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ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN № 621371

Proj. ECN

2. ECN Category (mark one) Supplemental [] Direct Revision [X] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	3. Originator's Name, Organization, MSIN, and Telephone No. Dave L. Banning, Technical Basis and Planning, R2-12, 372-2728	4. USQ Required? [] Yes [X] No	5. Date 03/01/99
	6. Project Title/No./Work Order No. Data Quality Objectives for TWRS Privatization Phase I	7. Bldg./Sys./Fac. No. N/A	8. Approval Designator Q
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) HNF-1558, Rev. 0	10. Related ECN No(s). N/A	11. Related PO No. N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

13b. Design Baseline Document? [] Yes [X] No

Complete revision.

14a. Justification (mark one)

Criteria Change	[X]	Design Improvement	[]	Environmental	[]	Facility Deactivation	[]
As-Found	[]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

14b. Justification Details

The DQOs are updated to reflect current requirements in the TWRS Privatization Contract.

15. Distribution (include name, MSIN, and no. of copies)

See attached distribution.

RELEASE STAMP

MAR 03 1999

DATE. STA: 4

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ID: 4

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ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1) ECN-621371

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[X] No	Savings	[] $	Savings	[] $	Delay	[]

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
N/A		

21. Approvals

Signature	Date	Signature	Date
Design Authority		Design Agent	
Cog. Eng. D.L. Banning *D L Banning*	3/2/99	PE	
Cog. Mgr. K.M. Hall *Kathleen M. Hall*	3/2/99	QA	
QA D.C. Board *Don Board*	3-3-99	Safety	
Safety		Design	
Environ.		Environ.	
Other J.W. Hunt *JW Hunt*	3/2/99	Other	
		DEPARTMENT OF ENERGY	
J.S. Garfield *J S Garfield*	3-2-99	Signature or a Control Number that tracks the Approval Signature	
		ADDITIONAL	

S

Data Quality Objectives for TWRS Privatization Phase I: Confirm Tank T is an Appropriate Feed Source for High-Level Waste Feed Batch X

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U.S. Department of Energy Contract DE-AC06-96RL13200

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RECORD OF REVISION

RECORD OF REVISION	(1) Document Number HNF-1558	Page 1

(2) Title
Data Quality Objectives for TWRS Privatization Phase I: Confirm Tank T is an Appropriate Feed Source for High-Level Waste Feed Batch X

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr.	Authorized for Release (6) Cog. Mgr. Date
0	(7) Initially released 08/20/98 on EDT-161500.	T.W. Crawford	J.S. Garfield
1 RS	Incorporate per ECN-621371.	D.L. Banning DL Banning	K.M. Hall Kathleen M. Hall 3-2-99

HNF-1558
Revision 1

DATA QUALITY OBJECTIVES FOR TWRS PRIVATIZATION PHASE 1: CONFIRM TANK T IS AN APPROPRIATE FEED SOURCE FOR HIGH-LEVEL WASTE FEED BATCH X

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Date Published
March 1999

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

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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LIST OF TERMS

Ci	curie
cP	centiPoise
°C	degrees Celsius
DOE	the U.S. Department of Energy
DOE-RL	U. S. Department of Energy, Richland Operations Office
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
g	grams
g/L	grams per liter
HLW	high-level waste
ICD	interface control document
LAW	low activity waste
μCi/g	microcuries per gram
μg/g	micrograms per gram
MRQs	minimum reportable quantities
%	percent
PHMC	Project Hanford Management Contract
PMBS	project master baseline schedule
PUREX	Plutonium Uranium Extraction (Facility)
QC	quality control
REDOX	reduction-oxidation
RTP	Readiness-To-Proceed
SAP	sampling and analysis plan
TRU	transuranic
TWRS	Tank Waste Remediation System
TWRSO&UP	Tank Waste Remediation System Operation and Utilization Plan

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DATA QUALITY OBJECTIVES FOR TWRS PRIVATIZATION PHASE 1: CONFIRM TANK T IS AN APPROPRIATE FEED SOURCE FOR HIGH-LEVEL WASTE FEED BATCH X

1.0 INTRODUCTION

The U. S. Department of Energy-Richland Operations Office (DOE-RL) has initiated Phase 1 of a two-phase privatization strategy for treatment and immobilization of high-level waste (HLW) that is currently managed by the Hanford Tank Waste Remediation System (TWRS) Project. In this strategy, DOE will purchase services from a contractor-owned and operated facility under a fixed price. The Phase 1 TWRS privatization contract requires that the Project Hanford Management Contract (PHMC) contractors, on behalf of DOE, deliver HLW feed in specified quantities and composition to the Privatization Contractor in a timely manner (DOE-RL 1996). Additional requirements are imposed by the interface control document (ICD) for HLW feed (PHMC 1997).

