1.78E-05	2.85E-06
NO_3^-	4.91E+00	5.12E+00	5.46E+00	6.36E+00
Pd^{+4}	1.79E-06	9.90E-05	2.28E-04	3.81E-05
PO_4^{-3}	1.23E-02	1.66E-03	5.54E-04	1.64E-03
Pu^{+4}	5.53E-06	3.51E-06	3.82E-06	3.47E-06
K^+	1.75E-01	2.74E-01	1.76E-01	1.93E-01
Pr^{+4}	4.27E-06	6.39E-06	8.02E-06	7.58E-06
Rh^{+4}	1.84E-06	2.76E-06	3.46E-06	3.27E-06
Rb^+	2.83E-06	4.25E-06	5.32E-06	5.03E-06
Ru^{+3}	1.12E-04	1.13E-04	1.20E-04	1.44E-04

Table 20. (Continued.)

	WM-180	WM-187	WM-188	WM-189
Se^{+4}	9.87E-06	1.09E-05	4.36E-06	1.29E-06
Si^{+4}	2.87E-07	3.03E-04	4.77E-04	3.12E-04
Ag^{+}	4.21E-06	4.17E-06	3.30E-06	9.41E-07
Na^{+}	1.88E+00	1.63E+00	1.36E+00	1.71E+00
Sr^{+2}	1.07E-04	8.38E-05	7.28E-05	1.14E-04
SO_4^{-2}	4.91E-02	3.41E-02	3.31E-02	8.36E-02
Tc^{+7}	5.31E-06	6.81E-06	1.03E-05	5.98E-06
Te^{+4}	1.47E-06	3.65E-06	3.52E-06	5.86E-06
Tb^{+4}	1.08E-09	1.62E-09	2.03E-09	1.92E-09
Th^{+4}	1.00E-10	1.91E-05	2.34E-05	2.91E-05
Sn^{+4}	6.01E-08	2.48E-05	3.26E-05	3.52E-05
Ti^{+4}	5.18E-05	4.71E-05	4.60E-05	6.09E-05
U^{+4}	3.56E-04	2.15E-04	3.26E-04	5.41E-04
V^{+5}	8.77E-04	4.89E-05	2.96E-05	2.52E-05
Y^{+3}	3.50E-06	5.24E-06	6.57E-06	6.22E-06
Zn^{+2}	9.41E-04	6.21E-04	7.36E-04	8.93E-04
Zr^{+4}	5.67E-05	1.52E-03	2.19E-03	6.62E-04
H_2O	4.51E+01	4.25E+01	4.37E+01	4.26E+01
	g/liter	g/liter	g/liter	g/liter
Density	1200	1200	1220	1280
TOC	0.21	2.23	0.86	0.58
Heel solids	5.0	54.2	35.6	39.4
	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)
Ra-226	4.04E-12	6.43E-12	8.48E-12	7.31E-12
Ac-227	1.90E-11	3.03E-11	3.99E-11	3.44E-11
Th-228	1.58E-09	2.51E-09	3.31E-09	2.86E-09
Th-230	4.06E-10	6.46E-10	8.51E-10	7.34E-10
Th-232	3.49E-16	5.56E-16	7.33E-16	6.32E-16
Pa-231	4.41E-11	7.02E-11	9.25E-11	7.98E-11
Pa-233	1.45E-06	2.30E-06	3.03E-06	2.62E-06
U-232	9.80E-10	1.56E-09	2.06E-09	1.77E-09
U-233	3.94E-11	6.28E-11	8.28E-11	7.14E-11
U-234	1.02E-06	1.03E-06	9.89E-07	1.43E-06
U-235	3.75E-08	5.34E-08	7.50E-08	5.55E-08
U-236	5.55E-08	4.56E-08	3.91E-08	6.32E-08
U-237	3.17E-09	5.06E-09	6.66E-09	5.75E-09
U-238	2.22E-08	2.09E-08	1.40E-08	3.41E-08
Np-236	1.88E-12	2.49E-12	3.19E-12	2.76E-12
Np-237	1.44E-06	5.32E-07	3.94E-07	4.22E-07
Pu-236	1.35E-09	2.35E-09	2.91E-09	2.87E-09
Pu-238	5.42E-04	4.08E-04	4.48E-04	4.20E-04
Pu-239	7.86E-05	4.81E-05	5.19E-05	4.67E-05
Pu-240	5.00E-06	8.66E-06	1.07E-05	1.06E-05
Pu-241	1.29E-04	2.86E-04	3.03E-04	4.05E-04
Pu-242	3.90E-09	6.93E-09	8.50E-09	8.39E-09
Pu-244	3.34E-16	3.25E-16	6.29E-16	1.17E-16
Am-241	6.72E-05	5.03E-05	4.85E-05	6.15E-05
Am-242m	7.50E-09	1.21E-08	1.61E-08	1.36E-08
Am-243	1.06E-08	1.71E-08	2.28E-08	1.92E-08

Table 20. (Continued.)

	WM-180 Ci/liter	WM-187 Ci/liter	WM-188 Ci/liter	WM-189 Ci/liter
Cm-243	1.40E-08	2.23E-08	2.94E-08	2.54E-08
Cm-244	8.69E-07	7.75E-07	8.27E-07	9.09E-07
Cm-245	1.47E-10	2.34E-10	3.09E-10	2.66E-10
Cm-246	9.70E-12	1.54E-11	2.04E-11	1.76E-11
H-3	1.73E-05	1.04E-05	1.18E-05	9.12E-06
Be-10	1.48E-12	2.36E-12	3.11E-12	2.68E-12
C-14	5.92E-11	9.43E-11	1.24E-10	1.07E-10
Se-79	2.15E-07	3.43E-07	4.52E-07	3.90E-07
Rb-87	1.45E-11	2.30E-11	3.03E-11	2.62E-11
Sr-90	1.93E-02	3.03E-02	3.93E-02	3.48E-02
Y-90	1.93E-02	3.03E-02	3.93E-02	3.48E-02
Zr-93	1.09E-06	1.74E-06	2.29E-06	1.98E-06
Nb-93m	8.42E-07	1.34E-06	1.77E-06	1.52E-06
Nb-94	5.62E-07	8.95E-07	1.18E-06	1.02E-06
Tc-98	1.27E-12	2.03E-12	2.67E-12	2.30E-12
Tc-99	8.91E-06	1.14E-05	1.73E-05	1.00E-05
Ru-106	4.59E-07	7.30E-07	9.62E-07	8.30E-07
Rh-102	4.25E-10	6.77E-10	8.92E-10	7.70E-10
Pd-107	8.15E-09	1.30E-08	1.71E-08	1.47E-08
Cd-113m	1.64E-06	2.61E-06	3.44E-06	2.97E-06
In-115	4.96E-17	7.91E-17	1.04E-16	8.99E-17
Sn-121m	3.30E-08	5.25E-08	6.92E-08	5.97E-08
Sn-126	2.03E-07	3.23E-07	4.25E-07	3.67E-07
Sb-125	6.36E-06	1.05E-05	1.36E-05	1.17E-05
Sb-126	2.84E-08	4.52E-08	5.95E-08	5.13E-08
Te-123	1.89E-19	3.01E-19	3.97E-19	3.42E-19
Te-125m	1.55E-06	2.47E-06	3.26E-06	2.81E-06
I-129	2.28E-08	4.14E-08	5.52E-08	4.76E-08
Cs-134	5.09E-06	1.52E-05	7.52E-06	3.11E-05
Cs-135	4.24E-07	6.75E-07	8.90E-07	7.67E-07
Cs-137	2.49E-02	2.17E-02	1.02E-02	3.85E-02
Ba-137m	2.35E-02	2.05E-02	9.68E-03	3.64E-02
La-138	9.42E-17	1.50E-16	1.98E-16	1.70E-16
Ce-142	1.47E-11	2.35E-11	3.09E-11	2.67E-11
Ce-144	3.09E-07	4.92E-07	6.49E-07	5.60E-07
Nd-144	7.93E-16	1.26E-15	1.66E-15	1.44E-15
Pm-146	2.51E-08	4.00E-08	5.27E-08	4.54E-08
Pm-147	8.40E-05	1.34E-04	1.76E-04	1.52E-04
Sm-146	1.36E-13	2.17E-13	2.85E-13	2.46E-13
Sm-147	3.63E-12	5.79E-12	7.62E-12	6.58E-12
Sm-148	1.87E-17	2.97E-17	3.92E-17	3.38E-17
Sm-149	1.66E-18	2.64E-18	3.48E-18	3.00E-18
Sm-151	1.66E-04	2.64E-04	3.47E-04	3.00E-04
Eu-152	1.24E-06	1.98E-06	2.60E-06	2.25E-06
Eu-154	4.41E-05	7.32E-05	3.67E-05	1.42E-04
Eu-155	8.10E-05	6.41E-05	2.09E-05	1.23E-04
Gd-152	7.01E-19	1.12E-18	1.47E-18	1.27E-18
Ho-166m	2.27E-11	3.62E-11	4.76E-11	4.11E-11
Co-60	3.93E-06	1.40E-05	7.51E-06	2.81E-05
Ni-63	2.34E-05	2.66E-05	3.31E-05	2.86E-05

Table 21. Coprocessing feeds, Direct Evaporation.

	WM-180	WM-187	WM-188	WM-189
Gallons	290,000	154,000	299,000	287,000
	Mol/liter	Mol/liter	Mol/liter	Mol/liter
H^{+}	1.07E+00	1.52E+00	2.22E+00	2.48E+00
Al^{+3}	5.75E-01	3.39E-01	4.96E-01	5.98E-01
Am^{+4}	2.98E-08	4.37E-08	5.60E-08	5.29E-08
Sb^{+5}	3.41E-08	9.00E-06	5.15E-06	6.28E-06
As^{+5}	4.48E-04	2.41E-05	9.62E-06	1.50E-06
Ba^{+2}	4.91E-05	3.95E-05	5.58E-05	5.00E-05
Be^{+2}	6.96E-06	8.45E-06	1.31E-05	1.67E-05
B^{+3}	1.02E-02	1.06E-02	1.55E-02	1.80E-02
Br^{-}	1.56E-07	2.28E-07	2.93E-07	2.77E-07
Cd^{+2}	7.11E-04	1.82E-03	2.40E-03	3.26E-03
Ca^{+2}	3.66E-02	3.39E-02	4.79E-02	6.12E-02
Ce^{+4}	4.24E-05	2.42E-05	2.38E-05	2.94E-05
Cs^{+}	9.47E-06	1.85E-05	2.39E-05	2.34E-05
Cl^{-}	2.85E-02	1.47E-02	2.22E-02	1.86E-02
Cr^{+3}	3.32E-03	4.16E-03	4.15E-03	4.79E-03
Co^{+2}	1.73E-05	2.00E-03	3.66E-05	3.95E-05
Cu^{+2}	6.25E-04	3.37E-04	5.91E-04	7.87E-04
Eu^{+3}	2.58E-07	3.79E-07	4.85E-07	4.59E-07
F^{-}	4.03E-02	2.39E-02	1.69E-02	1.36E-02
Gd^{+3}	1.59E-04	1.07E-04	1.26E-04	1.18E-04
Ge^{+4}	4.49E-09	6.59E-09	8.44E-09	7.98E-09
In^{+3}	7.07E-07	1.10E-06	1.48E-06	1.28E-06
I^{-}	1.29E-06	1.90E-06	2.43E-06	2.30E-06
Fe^{+3}	1.78E-02	1.30E-02	1.85E-02	2.26E-02
La^{+3}	4.69E-06	6.88E-06	8.82E-06	8.34E-06
Pb^{+2}	1.25E-03	6.34E-04	7.77E-04	9.78E-04
Li^{+}	3.50E-04	2.45E-04	2.50E-04	3.18E-04
Mg^{+2}	1.08E-02	1.47E-02	1.74E-02	1.90E-02
Mn^{+4}	1.26E-02	1.89E-02	1.44E-02	1.65E-02
Hg^{+2}	1.28E-03	3.49E-03	5.18E-03	5.53E-03
Mo^{+6}	1.73E-04	1.74E-04	1.90E-04	2.34E-04
Nd^{+3}	1.51E-05	2.22E-05	2.84E-05	2.69E-05
Np^{+4}	8.65E-06	2.93E-06	2.36E-06	2.53E-06
Ni^{+2}	1.37E-03	1.20E-03	1.65E-03	1.96E-03
Nb^{+5}	3.23E-08	7.70E-06	1.78E-05	2.85E-06
NO_3^{-}	4.91E+00	4.80E+00	5.46E+00	6.36E+00
Pd^{+4}	1.79E-06	9.87E-05	2.28E-04	3.81E-05
PO_4^{-3}	1.23E-02	1.50E-03	5.54E-04	1.64E-03
Pu^{+4}	5.53E-06	3.33E-06	3.82E-06	3.47E-06
K^{+}	1.75E-01	3.02E-01	1.73E-01	1.92E-01
Pr^{+4}	4.27E-06	6.26E-06	8.02E-06	7.58E-06
Rh^{+4}	1.84E-06	2.70E-06	3.46E-06	3.27E-06
Rb^{+}	2.83E-06	4.16E-06	5.32E-06	5.03E-06
Ru^{+3}	1.12E-04	1.09E-04	1.20E-04	1.44E-04
Sm^{+3}	2.81E-06	4.11E-06	5.27E-06	4.98E-06
Se^{+4}	9.87E-06	7.20E-06	4.46E-06	1.30E-06

Table 21. (Continued.)

	WM-180	WM-187	WM-188	WM-189
Si^{+4}	2.87E-07	3.07E-04	4.77E-04	3.12E-04
Ag^{+}	4.21E-06	3.67E-06	3.32E-06	9.44E-07
Na^{+}	1.88E+00	1.78E+00	1.35E+00	1.70E+00
Sr^{+2}	1.07E-04	7.99E-05	7.28E-05	1.14E-04
SO_4^{-2}	4.91E-02	3.63E-02	3.31E-02	8.36E-02
Tc^{+7}	5.31E-06	6.63E-06	1.03E-05	5.98E-06
Te^{+4}	1.47E-06	3.60E-06	3.52E-06	5.86E-06
Tb^{+4}	1.08E-09	1.58E-09	2.03E-09	1.92E-09
Th^{+4}	1.00E-10	1.91E-05	2.34E-05	2.91E-05
Sn^{+4}	6.01E-08	2.47E-05	3.26E-05	3.52E-05
Ti^{+4}	5.18E-05	4.54E-05	4.60E-05	6.09E-05
U^{+4}	3.56E-04	2.53E-04	3.26E-04	5.41E-04
V^{+5}	8.77E-04	5.29E-05	3.04E-05	2.53E-05
Y^{+3}	3.50E-06	5.13E-06	6.57E-06	6.22E-06
Zn^{+2}	9.41E-04	6.32E-04	7.37E-04	8.94E-04
Zr^{+4}	5.67E-05	1.64E-03	2.22E-03	6.67E-04
H_2O	4.51E+01	4.17E+01	4.37E+01	4.26E+01
	g/liter	g/liter	g/liter	g/liter
Density	1200	1200	1220	1280
TOC	0.21	2.43	0.84	0.59
Heel solids	5.0	64.8	35.6	39.4
	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)	Ci/liter (Jan, 2003)
Ra-226	4.04E-12	6.30E-12	8.48E-12	7.31E-12
Ac-227	1.90E-11	2.97E-11	3.99E-11	3.44E-11
Th-228	1.58E-09	2.46E-09	3.31E-09	2.86E-09
Th-230	4.06E-10	6.33E-10	8.51E-10	7.34E-10
Th-232	3.49E-16	5.45E-16	7.33E-16	6.32E-16
Pa-231	4.41E-11	6.88E-11	9.25E-11	7.98E-11
Pa-233	1.45E-06	2.26E-06	3.03E-06	2.62E-06
U-232	9.80E-10	1.53E-09	2.06E-09	1.77E-09
U-233	3.94E-11	6.15E-11	8.28E-11	7.14E-11
U-234	1.02E-06	9.99E-07	9.89E-07	1.43E-06
U-235	3.75E-08	5.20E-08	7.50E-08	5.55E-08
U-236	5.55E-08	4.36E-08	3.91E-08	6.32E-08
U-237	3.17E-09	4.95E-09	6.66E-09	5.75E-09
U-238	2.22E-08	2.02E-08	1.40E-08	3.41E-08
Np-236	1.88E-12	2.43E-12	3.19E-12	2.76E-12
Np-237	1.44E-06	4.90E-07	3.94E-07	4.22E-07
Pu-236	1.35E-09	2.31E-09	2.91E-09	2.87E-09
Pu-238	5.42E-04	3.92E-04	4.48E-04	4.20E-04
Pu-239	7.86E-05	4.54E-05	5.19E-05	4.67E-05
Pu-240	5.00E-06	8.51E-06	1.07E-05	1.06E-05
Pu-241	1.29E-04	2.84E-04	3.03E-04	4.05E-04
Pu-242	3.90E-09	6.85E-09	8.50E-09	8.39E-09
Pu-244	3.34E-16	3.12E-16	6.29E-16	1.17E-16
Am-241	6.72E-05	4.81E-05	4.85E-05	6.15E-05
Am-242m	7.50E-09	1.19E-08	1.61E-08	1.36E-08
Am-243	1.06E-08	1.67E-08	2.28E-08	1.92E-08
Cm-242	6.18E-09	2.36E-08	3.50E-08	2.72E-08

Table 21. (Continued.)

	WM-180 Ci/liter	WM-187 Ci/liter	WM-188 Ci/liter	WM-189 Ci/liter
Cm-243	1.40E-08	2.19E-08	2.94E-08	2.54E-08
Cm-244	8.69E-07	7.48E-07	8.27E-07	9.09E-07
Cm-245	1.47E-10	2.30E-10	3.09E-10	2.66E-10
Cm-246	9.70E-12	1.51E-11	2.04E-11	1.76E-11
H-3	1.73E-05	9.86E-06	1.18E-05	9.12E-06
Be-10	1.48E-12	2.31E-12	3.11E-12	2.68E-12
C-14	5.92E-11	9.23E-11	1.24E-10	1.07E-10
Se-79	2.15E-07	3.36E-07	4.52E-07	3.90E-07
Rb-87	1.45E-11	2.26E-11	3.03E-11	2.62E-11
Sr-90	1.93E-02	2.97E-02	3.93E-02	3.48E-02
Y-90	1.93E-02	2.97E-02	3.93E-02	3.48E-02
Zr-93	1.09E-06	1.70E-06	2.29E-06	1.98E-06
Nb-93m	8.42E-07	1.31E-06	1.77E-06	1.52E-06
Nb-94	5.62E-07	8.77E-07	1.18E-06	1.02E-06
Tc-98	1.27E-12	1.99E-12	2.67E-12	2.30E-12
Tc-99	8.91E-06	1.11E-05	1.73E-05	1.00E-05
Ru-106	4.59E-07	7.16E-07	9.62E-07	8.30E-07
Rh-102	4.25E-10	6.63E-10	8.92E-10	7.70E-10
Pd-107	8.15E-09	1.27E-08	1.71E-08	1.47E-08
Cd-113m	1.64E-06	2.56E-06	3.44E-06	2.97E-06
In-115	4.96E-17	7.75E-17	1.04E-16	8.99E-17
Sn-121m	3.30E-08	5.15E-08	6.92E-08	5.97E-08
Sn-126	2.03E-07	3.16E-07	4.25E-07	3.67E-07
Sb-125	6.36E-06	1.03E-05	1.36E-05	1.17E-05
Sb-126	2.84E-08	4.43E-08	5.95E-08	5.13E-08
Te-123	1.89E-19	2.95E-19	3.97E-19	3.42E-19
Te-125m	1.55E-06	2.42E-06	3.26E-06	2.81E-06
I-129	2.28E-08	4.07E-08	5.52E-08	4.76E-08
Cs-134	5.09E-06	1.52E-05	7.52E-06	3.11E-05
Cs-135	4.24E-07	6.61E-07	8.90E-07	7.67E-07
Cs-137	2.49E-02	2.09E-02	1.02E-02	3.85E-02
Ba-137m	2.35E-02	1.98E-02	9.68E-03	3.64E-02
La-138	9.42E-17	1.47E-16	1.98E-16	1.70E-16
Ce-142	1.47E-11	2.30E-11	3.09E-11	2.67E-11
Ce-144	3.09E-07	4.82E-07	6.49E-07	5.60E-07
Nd-144	7.93E-16	1.24E-15	1.66E-15	1.44E-15
Pm-146	2.51E-08	3.92E-08	5.27E-08	4.54E-08
Pm-147	8.40E-05	1.31E-04	1.76E-04	1.52E-04
Sm-146	1.36E-13	2.12E-13	2.85E-13	2.46E-13
Sm-147	3.63E-12	5.67E-12	7.62E-12	6.58E-12
Sm-148	1.87E-17	2.91E-17	3.92E-17	3.38E-17
Sm-149	1.66E-18	2.59E-18	3.48E-18	3.00E-18
Sm-151	1.66E-04	2.58E-04	3.47E-04	3.00E-04
Eu-152	1.24E-06	1.94E-06	2.60E-06	2.25E-06
Eu-154	4.41E-05	7.23E-05	3.67E-05	1.42E-04
Eu-155	8.10E-05	6.14E-05	2.09E-05	1.23E-04
Gd-152	7.01E-19	1.09E-18	1.47E-18	1.27E-18
Ho-166m	2.27E-11	3.54E-11	4.76E-11	4.11E-11
Co-60	3.93E-06	1.41E-05	7.51E-06	2.81E-05
Ni-63	2.34E-05	2.59E-05	3.31E-05	2.86E-05

To reduce the concentration of undissolved solids in WM-187 from that shown in Tables 20 and 21, one additional step could be added to the tank blending process. After the sequence described above, if Tank WM-187 were then filled to capacity (285,000 gal) with waste from WM-180, the undissolved solids would be reduced to a concentration of 34 g/liter. This would require a transfer of 104,600 gallons from WM-180 for the CMACT alternative or 134,400 gallons for the direct evaporation alternative.

2.6.3 Estimated Liquid Composition Range

The SBW treatment facility feed will vary in composition for two major reasons: the known variation in composition from tank to tank, and uncertainties in present sample analysis data and estimates of future waste composition and blending.

Variability in concentration for all chemical species is depicted graphically in Figure 1 for the four wastes fed to the co-processing alternatives. The farther away points are from the y-axis value of 1, the greater the variability for that specie. The feed variability data points are maximums and minimums of the ratios of the concentration of a particular specie in one of the four TFF tanks relative to the average concentration of that specie in all four tanks. The plot shows that many, but not all, species lie within the ±50% lines (0.5 to 1.5). The greatest variability is seen for Co^{+2}, As^{+5}, and V^{+5}. Variability shows a decrease with increasing concentration for species whose concentrations are greater than about 10^{-2} molar. Except for the few species whose concentrations are greater than about 0.5 molar, very few species show variability less that about ±20%.

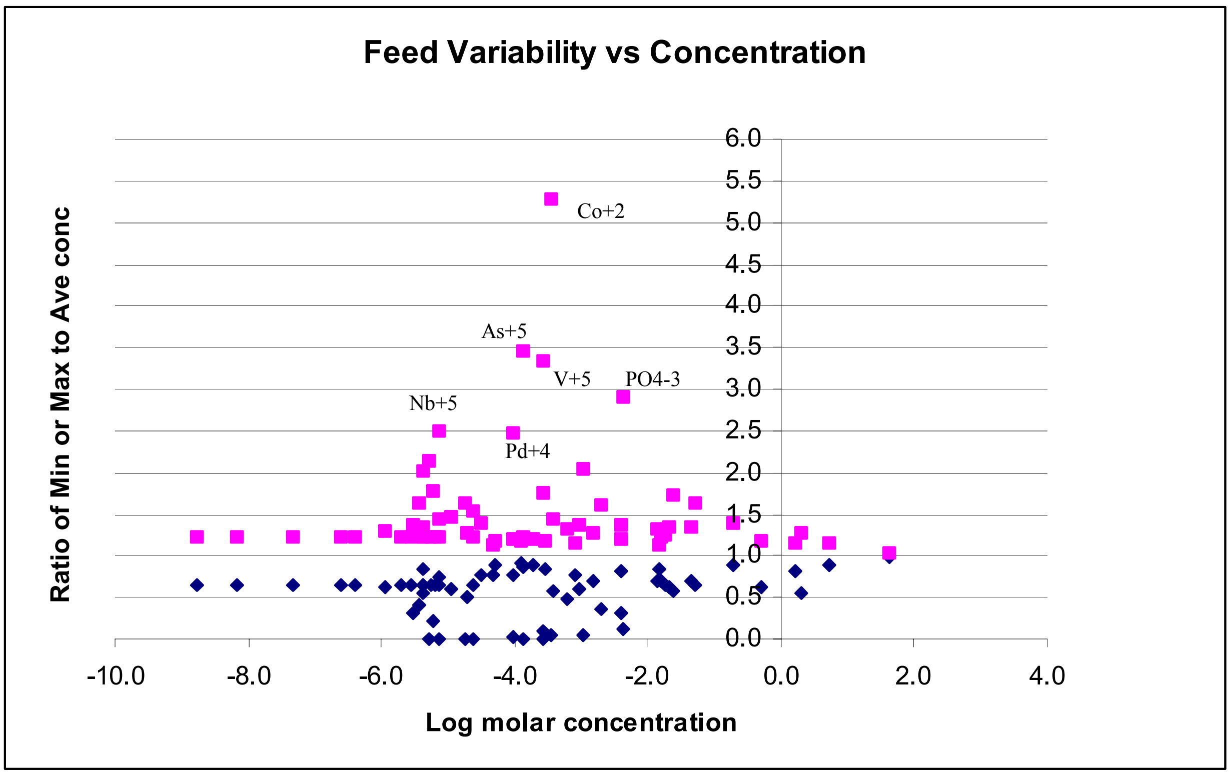

Figure 1. Feed variability versus concentration for co-processing feeds.

Various uncertainties will also result in potential feed composition variation, including (a) uncertainties in sample analyses data, (b) uncertainties in NGLW quantity and composition, (c) uncertainties in the amount of waste solids in the feed, (d) uncertainties in solids composition, and (e) potential changes in the tank mixing scenario. The first two of these uncertainties will affect the liquid composition, the second two affect the solids composition and the final uncertainty affects both liquid and solid composition. The magnitude of some of these uncertainties is known or can be estimated.

For recent analyses of Tank WM-189 and WM-188 samples, Batcheller[4] and Johnson[5] estimated analytical uncertainties to be 10% for most cations and 20 to 25% for Hg, Sb, Ce, Si and Te. Anion concentrations were determined by ion chromatography, a different method than that used for cation concentrations, and the uncertainty for anion species is expected to be larger but has not been quantified.

Batcheller[4] and Johnson[5] have also reported uncertainties in measured radionuclide concentrations. While the analytical uncertainties for many radionuclides are less than 20%, the uncertainty in uranium and plutonium isotopes ranges from 13 to100%. Typically, analyses of a tank waste sample are performed for only 15 to 25 isotopes. Concentrations of others are estimated. The uncertainty for these estimates is expected to be ±100%.

Approximately 5 to 8% of the total liquid feed is from NGLW. Although the uncertainty in generated waste composition is high, the effect of this uncertainty on the SBW treatment facility feeds will be low because of the high dilution of generated waste in SBW. Also, the NGLW compositional data that are available generally show that the composition of NGLW, when concentrated, is nearly identical to SBW composition. Thus deviations from historical analyses will likely still fall within the range of SBW compositions. Finally, since NGLW itself is a blend of several dozen different waste streams, compositional variations in a few of the streams will have only a small effect on the composition of the final concentrated blend.

The effects of uncertainties in solids quantity and composition, and changes in the tank mixing scenario, on the combined feed composition are discussed in Section 3.2. Table 22 shows estimated liquid composition ranges for both CsIX and solids co-processing treatment alternatives. The range of composition shown in Table 22 is the maximum and minimum composition of the different tank wastes, adjusted by the factor shown in the "Basis" columns. The adjustments were made only to account for analytical uncertainty and adjustment factors are mostly based on analytical uncertainties reported by Batcheller[4] and Johnson.[5] For species not detected, the minimum adjustment factor was set to –100% and the maximum factor at 0, i.e., no change to the maximum reported concentration, which is a detection limit. For species in which the concentration was estimated, adjustment factors of ±100% were used. Compositions shown in Table 22 are treatment facility feed compositions, and include a dilution from steam in transferring the waste from the Tank Farm to the treatment facility.

Table 22. Liquid waste composition ranges.

	Basis		CsIX		CMACT, SR, DE	
	Min %	Max %	Min Mol/liter	Max Mol/liter	Min Mol/liter	Max Mol/liter
H+	-6	6	1.0E+00	2.9E+00	1.0E+00	2.6E+00
Al+3	-10	10	4.8E-01	7.4E-01	2.8E-01	6.6E-01
Am+4	-15	15	2.5E-08	7.4E-08	2.5E-08	6.4E-08
Sb+5	-22	22	2.7E-08	8.7E-06	2.7E-08	1.3E-05
As+5	-100	0	0	4.5E-04	0	4.5E-04
Ba+2	-10	10	4.4E-05	6.8E-05	3.5E-05	6.1E-05
Be+2	-10	10	6.3E-06	2.1E-05	6.3E-06	1.8E-05

Table 22. (Continued).

	Basis		CsIX		CMACT, SR, DE	
	Min	Max	Min	Min	Max	Min
	%	%	Mol/liter	Mol/liter	Mol/liter	Mol/liter
Br-	-100	100	0	6.8E-07	0	5.9E-07
Cd+2	-10	10	6.4E-04	4.1E-03	6.4E-04	3.6E-03
Ca+2	-10	10	3.3E-02	7.6E-02	2.8E-02	6.7E-02
Ce+4	-20	20	2.1E-05	5.1E-05	1.9E-05	5.1E-05
Cs+	-10	10	8.5E-06	3.0E-05	8.5E-06	2.6E-05
Cl-	-50	50	9.8E-03	4.3E-02	6.7E-03	4.3E-02
Cr+3	-10	10	3.0E-03	5.9E-03	3.0E-03	5.3E-03
Co+2	-10	10	1.6E-05	7.6E-05	1.6E-05	2.2E-03
Cu+2	-10	10	5.6E-04	1.0E-03	2.5E-04	8.7E-04
Eu+3	-10	10	2.3E-07	6.2E-07	2.3E-07	5.3E-07
F-	-50	50	6.5E-03	6.0E-02	6.8E-03	6.0E-02
Gd+3	-10	10	1.2E-04	1.7E-04	9.6E-05	1.7E-04
Ge+4	-100	100	0	2.0E-08	0	1.7E-08
In+3	-100	100	0	3.5E-06	0	3.0E-06
I-	-100	100	0	5.6E-06	0	4.9E-06
Fe+3	-10	10	1.6E-02	2.8E-02	1.1E-02	2.5E-02
La+3	-100	100	0	2.0E-05	0	1.8E-05
Pb+2	-10	10	8.4E-04	1.4E-03	5.0E-04	1.4E-03
Li+	-10	10	2.5E-04	4.0E-04	2.3E-04	3.8E-04
Mg+2	-10	10	9.7E-03	2.3E-02	9.7E-03	2.1E-02
Mn+4	-10	10	1.1E-02	2.0E-02	1.1E-02	2.1E-02
Hg+2	-10	10	1.2E-03	6.8E-03	1.2E-03	6.1E-03
Mo+6	-10	10	1.6E-04	2.9E-04	1.6E-04	2.6E-04
Nd+3	-100	100	0	6.6E-05	0	5.7E-05
Np+4	-10	10	2.3E-06	9.5E-06	2.1E-06	9.5E-06
Ni+2	-10	10	1.2E-03	2.4E-03	9.6E-04	2.2E-03
Nb+5	-100	0	0	2.3E-05	0	1.8E-05
NO3-	-5	5	4.7E+00	7.5E+00	4.6E+00	6.7E+00
Pd+4	-100	0	0	3.0E-04	0	2.3E-04
PO4-3	-50	50	1.9E-04	1.8E-02	2.8E-04	1.8E-02
Pu+4	-25	25	2.8E-06	6.9E-06	2.5E-06	6.9E-06
K+	-10	10	1.6E-01	3.6E-01	1.6E-01	3.0E-01
Pr+4	-100	100	0	1.9E-05	0	1.6E-05
Rh+4	-100	100	0	8.0E-06	0	6.9E-06
Rb+	-100	100	0	1.2E-05	0	1.1E-05
Ru+3	-100	100	0	3.3E-04	0	2.9E-04
Sm+3	-100	100	0	1.2E-05	0	1.1E-05
Se+4	100	0	1.6E-06	9.9E-06	2.6E-06	1.1E-05
Si+4	-25	25	2.2E-07	7.1E-04	2.2E-07	6.0E-04
Ag+	-10	10	5.6E-08	4.6E-06	8.5E-07	4.6E-06
Na+	-10	10	1.2E+00	2.1E+00	1.2E+00	2.1E+00
Sr+2	-10	10	6.9E-05	1.5E-04	6.6E-05	1.3E-04
SO4-2	-50	50	1.3E-02	1.5E-01	1.7E-02	1.3E-01
Tc+7	-10	10	4.8E-06	1.4E-05	4.8E-06	1.1E-05
Te+4	-25	25	1.1E-06	8.6E-06	1.1E-06	7.3E-06

Table 22 (Continued).

	Basis		CsIX		CMACT, SR, DE	
	Min	Max	Min	Min	Max	Min
	%	%	Mol/liter	Mol/liter	Mol/liter	Mol/liter
Th+4	-100	100	0	6.6E-05	0	5.8E-05
Sn+4	-12	12	5.3E-08	4.4E-05	5.3E-08	3.9E-05
Ti+4	-10	10	4.5E-05	7.6E-05	4.1E-05	6.7E-05
U+4	-10	10	3.0E-04	7.0E-04	1.9E-04	5.9E-04
V+5	-10	10	1.9E-05	9.6E-04	2.3E-05	9.6E-04
Y+3	-100	100	0	1.5E-05	0	1.3E-05
Zn+2	-10	10	6.9E-04	1.1E-03	5.6E-04	1.0E-03
Zr+4	-10	10	5.1E-05	2.7E-03	5.1E-05	2.4E-03
H2O	-5	5	3.8E+01	4.7E+01	4.0E+01	4.7E+01
			Ci/liter	Ci/liter	Ci/liter	Ci/liter
	%	%	(Jan, 2003)	(Jan, 2003)	(Jan, 2003)	(Jan, 2003)
Ra-226	-100	100	0	2.0E-11	0	1.7E-11
Ac-227	-100	100	0	9.4E-11	0	8.0E-11
Th-228	-100	100	0	7.8E-09	0	6.6E-09
Th-230	-100	100	0	2.0E-09	0	1.7E-09
Th-232	-100	100	0	1.7E-15	0	1.5E-15
Pa-231	-100	100	0	2.2E-10	0	1.8E-10
Pa-233	-100	100	0	7.1E-06	0	6.1E-06
U-232	-100	100	0	4.8E-09	0	4.1E-09
U-233	-100	100	0	1.9E-10	0	1.7E-10
U-234	-20	20	8.1E-07	2.0E-06	7.9E-07	1.7E-06
U-235	-85	85	5.6E-09	1.7E-07	5.6E-09	1.4E-07
U-236	-75	75	1.0E-08	1.3E-07	9.8E-09	1.1E-07
U-237	-100	100	0	1.6E-08	0	1.3E-08
U-238	-100	100	0	8.3E-08	0	6.8E-08
Np-236	-100	100	0	7.4E-12	0	6.4E-12
Np-237	-8	8	3.9E-07	1.6E-06	3.6E-07	1.6E-06
Pu-236	-100	100	0	6.6E-09	0	5.7E-09
Pu-238	-25	25	2.8E-04	6.8E-04	2.8E-04	6.8E-04
Pu-239	-25	25	3.2E-05	9.8E-05	3.1E-05	9.8E-05
Pu-240	-100	100	0	2.5E-05	0	2.1E-05
Pu-241	-30	30	9.1E-05	5.9E-04	9.1E-05	5.9E-04
Pu-242	-100	100	0	1.9E-08	0	1.7E-08
Pu-244	-100	100	0	1.6E-15	0	1.3E-15
Am-241	-15	15	4.5E-05	8.0E-05	4.1E-05	7.7E-05
Am-242m	-100	100	0	3.8E-08	0	3.2E-08
Am-243	-100	100	0	5.4E-08	0	4.6E-08
Cm-242	-75	75	1.5E-09	7.3E-08	1.5E-09	6.1E-08
Cm-243	-100	100	0	6.9E-08	0	5.9E-08
Cm-244	-20	20	7.0E-07	1.2E-06	6.2E-07	1.1E-06
Cm-245	-100	100	0	7.2E-10	0	6.2E-10
Cm-246	-100	100	0	4.8E-11	0	4.1E-11
H-3	-20	20	7.3E-06	2.1E-05	7.3E-06	2.1E-05
Be-10	-100	100	0	7.3E-12	0	6.2E-12

Table 22 (Continued).

	Basis		CsIX		CMACT, SR, DE	
	Min	Max	Min	Min	Max	Min
	%	%	Ci/liter	Ci/liter	Ci/liter	Ci/liter
Se-79	-100	100	0	1.1E-06	0	9.0E-07
Rb-87	-100	100	0	7.1E-11	0	6.1E-11
Sr-90	-10	10	1.7E-02	5.0E-02	1.7E-02	4.3E-02
Y-90	-10	10	1.7E-02	5.0E-02	1.7E-02	4.3E-02
Zr-93	-100	100	0	5.4E-06	0	4.6E-06
Nb-93m	-100	100	0	4.1E-06	0	3.5E-06
Nb-94	-100	0	0	1.4E-06	0	1.2E-06
Tc-98	-100	100	0	6.3E-12	0	5.3E-12
Tc-99	-10	10	8.0E-06	2.3E-05	8.0E-06	1.9E-05
Ru-106	-100	100	0	2.3E-06	0	1.9E-06
Rh-102	-100	100	0	2.1E-09	0	1.8E-09
Pd-107	-100	100	0	4.0E-08	0	3.4E-08
Cd-113m	-100	100	0	8.1E-06	0	6.9E-06
In-115	-100	100	0	2.4E-16	0	2.1E-16
Sn-121m	-100	100	0	1.6E-07	0	1.4E-07
Sn-126	-100	100	0	1.0E-06	0	8.5E-07
Sb-125	-100	0	0	1.6E-05	0	1.4E-05
Sb-126	-100	100	0	1.4E-07	0	1.2E-07
Te-123	-100	100	0	9.3E-19	0	7.9E-19
Te-125m	-100	100	0	7.6E-06	0	6.5E-06
I-129	-100	0	0	6.5E-08	0	5.5E-08
Cs-134	-10	10	3.3E-06	4.2E-05	4.6E-06	3.4E-05
Cs-135	-10	10	3.8E-07	1.1E-06	3.8E-07	9.8E-07
Cs-137	-8	8	5.6E-03	5.1E-02	9.4E-03	4.2E-02
Ba-137m	-8	8	5.3E-03	4.9E-02	8.9E-03	3.9E-02
La-138	-100	100	0	4.6E-16	0	4.0E-16
Ce-142	-100	100	0	7.3E-11	0	6.2E-11
Ce-144	-100	100	0	1.5E-06	0	1.3E-06
Nd-144	-100	100	0	3.9E-15	0	3.3E-15
Pm-146	-100	100	0	1.2E-07	0	1.1E-07
Pm-147	-100	100	0	4.1E-04	0	3.5E-04
Sm-146	-100	100	0	6.7E-13	0	5.7E-13
Sm-147	-100	100	0	1.8E-11	0	1.5E-11
Sm-148	-100	100	0	9.2E-17	0	7.8E-17
Sm-149	-100	100	0	8.2E-18	0	7.0E-18
Sm-151	-100	100	0	8.1E-04	0	6.9E-04
Eu-152	-100	100	0	6.1E-06	0	5.2E-06
Eu-154	-10	10	1.8E-05	1.9E-04	3.3E-05	1.6E-04
Eu-155	-100	100	0	3.1E-04	0	2.5E-04
Gd-152	-100	100	0	3.4E-18	0	2.9E-18
Ho-166m	-100	100	0	1.1E-10	0	9.5E-11
Co-60	-100	5	0	3.6E-05	0	3.0E-05
Ni-63	-100	0	0	4.0E-05	0	3.3E-05

2.7 Organic Species in Sodium-bearing Waste

Estimated concentrations for total organic compounds (TOC) for various tank wastes are shown in Tables 3, 7, 9-16, 18, 20, and 21. This section provides additional information regarding organic species in SBW.

Recent analysis of samples of Tank WM-189 waste showed 0.092-0.3 mg/liter volatile organic compounds and 0.24-2.0 mg/liter semi-volatile organic compounds.[4] The volatile and semi-volatile compounds amount to only a very small fraction of the TOC in these samples, which was measured to be 513-625 mg/liter. Analysis of a Tank WM-188 sample showed volatile organics present at a concentration of 0.45 mg/liter, semi-volatile organics at a concentration of 0.45 mg/liter, and TOCs at 435 mg/liter.

Other samples of tank wastes have been analyzed for organic compounds. While these samples were from tanks that typically contained reprocessing wastes rather than SBW, the results may in general be applicable to SBW. This data is compiled in Table 23.

Additional analysis data is available for organic compounds in waste from Tanks WM-189 and WM-185 sampled in 1999 in the NWCF blend and hold cell tanks. Analyses were performed for 68 semivolatile species. No compounds were present at a concentration greater than detection limits.[30]

A recent study evaluated the destruction of 22 different volatile and 21 different semi-volatile organic compounds in simulated SBW.[31] The surrogate was prepared with nitric acid, aluminum sulfate, calcium chloride, iron sulfate, potassium fluoride and sodium sulfate. The spiked organic compounds represented a wide range of organic classes and functional groups. Concentrations of the organic species in the simulant were measured at intervals during a 32-day period. Some of the results of this study were:

- Except for chloromethane and bromomethane, levels of all volatile organic compounds (VOCS) decreased over time. The most volatile species rapidly decreased, sometimes to near 0% of the initial spike concentration, even prior to the Day 1 analysis. Lower volatility volatile organic compounds and those with higher water solubility (like acetone, methylisobutylketone, methylene chloride, and carbon disulfide) either decreased more slowly, or showed erratic results. However they nevertheless almost always decreased to 30% or less of the initial spike concentration after 32 days. All VOCs, even those species with slower or erratic depletion rates, would be expected to be highly depleted from the actual SBW that has been held in storage for many years and also exposed to 100^{o}C temperatures during evaporation processes. The increase in concentration seen for chloromethane and bromomethane was thought to be an artifact of the analysis method, as these compounds are products of reactions occurring on the carbon sorbent based trap used to separate the organics from the acid sample.

- Measured levels of semivolatile organic compounds (SVOCs) decreased more slowly, and in some cases were more erratic, than the VOCs. More reactive SVOCs, like those with double bonds (1,7-octadiene and hexachlorobutadiene) and phenyl groups (cresol, analine, and phenol) were rapidly depleted to a concentration near zero.