In response to these requirements, the Tank Waste Remediation System Operation and Utilization Plan (TWRSO&UP) (Kirkbride et al. 1997) was prepared by the PHMC. The TWRSO&UP, as updated by the Readiness-To-Proceed (RTP) deliverable (Payne et al. 1998), establishes the baseline operating scenario for the delivery of HLW feed to the Privatization Contractor. The scenario specifies tanks from which HLW will be provided for each feed batch, the operational activities needed to prepare and deliver each batch, and the timing of these activities. The operating scenario was developed based on current knowledge of waste composition and chemistry, waste transfer methods, and operating constraints such as tank farm logistics and availability of tank space.

A project master baseline schedule (PMBS) has been developed to implement the operating scenario. The PMBS also includes activities aimed at reducing programmatic risks. One of the activities, "Confirm Tank T[1] is Acceptable for Feed," was identified to verify the basis used to develop the scenario. Additional data on waste quantity, physical and chemical characteristics, and transfer properties will be needed to support this activity.

This document describes the data quality objective (DQO) process undertaken to assure appropriate data will be collected to support the activity, "Confirm Tank T is Acceptable for HLW Feed." The DQO process was implemented in accordance with the TWRS DQO process (Banning 1997) with some modifications to accommodate project or tank-specific requirements and constraints.

[1] "Tank T" refers to the contents from one candidate HLW feed tank.

2.0 STATEMENT OF THE PROBLEM

An initial screening of tank waste composition has been conducted to identify potential waste feed for the Phase I TWRS Privatization Contractor. Tanks 241-AZ-101, 241-AZ-102, 241-C-102, 241-C-104, and 241-C-106 currently contain waste that is targeted as candidate HLW feed. The screening was based on current best-basis estimates, process test data, process simulation, and project schedules. To minimize programmatic risks, additional data are needed to supplement existing knowledge regarding waste characteristics and behavior.

Data are needed to demonstrate that Privatization Contract limits and waste transfer requirements can be satisfied. In other words, sufficient data must be available to prevent an occurrence of the following potential "problems":

1. The characteristics of a delivered feed batch exceed the limits required by the TWRS Privatization Contract (i.e., the feed envelope).
2. The characteristics and behavior of the HLW are such that the PHMC cannot transfer the waste, when needed, from a candidate waste tank to a feed staging tank.
3. The quantity properties (volume and solids content) of HLW transferred to a feed staging tank are outside the requirements for a feed batch.

3.0 IDENTIFY THE DECISIONS

To avoid the "problems" discussed in the previous section, the following principal study questions must be answered:

1. *Do the HLW feed characteristics exceed the envelope limits?*

2. *Do the physical and rheological characteristics of the HLW exceed the waste transfer criteria?*

3. *Are the quantity properties of waste in Tank T outside the requirements for a feed batch?*

In combination, the answers to these questions will resolve the overall primary question:

Is the waste in Tank T appropriate for use as source material for HLW feed batch X?

3.1 FEED ENVELOPE DECISION

The alternative actions that could result from resolution of the principal study question regarding feed envelope requirements include:

1. All HLW feed characteristics are within the envelope limits. No further action is needed.

2. One or more of the HLW feed characteristics are outside the envelope limits. Another waste could be selected as candidate feed. Alternatively, DOE could negotiate with the Privatization Contractor to accept out-of-specification waste feed or modify the envelope.

3.2 WASTE TRANSFER DECISION

The alternative actions that could result from resolution of the principal study question regarding waste transfer requirements include:

1. All physical and rheological characteristics of the waste meet the established criteria for waste transfer. No further action is needed.

2. One or more physical or rheological characteristics of the waste exceed the established criteria for waste transfer. The waste properties could be adjusted, the waste transfer criteria could be modified, or another waste could be selected.