- More stable SVOCs like ethers (1,4-dioxane) and water-soluble species like pyridine were depleted more slowly to a relatively stable level, and may not be highly depleted even after long time durations. Levels of some other SVOCs (like nonanoic acid and the nitrophenols) were erratic, and suggest that either (a) in some samples, recovery of these more water-soluble compounds was poor, or (b) these compounds were being formed later in the longer-duration samples.

Table 23. Organic analyses of TFF samples

Tank	Compound	Concentration µg/liter	Validation Flag	Reference
WM-182	2,4-Dinitrophenol	260	J	7
WM-182	2,4-Dinitrophenol	66	J	7
WM-182	2,4-Dinitrophenol	52	J	7
WM-182	2-Butanone	10	J	7
WM-182	2-Butanone	9	J	7
WM-182	Acetone	110	J	7
WM-182	Acetone	230	E, J	7
WM-182	Acetone	120	J	7
WM-182	Acetone	110	J	7
WM-183	Acetone	49		7
WM-183	Arochlor-1260	2.8	J	7
WM-183	Arochlor-1260	2.5	J	7
WM-182	Benzene	5	J	7
WM-182	Benzene	11		7
WM-182	Benzene	84	J	7
WM-182	Bromomethane	98	J	7
WM-182	Chloroethane	8	J	7
WM-182	Chloromethane	34	J	7
WM-182	Chloromethane	220	J	7
WM-182	Chloromethane	530	E, J	7
WM-183	Chloromethane	42	J	7
WM-182	Ethylbenzene	4	J	7
WM-182	Ethylbenzene	3	J	7
WM-182	Xylene (total meta and para)	14	J	7
WM-182	N-nitrosodimethylamine	31	J	7
WM-182	N-nitrosodimethylamine	16	J	7
WM-182	Tri-n-butylphosphate	50	J	7
WM-188	Acetone	12	J	29
WM-188	Acetone	86		29
WM-185	Acetone	7.7	J	29
WM-185	Acetone	7.3	J	29
WM-188	Carbon disulfide	6	U	29
WM-188	Carbon disulfide	8	U	29
WM-185	Carbon disulfide	4.4	U	29
WM-185	Carbon disulfide	2	U	29
WM-188	2-Butanone	9	U	29
WM-188	2-Butanone	24	U	29
WM-185	2-Butanone	6.7	U	29
WM-185	2-Butanone	6.4	U	29
WM-188	1,1,1-Trichloroethane	3	U	29
WM-188	1,1,1-Trichloroethane	8	U	29
WM-185	1,1,1-Trichloroethane	2.2	U	29
WM-185	1,1,1-Trichloroethane	1	U	29
WM-188	Carbon tetrachloride	3	U	29
WM-188	Carbon tetrachloride	4	U	29
WM-185	Carbon tetrachloride	2.2	U	29

Table 23. (Continued.)

Tank	Compound	Concentration µg/liter	Validation Flag	Reference
WM-188	Benzene	4.6	U	29
WM-188	Benzene	8	U	29
WM-185	Benzene	2.2	U	29
WM-185	Benzene	1	U	29
WM-188	4-Methyl-2-pentanone	9	U	29
WM-188	4-Methyl-2-pentanone	20	U	29
WM-185	4-Methyl-2-pentanone	6.7	U	29
WM-185	4-Methyl-2-pentanone	3	U	29
WM-188	Toluene	3	U	29
WM-188	Toluene	12	U	29
WM-185	Toluene	2.2	U	29
WM-185	Toluene	1	U	29
WM-188	Xylene (total meta and para)	3	U	29
WM-188	Xylene (total meta and para)	4	U	29
WM-185	Xylene (total meta and para)	2.2	U	29
WM-185	Xylene (total meta and para)	1	U	29
WM-188	Xylene (ortho)	3	U	29
WM-188	Xylene (ortho)	8	U	29
WM-185	Xylene (ortho)	2.2	U	29
WM-185	Xylene (ortho)	1	U	29
WM-188	Triphenylester phosphoric acid	61	J, N	29
WM-188	Unknown phthalates	1600	J	29
WM-188	Unknown semi-volatiles	6500	J	29
WM-185	Unknown semi-volatiles	1100	J, B	29
WM-189	Organomercury compound	62	J	29
WM-188	Pyridine	26	E	29
WM-185	Pyridine	160	E	29
WM-188	Phenol	10	U	29
WM-185	Phenol	10	U	29
WM-188	2-Nitropyridine	520	J, N	29
WM-188	Dinitrobenzene	30	J	29
WM-185	Dinitrobenzene	55	J	29
WM-188	Chlorinated dinitrobenzene	32	J	29
WM-188	Bis (2-ethylhexyl) phthalate	38	J, N, B	29
WM-188	Bis (2-ethylhexyl) phthalate	41	J, N	29
WM-189	Dibutyl phthalate	200	J, N	29
WM-185	Diethyl phthalate	44	J, N	29
WM-188	Butylated hydoxytoluene	18	J, N	29
WM-188	Tributyl phosphate	12	J, N	29
WM-185	Tributyl phosphate	58	J, N, B	29
WM-185	Diisopropyl ether	36	J, N	29
WM-185	Dimethyl sulfone	33	J	29
WM-185	Benzylquinoline	500	J	29

[a] U = not detected; J = estimated; N = tentatively identified; B = compound associated with blank; E = concentration exceeds calibration range.

- The VOC gas chromatography/mass spectrometer scans were evaluated to find any tentatively identified compounds that were not included in the spike compounds and that could have been reaction products of the spiked VOCs. No tentatively identified compounds were detected in appreciable amounts. Even if some reactions of spiked VOCs resulted in reaction products, these products were either (a) volatilized, or (b) too water-soluble to efficiently extract from the aqueous media to be detected.

- Some SVOC tentatively identified compounds were detected in the SVOC scans and suggest that nitration, oxidation, and chlorination reactions occurred in the samples and could occur in the SBW during storage.

2.8 Liquid SBW Properties

Densities of the tank wastes are given in Table 18; densities for feeds to co-processing alternatives are given in Table 20.

The viscosity of Tank WM-189 liquid was measured at 1.94 cP (30.2°C, 60 rpm),[4] and WM-188 liquid 1.81 cP.[5] These viscosity values are consistent with measurements[28] of samples from other tanks:

WM-180	2.2 cP
WM-181	1.8 cP
WM-182	1.3 cP
WM-186	1.8 cP.

Solids in samples from the above tanks were allowed to settle prior to withdrawing a portion of the liquid for the viscosity measurements.[28]

In Reference 4, Batcheller reports and discusses viscosity data for the WM-189 bottom sample as received. This sample contained about 9 g/liter UDS. At 60 rpm (73.4 sec^{-1} shear rate) the viscosity was 2.6 cP, while at 30 rpm (36.7 sec^{-1} shear rate) the viscosity was 2.1 cP.

Viscosity measurements for tank slurries with higher solids fractions are discussed in Section 3.3.

3. TANK SOLIDS

Undissolved solids are present in Tank Farm tanks that will need to be processed either together with the liquid waste or separately. Solids from Tanks WM-182 and WM-183 have been flushed to WM-187. Solids from four other tanks (WM-181, WM-184, WM-185 and WM-186) are scheduled to be flushed to WM-187 by the middle of FY-2005. Estimates of the quantity, composition and properties of tank solids are given in the following sections. These estimates are needed at this time to provide a basis for SBW treatment design activities. Additional sampling and analysis of tank solids in future years will provide additional solids data to confirm and improve the estimates presented here.

3.1 Tank Solids Quantity

Light Duty Utility Arm (LDUA) video evidence of the height of tank sludge layers, along with measurement of sludge samples from these tanks provides good estimates of solids quantities for three tanks. Tank WM-188 was sampled using the LDUA in 1998;[6] and WM-182 and WM-183 in 2000.[8] Based on the videos, the sludge layers in Tanks WM-188, WM-182, and WM-183 were estimated to be 0.25-inch, 4 inches and 8 inches respectively. Using the history on each tank as a guide, and measurements from WM-183 samples that showed the sludge was approximately 25 vol % solids and that the solids had a particle density of 2 kg/liter, Poloski estimated sludge volumes[8] and Tyson[9] estimated the corresponding mass of solids in each tank in the Tank Farm. These sludge volume and mass estimates, shown in Table 24, have been widely used since they were developed for SBW treatment studies,[23, 25] the SBW Waste Incidental to Reprocessing (WIR) evaluation,[9] and the basis for the radiological source term for Tank Farm safety analyses.[21]

Table 24. Estimated solids quantities based on LDUA samples and videos,[6, 8, 9]

Tank	Sludge Height (in.)	Sludge on Walls (equiv. in.)	Total Sludge (equiv. in.)	Total Solids (kg)
WM-180 (like WM-182)	4.00	0.50	4.5	10,452
WM-181 (like WM-182)	4.00	0.50	4.5	10,452
WM-182	4.00	0.50	4.5	10,452
WM-183	8.00	0.50	8.5	19,743
WM-184 (like WM-182)	4.00	0.50	4.5	10,452
WM-185 (like WM-182)	4.00	0.50	4.5	10,452
WM-186 (like WM-182)	4.00	0.50	4.5	10,452
WM-187 (like WM-188)	0.25	0.25	0.5	1,161
WM-188	0.25	0.25	0.5	1,161
WM-189 (like WM-188)	0.25	0.25	0.5	1,161
Total	32.75	4.25	37.0	85,941

Since the estimates listed in Table 24 were made the following has occurred: (1) waste from Tanks WM-181, WM-184, WM-186 and WM-185 has been evaporated to heel level and the concentrate added to Tanks WM-188 and WM-189, (2) Tanks WM-189 and WM-188 have been sampled, and (3) solids in Tanks WM-182 and WM-183 have been flushed to WM-187. During evaporation of waste from Tank WM-186, as the waste was lowered to about the 15,000 gallon level, severe plugging problems were experienced in instrument probes and some other lines.[22] Evaporation of waste from Tanks WM-181 and WM-185, in addition to WM-186, was stopped when high undissolved solids caused plugging in instrument probes.[b] The heel level of each of these three tanks when processing by evaporation was stopped was between 13,000 and 23,000 gallons. Since the estimates of sludge volume shown in Table 24 for these tanks are only about 5,000 gallons each, the solids seen in the evaporator probes suggest that there may be more solids in these tanks than originally estimated.

In March 2002, a sample from near the bottom of Tank WM-189 was taken using an existing steam jet located approximately 2-inches off the tank bottom. The 165 ml sample was allowed to settle for 24 hours, at which time a sludge layer of approximately 22 ml was seen.[4] In contrast, undissolved solids from a sample taken by steam jet, ~3-inches off the bottom, from Tank WM-180 were measured to be only 0.23 g/liter. While a direct comparison of data from these two tank samples is difficult, it appears the WM-189 sample had considerably more solids than the WM-180 sample.

Additional samples of the heel in several tanks have been taken this year and will help resolve present uncertainties in the estimates of total tank solids. However, in light of the above indications that there could be more solids than originally estimated, the following estimates are proposed for the quantity of solids that will be present in the tanks at the commencement of SBW treatment.

	Expected	Maximum
WM-180	5,000 kg	10,000 kg
WM-188	5,000 kg	10,000 kg
WM-189	10,000 kg	20,000 kg
WM-187	100,000 kg	160,000 kg
Total	120,000 kg	200,000 kg

The bases for the above estimates are as follows:

- **WM-180**: The estimated maximum is consistent with the previous estimate (Table 24). The expected quantity is based on assuming 3-inches of sludge with an average solids content of 16-vol %[c] and a solids density of 2 g/cm^3.

- **WM-187**: The estimated maximum is based on the summing the volumes of heel presently in tanks that will be flushed to WM-187, and assuming a solids content of 25 vol % and a solids density of 2 g/cm^3. The expected quantity is based on the same volume of sludge and the assumption of 16 vol % solids[c] in the sludge.

- **WM-188 and WM-189**: When tank WM-188 was at heel level, LDUA videos showed very little (~1/4 inch) solids. WM-188 has since been filled with HLLWE concentrate. A sample from WM-189, which was filled with much the same evaporator concentrate, showed significantly more solids than a similar sample from WM-180. However, other high solids waste, i.e., NWCF flushes and off-gas scrub, were added to WM-189 and not to WM-188. Thus Tank WM-189 should have

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[b] Personal communication with Dan Griffith, October 23, 2002.

[c] A solids content of 16 vol % is based on the solids content of WM-183 heel in early 1997 and also the average of WM-183 LDUA sludge sample solids content (25 %) and WM-189 sludge solids content (~7%).

more solids than WM-180, and WM-188 likely has less solids than WM-189. For lack of additional data, the amount of solids WM-188 was assumed to be equal to that in WM-180 and the amount in WM-189 twice the amount in WM-180. The estimated expected amount of settled solids in WM-189 and the maximum amount in WM-188, 10,000 kg, is approximately equivalent to 20,000 gallons of sludge with a solids content of 7 vol % and a solids density of 2 g/cm^3.

3.2 Solids Composition

For SBW treatment facility design studies, solids compositions are needed for the solids contained in treatment facility feeds. For CsIX, in which solids must be processed separately, a relatively small amount of solids will be present in the SBW feeds from Tanks WM-180, WM-188 and WM-189. These entrained solids will be present in varying but small concentrations in the highly acidic SBW. In contrast, the waste feed from WM-187 will be received at the treatment facility in a dilute acid/salt solution and at a relatively high solids concentration. Solids that have settled to the bottom of Tanks WM-180, WM-188, and WM-189 would be flushed with water to the SBW Treatment Facility after the liquid has been removed. Specie concentrations of primary importance are cesium isotopes in the smallest particle size range. Other chemical species are of interest primarily to prepare adequate surrogates for equipment performance verification tests. Composition of the settled solids is needed primarily to ensure meeting transportation and disposal requirements for these solids in final waste form.

For treatment alternatives in which solids are co-processed with liquid SBW, solids from WM-187 will be mixed with the highly acidic waste in the other tanks prior to treatment. According to the present mixing scenario, the treatment facility will process waste from Tanks WM-188, WM-189, and WM-187 with solids of similar composition because the majority of the solids in each of these will have come from solids mixed in and transferred from WM-187. Solids in Tank WM-180 will be of lower concentration and of a somewhat different composition.

The following sections discuss results of tank solids analyses and suggest how to relate the analysis data to the solids in SBW Treatment Facility feeds.

Table 25 shows the results of analyses of samples taken by the LDUA from Tanks WM-182, WM-183, and WM-188.

Table 26 shows adjusted compositions for the solids in WM-182, WM-183, and WM-188. The following adjustments were made to estimate the solids composition without interstitial liquid, in charge balance and with radionuclide concentrations decayed to a common date.

- Contributions due to interstitial liquid were subtracted from the raw analytical results for Tanks WM-182 and WM-183. From mass and volume measurements made during drying the WM-183 LDUA sample, it was determined interstitial liquid accounted for 27.6 wt % of the dried solids sample. Analytical data for WM-183 liquid samples taken at the same time as the sludge sample was used to make this adjustment. The same fraction of interstitial liquid was assumed for the WM-182 sample, since no drying measurements were available. For a few species such as nitrate and ^{155}Eu, this subtraction gave negative concentrations, which were then changed to zero. However, for WM-188, the analysis report[6] documents that washing the solids repeatedly with 0.1 M nitric acid followed by centrifuging the sample showed no decrease in solids radionuclide concentrations based on gamma scans. Based on this result, no contribution due to interstitial liquid was made to the WM-188 analysis data.

- Weight fractions of oxide for each sample were calculated by charge balance.

Table 25. Analyses of solids samples from Tanks WM-182, WM-183, and WM-188.[6,8]

	WM-182 mg/kg	WM-183 mg/kg	WM-188 mg/kg		WM-182 mg/kg	WM-183 mg/kg	WM-188 mg/kg
Al^{+3}	21,880	24,911	35,406	Sr^{+2}	<9	11	
Sb^{+5}	<14	32	<34	SO_4^{-2}	33,240	13,647	
As^{+5}	281	56	351	S^{+6}	8,743	2,849	
Ba^{+2}	127	24	12,542	Tc^{+7}		0	
Be^{+2}	<1	<0.9 1	0.2	Tl^{+3}	<17	<14	<783
B^{+3}	150	182	<482	Sn^{+4}	4,072	1,466	
Cd^{+2}	325	142	1,189	Ti^{+4}	650	711	
Ca^{+2}	1,765	1,868	5,630	U^{+4}	<46	0.193	
Ce^{+4}	<21	20		V^{+5}	13	11	6
Cs^{+}	42	9	<128	Zn^{+2}	179	148	126
Cl^{-}	2,015	1,308		Zr^{+4}	101,470	34,867	70,600
Cr^{+3}	552	949	1,341	Total	437,827	486,039	165,675
Co^{+2}	<9	9	9	TOC			<1215
Cu^{+2}	298	166					
F^{-}	14,800	4,373					

	WM-182 mg/kg	WM-183 mg/kg	WM-188 mg/kg		WM-182 mCi/g (Jan, 2000)	WM-183 mCi/g (Jan, 2000)	WM-188 mCi/g (March, 1999)
Gd^{+3}	53	170					
Fe^{+3}	4,476	17,967	5,769	Am-241	8.46E-04	2.45E-04	2.11E-04
Pb^{+2}	369	274	647	Sb-125	5.77E-02	2.90E-03	1.12E-02
Li^{+}	6	4		Cs-134	6.64E-03	5.89E-04	7.97E-03
Mg^{+2}	410	434		Cs-137	4.24E-01[a]	8.68E-01	2.44E+00
Mn^{+4}	565	740	758	Co-60	2.14E-04		6.30E-04
Hg^{+2}	310	324	1,566	Cm-244	2.84E-06		
Mo^{+6}	2,495	694	2,770	Eu-154	1.48E-03	7.56E-04	5.43E-04
Ni^{+2}	309	417	427	I-129	<2.22E-07	<9.03E-08	<1.53E-03
Nb^{+5}	1,279	623	5,370	Np-237	1.68E-06	1.76E-06	2.85E-06
NO_3^{-}	70,720	174,955		Nb-95			3.68E-03
Pd^{+4}	5,766	1,444		Pu-238	1.93E-02	4.00E-03	7.56E-03
PO_4^{-3}	68,410	125,612		Pu-239	1.47E-03	1.25E-03	4.30E-04
P^{+5}	9,586	4,607	17,700	Sr-90	2.29E-01	1.82E-01	5.46E+00
K^{+}	7,050	10,900		Tc-99	2.63E-03	3.29E-05	4.49E-03
Ru^{+3}	829	2,126	<313	H-3	1.15E-05		
Se^{+4}	91	<13	<1,720	U-234	<2.40E-06	3.30E-06	<2.10E-05
Si^{+4}	43,920	35,344		U-235	2.61E-07	9.29E-08	1.97E-07
Ag^{+}	65	220	9	U-236	3.05E-07	<3.40E-08	<2.20E-07
Na^{+}	30,400	21,400		U-238	3.83E-08	6.91E-08	1.18E-07

[a] Concentration corrected based on reissued lab report

- The amount of hydrated water was assumed or calculated. The amount of hydrated water in the LDUA sample of WM-188 solids was measured by screening the solids, washing them with 0.1 molar HNO_3, then air drying, adding water to rehydrate the solids, and comparing the mass of rehydrated solids with the mass of dried solids. Three WM-188 samples gave results of 55.1%, 56.8%, and 59.1% water in the solids. The average of these values, 57%, was used for WM-188 solids. The amount of hydrated waster in WM-182 and WM-183 solids was assumed to be the average of the measured water in WM-188 solids (57%), and the measured hydrated water in WM-180 solids (25%).

Table 26. Adjusted solids composition of WM-182, WM-183 and WM-188.

	WM-182 Wt Frac	WM-183 Wt Frac	WM-188 Wt Frac		WM-182 Ci/kg	WM-183 Ci/kg	WM-188 Ci/kg
Al+3	1.56E-02	1.62E-02	3.63E-02	C-14	9.55E-10	1.99E-09	5.37E-09
Sb+5	2.09E-05	6.41E-05	3.44E-05	Ni-59	3.01E-05	6.27E-05	1.70E-04
As+5	4.20E-04	1.12E-04	3.60E-04	Ni-63	2.49E-04	5.17E-04	1.40E-03
Ba+2	1.82E-04	2.74E-05	1.29E-02	Se-79	3.44E-06	7.16E-06	1.93E-05
Be+2	1.67E-06	1.65E-06	2.33E-07	Sr-90	8.49E-03	6.75E-03	2.01E-01
B+3	1.25E-04	7.81E-05	4.94E-04	Y-90	8.49E-03	6.75E-03	2.01E-01
Cd+2	3.54E-04	5.00E-05	1.22E-03	Nb-94	8.87E-06	1.85E-05	3.68E-03
Ca+2	1.52E-03	6.94E-04	5.77E-03	Tc-99	7.50E-05	1.56E-04	4.21E-04
Ce+4	2.37E-05	2.25E-05		Ru-106	7.43E-06	1.55E-05	4.18E-05
Cs+	5.70E-05		1.31E-04	Rh-106	7.43E-06	1.55E-05	4.18E-05
Cl-	2.37E-03	1.80E-03	1.37E-03	Sn-126	3.25E-06	6.76E-06	1.83E-05
Cr+3	6.10E-04	6.14E-04	1.37E-03	Sb-125	3.18E-02	1.67E-03	4.29E-03
Co+2	1.20E-05	3.35E-06	8.89E-06	I-129	4.20E-07	8.75E-07	2.36E-06
Cu+2	4.16E-04	1.18E-04		Cs-134	2.33E-03	2.19E-04	1.72E-03
F-	2.08E-02	6.84E-03	5.49E-03	Cs-135	5.89E-06	1.23E-05	3.31E-05
Gd+3	3.00E-05	1.26E-05		Cs-137	3.34E-01	6.95E-01	1.88E+00
Fe+3	5.33E-03	3.11E-02	5.91E-03	Ba-137m	3.16E-01	6.57E-01	1.78E+00
Pb+2	3.94E-04	1.18E-04	6.64E-04	Ce-144	5.05E-06	1.05E-05	2.84E-05
Li+	6.84E-06	2.89E-06		Pr-144	5.05E-06	1.05E-05	2.84E-05
Mg+2	5.44E-04	3.02E-04		Pm-147	1.34E-03	2.78E-03	7.51E-03
Mn+4	3.40E-04	1.64E-04	7.77E-04	Sm-151	2.67E-03	5.55E-03	1.50E-02
Hg+2	9.13E-05		1.61E-03	Eu-152	1.15E-05	2.40E-05	6.49E-05
Mo+6	3.71E-03	1.26E-03	2.84E-03	Eu-154	7.20E-04	3.73E-04	2.35E-04
Ni+2	3.53E-04	2.00E-04	4.38E-04	Eu-155	7.54E-04	1.57E-03	4.24E-03
Nb+5	1.91E-03	1.26E-03	5.51E-03	Th-230	6.31E-09	1.31E-08	3.55E-08
Pd+4	8.64E-03	2.96E-03		U-232	1.28E-08	2.67E-08	7.22E-08
PO4-3	1.02E-01	2.57E-01	5.56E-02	U-233	2.21E-10	4.61E-10	1.25E-09
K+	6.18E-03	1.43E-02	1.17E-02	U-234	5.54E-06	2.94E-06	3.11E-05
Ru+3	1.23E-03	4.32E-03	3.21E-04	U-235	2.27E-07	1.51E-07	1.71E-07
Se+4	1.36E-04	2.54E-05	1.76E-03	U-236	2.65E-07	4.72E-07	1.28E-06
Si+4	6.57E-02	7.21E-02	3.92E-02	U-238	2.21E-08	3.62E-08	6.84E-08
Ag+	9.65E-05	4.50E-04	9.34E-06	Np-237	1.68E-06	1.76E-06	2.85E-06
Na+	2.37E-02	6.09E-03	3.51E-02	Pu-236	1.78E-08	3.71E-08	1.00E-07
Sr+2	5.73E-06			Pu-238	1.43E-02	2.95E-03	5.56E-03
SO4-2	4.64E-02	2.15E-02	1.45E-02	Pu-239	1.22E-03	1.04E-03	3.57E-04
Tl+3	2.44E-05	2.53E-05	8.03E-04	Pu-240	6.87E-05	1.43E-04	3.87E-04
Sn+4	6.10E-03	3.00E-03	2.86E-03	Pu-241	1.08E-02	2.22E-03	4.19E-03
Ti+4	9.71E-04	1.45E-03		Pu-242	5.18E-08	1.08E-07	2.91E-07
V+5		1.68E-05	6.25E-06	Pu-244	4.44E-15	9.25E-15	2.50E-14
Zn+2	2.22E-04	8.75E-05	1.29E-04	Am-241	6.52E-04	1.89E-04	1.39E-03
Zr+4	1.52E-01	7.11E-02	7.24E-02	Am-243	1.33E-07	2.77E-07	7.49E-07
				Cm-242	4.33E-10	9.02E-10	2.44E-09
O-2	1.21E-01	7.43E-02	1.12E-01	Cm-243	2.22E-07	4.62E-07	1.25E-06
H2O	4.10E-01	4.10E-01	5.70E-01	Cm-244	1.39E-05	2.90E-05	7.83E-05
				Cm-245	2.36E-09	4.90E-09	1.32E-08
Total	1.0000	1.0000	1.0000	Cm-246	1.53E-10	3.18E-10	8.59E-10
				Cm-247	1.72E-16	3.58E-16	9.67E-16

- Analysis of some of the major species expected in the solids was not performed for WM-188 due to an inadequate sample quantity. For these species, namely Cl, F, Si, Na, K, SO_4 and Sn, the average of measured concentrations in other tanks (WM-180, WM-181, WM-182, WM-183, and a later WM-188 sample) was assumed for WM-188.

- The resultant chemical concentrations were normalized.

- Concentrations of radionuclides not included in the sample analysis slate were estimated, based on Swenson.[21]

- Radionuclide concentrations were adjusted to a decay date of January 1, 2003.

Table 27 shows results of analyses of samples taken of Tank Farm waste transferred to the NWCF blend and hold cell for sampling. Tank WM-180 was sampled in June 2000; the tank was full of waste at the time of sampling. The solids were obtained from the waste sample by allowing two weeks for settling, drawing off liquid, and centrifuging the remaining sample. The solids were not washed but J. Christian, who reported WM-180 sample results,[3] states that approximately 4% of the weight of the dried solids was due to dissolved solids in interstitial liquid that crystallized during drying. The WM-180 analytical results shown in Table 27 are as reported by Garn.[35]

Tanks WM-181, WM-186 and WM-188 were sampled in 2003. Tanks WM-181 and WM-186 were at heel level when sampled, while WM-188 was about three-quarters full of liquid. Solids from each of these tanks were washed with water prior to analysis. The analysis of solids from the WM-186 sample is incomplete at this time and will be included in the next revision to this report. Some results of WM-186 solids characterization are included in Section 3.4.

Table 28 shows solids compositions after adjustments and additions were made to analytical results. Adjustments include calculating the oxide concentration by charge balance, normalizing chemical species concentrations after assuming hydrated water concentrations, and estimating concentrations of radionuclides which were not included in the analyses. For WM-180 solids, corrections were also made to delete contributions from interstitial liquid and to decay the radionuclide concentrations to January 1, 2003.

For WM-180, the value for hydrated solids shown in Table 28 was calculated by subtracting the sum of all other species from unity, and agrees well with the measured amount of mass lost during drying of the solids. Estimated radionuclide concentrations are shown in italics. Concentrations of radionuclides not measured in WM-180 and WM-181 solid were estimated based on WM-182 concentrations and ratios of known WM-180 radionuclides to the same species in WM-182. Radionuclide concentration estimates for the WM-188 NWCF sample were based on WM-188 LDUA concentrations. No decay adjustments were made for radionuclide concentrations for samples from Tanks WM-181, WM-186 and WM-188 since these tanks were all sampled in 2003. The concentration of hydrated water in WM-181 and WM-188 solids was assumed to be the same as in WM-182 and WM-183 solids.

Table 27. Analysis data for tank solids samples obtained through NWCF.

	WM-180 mg/kg	WM-181 mg/kg	WM-186 mg/kg	WM-188 Mg/kg		WM-180 mg/kg	WM-181 mg/kg	WM-186 mg/kg	WM-188 mg/kg
Al^{+3}	59,619	5,870		14,568	Sr^{+2}	23			14
Sb^{+5}	41	19		<9	SO_4^{-2}	9,220	3,974		10,787
As^{+5}	<10	36		<40	S^{+6}	5,199			3,711
Ba^{+2}	34	10		29	Tc^{+7}	0			
Be^{+2}	<2	0.23		<2	Tl^{+3}	*1,360*			50
B^{+3}	<520	49		413	Sn^{+4}	2,120	4,117		2,178
Cd^{+2}	183	61		216	Ti^{+4}	959			477
Ca^{+2}	4,427	449		2,396	U^{+4}	353			330
Ce^{+4}	44			<30	V^{+5}	*13*	*5*		12
Cs^{+}	524			<25	Zn^{+2}	200	27		73
Cl^{-}	909	1,110			Zr^{+4}	27,971	37,930		32,209
Cr^{+3}	692	241		621	Total	815,414	272,464		258,274
Co^{+2}	<15	<1		7	Radionuclides				
Cu^{+2}	139	41		55		mCi/g	mCi/g		mCi/g
F^{-}	93	2,165				(Oct 2000)	(2003)		(2003)
Gd^{+3}	84			25	Am-241	3.20E-04	1.49E-04		5.31E-04
Fe^{+3}	20,200	3,985		4,385	Sb-125	3.37E-03	2.45E-03		1.17E-02
Pb^{+2}	541	47		175	Cs-134	2.62E-04	3.37E-04		1.70E-03
Li^{+}	<160			<17	Cs-137	2.63E-01	2.43E-01		2.62E+00
Mg^{+2}	1,402	235		460	Co-60	3.59E-05	7.18E-05		7.75E-04
Mn^{+4}	1,618	116		579	Cm-244				1.70E-05
Hg^{+2}	<8,930	25			Eu-154	4.32E-04	2.07E-04		2.12E-03
Mo^{+6}	357	283		207	I-129				
Ni^{+2}	282	57		355	Np-237	3.41E-06	6.23E-07		6.41E-06
Nb^{+5}	<1,040			1,888	Nb-95	2.13E-04			
NO_3^{-}	455,000	645			Pu-238	8.76E-02	1.43E-02		2.45E-02
Pd^{+4}	<760			345	Pu-239	1.31E-02	1.42E-03		3.36E-03
PO_4^{-3}	37,000	197,980		25,428	Sr-90	6.24E-02			5.51E-02
P^{+5}	54,360			54,901	Tc-99	2.42E-05			2.23E-03
K^{+}	15,200	8,761		12,309	H-3				
Ru^{+3}	360			<803	U-234	4.49E-06	3.07E-06		1.18E-05
Se^{+4}	<1,280			<43	U-235	9.24E-08	2.15E-07		8.89E-07
Si^{+4}	20,920			52,601	U-236	1.74E-07	1.86E-07		
Ag^{+}	50	1,299		190	U-238	3.95E-08	2.26E-09		2.09E-07
Na^{+}	81,200	2,926		35,291					

The composition of solids shown in Table 28 for WM-180 is recommended for use in design of the CsIX process for UDS in Tank WM-180 waste, and the composition shown for WM-188 is recommended for Tanks WM-188 and WM-189 UDS.

Table 28. Adjusted compositions for solids in WM-180, WM-181, and WM-188.

Species	WM-180	WM-181	WM-188
	Weight %	Weight %	Weight %
Al^{+3}	4.81E+00	1.03E+00	2.35E+00
Sb^{+5}	3.29E-03	3.27E-03	4.69E-03
As^{+5}	5.85E-04	6.33E-03	6.47E-03
Ba^{+2}	2.80E-03	1.83E-03	4.69E-03
Be^{+2}	1.56E-04	4.06E-05	3.23E-04
B^{+3}	4.21E-02	8.60E-03	6.66E-02
Cd^{+2}	1.46E-02	1.07E-02	3.48E-02
Ca^{+2}	3.54E-01	7.87E-02	3.86E-01
Ce^{+4}	3.54E-03	5.06E-03	4.85E-03
Cs^{+}	4.31E-02	2.55E-02	4.04E-03
Cl^{-}	7.48E-02	1.94E-01	2.15E-01
Cr^{+3}	5.61E-02	4.22E-02	1.00E-01
Co^{+2}	1.23E-03	1.83E-04	1.13E-03
Cu^{+2}	1.12E-02	7.24E-03	8.89E-03
F^{-}	2.72E-03	3.79E-01	8.63E-01
Gd^{+3}	6.67E-03	1.45E-02	4.04E-03
Fe^{+3}	1.66E+00	6.98E-01	7.06E-01
Pb^{+2}	4.31E-02	8.20E-03	2.81E-02
Li^{+}	1.32E-02	8.18E-03	2.70E-03
Mg^{+2}	1.14E-01	4.12E-02	7.41E-02
Mn^{+4}	1.29E-01	2.03E-02	9.33E-02
Hg^{+2}	7.33E-01	4.42E-03	4.96E-02
Mo^{+6}	2.93E-02	4.96E-02	3.33E-02
Ni^{+2}	2.27E-02	1.01E-02	5.72E-02
Nb^{+5}	8.26E-01	3.64E-01	3.04E-01
NO_3^{-}	3.57E+01	1.13E-01	0
Pd^{+4}	6.26E-02	3.64E-01	5.56E-02
PO_4^{-3}	1.37E+01	3.47E+01	2.71E+01
K^{+}	1.21E+00	1.53E+00	1.98E+00
Ru^{+3}	2.96E-02	1.55E-01	1.29E-01
Se^{+4}	1.05E-01	1.10E-01	6.95E-03
Si^{+4}	1.72E+00	6.69E+00	8.47E+00
Ag^{+}	4.03E-03	2.28E-01	3.06E-02
Na^{+}	6.43E+00	5.13E-01	5.68E+00
Sr^{+2}	1.81E-03	2.49E-03	2.26E-03
SO_4^{-2}	1.25E+00	6.96E-01	1.74E+00
Tl^{+3}	1.12E-01	6.52E-04	8.10E-03
Sn^{+4}	1.75E-01	7.21E-01	3.51E-01
Ti^{+4}	7.89E-02	1.22E-01	7.68E-02
U^{+4}	2.86E-02	2.94E-02	5.32E-02
V^{+5}	8.23E-04	8.11E-04	1.94E-03
Zn^{+2}	1.61E-02	4.69E-03	1.18E-02
Zr^{+4}	2.30E+00	6.65E+00	5.19E+00
O^{-2}	3.01E+00	3.37E+00	2.69E+00
H_2O (Hydrate)	25	41	41
Total	100.00	100.00	100.00

Table 28 (continued)

Radionuclides	WM-180 Ci/kg (Jan, 2003)	WM-181 Ci/kg (Jan, 2003)	WM-188 Ci/kg (Jan, 2003)
C-14	*5.93E-10*	*6.96E-10*	*7.48E-09*
Co-60	9.53E-06	7.18E-05	7.75E-04
Ni-59	*1.87E-05*	*2.20E-05*	*2.36E-04*
Ni-63	*1.54E-04*	*1.81E-04*	*1.95E-03*
Se-79	*2.14E-06*	*2.51E-06*	*2.69E-05*
Sr-90	4.83E-02	*6.19E-03*	5.51E-02
Y-90	4.83E-02	*6.19E-03*	5.51E-02
Nb-94	*5.51E-06*	*6.46E-06*	*6.95E-05*
Tc-99	2.35E-05	*5.46E-05*	*2.23E-03*
Ru-106	*4.62E-06*	*5.42E-06*	*5.82E-05*
Rh-106	*4.62E-06*	*5.42E-06*	*5.82E-05*
Sn-126	*2.02E-06*	*2.37E-06*	*2.54E-05*
Sb-125	3.08E-04	2.45E-03	1.17E-02
I-129	*2.61E-07*	*3.06E-07*	*3.29E-06*
Cs-134	8.99E-06	3.37E-04	1.70E-03
Cs-135	*3.66E-06*	*4.29E-06*	*4.61E-05*
Cs-137	2.07E-01	2.43E-01	2.62E+00
Ba-137m	*1.96E-01*	*2.30E-01*	*2.47E+00*
Ce-144	*3.13E-06*	*3.68E-06*	*3.95E-05*
Pr-144	*3.13E-06*	*3.68E-06*	*3.95E-05*
Pm-147	*8.30E-04*	*9.74E-04*	*1.05E-02*
Sm-151	*1.66E-03*	*1.94E-03*	*2.09E-02*
Eu-152	*3.14E-06*	*3.32E-06*	*6.89E-05*
Eu-154	1.96E-04	2.07E-04	2.12E-03
Eu-155	*2.05E-04*	*2.17E-04*	*4.50E-03*
Th-230	*4.91E-09*	*3.50E-09*	*2.71E-08*
U-232	*1.13E-08*	*7.41E-09*	*7.25E-08*
U-233	*1.94E-10*	*1.28E-10*	*1.25E-09*
U-234	4.31E-06	3.07E-06	1.18E-05
U-235	8.88E-08	2.15E-07	8.89E-07
U-236	1.67E-07	1.86E-07	1.35E-06
U-238	3.79E-08	2.26E-09	2.09E-07
Np-237	3.37E-06	6.23E-07	6.41E-06
Pu-236	*1.45E-07*	*1.93E-08*	*7.97E-08*
Pu-238	8.09E-02	1.43E-02	2.45E-02
Pu-239	1.30E-02	1.42E-03	3.36E-03
Pu-240	*5.60E-04*	*7.44E-05*	*3.07E-04*
Pu-241	*8.79E-02*	1.17E-02	1.89E-02
Pu-242	*4.22E-07*	5.61E-08	2.32E-07
Pu-244	*3.62E-14*	*4.81E-15*	*1.99E-14*
Am-241	*3.08E-04*	1.49E-04	5.31E-04
Am-243	*6.29E-08*	*3.04E-08*	*2.59E-07*
Cm-242	*1.47E-09*	*2.75E-10*	*5.29E-10*
Cm-243	*7.52E-07*	*1.41E-07*	*2.71E-07*
Cm-244	*4.71E-05*	*8.82E-06*	1.70E-05

Table 28 (continued)

	WM-180 Ci/kg	WM-181 Ci/kg	WM-188 Ci/kg
Cm-245	*7.97E-09*	*1.49E-09*	*2.88E-09*
Cm-246	*5.17E-10*	*9.68E-11*	*1.87E-10*
Cm-247	*5.81E-16*	*1.09E-16*	*2.10E-16*

Table 29 shows the expected composition of solids collected in Tank WM-187 that would be fed to the CsIX process. An estimated composition range for these solids is also shown in Table 29. The expected composition was calculated based on estimated relative fractions of solids from source tanks, i.e., WM-181, WM-182, WM-183, WM-184, WM-185, WM-186, and WM-187. Solids compositions for five of these seven tanks are known. The composition of the solids for the other two were assumed to be equivalent to WM-182, which contained waste of the most similar liquid chemistry. LDUA sampling provided data from which the quantities of solids transferred from WM-182 and WM-183 to WM-187 were estimated. The balance of solids expected to be in WM-187 was proportioned between the different source tanks based on tank heel volumes. Radionuclide concentration shown in Table 29 have been decayed to January, 2003.

Uncertainties in the composition of WM-187 include (a) analytical uncertainties in solids analysis, (b) uncertainties in the total quantity of solids that will be contained in WM-187, (c) uncertainties in the relative fractions of solids from the different source tanks, (d) the possibility that the compositions of unsampled tank solids differ from the composition assumed for that particular tank, (e) potential precipitation or dissolution reactions that generate or consume solids when new wastes are added to Tank WM-187, and (f) nonhomogeneity of solids in a tank causing the sample to be non-representative.

As per Batcheller[4] and Johnson,[5] the analytical uncertainty is 10% for most cations, ~25% for a few cations, and higher for anions and some radionuclides. The uncertainty in the final mass of solids that will be collected in WM-187 will affect the combined solid/liquid composition, but will not affect the solids composition except as it affects the relative fraction of solids from different source tanks. To estimate the magnitude of the uncertainties (c) and (d), ten solids compositions were calculated assuming a 50% increase in solids from each source tank (5 cases) and replacement of the assumed composition for Tank WM-184 and WM-185 solids with that of a different tank (5 more cases). The composition range shown in Table 29 is the minimum and maximum concentrations of these 10 theoretical cases, adjusted to include analytical uncertainty. The analytical uncertainties were taken from solids analysis of a WM-189 sample.[4] Uncertainty (e), that of precipitation or dissolution reactions, was assumed to have a negligible effect on solids composition based on the fact that all tanks will be washed with water, thus creating a very dilute acid and salt solution both in the wash slurry and WM-187. Finally, no data is available to determine the homogeneity of sampling by either the LDUA or steam jets. This uncertainty is assumed small relative to those included in the calculation of WM-187 solids composition range.

For solids co-processing treatment alternatives, mixing pumps will be installed in Tanks WM-187, WM-188, and WM-189, and waste transfers will be made prior to processing to more uniformly distribute solids between these tanks. Both of these operations – mixing and blending – will reduce the feed variability seen by the treatment facility. However, the blending step provides an additional source of uncertainty in estimating the solids composition at the present time. The uncertainty in blending is that either more or less solids are transferred between two tanks than predicted because of either a greater or lesser volume transferred than currently estimated or because of a different solids concentration in the waste than currently estimated. On the high side, both of these possibilities should be covered by the assumption of 50% more solids in any given tank.

Table 29. WM-187 solids expected composition and range.