3.3 QUANTITY DECISION

The alternative actions that could result from resolution of the principal study question regarding feed quantity requirement include:

1. The quantity properties of HLW in Tank T are within the requirement for a specified feed batch (Feed Batch X). No further action is needed.

2. The quantity properties of HLW in Tank T are outside the requirements for Feed Batch X. Another candidate waste could be selected or the waste volume and/or solids content could be modified to meet the requirements.

3.4 SUMMARY OF DECISIONS

Based on the study questions and the associated alternative actions, the following decision statements are established:

1. Determine whether or not chemical and radiological characteristics of the HLW feed exceed the envelope limits and, therefore, require actions to accept out-of-specification feed, modify the envelope, or select another candidate waste.

2. Determine whether or not physical and rheological properties of the waste exceed established waste transfer criteria and, therefore, require actions to adjust the waste properties, modify the waste transfer criteria, or select another candidate waste.

3. Determine whether or not the quantity properties of HLW in Tank T are outside the requirements for a feed batch and, therefore, require actions to modify the waste properties or select another candidate waste.

4.0 IDENTIFY THE INPUTS TO THE DECISIONS

The information inputs required to resolve the decision statements are divided into three sections for clarification: Inputs for Feed Envelope Decision, for Waste Transfer Decision, and for Quantity Decision (Sections 4.1, 4.2, and 4.3). The bases for selecting the required inputs are also discussed in these sections. The analytical methods and quality control requirements for these inputs are provided in Section 4.4.

4.1 INPUTS FOR FEED ENVELOPE DECISION

HLW feed will be mixed and transferred to a staging tank as slurry. HLW slurry will contain a mixture of liquid (Envelope A, B, or C) and solids (Envelope D). Feed envelope requirements for the solids fraction are addressed in this document. Envelope requirements for the liquid fraction are addressed in the *Data Quality Objectives for TWRS Privatization Phase I: Confirm Tank T Is An Appropriate Feed Source for Low-Activity Waste Feed Batch X* (Nguyen 1999).

Feed envelope requirements for the HLW solids fraction consist of concentration limits for non-volatile and volatile components and for radionuclides. Specific feed envelope requirements (Envelope D) are shown in Tables 4.1 through 4.4. These requirements are specified in Specification 8, Section C.6 of the Privatization Contract (DOE-RL 1996).

TABLE 4.1. HIGH-LEVEL WASTE FEED UNWASHED SOLIDS MAXIMUM NON-VOLATILE COMPONENT COMPOSITION
(grams of component per 100 grams of non-volatile oxides)

Non-Volatile Element	Maximum (g/100 g waste oxides)	Non-Volatile Element	Maximum (g/100 g waste oxides)
As	0.16	Pu	0.054
B	1.3	Rb	0.19
Be	0.065	Sb	0.84
Ce	0.81	Se	0.52
Co	0.45	Sr	0.52
Cs	0.58	Ta	0.03
Cu	0.48	Tc	0.26
Hg	0.1	Te	0.13
La	2.6	Th	0.52
Li	0.14	Tl	0.45
Mn	6.5	V	0.032
Mo	0.65	W	0.24
Nd	1.7	Y	0.16
Pr	0.35	Zn	0.42

TABLE 4.2. HIGH-LEVEL WASTE FEED UNWASHED SOLIDS MAXIMUM VOLATILE COMPONENT COMPOSITION
(grams per 100 grams of non-volatile oxides)

Volatile Components	Maximum (g/100g waste oxides)
Cl^-	0.33
CO_3^{-2}	30
NO_2^-, NO_3^-	36 (total NO_2, NO_3) as NO_3
TOC	11
CN^-	1.6
NH_3^-	1.6

TABLE 4.3. HIGH-LEVEL WASTE FEED UNWASHED SOLIDS MAXIMUM RADIONUCLIDE COMPOSITION
(curies per 100 grams of non-volatile oxides)

Isotope	Maximum (Ci/100g waste oxides)	Isotope	Maximum (Ci/100g waste oxides)	Isotope	Maximum (Ci/100g waste oxides)
^{3}H	6.5 E-05	^{129}I	2.9 E-07	^{237}Np	7.4 E-05
^{14}C	6.5 E-06	^{137}Cs	1.0 E+01	^{238}Pu	3.5 E-04
^{60}Co	1.0 E-02	^{152}Eu	4.8 E-04	^{239}Pu	3.1 E-03
^{90}Sr	1.0 E +01	^{154}Eu	5.2 E-02	^{241}Pu	2.2 E-02
^{99}Tc	1.5 E-02	^{155}Eu	2.9 E-02	^{241}Am	9.0 E-02
^{125}Sb	3.2 E-02	^{233}U	9.0 E-07	$^{243+244}Cm$	3.0 E-03
^{126}Sn	1.5 E-04	^{235}U	2.5 E-07		