	Expected	Range			Expected	Range	
	Wt %	Min, Wt %	Max, Wt %		Wt %	Min, Wt %	Max, Wt %
Al+3	1.32E+00	1.1E+00	2.2E+00	Mo+6	1.64E-01	8.4E-02	2.0E-01
Sb+5	3.54E-03	0	4.4E-03	Ni+2	2.04E-02	1.4E-02	2.7E-02
As+5	1.84E-02	0	2.0E-02	Nb+5	2.63E-01	2.2E-01	4.3E-01
Ba+2	7.11E-03	3.2E-03	3.1E-01	NO3-	5.44E-02	4.8E-02	7.8E+00
Be+2	1.07E-04	7.0E-05	1.5E-04	Pd+4	5.02E-01	0	5.3E-01
B+3	1.03E-02	8.4E-03	2.4E-02	PO4-3	2.53E+01	1.9E+01	3.6E+01
Cd+2	1.75E-02	1.0E-02	3.9E-02	K+	1.23E+00	1.1E+00	1.7E+00
Ca+2	1.03E-01	7.8E-02	2.1E-01	Ru+3	1.99E-01	0	5.3E-01
Ce+4	3.67E-03	0	4.2E-03	Se+4	5.79E-02	0	9.1E-02
Cs+	1.41E-02	1.2E-02	2.4E-02	Si+4	6.78E+00	5.2E+00	7.9E+00
Cl-	2.05E-01	8.6E-02	3.1E-01	Ag+	1.22E-01	8.0E-02	2.2E-01
Cr+3	5.24E-02	4.4E-02	7.5E-02	Na+	1.17E+00	7.1E-01	2.2E+00
Co+2	5.37E-04	3.0E-04	6.4E-04	Sr+2	1.40E-03	1.2E-03	2.0E-03
Cu+2	1.88E-02	9.2E-03	2.2E-02	SO4-2	2.22E+00	1.1E+00	2.9E+00
F-	9.72E-01	2.7E-01	1.6E+00	Tl+3	1.35E-03	0	2.4E-02
Gd+3	8.23E-03	6.8E-03	1.2E-02	Sn+4	6.00E-01	4.6E-01	6.8E-01
Fe+3	1.12E+00	9.7E-01	1.8E+00	Ti+4	1.19E-01	8.9E-02	1.4E-01
Pb+2	1.88E-02	1.1E-02	2.7E-02	U+4	1.60E-02	1.1E-02	3.4E-02
Li+	4.24E-03	3.4E-03	7.8E-03	V+5	7.45E-04	6.2E-04	1.3E-03
Mg+2	4.35E-02	2.9E-02	6.1E-02	Zn+2	1.10E-02	6.7E-03	1.3E-02
Mn+4	2.46E-02	1.9E-02	4.9E-02	Zr+4	9.36E+00	6.0E+00	1.1E+01
Hg+2	5.53E-03	3.3E-03	1.7E-01	O-2	6.87E+00	4.4E+00	8.0E+00
	Ci/kg	Ci/kg	Ci/kg	H2O	4.10E+01	3.4E+01	4.9E+01
C-14	1.02E-09	0	1.2E-09		Ci/kg	Ci/kg	Ci/kg
Co-60	3.46E-05	2.9E-05	5.4E-05	Eu-155	6.47E-04	0	1.6E-03
Ni-59	3.23E-05	0	3.9E-05	Th-230	6.22E-09	0	1.5E-08
Ni-63	2.66E-04	0	3.2E-04	U-232	1.28E-08	0	3.1E-08
Se-79	3.68E-06	0	8.9E-06	U-233	2.21E-10	0	5.4E-10
Sr-90	6.94E-03	4.7E-03	1.7E-02	U-234	3.77E-06	2.1E-06	4.7E-06
Y-90	6.94E-03	4.7E-03	1.7E-02	U-235	2.04E-07	7.8E-08	3.1E-07
Nb-94	9.49E-06	6.14E-06	1.4E-05	U-236	2.65E-07	1.4E-07	4.1E-07
Tc-99	8.02E-05	5.8E-05	1.1E-04	U-238	1.51E-08	2.11E-09	3.3E-08
Ru-106	7.96E-06	0	1.9E-05	Np-237	1.17E-06	7.7E-07	1.6E-06
Rh-106	7.96E-06	0	1.9E-05	Pu-236	2.21E-08	0	9.7E-08
Sn-126	3.48E-06	0	8.4E-06	Pu-238	1.19E-02	7.6E-03	2.9E-02
Sb-125	1.14E-02	0	1.3E-02	Pu-239	1.27E-03	8.6E-04	4.2E-03
I-129	4.50E-07	0	5.4E-07	Pu-240	8.53E-05	0	3.7E-04
Cs-134	9.27E-04	4.0E-04	1.1E-03	Pu-241	9.41E-03	6.5E-03	2.8E-02
Cs-135	6.30E-06	4.6E-06	8.4E-06	Pu-242	6.43E-08	0	2.8E-07
Cs-137	3.57E-01	2.6E-01	4.7E-01	Pu-244	5.51E-15	0	2.4E-14
Ba-137m	3.38E-01	2.5E-01	4.5E-01	Am-241	3.11E-04	1.5E-04	3.8E-04
Ce-144	5.40E-06	0	1.3E-05	Am-243	1.10E-07	0	2.8E-07
Pr-144	5.40E-06	0	1.3E-05	Cm-242	4.44E-10	8.9E-11	1.1E-09
Pm-147	1.43E-03	0	3.5E-03	Cm-243	2.28E-07	0	6.7E-07
Sm-151	2.85E-03	0	6.9E-03	Cm-244	1.43E-05	9.1E-06	2.5E-05
Eu-152	9.90E-06	0	2.5E-05	Cm-245	2.41E-09	0	7.1E-09

Table 30 shows the expected and range of solids compositions for the co-processing alternatives. Expected compositions are shown for each of the three tanks in which solids and SBW will be blended. The range shown is intended to be valid for all three tanks. Using the WM-187 range shown in Table 29, low and high concentrations were calculated for each of the three tanks after mixing. The low values of the range shown in Table 30 are minimum values for the three tanks, while the high values are maximums for the three tanks. Uncertainty due to tank transfers is neglected for reasons discussed above and uncertainty in initial WM-188 and WM-189 solids is neglected because of the small quantities of these solids relative to the quantity of WM-187 solids.

Table 30. Estimated tank solids composition and composition range after blending.

	WM-187 Expected	WM-188 Expected	WM-189 Expected	Range	
				Low	High
	Wt %	Wt %	Wt %	Wt %	Wt %
Al^{+3}	1.38E+00	1.46E+00	1.45E+00	1.2E+00	2.2E+00
Sb^{+5}	3.60E-03	3.69E-03	3.68E-03	2.4E-04	4.5E-03
As^{+5}	1.77E-02	1.67E-02	1.69E-02	3.3E-04	1.9E-02
Ba^{+2}	6.99E-03	6.78E-03	6.81E-03	3.3E-03	2.9E-01
Be^{+2}	1.18E-04	1.37E-04	1.34E-04	8.3E-05	1.8E-04
B^{+3}	1.32E-02	1.80E-02	1.74E-02	1.1E-02	2.9E-02
Cd^{+2}	1.84E-02	1.98E-02	1.96E-02	1.1E-02	3.9E-02
Ca^{+2}	1.18E-01	1.42E-01	1.39E-01	9.3E-02	2.3E-01
Ce^{+4}	3.73E-03	3.83E-03	3.82E-03	2.5E-04	4.3E-03
Cs^{+}	1.36E-02	1.27E-02	1.29E-02	1.0E-02	2.3E-02
Cl^{-}	2.06E-01	2.07E-01	2.06E-01	9.2E-02	3.1E-01
Cr^{+3}	5.49E-02	5.90E-02	5.84E-02	4.7E-02	7.8E-02
Co^{+2}	5.68E-04	6.19E-04	6.12E-04	3.4E-04	7.1E-04
Cu^{+2}	1.83E-02	1.74E-02	1.76E-02	9.2E-03	2.2E-02
F^{-}	9.67E-01	9.57E-01	9.59E-01	3.0E-01	1.5E+00
Gd^{+3}	8.01E-03	7.65E-03	7.70E-03	6.3E-03	1.1E-02
Fe^{+3}	1.10E+00	1.06E+00	1.07E+00	9.2E-01	1.8E+00
Pb^{+2}	1.93E-02	2.01E-02	2.00E-02	1.2E-02	2.7E-02
Li^{+}	4.16E-03	4.03E-03	4.05E-03	3.3E-03	7.6E-03
Mg^{+2}	4.50E-02	4.77E-02	4.73E-02	3.1E-02	6.3E-02
Mn^{+4}	2.81E-02	3.40E-02	3.32E-02	2.3E-02	5.5E-02
Hg^{+2}	7.78E-03	1.16E-02	1.10E-02	5.6E-03	1.6E-01
Mo^{+6}	1.57E-01	1.46E-01	1.48E-01	7.5E-02	1.9E-01
Ni^{+2}	2.22E-02	2.54E-02	2.50E-02	1.6E-02	3.1E-02
Nb^{+5}	2.65E-01	2.69E-01	2.68E-01	2.3E-01	4.3E-01
NO_3^{-}	5.17E-02	4.70E-02	4.76E-02	4.0E-02	7.4E+00
Pd^{+4}	4.79E-01	4.41E-01	4.46E-01	2.8E-03	5.0E-01
PO_4^{-3}	2.54E+01	2.55E+01	2.55E+01	2.0E+01	3.6E+01
K^{+}	1.27E+00	1.34E+00	1.33E+00	1.1E+00	1.7E+00
Ru^{+3}	1.96E-01	1.90E-01	1.91E-01	6.6E-03	5.1E-01
Se^{+4}	5.53E-02	5.10E-02	5.16E-02	3.5E-04	8.7E-02
Si^{+4}	6.86E+00	7.01E+00	6.99E+00	5.4E+00	8.0E+00
Ag^{+}	1.17E-01	1.09E-01	1.10E-01	7.1E-02	2.1E-01
Na^{+}	1.40E+00	1.78E+00	1.73E+00	9.6E-01	2.7E+00
Sr^{+2}	1.45E-03	1.52E-03	1.51E-03	1.2E-03	2.0E-03
SO_4^{-2}	2.19E+00	2.15E+00	2.16E+00	1.2E+00	2.8E+00
Tl^{+3}					

Table 30. (Continued)

	WM-187 Expected	WM-188 Expected	WM-189 Expected	Range Low	Range High
	Wt %	Wt %	Wt %	Wt %	Wt %
Sn^{+4}	5.87E-01	5.66E-01	5.68E-01	4.4E-01	6.7E-01
Ti^{+4}	1.16E-01	1.13E-01	1.13E-01	8.7E-02	1.4E-01
U^{+4}	1.79E-02	2.11E-02	2.07E-02	1.3E-02	3.6E-02
V^{+5}	8.06E-04	9.08E-04	8.94E-04	6.9E-04	1.4E-03
Zn^{+2}	1.10E-02	1.11E-02	1.11E-02	6.9E-03	1.3E-02
Zr^{+4}	9.15E+00	8.79E+00	8.84E+00	5.9E+00	1.0E+01
O^{-2}	6.66E+00	6.30E+00	6.35E+00	4.1E+00	7.7E+00
H2O	4.10E+01	4.10E+01	4.10E+01	3.4E+01	4.8E+01
Radionuclides	Ci/kg (Jan, 2003)	Ci/kg (Jan, 2003)	Ci/kg (Jan, 2003)	Ci/kg (Jan, 2003)	Ci/kg (Jan, 2003)
C-14	1.02E-09	9.92E-10	9.96E-10	3.8E-11	1.2E-09
Co-60	3.77E-05	4.12E-05	4.08E-05	3.2E-05	5.9E-05
Ni-59	3.21E-05	3.13E-05	3.14E-05	1.2E-06	3.8E-05
Ni-63	2.65E-04	2.58E-04	2.59E-04	9.9E-06	3.2E-04
Se-79	3.66E-06	3.57E-06	3.59E-06	1.4E-07	8.6E-06
Sr-90	1.00E-02	1.41E-02	1.35E-02	8.9E-03	2.4E-02
Y-90	1.00E-02	1.41E-02	1.35E-02	8.9E-03	2.4E-02
Nb-94	9.44E-06	9.21E-06	9.24E-06	7.1E-06	1.3E-05
Tc-99	8.99E-05	1.02E-04	1.00E-04	7.3E-05	1.4E-04
Ru-106	7.91E-06	7.72E-06	7.75E-06	3.0E-07	1.9E-05
Rh-106	7.91E-06	7.72E-06	7.75E-06	3.0E-07	1.9E-05
Sn-126	3.46E-06	3.38E-06	3.39E-06	1.3E-07	8.2E-06
Sb-125	1.09E-02	9.99E-03	1.01E-02	6.0E-05	1.2E-02
I-129	4.47E-07	4.37E-07	4.38E-07	1.7E-08	5.4E-07
Cs-134	8.90E-04	8.25E-04	8.34E-04	3.6E-04	1.1E-03
Cs-135	6.27E-06	6.12E-06	6.14E-06	5.2E-06	8.2E-06
Cs-137	3.55E-01	3.47E-01	3.48E-01	2.9E-01	4.7E-01
Ba-137m	3.36E-01	3.28E-01	3.29E-01	2.8E-01	4.4E-01
Ce-144	5.37E-06	5.24E-06	5.26E-06	2.0E-07	1.3E-05
Pr-144	5.37E-06	5.24E-06	5.26E-06	2.0E-07	1.3E-05
Pm-147	1.42E-03	1.39E-03	1.39E-03	5.3E-05	3.4E-03
Sm-151	2.84E-03	2.77E-03	2.78E-03	1.1E-04	6.7E-03
Eu-152	9.82E-06	9.56E-06	9.59E-06	3.5E-07	2.4E-05
Eu-154	3.89E-04	3.73E-04	3.75E-04	2.5E-04	4.5E-04
Eu-155	6.42E-04	6.24E-04	6.27E-04	2.3E-05	1.6E-03
Th-230	6.07E-09	5.77E-09	5.81E-09	1.4E-10	1.5E-08
U-232	1.26E-08	1.21E-08	1.22E-08	3.7E-10	3.0E-08
U-233	2.17E-10	2.09E-10	2.10E-10	6.4E-12	5.2E-10
U-234	3.65E-06	3.43E-06	3.46E-06	2.1E-06	4.5E-06
U-235	1.99E-07	1.89E-07	1.90E-07	8.8E-08	3.0E-07
U-236	2.60E-07	2.48E-07	2.50E-07	1.5E-07	4.0E-07
U-238	1.56E-08	1.61E-08	1.60E-08	3.2E-09	3.3E-08
Np-237	1.15E-06	1.10E-06	1.11E-06	8.5E-07	1.6E-06
Pu-236	2.15E-08	2.03E-08	2.04E-08	4.1E-10	9.2E-08
Pu-238	1.15E-02	1.06E-02	1.08E-02	7.1E-03	2.8E-02

Table 30. (Continued)

	WM-187 Expected Ci/kg	WM-188 Expected Ci/kg	WM-189 Expected Ci/kg	Range Low Ci/kg	Range Expected Ci/kg
Pu-240	8.29E-05	7.81E-05	7.88E-05	1.6E-06	3.6E-04
Pu-241	9.04E-03	8.40E-03	8.49E-03	5.9E-03	2.6E-02
Pu-242	6.25E-08	5.89E-08	5.94E-08	1.2E-09	2.7E-07
Pu-244	5.36E-15	5.05E-15	5.09E-15	1.0E-16	2.3E-14
Am-241	2.98E-04	2.76E-04	2.79E-04	1.4E-04	3.7E-04
Am-243	1.06E-07	9.92E-08	1.00E-07	1.3E-09	2.7E-07
Cm-242	4.25E-10	3.91E-10	3.96E-10	8.5E-11	1.1E-09
Cm-243	2.18E-07	2.01E-07	2.03E-07	1.4E-09	6.4E-07
Cm-244	1.36E-05	1.26E-05	1.27E-05	8.0E-06	2.4E-05
Cm-245	2.31E-09	2.13E-09	2.15E-09	1.5E-11	6.8E-09
Cm-246	1.50E-10	1.38E-10	1.39E-10	9.5E-13	4.4E-10
Cm-247	1.69E-16	1.55E-16	1.57E-16	1.1E-18	5.0E-16

In summary, Table 31 shows tank solids compositions are recommended for use in design studies.

Table 31. Tank solid compositions recommended for use in design studies.

CsIX Alternative		Recommended Composition
Feeds to liquid processing		
1	Solids in WM-180 liquid	Table 28, WM-180
2	Solids in WM-188 liquid	Table 28, WM-188
3	Solids in WM-189 liquid	Table 28, WM-188
Feeds to solids processing		
4	Solids in WM-187 slurry	Table 29
5	Slurried filter cake from liquid processing	Calculated from #1-3
6	Solids in flushes from WM-180	Table 28, WM-180
7	Solids in flushes from WM-188	Table 28, WM-188
8	Solids in flushes from WM-189	Table 28, WM-188
CMACT, Direct Evaporation and Steam Reforming Alternatives		Recommended Composition
9	Solids in WM-180 liquid	Table 28
10	Mixed solids from blended waste from WM-187	Table 30
11	Mixed solids from blended waste from WM-188	Table 30
12	Mixed solids from blended waste from WM-189	Table 30

3.3 Solids Properties

Poloski[12] reports that the particle density of air-dried solids from the WM-183 LDUA sample was measured to be 1.88 g/ml. Using measurements of the sludge sample mass, volume and percent water for the same tank sample, a solids particle density of 1.98 g/ml can be derived. These values are commonly rounded to a bulk density of 2.0 g/ml for dried tank solids.

Particle size distributions (PSD) are reported for WM-180 solids by Christian,[3] for WM-182 and WM-183 solids by Poloski,[8] for WM-189 solids by Batcheller,[4] for WM-188 solids by Johnson,[5] and for WM-181 solids by Johnson.[10] The WM-180 solid particles were normally distributed between 2 and 65 µm, with the center of the distribution at 10 µm.[4] PSDs for WM-182 and WM-183 sonicated solids show median particle sizes of 8 µm and 12 µm respectively. Without sonification, the WM-182 and WM-183 solids size distributions are shifted to larger particle sizes.[8] Particle sizes for the WM-189 sludge sample ranged from 0.5 to 100 µm with a peak at approximately 20 µm.[4] A comparison of particle size distribution for solids from WM-180, WM-182 (without sonification), WM-183 (without sonification) and WM-189, as reported by Batcheller,[4] is shown in Figure 2. WM-188 particles, without sonification, were distributed between 0.5 and 60 µm, with the average size 4 µm.[5] WM-181 particles were distributed between 0.5 and 30 µm, with the average size about 9 µm.[10]

Poloski[8] also reports settling rate data for solids in the WM-182 LDUA sample. To obtain a settling rate, a sample was shaken, and photographs were taken as the solids settled. From the photographs, the height of the solids layer was measured. Results are shown in Table 32..

Table 32. Settling rates for WM-182 solids.

Time, min	Percent settled	Interface velocity, mm/hr
20	8	-
38	12	9.2
78	21	7.4
122	28	5.4
138	30	5.2
152	31	4.9

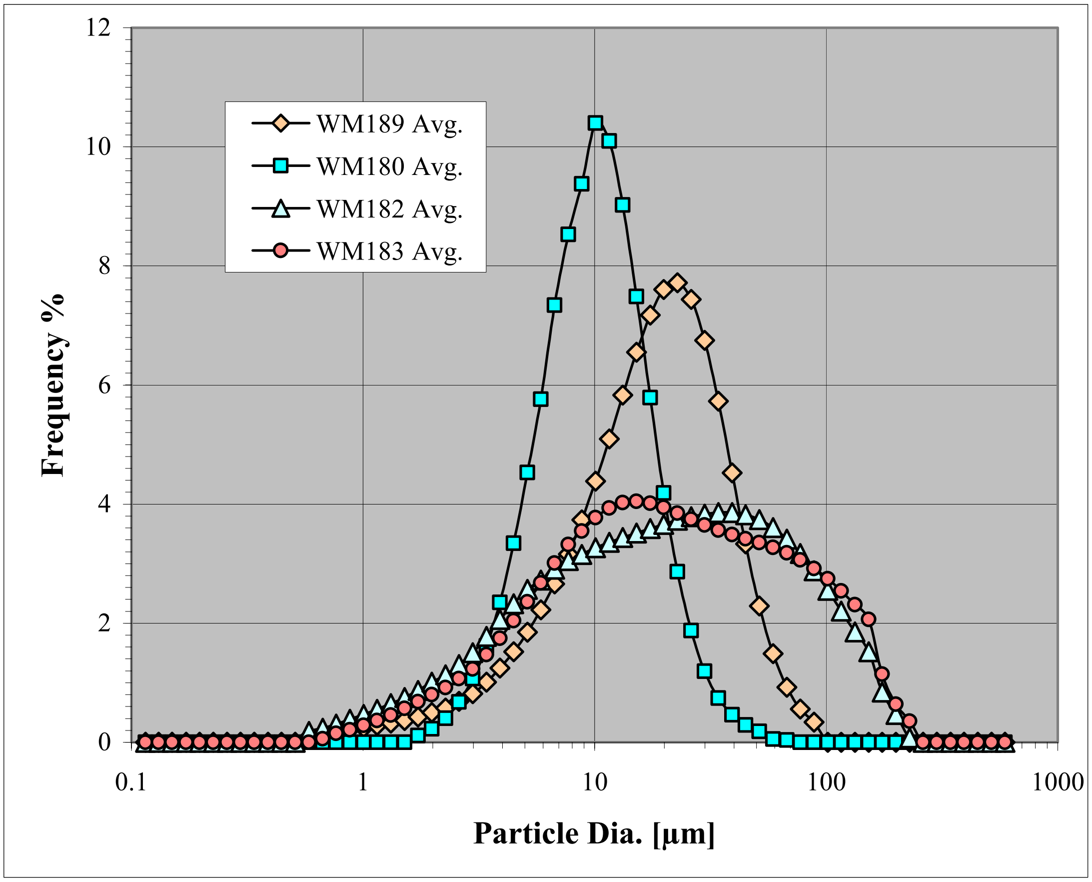

Figure 2. Comparison of WM-189, WM-180, WM-182, and WM-183 solids particle size distribution analyses under non-sonicated condition (from Reference 4).

Johnson reports settling rates of solids from samples of waste in Tanks WM-182, WM-188 and WM-189, and a graphical comparison, taken from his report,[5] is shown in Figure 3. Additional settling data, for WM-181 solids, is given in Reference 10. Batcheller[4] discusses possible differences between the WM-182 and WM-189 sludge samples that could cause the different settling rates, and concludes that the primary factor contributing to the different settling rate of the two samples is the higher "sludge loading" of the WM-182 sample. The sludge in the WM-189 sample amounted to about 16% of the sample, whereas the sludge in the WM-182 sample was approximately 60%. Batcheller also notes that the WM-182 solids were dark and nearly opaque, while the WM-189 solids were light gray in color and fairly translucent. Solids from Tank WM-188 took 8 days to settle completely, compared to 2 hours for solids in the WM-189 sample,[5] and 48 hours for solids from WM-181.[10]

Viscosity measurements were made on both the settled WM-182 sludge and the same sludge diluted with an equal volume of demineralized water. Poloski fit the data to the following flow curves:

Undiluted WM-182 sludge:
Shear stress, dyne/cm^2 = 7.25 x (shear rate, sec^{-1})$^{0.619}$ $R^2 = 0.997$

Diluted WM-182 sludge:
Shear stress, dyne/cm^2 = 10.25 x (shear rate, sec^{-1})$^{0.218}$ $R^2 = 0.988$

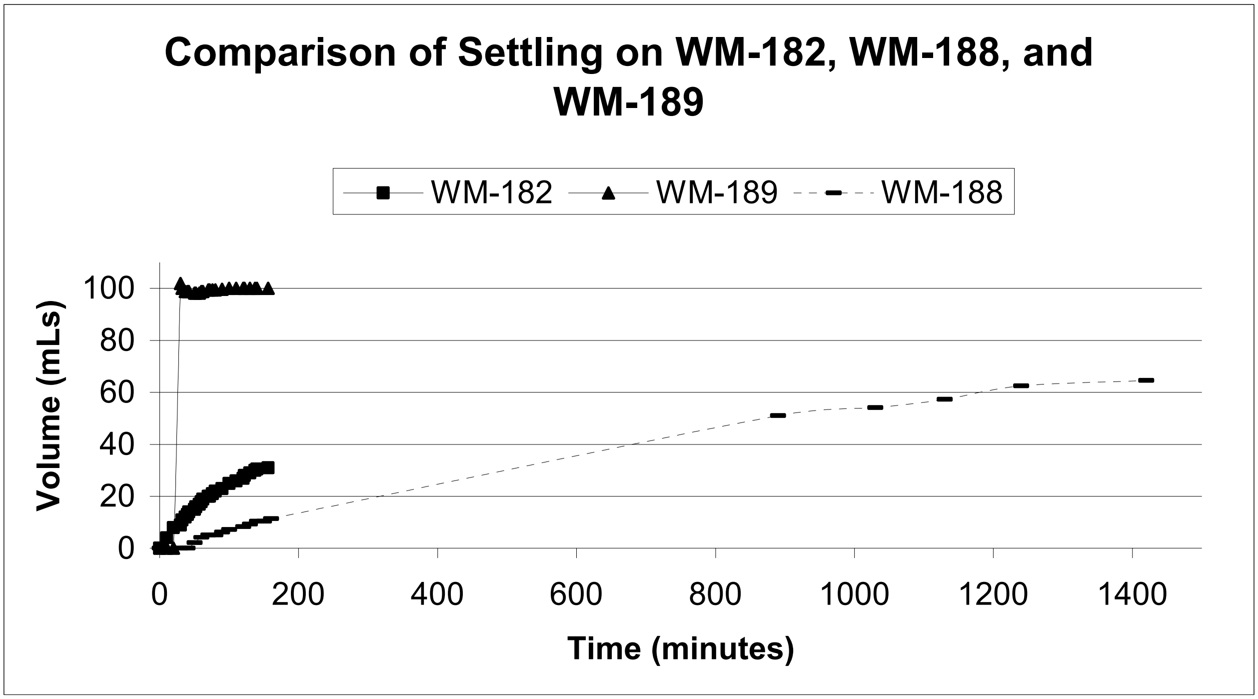

Figure 3. WM-189 and WM-182 relative volume % settled sludge vs. settling time.

The viscosity of WM-182 undiluted sludge was approximately 200 cP,[24] WM-182 sludge diluted with an equal volume of water about 50 cP,[24] WM-189 sludge 3.5 cP,[4] WM-188 sludge 5.5 cP,[5] and WM-181 sludge 2.76 cP at 28.3^{o}C and 60 rpm.[10] Based on the viscosity measurements of WM-189 "as received" sample and sludge, Batcheller[4] recommended that sludge viscosity measurements be performed using instrumentation with at least 500 reciprocal seconds shear rate in order to obtain accurate values. The maximum shear rate of the instrument used WM-189 viscosity measurements was 79 sec^{-1}.

Harbour et al[15] used the chemical and particle size distribution data from WM-182 and WM-183 LDUA samples to prepare simulants of INEEL tank solids and then measured shear stress versus shear rate for the prepared slurries. One simulant was prepared with water as the liquid, another with 0.4 molar nitric acid. Shear stress versus shear rate curves for these two simulants are shown in Figures 4 and 5.

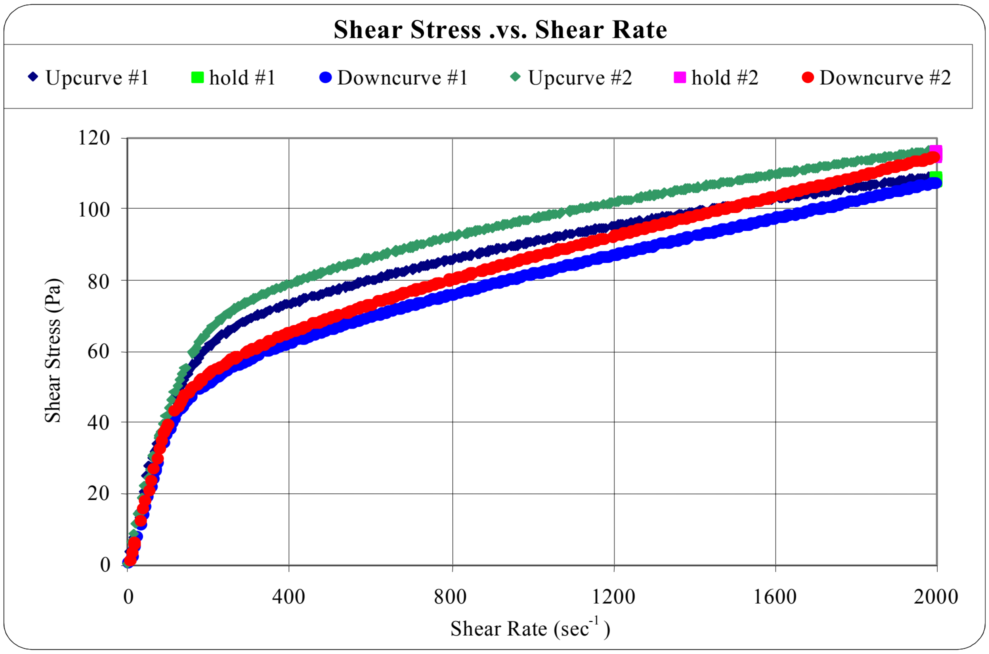

Figure 4. Shear Stress versus Shear Rate; solids in water

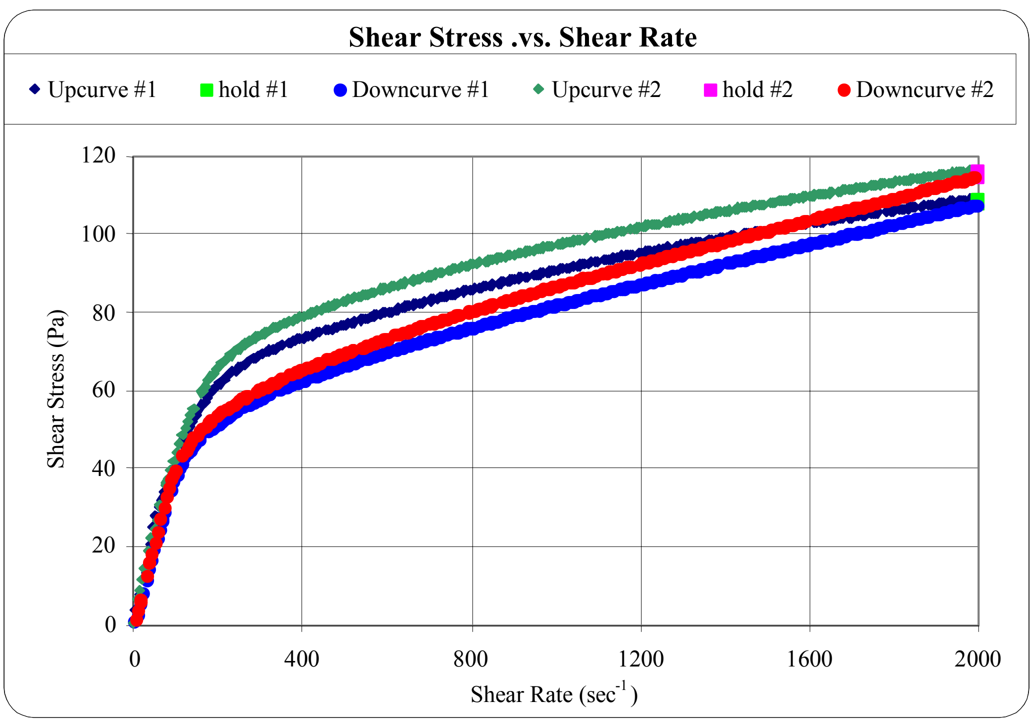

Figure 5. Shear Stress versus Shear Rate; Solids in 0.4 molar nitric acid.

3.4 FY 2003 Solids Simulant Development

3.4.1 Introduction

3.4.1.1 Objective

The objective of FY 2003 simulant development was to develop simulants for the solids contained in the INTEC Tank Farm storage tanks. These simulants will subsequently be needed in various tests to demonstrate technologies suitable for moving the solids between tanks, removing solids from the tanks, and various technologies that could be used to treat the waste. Consequently, a further objective is to develop simulants with chemical and physical properties that emulate those properties of the Tank Farm solids which will be of interest in the tests.

3.4.1.2 Background

The INEEL historically reprocessed fuels from nuclear reactors. The wastes resulting from reprocessing were liquids that were then stored in underground storage tanks at the INTEC Tank Farm. Over the active reprocessing years, solids were introduced into the tanks, as about 1.5% of the fuel did not dissolve. The liquids were subject to evaporative processes, which reduced their volume and increased the concentrations of the solution components; which led to the formation of additional solids. The liquid reprocessing waste was ultimately removed from the tanks leaving behind solids that had settled to the bottom of the tanks. Subsequent activities at INTEC resulted in the generation of additional liquid radioactive wastes, some with high solids content or actual solids carried along with the liquid, which were sent through the evaporators and routinely sent to the Tank Farm tanks. Consequently, solids were carried into the tanks and others formed in the tanks.

A significant effort is underway to determine the best means to remove the solids from the Tank Farm tanks and process the solids to reduce their volume and convert them to a form suitable for transporting and them and also for long-term storage. Some of the tanks have been sampled and analyses run to determine the physico-chemical properties of the contents, as well as to determine the volume of material that must be processed. The results-to-date are largely qualitative, but nonetheless quite informative. Analyses show that about two-thirds or more of the elements on the Periodic Chart are present in determinable quantities in the tank samples, the solids are amorphous, and the liquids and solids are substantially radioactive. These three conditions make it difficult to understand the physical and chemical behavior of the solids in sufficient detail and certainty to move ahead with treating them. That is, the solids are a complex amorphous mixture of hazardous and radioactive elements, ions, salts, and minerals, which are difficult to analyze, test, and handle.

3.4.1.3 Scope

The scope of work pursued in FY 2003 was two-fold. The first was to provide a solid simulant that could be used in various tests of treatment technologies to evaluate its performance. The second was to analyze the Tank Farm solids more extensively. This latter part of the scope is, similarly, two-fold in nature. First, it provides better information that is used to improve the solid simulant formulation, and second, it gives us insight that will be useful in predicting the solids behavior under conditions that have not been rigorously tested.

3.4.2 Rationale and Methodology

3.4.2.1 Simulant Development and Preparation

The tank sludge is a complex mixture of unknowns. The small size of the particles, the conditions under which the sludge was formed, and the large variety of elements present make duplicating the sludge a difficult and uncertain task. The Savannah River Technical Site (SRTC) took early analytical data from Tanks WM-182 and WM-183 and came up with a formulation for a simulant sludge by adding various minerals and chemicals that gave a reasonably close element balance and particle size (see Reference 17). The SRTC simulant was used in some early filtering tests, but was later substituted with a second-generation simulant that incorporated metathesis reactions to generate solids. Early analyses of the tank sludge did not identify any of the mineral matter, nor did it reveal the true nature of the particles. Subsequent analyses conducted as part of this effort and reported herein have revealed some of the mineral matter and the nature of the particles, making it desirable to modify the solid simulant formulation.

One option for preparing a new simulant was to use metathesis reactions in the laboratory, but under conditions similar to those in the Tank Farm tanks. Metathesis reactions in this scenario are those reactions that occur in aqueous solution between cations and anions, which result in the formation of insoluble solids. The overall scheme would be to: first, prepare an aqueous acidic solution of soluble compounds, and second, to subsequently add solutions containing ions and compounds that when mixed with the first solution would cause solids to form. This approach was used to produce solid simulant for several tests and will be modified in the future as analytical data suggest, and also to incorporate surrogates for radionuclides.

Initially, non-hazardous chemicals (except for the acids) were used in the metathesis preparation of the solid simulant.

3.4.2.2 Analytical

It is necessary to know what the Tank Farm solids are in order to prepare a defensible simulant. Previous elemental, anion, and radiological analyses revealed qualitative information regarding the elemental, anions, and isotopic components of the solids, but provided little quantitative data. Further, no data was available indicating the mineral phases present, as x-ray diffraction experiments produced no discernable peaks.

There are numerous analytical techniques that can be used to better determine the composition of the Tank Farm solids. Efforts to apply these techniques were made. They are briefly identified and explained below. Results of the analyses would be incorporated into the simulant preparatory procedures, as applicable.

Elemental analyses:

Fusion: This is not an analysis. Rather, it is a necessary first step to dissolve the solids. Three different fusion procedures would be used. They incorporate sodium hydroxide, sodium carbonate, and sodium borate, respectively, to yield solutions that are subsequently analyzed for elements and anions. Each method offers better results for some of the specific elements or anions.

ICP/AES: Inductively Coupled Plasma/Atomic Emission Spectroscopy is used to analyze for elements in the solutions dissolved using the fusion procedures. This technique yields quantitative elemental analyses for many elements.

ICP/MS: Inductively Coupled Plasma/Mass Spectroscopy is used to analyze for elements in the solutions dissolved using the fusion procedures. This technique is more sensitive for some of the elements than the ICP/AES method. This technique yields quantitative elemental analyses for many elements.

Oxygen: Oxygen is analyzed using a LECO oxygen analyzer. This technique yields quantitative oxygen analyses.

XRF: X-Ray Fluorescence is used to analyze for elements in the solid state. This is a semi-quantitative technique as used in this task. Standards are not available that would make XRF quantitative for the Tank Farm sludges.

Thermal Analyses:

TGA: Thermogravimetric Analysis is used to record the mass of a sample as the sample is heated. The results are interpreted with regard to water content and off-gasses resulting from various decompositions. This technique yields quantitative analyses for free water, absorbed water, adsorbed water, water included as part of molecular formulas, water that forms as a consequence of molecular decomposition and recombinations, and other gasses that may be released from the sample as it is heated.

DSC (C_P): Differential Scanning Calorimetry is used to record the temperature of a sample as the sample is heated. The results are interpreted with regard to exothermic and endothermic reactions occurring in the sample, determining the heat capacity (specific heat) of the sample, and modified procedures can yield thermal conductivity data. This is a quantitative technique.

Mineral Analyses:

XRD: Powder X-Ray Diffraction is used to identify mineral phases present in the sample. This is a quantitative technique whose results are dependent upon the amount and size of crystalline material present.

TEM: Transmission Electron Microscopy is used to analyze small sections of a sample to determine elemental composition and microcrystalline phases present. The scale of interest is frequently in the tens of nanometers or smaller. This is a qualitative technique as used in this task. Standards are not available that would make TEM quantitative for the Tank Farm sludges.

SEM: Scanning Electron Microscopy is used to analyze small sections of a sample to determine elemental composition and microcrystalline phases present. The scale of interest is frequently on the order of tens of microns or larger. This is a qualitative technique as used in this task. Standards are not available that would make SEM quantitative for the Tank Farm sludges.

XAFS: X-Ray Absorption Fine Structure is used to determine mineral phases of specific target elements. This is a qualitative technique.

XPS: X-Ray Photoelectron Spectroscopy is used to determine the chemical composition or mineral phases of liquids or amorphous solids. This is a qualitative technique.

Radiological Analyses:

Counting Methods: X-rays and gamma radiation emanating from the sample are detected and interpreted with regard to the radionuclides emitting the radiation. This technique yields quantitative radiologic information.

3.4.3 Experimental

3.4.3.1 Preparation of Solid Simulant

Technical and reagent grade chemicals were used to prepare the solid simulant. They are shown below with the approximate amount used to generate 100 grams of solid simulant.

Solution 1	Amount added to make 100 g solid
$Al(NO_3)_3 \cdot 9H_2O$	124 g
$ZrO(NO_3)_2 \cdot H_2O$	20 g
$Ca(NO_3)_2 \cdot 4H_2O$	11.6 g
$Fe(NO_3)_2 \cdot 9H_2O$	11.6 g
$Mn(NO_3)_2 \cdot H_2O$	2.6 g
$Mg(NO_3)_2 \cdot 6H_2O$	8 g
$SnCl_2 \cdot 2H_2O$	8 g
NaF	0.8 g

Solution 2	Amount added to make 100 g solid
27% SiO_2 in 14% NaOH (Aldrich)	68 ml

Solution 3	Amount added to make 100 g solid
H_2SO_4 (95 – 98 wt. %)	2.4 ml
H_3PO_4 (85 wt. %)	10.4 ml

Three solutions were prepared with water added as necessary to dissolve the compounds. Solution 1 was mixed up in an 8-L or 12-L 3-neck round-bottom flask and heated to 50 ºC. Solutions 2 and 3 were simultaneously added to the round-bottom flask containing Solution 1, over a period ranging from ½ hour to 1 hour. The solution was stirred constantly using a magnetic stirrer while the additions were made.

Precipitates formed immediately, and stirring was discontinued upon complete addition of all chemicals to the round-bottom flask. The mixture was allowed to stand over night; after which it was filtered under vacuum in a Buchner funnel using Whatman No. 42 filter paper. Portions of the solid simulant were washed with a water rinse for subsequent analyses. The bulk of the material was not rinsed, and later used in various tests.

3.4.3.2 Analytical

Many of the solid samples were washed before the analyses were conducted as discussed in the following table.

Wash Solution	Comments
None	Samples were collected and the supernatant decanted off the top, and the solid was allowed to dry.
Water	Samples were collected and the supernatant decanted off the top. Solids were then shaken with water, allowed to settle, and the supernatant decanted. The ratio of solid to wash solution was ca. 1 g or less, to 20 ml. Wash was performed twice.

Nitric Acid	Samples were collected and the supernatant decanted off the top. Solids were then shaken with 0.1 M nitric acid solution, allowed to settle, and the supernatant decanted. The sample was then washed with water. The ratio of solid to wash solution was about 1 g or less solids to 20 ml wash.
Hydrofluoric Acid	Samples were collected and the supernatant decanted off the top. Solids were then shaken with 0.1 M HF acid solution, allowed to settle and stand over night, and the supernatant decanted. The sample was then washed with water. The ratio of solid to wash solution was about 1 g or less solids to 20 ml wash.
Liquid Simulant	Samples were collected and the supernatant decanted off the top. Solids were then shaken with an acidic simulant solution containing only the major non-hazardous components of the original solution, allowed to settle, and the supernatant decanted. The sample was then washed with water. The ratio of solid to wash solution was ca. 1 g or less, to 20 ml.
	Samples were dried at 100 ºC to constant weight prior to analyses.

Analyses included the following:

TEM: Solids from Tank WM-186 heel were characterized using transmission electron microscopy (TEM). Samples were prepared by bonding granular solids from WM-186 heel in an epoxy. Disc-shaped samples were then ground to about 100µm in thickness, followed by dimple grinding in a glovebox. Ion milling of the dimpled samples was conducted at 3.2keV and 6^{o} angle until perforation. The objective of this TEM characterization is to determine (i) morphology, (ii) chemical composition, and (iii) phase content of solids from WM-186 heel. Note that these TEM samples experienced a maximum temperature of 120^{o}C that occurred during sample mounting and ion milling. Also note that the contamination from sample preparation (mainly from ion milling) may contribute to Ar, Si, Cu and Zn concentration determined by energy dispersive X-ray spectrometry (EDS).

The instrument used was a JEOL 2010 transmission electron microscope. It is capable of operating at accelerating voltages up to 200 keV. The microscope is equipped with an Oxford Link ISIS energy dispersive X-ray spectrometer.

SEM: The two samples that were used for TEM analysis were also used for SEM analysis. The SEM offers the advantage of examining more material, since the TEM can only examine that small portion of the sample that is electron transparent. Also, the results of X-ray spectroscopy performed using the SEM can be quantified because the interaction volume is known.

The instrument used for these analyses was a Zeiss DSM 960a digital scanning electron microscope. It is capable of operating at accelerating voltages up to 30 keV. In addition to secondary and back scattered electron detectors, this instrument is equipped with an Oxford Link ISIS system. The ISIS system drives an energy dispersive X-ray spectrometer and six crystal wavelength dispersive X-ray spectrometer, and is capable of digital image acquisition. An Oxford INCA Crystal electron back scatter diffraction camera is also available, along with a forward scattered electron detector for imaging.

3.4.4 Results and Discussion

TEM: Solids characterized in this study were first washed by either water or HNO_3. Typical microstructure of these solids is shown in Figure 6. These solids exhibit hard agglomerates of sub-micron rock-shaped particles. In several areas, fiber-shaped particles were also found. Figure 7 shows an example. Selected area electron diffraction (SAD) patterns from these agglomerates suggest that they are amorphous. The main elements in these agglomerates identified by EDS are Al, Si, Zr, P, K and O. The relative amount of these elements varies from one area to the other in a submicron scale. Figure 8 is an EDS spectrum from a typical amorphous area. Minor elements such as Na, Ca, Fe, Cr, Ni, Ti, Sn, Mg, Cu, Zn, Nb, Ag, Ru, S and N were detected in various areas.