TABLE 4.4. ADDITIONAL HIGH-LEVEL WASTE FEED COMPOSITION FOR NON-VOLATILE COMPONENTS [1]
(grams per 100 grams of non-volatile oxides)

Non-Volatile Element	Maximum (g/100g waste oxides)	Non-Volatile Element	Maximum (g/100g waste oxides)
Ag	0.55	Ni	2.4
Al	14	P	1.7
Ba	4.5	Pb	1.1
Bi	2.8	Pd	0.13
Ca	7.1	Rh	0.13
Cd	4.5	Ru	0.35
Cr	0.68	S	0.65
F	3.5	Si	19
Fe	29	Ti	1.3
K	1.3	U	14
Mg	2.1	Zr	15
Na	19		

[1] The feed components listed in this table are important to HLW glass production but the associated specifications are not considered as feed envelope requirements. In other words, concentration data for these components are needed, but the "maximums" specified in the TWRS Privatization contract are not requirements that must be met.

The data from Tables 4.1 to 4.4 will be obtained from analysis of undissolved solids that remain after waste samples undergo process tests to simulate mixing (and dilution if necessary). In addition, the Privatization Contract requires that the waste feed does not contain a separate organic layer. This last requirement will be satisfied based on a visual observation of the waste samples.

4.2 INPUTS FOR WASTE TRANSFER DECISION

Candidate HLW feed will be mixed in-tank and then transferred to the staging tank. Measurements of physical and rheological properties of the waste are needed to confirm that the waste can be effectively mixed and transferred to the Privatization Contractor. These properties are shown in Table 4.5. The associated limits were established based on an analysis of the capability of the proposed transfer routes (Galbraith et al. 1996).

TABLE 4.5. WASTE TRANSFER PROPERTIES AND ASSOCIATED LIMITS

Property	Limit
Viscosity	10 cP
Specific gravity	1.5
Volume percent solids	30

The properties listed in Table 4.5 will be obtained by measuring sample material that has been prepared to simulate mixed and/or diluted tank waste. If the data indicate that these properties exceed the corresponding limits, process tests will be performed to determine the necessary dilution ratio (i.e., volume of diluent to that of waste). The following data will be needed to support mixing and/or dilution operations:

- The fraction of solids that dissolve during mixing,
- The solids dissolution rate or the total amount of time required to dissolve the solids, and
- The settling rate of undissolved solids after mixing.
- Physical properties of undissolved solids (before and after mixing) for modeling waste behavior during feed delivery operations. These properties include particle size distribution and density.

Dilution may be necessary in some cases to satisfy the waste transfer requirements. The target dilution ratio will be estimated from existing waste composition and thermodynamic equilibrium calculations. The desired dilution ratio will be confirmed through process tests and will fall within the following range:

- The minimum dilution ratio at which the diluted waste satisfies all above waste transfer requirements, and
- The maximum dilution ratio, beyond which gibbsite would form (at a temperature between 25°C and 65°C) or based on tank space requirement.

Details of these process tests will be developed and documented in laboratory test plans.

4.3 INPUTS FOR QUANTITY DECISION

The TWRS Privatization Contract (Section H) specifies quantity requirements for feed delivery in terms of:

1. waste volume per batch (at least 600,000 liters with 10 to 200 grams/liter of insoluble solids for the initial batch; 200,000 to 600,000 liters with the same mass of solids thereafter),

2. volume per month (up to 600,000 liters per month) before low-activity waste (LAW) immobilization services are available,

3. quantity of Envelope D waste sufficient to produce a maximum number of canisters of HLW glass per 100 days (33) after LAW immobilization services are provided, and

4. quantity of Envelope D waste sufficient to produce a maximum cumulative number of canisters per year of operation (see Table 4.6).

To determine whether these requirements can be met, the following data (inputs) will be needed:

- The volume of HLW feed that will result from retrieving the contents of Tank T. The total quantity of waste will be determined from level measurements and dilution factor (if necessary) to be established by process tests discussed in Section 4.2. Tank liquid level measurements are performed as part of routine tank farm operations. This requirement will no longer be considered in this DQO.