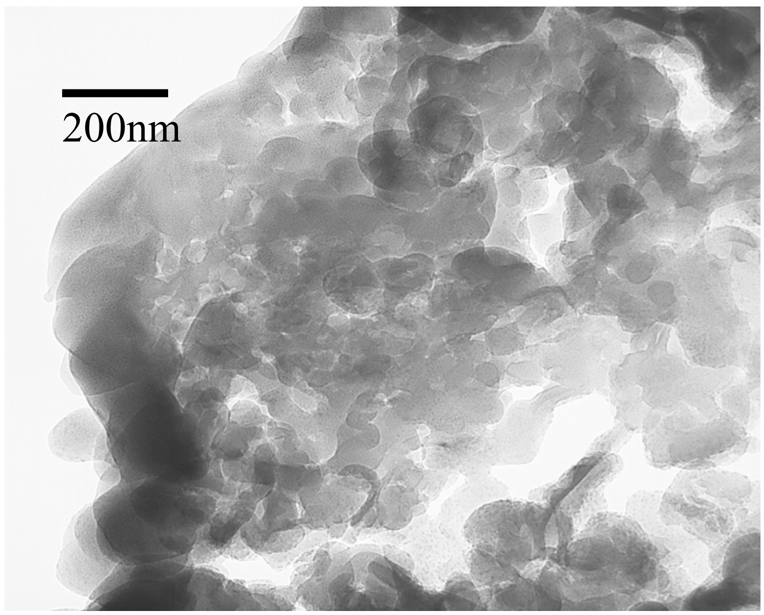

Figure 6. A TEM micrograph shows the typical microstructure of the solid matrix.

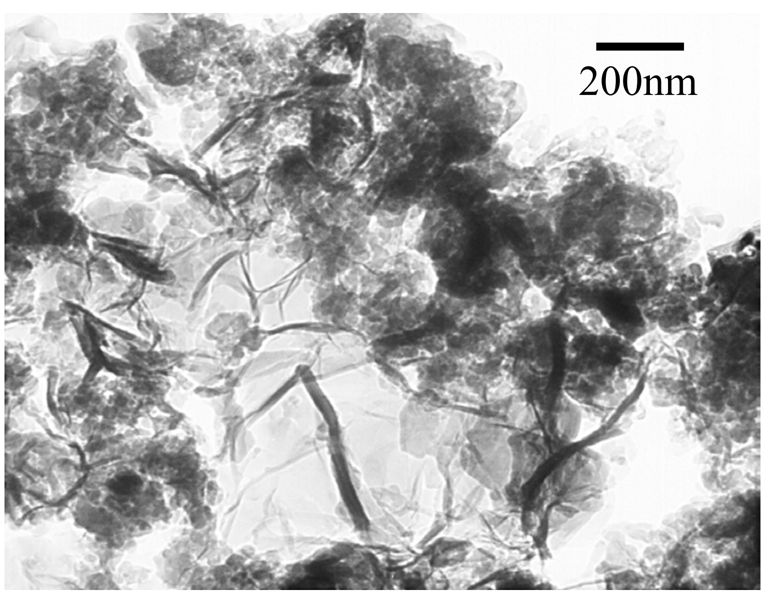

Figure 7. A TEM micrograph shows the fiber-shaped particles.

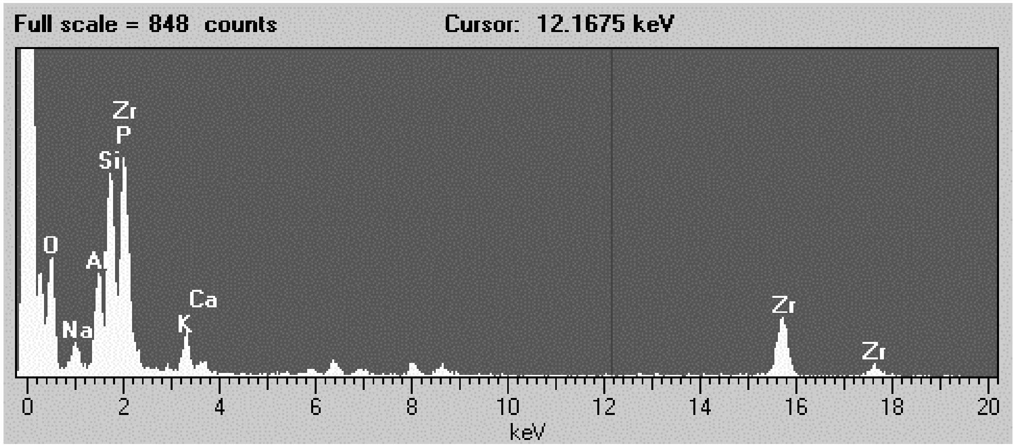

Figure 8. A EDS spetrum from a typical amorphous area.

Even though the solids are mainly amorphous, many submicron crystalline particles were also found. Zirconium oxide, aluminum oxide, Gibbsite (aluminum hydroxide), Mg-Al spinel, and titanium oxide are some of the crystalline phases identified in these samples. Figure 9 is a TEM micrograph showing a Gibbsite crystal surrounded by an amorphous matrix. Inserted in this Figure is an SAD pattern from this crystal. The image of a spinel ($MgAl_2O_4$) crystal and the SAD pattern from this crystal are shown in Figure 10. In a few areas, nano-sized silicon oxide particles were found. Figure 11 shows an example.

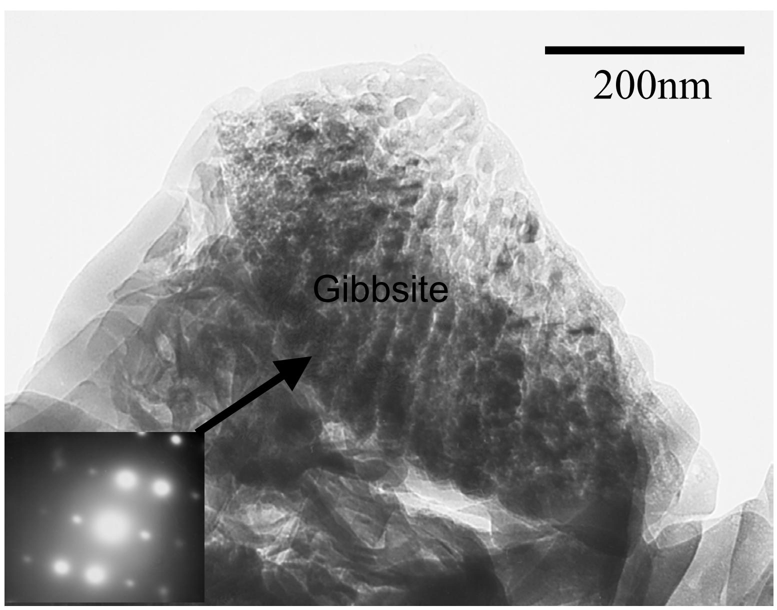

Figure 9. A TEM micrograph shows a Gibbsite crystal.

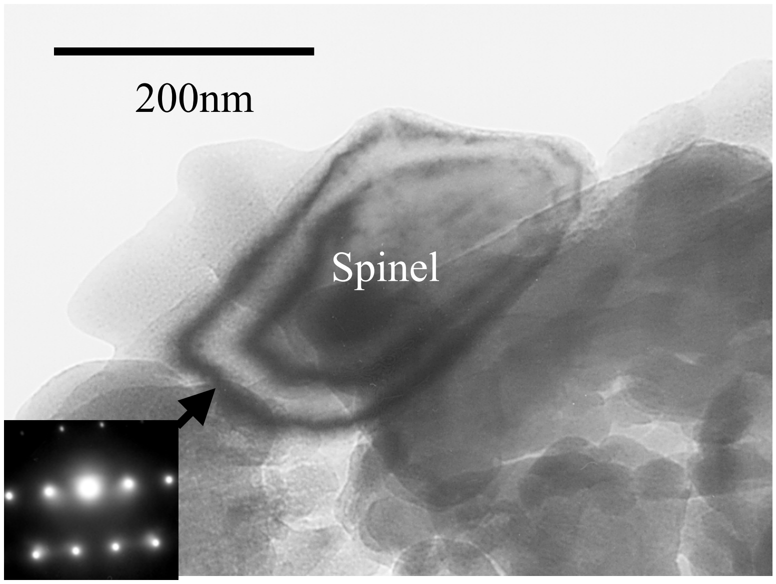

Figure 10. A TEM micrograph shows a spinel crystal.

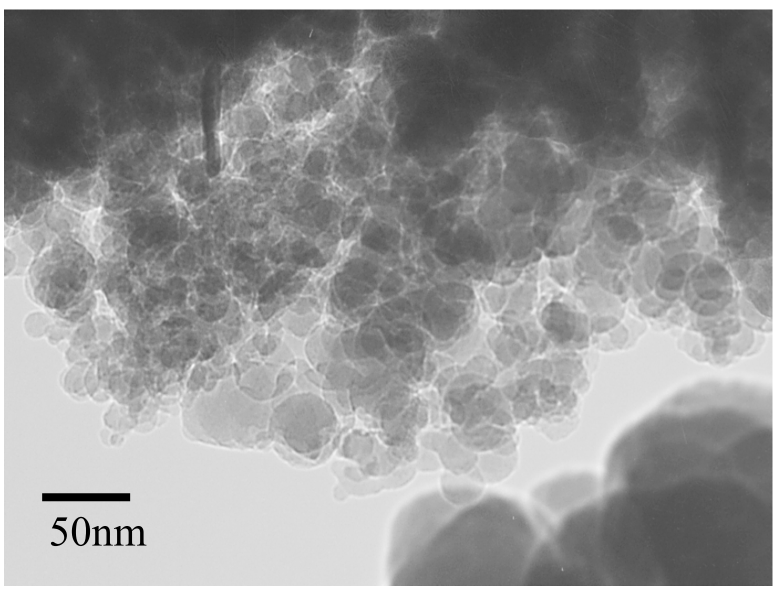

Figure 11. A TEM micrograph shows a cluster of nano-sized silicon oxide.

Based on the results from TEM characterization, the following conclusions can be drawn:

- The matrix of the solids consists of agglomerates of sub-micron rock-shaped amorphous particles. Fiber-shaped amorphous particles are also found in some areas.

- EDS reveals that these amorphous agglomerates have Al, Si, Zr, P, K, and O as the major constituents.

- Size, geometry, and chemical composition of the agglomerates vary from one place to the other on a submicron scale.

- Minor elements such as Na, Ca, Fe, Cr, Ni, Ti, Sn, Mg, Cu, Zn, Nb, Ag, Ru, S and N were found in various areas.

- Crystalline particles identified in this study are: zirconium oxide, aluminum oxide, Gibbsite (aluminum hydroxide), Mg-Al spinel, and titanium oxide.

- Agglomerates of very tiny SiO_2 particles (10-20 nm, non-crystalline) were found in a couple areas.

SEM: Elemental analyses were performed on all three samples to determine an average elemental composition. Analysis was performed by the so-called "standardless" method, using ZAF correction. Approximately 0.04 mm^2 was analyzed on each sample. Back scattered electron images of the areas analyzed are shown in Figure 12.

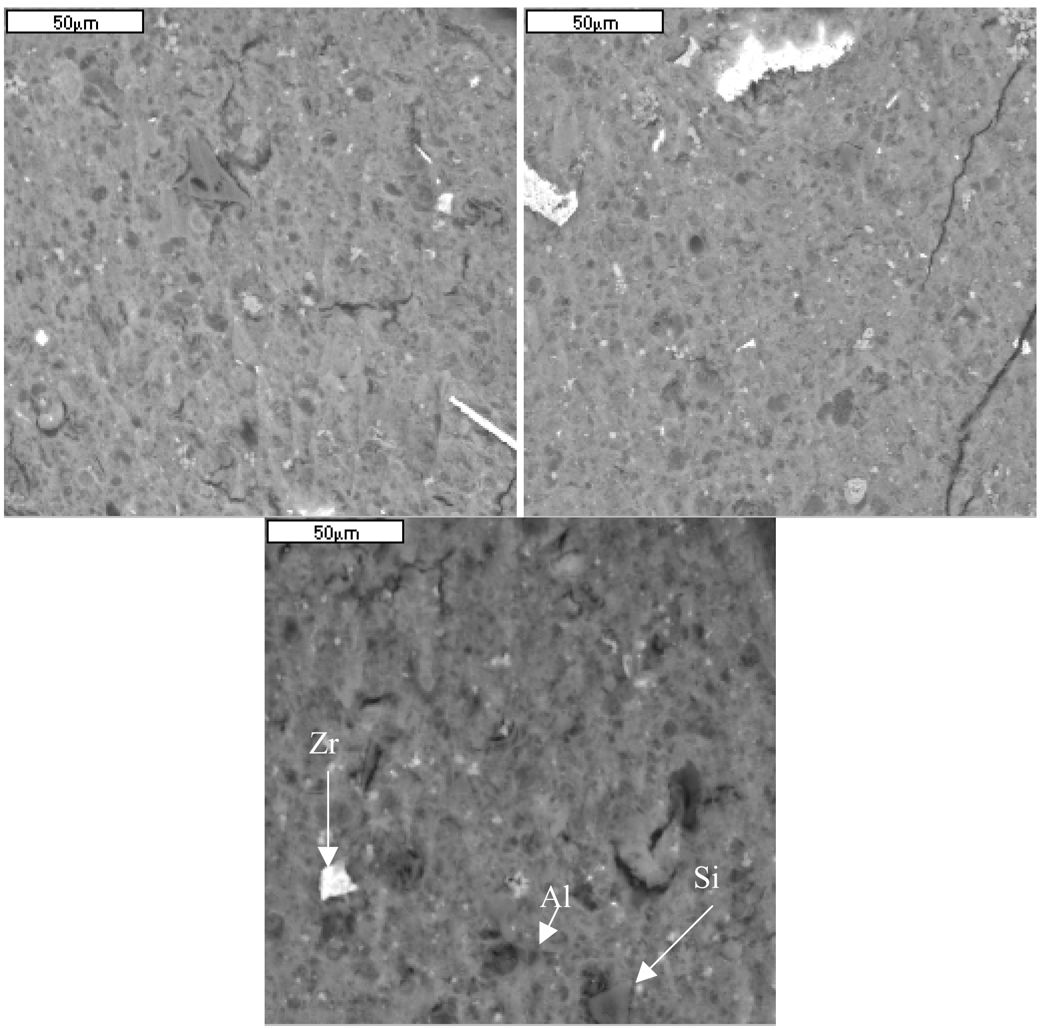

Figure 12. Back scattered electron images of the areas from the three samples analyzed to determine average elemental composition. The three features labeled Zr, Al, and Si were rich in zirconium, aluminum, and silicon respectively.

X-ray spectra were gathered while the beam was rastered across these areas. Thus the spectra collected represent average compositions for each area. These spectra were analyzed and the results averaged to estimate an average elemental composition for the material. The results are presented in Table 33.

Table 33. Average elemental composition of solids from Tank WM-186 as measured by energy dispersive spectrometry. Maxima and minima are also shown.

	O	Na	Al	Si	P	K	Fe	Zr
Mean weight %	50.2	0.64	6.26	11.85	11.01	1.14	1.47	17.40
Min weight %	49.62	0.36	5.84	11.63	10.74	1.07	0.94	16.07
Max weight %	50.63	1.01	6.76	12.01	11.19	1.22	2.01	18.30
Mean atomic %	70.98	0.63	5.24	9.54	8.07	0.66	0.59	4.31
Min atomic %	70.59	0.35	4.94	9.37	7.85	0.61	0.38	3.94
Max atomic %	71.62	0.99	5.61	9.68	8.17	0.71	0.82	4.54

The three features identified as Zr, Al, and Si in Figure 12 were also analyzed individually. The results are shown in Table 34. The technique does not reveal the mineral form, so the elements may be present as phosphates, silicates, aluminates, etc. The excess oxygen indicated in Table 33 (relative to the amount required to charge balance the cations) suggests the possible presence of hydroxides and/or hydrated species.

Table 34. Compositions of the three features identified in Figure 12 as Zr, Al, and Si.

Spot →	**Zr**	**Al**	**Si**
Element ↓	Wt. %	Wt. %	Wt. %
Al	2.52	38.42	1.86
Si	2.45	5.07	39.57
P	2.96	3.54	2.42
Fe	0.68		
Zr	60.88	5.47	4.39
K		0.29	0.24
Na		0.53	
Total →	69.49	53.32	48.48

It should be noted that the phosphorous K_{α} line (at 2.0130 keV) and the zirconium L_{α} line (at 2.0420 keV) overlap so as to be indistinguishable given the resolution of the EDS detector. The presence of zirconium was verified by evaluating the K_{α} line at 15.747 keV. The presence of phosphorous was verified by WDS as shown in Figure 13.

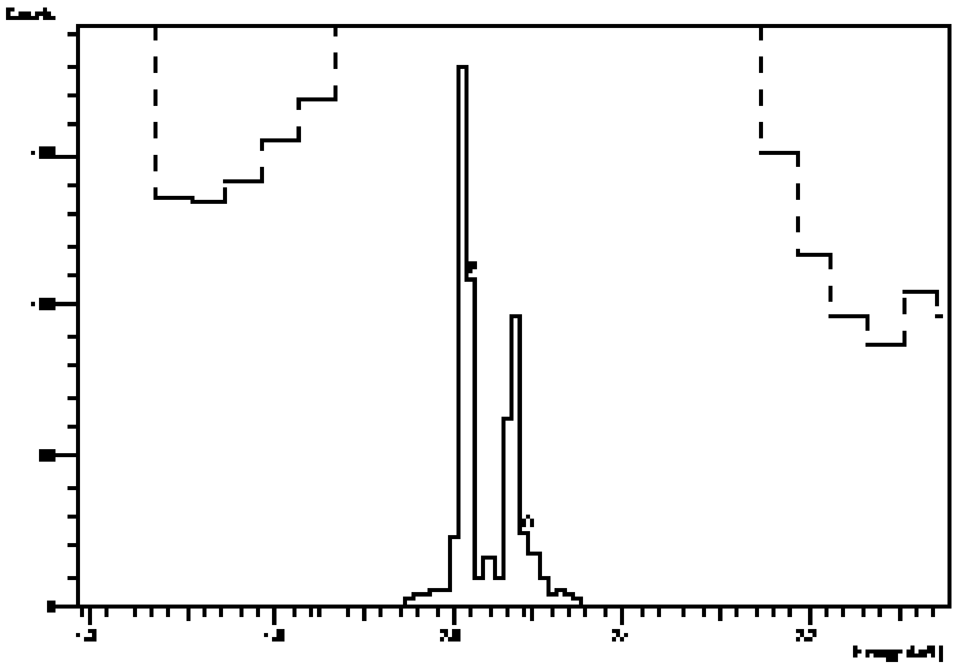

Figure 13: WDS spectrum confirming the presence of both phosphorous (left peak) and zirconium (right peak).

X-ray maps of the area shown as the bottom image in Figure 12 were obtained to show the spatial distribution of major elements phosphorous, aluminum, silicon, and zirconium. The results (shown in Figure 14) show a fairly uniform distribution of phosphorous, and localized high concentration areas of aluminum, silicon, and phosphorous.

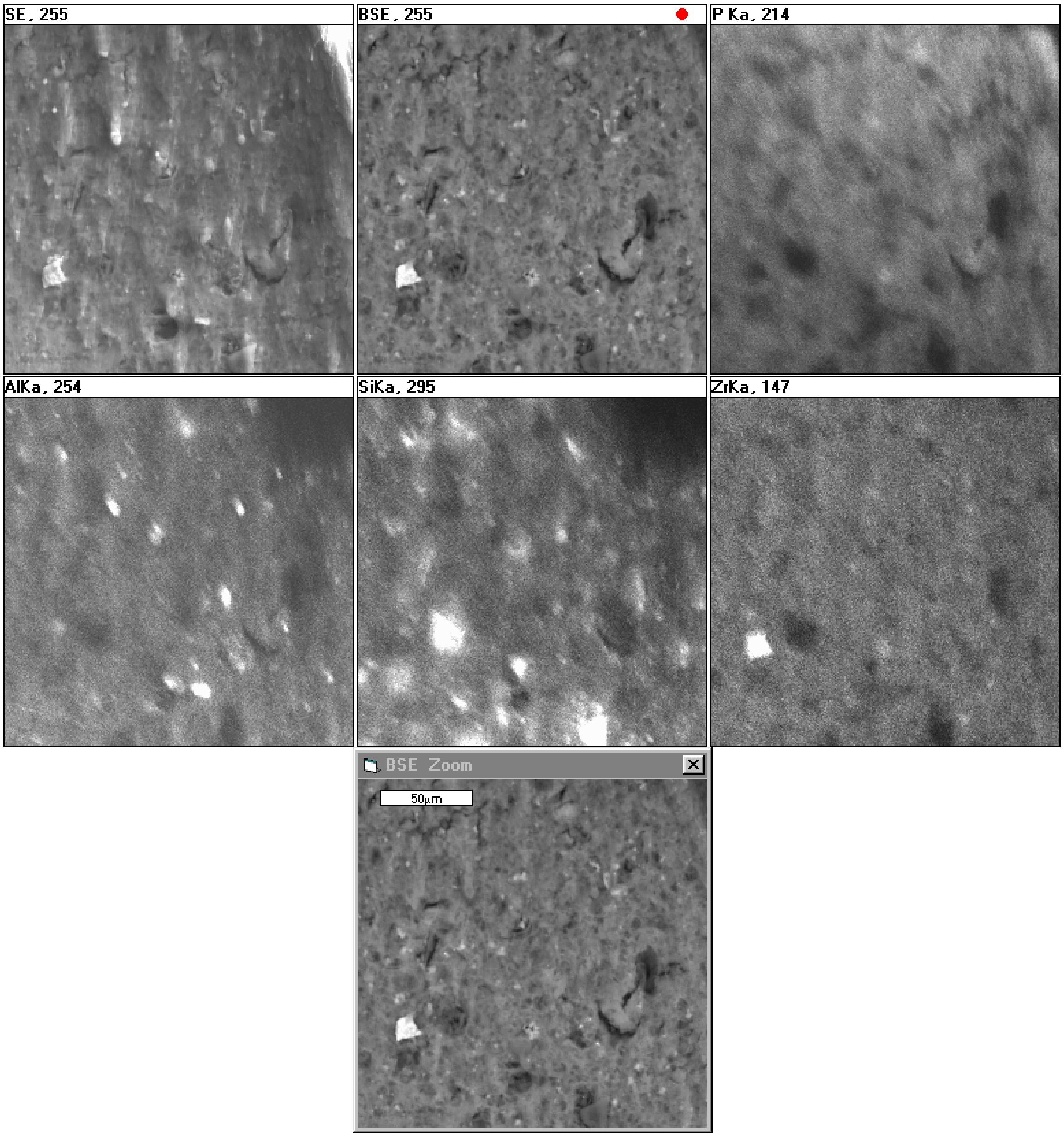

Figure 14: X-ray maps showing the distribution of major elements phosphorous, aluminum, silicon, and zirconium. Secondary (SE) and back scattered (BSE) electron images are also shown. The bottom image is a duplicate BSE image to show scale.

X-ray Fluorescence and X-ray Diffraction: X-ray fluorescence and X-ray diffraction were performed on samples of solids from Tank WM-186 that had been washed in various solutions. These were water, nitric acid, simulated supernatant, and hydrofluoric acid (followed by a water rinse). The hydrofluoric acid was allowed to contact the sample overnight, and very little material remained in the morning.

The results of X-ray fluorescence analysis are shown in Table 35. It should be noted that this X-ray fluorescence spectrometer cannot detect elements with atomic numbers below 13 (aluminum).

Table 35: Results of X-ray fluorescence spectrometry expressed as weight percent. Blank fields indicate that the element was not detected.

Wash:	Water	Nitric Acid	Supernatant	None	Hydrofluoric
Zr	74.71	68.34	49.17	48.34	3.93
K	6.55	9.05	21.55	17.22	38.91
Fe	5.80	5.68	12.39	9.91	3.18
Ca	3.70	4.63	9.59	7.77	45.66
Sn	2.08	1.92		1.02	
Mn	1.93	2.80	2.20	6.35	
Zn	1.26	3.48	0.70	0.34	
Nb	1.20	1.15	0.80	0.88	
Ti	0.92	1.27	1.11	0.83	4.41
Cr	0.84	1.24	1.13	2.09	
Ni	0.40	0.46	0.54	1.21	
Hg	0.32			1.02	
Br	0.22				
Au	0.09				
Ac				0.81	
U				0.55	
Cu			0.82	0.88	

Very little crystalline material was detected by X-ray diffraction. In the water washed sample and the nitric acid washed sample, sodium nitrate and quartz were detected. Only sodium nitrate was detected in the supernatant washed and unwashed samples. In the hydrofluoric acid washed sample, potassium oxide and quartz were detected, along with several unidentified peaks.

Several analyses have not yet been completed. They include oxygen analyses, XPS, XAFS, thermal analyses, radiological analyses, and physical testing for the WM-186 sample and the simulant. Those results will be reported later.

3.4.5 Simulant Development Conclusions

There was only a small amount of Tank Farm solids material available and analyzed in this effort. Yet several conclusions that can be drawn.

The small amount of material examined by TEM seems to be representative of the whole WM-186 sample. The qualitative results of TEM, SEM, and XRF analyses conducted at various spots on prepared samples were consistent within experimental error. This includes results of the elemental composition, which was semi-quantitatively determined down to the parts per thousand range.

Quantitative oxygen analyses were not completed at the time of writing, however, the results clearly show oxygen is present in many forms and that many of the cations are present as complex hydroxyl compounds, oxides, oxy-hydrates, hydroxy-oxides, and/or hydroxides, rather than as simple oxides. This strongly supports the metathesis formation of the simulant since a complex mixture of various oxy-compounds cannot be conveniently formulated any other way.

The Tank Farm solids are largely amorphous. There is not much crystalline material present. The individual particle size ranges from several nanometers to several hundred nanometers. A small portion of the solids are microcrystalline and give rise to x-ray or electron diffraction when examined under a micro-probe. The amorphous nano-particles agglomerate upon standing and form larger particles ranging in size up to about 1 millimeter, with the bulk of the mass of particles between 1 μm to 200 μm when slurried.

An unusual characteristic of this material is that for such finely divided material, it is not easily dispersable when dried. In fact, it forms fairly tough and hard granules or chunks. This observation, along with the ubiqitous presence of phosphorous may suggest the presence of a phosphate compound(s) that acts as a binder. This would be analogous to the phosphate binders used, for example, in some refractory cements and castables.

4. RECOMMENDATIONS

4.1 Characterization Recommendations

Liquids and solids from the Tank Farm Facility will be the feeds to the SBW Treatment Facility. Additional characterization data would reduce risks in the design of these treatment processes due to the uncertainties discussed in Sections 2.6.3 and 3.2. Characterization data will also be needed for design activities that verify that waste products from the treatment facility will meet disposal site waste acceptance criteria and transportation requirements. Many of the characterization needs discussed below have been incorporated into the Tank Sampling and Characterization Plan.[32]

4.1.1 Tank WM-188 Liquid

Tank WM-188 was sampled in late 2002, when the tank was about three-quarters full. Additional samples of the tank are needed as the tank reaches capacity, in order to confirm the composition for this tank waste used in the treatment facility design. Analyses for organics, including VOCs and SVOCs, should be included in the analyses performed on WM-188 samples.

4.1.2 Generated Liquid Wastes

Liquid wastes generated through FY-2005 are considered “sodium-bearing waste” and will be concentrated in existing INTEC evaporators and sent to Tank WM-188. Either the composition of wastes added to WM-188 or samples of WM-188 after additions are needed to confirm that the waste from this tank remains within the design feed range.

Waste generated after FY-2005 is referred to as newly generated liquid waste and is currently planned to be stored in Tanks WM-100, WM-101 and WM-102. Treatment of this waste has been included in the requirements of the SBW Treatment Facility. Hence composition data are needed for these waste streams to verify both designs and that final waste forms will meet disposal requirements.

A Sampling and Analysis Plan (PLN-613) has been issued[33] for these liquid waste streams that addresses characterization relative to Resource Conservation and Recovery Act (RCRA) Part B permit compliance and hazardous waste treatment, i.e., use of existing evaporators to concentrate the waste, and also characterization to treat, store and dispose of these wastes. As the treatment path of the NGLW becomes more definitive, PLN-613 should be reviewed and updated as needed. However two needs apparent at this time are for radioanalysis to determine concentrations of radionuclides in NGLW streams and organic analyses to better determine the amount and speciation of organics in NGLW. Also, cesium should be added to the list of 27 chemical species that PLN-613 identifies for analysis.

4.1.3 Volume of Solids

An improved estimate of the total volume of tank solids is needed. The volume of solids will affect the feed rate to the treatment facility and hence sizing of equipment that processes solids, either separately or together with liquid waste. The volume of solids will also affect the volume of treatment facility wastes and hence waste disposal costs for the SBWT facility.

As of late FY 2003, samples have been obtained of heels from Tanks WM-181, WM-186 and WM-187, but analyses of these samples are not complete. Knowing the fraction of solids in the sludge from these samples would improve the present estimate of solids volume. Further improvement can be obtained by video inspections of solids in Tank WM-187 after solids have been received from other tanks. Data is also needed that will provide a basis for determining how much if any the quantity of solids increases or decreases during the tank flushing process, in which a tank heel is flushed with water, and the tank mixing process, in which the solids in WM-187 are mixed with SBW from other tanks.

4.1.4 Tank WM-187 Solids Composition

The composition of solids in Tank WM-187 is needed to verify current estimates. Current plans show solids in Tanks WM-185 and WM-186 flushed to WM-187 in late FY 2003 and sampled in early FY 2004. Tank WM-184 will then be flushed to WM-187 and the Tank sampled again in March 2004. At that time all solids from the empty tanks will have been collected in Tank WM-187 except those in Tank WM-181. Since WM-181 solids have been analyzed, analyses of the two additional WM-187 samples will provide the design data needed for WM-187 solids composition.

The following analyses are needed.

Major Crystalline Species. Major crystalline species could be identified in a small sample of solids by using x-ray diffraction, energy dispersive x-ray spectroscopy. SEM photos are also requested. This information is needed for material balances and to model precipitate formation in the tanks.

Chemical Analyses. Chemical analyses are needed to evaluate the performance of moderate and high temperature processes such as calcination and steam reforming. The chemical composition of the feed to these processes affects feed additive requirements, calciner/reformer operating conditions, materials of construction/corrosion, and off-gas composition, which in turn determines off-gas treatment requirements and design. Species that affect feed additive requirements and/or calciner/reformer waste properties are: Al, Na, K, Ca, Si, B, and NO_3. Species that affect materials of construction and corrosion include F, Cl, S or SO_4, P, or PO_4. Species that affect off-gas treatment requirements and equipment include NO_3, S or SO_4, Cl, F, Hg, Pb, and Cs. Other species such as Fe, Pd or Ru may have catalytic effects in the reactor that could affect either the additive requirements, operating conditions or resulting off-gas composition. While not expected to be significant for the design, other species that would be of interest for the high temperature processes to "close the mass balance" or develop simulants for verification tests would include Ba, Cd, Cr, Se, Zn, Ce, Cu, Mg, Mn, Nb, Sn, Ti, U, and Zr.

Radionuclide Analyses. Radionuclide analyses are needed to (a) determine the disposal site of waste product, (b) confirm that the final waste will meet disposal site waste acceptance criteria, (c) confirm that the final waste will meet transportation requirements, and (d) determine dose rates and shielding requirements for processing equipment and the final waste package. The concentrations of the following isotopes are needed: ^{241}Am, ^{137}Cs, ^{134}Cs, ^{244}Cm, ^{60}Co, ^{152}Eu, ^{154}Eu, ^{129}I, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{126}Sb, ^{90}Sr, ^{99}Tc, ^{234}U, ^{235}U, ^{236}U, and ^{238}U. Concentrations of radionuclide by particle size are desirable. For example, the fines that pass through the solids filter are expected to contain radioactive cesium that could seriously affect the dose rate of grouted waste in the CsIX process. Also, the TRU content of these same fines will in part determine how the spent cesium sorbent in packaged for disposal and could also affect what disposal site the waste is sent to. Thus concentrations of ^{137}Cs and TRU species in a fines fraction of the solids are needed.

Water of Hydration/Moisture Content of Filtered and Dried Solids. The assumed disposal form of the tank solids for the CsIX process at the present time is as bulk, dry solids. Various methods of drying the solids could be used. To select and design a drying method the moisture content of the solids are needed, as filtered, and also after air-drying. The air-dried moisture content of the solids is also needed to calculate potential hydrogen generation in the waste container. This moisture-content data needs to include all forms of water, whether residual adsorbed water or water of hydration. The water of hydration content of the solids is needed for all alternatives as it affects the mass balance of each process, and could have a significant impact, along with the total solids mass, on the amount of waste produced by the treatment processes.

4.1.5 Solids Physical Properties

Settling Rate Data. Figure 3 (page 69) shows widely different settling rates for solids from the different tanks, and no data is yet available that shows settling rate for solids in WM-187. Data is thus needed on settling rate of solids in the dilute acid and salt solution that will be present in WM-187. Settling rate data is needed to size the treatment facility solids receiving tank for the CsIX process, and also to design equipment and piping to transfer the solids to the receiving tank and then from the tank to solids processing equipment.

Filtration Rate Data. Filtration rate data is needed for SBW (from Tanks WM-180, WM-188 and WM-189) with a low concentration of undissolved solids and the Tank WM-187 waste with a high solids concentration and dilute acid and salt solution. The CsIX alternative is expected to have two separate filters for these two different types of feed. Filtration rate data is needed to help determine the feasibility and performance of filtration for these two applications.

Bulk Dry, Particle and Slurry Density. The bulk dry density is needed to determine the volume of final solids waste. A curve of slurry density versus solids content, from zero to 25 wt % solids, is needed to design equipment to transport the solids. Dry density is needed for WM-187 solids, i.e., undissolved solids in a very dilute aqueous solution. Slurry density is needed for slurries representative of tanks waste after mixing, i.e., WM-187 solids remixed with SBW from the other tanks, and of WM-187 solids in dilute solution. Also, the particle density is needed to evaluate settling and to better determine tank solids quantities.

Slurry viscosity. The slurry viscosity over the range of zero to 25 wt % solids is also needed to design equipment to transport the solids.

Particle Size Distribution with and without Sonification. The particle size distribution (PSD) is needed to select the solids filter and design a settling tank for the tank solids slurry. Previous PSD analysis of samples obtained with the Light Duty Utility Arm (LDUA) showed that sonification significantly affected the PSD, indicating that the samples as received contained flocculent particles.

4.2 Tank Management Plan Recommendations

Treatment alternatives differ in whether existing INTEC evaporators or fractionators are an integral part of the treatment process, in the amount of dilute waste generated that are processed through existing INTEC facilities, and also in whether or not dilute waste will be generated prior to SBW treatment due to decontamination of equipment that would be used in the alternative. It is recommended that once a treatment alternative has been selected, the Tank Farm Management Plan[16] be updated to reflect the unique waste generation and facility utilization for that alternative. This update is needed to confirm that Tank WM-188 has the necessary capacity to hold concentrated waste from WM-187 evaporations, and also to verify that WM-100, WM-101, and WM-102 have adequate capacity for NGLW, or if not, to supply new capacity or use other existing tanks. These three tanks each have a capacity of 18,000 gallons. Present estimates of NGLW show that the capacity of these three tanks is adequate for the direct evaporation alternative, but the other alternatives exceed the available capacity by 25,000-30,000 gallons. However, even for the direct evaporation alternative, the logistics of using the tanks for both dilute and concentrated NGLW needs to be reviewed to ensure adequate capacity.

4.3 Simulant Development Recommendations

It is recommended to continue the analyses of the Tank Farm solids and complete those analyses that have been started. That is, it is desirable to complete the suite of analyses for the WM-186 sample, and compile results from various analyses conducted on the WM-181, -182, and -183 solids to establish a basis data set from which to compare with each other and to compare with future results from the WM-187 solids. This is necessary to establish transferability of results from previous analyses of unmixed solids to the future analyses of the solids mixed in WM-187.

Testing and development of the solid simulant should continue so it can better approximate the actual Tank Farm solids in physical and chemical behavior. The effort needs to follow parallel paths. One path is the continuation of analyses and characterization of the simulant so direct comparisons can be made between the Tank Farm solids and the solid simulant. The second path is to develop an improved formulation of the simulant that includes surrogate materials for radionuclides, and hydrothermal processing to effect mineral transformations that would otherwise only occur through aging.

5. REFERENCES

1. M. D. Staiger, C. B. Millet, R. A. Nichelson, R. A. Wood, A. Chambers, "Tank Farm Facility, Tank and Waste Data*," Engineering Design File EDF-1598*, February 27, 2001.

2. C. B. Millet, "Composition of Tank Farm Waste as of October 2002", INEEL Interoffice Memorandum Mil-07-02 to J. I. Pruitt, December 12, 2002.

3. J. D. Christian, *Composition and Simulation of Tank WM-180 Sodium-Bearing Waste at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-2001-00600, May 2001.

4. T. A. Batcheller, D. D. Taylor, V. J. Johnson, *Characterization of Tank WM-189 Sodium-Bearing Waste at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-02-01171 Rev. 1, July 2003.

5. V. J. Johnson, R. L. Demmer, T. A. Batcheller, *Characterization of Tank WM-188 Sodium-Bearing Waste at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-03-00478, June 2003.

6. M. Patterson, *Light Duty Utility Arm Deployment in Tank WM-188*, INEEL/EXT-99-01302, December 1999.

7. *Idaho Hazardous Waste Management Act/Resource Conservation and Recovery Act Closure Plan for Idaho Nuclear Technology and Engineering Center Tanks WM-182 and WM-183*, DOE/IC-10802, Appendix B, "Data Summary for Tanks WM-182 and WM-183," DOE/ID-10802, November 2001.

8. A. Poloski, "Solids Characterization," *Engineering Design File EDF-TST-001*, September 20, 2000.

9. D. R. Tyson, "Validation of the Radionuclide Mass Balance Used in the INTEC SBW WIR Determination Report," *Engineering Design File EDF-1920*, Revision 4, August 29, 2002.

10. V. J. Johnson, R. L. Demmer, *Characterization of Tank WM-181 Sodium-Bearing Waste Solids at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-03-00979, September, 2003.

11. M. C. Swenson, *Historical Tank Farm Sample Results*, MCS-27-92, December 17, 1992.

12. A. P. Poloski, "INTEC Tank Farm Sludge Density Measurements/Calculations," Engineering Design File 15722-040, July 12, 2000.

13. J. A. Nenni, "Balance-of-Plant Sample Data Compilation," *Engineering Design File,* EDF-2506, September 2002.

14. J. L. Tripp, *Supporting Information for the INEEL Liquid Waste Management Plan, Appendix B*, INEEL/EXT-98-00730, July 1998.

15. C. M. Barnes, "NGLW Volumes and Compositions for Treatment Study," INEEL Interoffice Memorandum CMB-07-02, Rev. 1, to W. H. Landman, April 8, 2002.

16. C. M. Barnes, C. B. Millet, INTEC Tank Farm Facility Management Plan, Plan-1112, September 30, 2002.

17. J. R. Harbour, R. F. Schumacher, A. Choi, A. K. Hansen, *Development of an Initial Simulant for the Idaho Tank Farm Solids*, WSRC-TR-2002-00436, November 11, 2002.

18. W. B. Palmer, C. B. Millet, M. D. Staiger, M. C. Swenson, W. B. McNaught, F. S. Ward, *INTEC Waste Management Through 2070,* INEEL/EXT-2000-01005, December 2000.

19. R. A. Wood, "Heel Solids Process Evaluation for the Idaho Tank Farm Project NWCF MACT Upgrade Option," *Engineering Design File EDF-3049*, December 2002.

20. E. Bart Packer, "Preliminary Assessment of Evaporator Technologies for Direct Evaporation of Sodium Bearing Waste," EDF-3443, April 8, 2003.

21. M. C. Swenson, "Radiological and Fissile Material Source Term for Tank Farm Undissolved Solids," INEEL Interoffice Correspondence MCS-06-02 to R. P. Durante, November 7, 2002.

22. M. C. Swenson, "HLLWE Plugging Problems Associated with WM-186 Waste," INEEL Interoffice Correspondence MCS-04-01 to M. W. Patterson, May 30, 2001.

23. C. M. Barnes, R. A. Wood, B. H. O'Brien, "Process Design of SBW Treatment Alternatives," *Engineering Design File EDF-2373*, September 10, 2002.

24. K. J. Rebish, J. A. Nenni, "Tank Farm Inventory, 1994," INEL Interoffice Correspondence KYR-02-94/JAN-03-94, to B. H. O'Brien and D. V. Croson, June 23, 1994.

25. C. M. Barnes, *Feed Composition for the Sodium-Bearing Waste Treatment Process*, INEEL/EXT-2000-01378, Revision 1, July 2001.

26. C. M. Barnes, "Sodium-Bearing Waste Composition for Use in Treatment Evaluation," INEEL Interoffice Memorandum CMB-09-02 to A. L. Olson, May 7, 2002.

27. D. Wenzel, "Relative Inventories of Reactor-Produced Species in INTEC Waste Types," *Engineering Design File EDF-CRPD-001*, November 4, 2002.

28. A. Poloski, "Reology of the INTEC Tank Farm Closure Surrogate and WM-182 LDUA Sample Dissolution of the WM-182 LDUA Sample in 6M Nitric Acid," *Engineering Design File 1914,* February 19, 2001.

29. HLW Program Office, *Analysis of the HLW Calcined During the NWCF Campaign H-4*, LMITCO Internal Report, INEEL/INT-98-00931, September 1998.

30. L. J. Young, N. R. Soelberg, B. H. O'Brien, R. D. Boardman, L. A. Matejka, M. L. Abbott, G. R. Hassel, *NWCF Calciner Emissions Inventory – Final Report for Test Series 1, 2, and 3*, INEEL/EXT-2000-00114, January, 2000, Part 2, Appendix F.

31. N. Soelberg, et. al, "Delisting Data Quality Objectives Project Organic Compound Stability Study," Revision 1 (unpublished), April 10, 2002.

32. D. Griffith, *Tank Sampling and Characterization Plan*, INEEL PLN-1129, September 26, 2002.

33. *Balance of Plant Sampling and Analysis Plan for the INTEC Liquid Waste Management System*, INEEL PLAN-613, Revision 2, May 15, 2002.

34. M. C. Swenson, "Validation of the Radionuclide Inventory and Mass Balance Used in the INTEC SBW and Tank Farm Residuals WIR Determination Reports," *Engineering Design File EDF-1920 INEEL/EXT-2001-534*, Revision 5, September 2003.

35. T. G. Garn, "Sampling and Characterization of WM-180," INEEL Interoffice Memorandum TGG-01-01 to J. A. Rindfleisch, January 11, 2001.