- The mass of insoluble solids in the waste feed. This property will be determined by measuring undissolved solids in waste samples (diluted if needed) after mixing. Another method of estimating the amount of insoluble solids in diluted or undiluted HLW is by direct in-tank measurements. Sludge level measurements may be used to determine the total amount of settled solids in a tank.

- The total number of canisters of HLW glass that will be produced by treating the contents of the tank (or the volume of waste equivalent to one canister of HLW glass). This input can be calculated from concentrations of the components listed in Table 4.7. The minimum levels of HLW glass components shown in the table are not applicable to feed delivery. In other words, a HLW is not required to demonstrate that these levels can be met before transfer. However, sufficient data must be obtained for these components to allow an accurate estimate of the total number of HLW glass canisters.

  The data will be obtained for both aqueous and caustic insoluble fractions in the waste. The mass and composition of these fractions will be determined from process tests that meet the requirements specified in Specifications 12.2.2 and 12.2.3 of the TWRS Privatization Contract.

TABLE 4.6. CUMULATIVE NUMBER OF CANISTERS OF HLW GLASS

Year of Operation	Maximum Cumulative Number of Canisters
1	100
2	200
3	300
4	400
5	500
6	600
7	600
8	600
9	600
10	600
11	600

TABLE 4.7. HLW GLASS COMPONENTS NEEDED TO ESTIMATE THE NUMBER OF CANISTERS PER BATCH OF HLW FEED (2 Sheets)

Component	Minimum Weight Percent in HLW Glass
Fe_2O_3	12.5
Al_2O_3	11.0
Na_2O+K_2O	15.0
ZrO_2	10.0
UO_2	8.0
CaO	7.0
MgO	5.0
BaO	4.0
CdO	3.0
NiO	3.0
PbO	1.0
TiO_2	1.0
Bi_2O_3	2.0
P_2O_5	3.0
F	1.7
$Al_2O_3+ZrO_2$	14.0
$Al_2O_3+ZrO_2+Fe_2O_3$	21.0
MgO+CaO	8.0
Cr_2O_3	0.5
SO_3	0.5
Ag_2O	0.25
$Rh_2O_3+Ru_2O_3+PdO$	0.25

TABLE 4.7. HLW GLASS COMPONENTS NEEDED TO ESTIMATE THE NUMBER OF CANISTERS PER BATCH OF HLW FEED (2 Sheets)

Component	Minimum Weight Percent in HLW Glass
Any single waste oxide (exclusive of Si) not specifically identified in Tables 4.1 and 4.4	0.2
Total of all other oxides (exclusive of Si) not specifically identified in this table	8.0
Total of all waste oxides, excluding Na_2O and SiO_2	40.0

4.4. ANALYTICAL METHODS AND QUALITY CONTROL REQUIREMENTS

The suggested analytical methods and the quality control (QC) requirements applicable to each analysis are provided in Table 4.8. For purposes of this DQO, total alpha activity will be used as a screening analysis and conservative indicator of transuranic (TRU) content. If the total alpha activity is greater than 80 percent of the TRU envelope limit, isotopic distribution will be required.

TABLE 4.8. SUGGESTED ANALYTICAL METHODS AND QUALITY CONTROL REQUIREMENTS (3 SHEETS)

Analyte (Measured in Solids)	Analytical Technique	QC Acceptance Criteria		
		LCS %Recovery [1]	Spike %Recovery [2]	Duplicate RPD [3]
Cations listed in Table 4-1 (except Hg, Pr, Pu, and Rb)	ICP/AES [7,6]	80 – 120%	75 - 125%	≤ 20%
Hg	CVAA [7,6]	80 – 120%	75 - 125%	≤ 20%
Pr, Rb, Pd, Rh, Ru	To be developed	--	--	—
NO_2, NO_3, Cl	Ion Chromatography [7]	80 – 120%	75 - 125%	≤ 20%
CN	Distillation/ calorimetric	80 – 120%		
NH_3	Ion selective electrode	80 – 120%	75 - 125%	≤ 20%
Total Inorganic Carbon (CO_3)	Persulfate	80 – 120%	75 - 125%	≤ 20%
TOC	Silver catalyzed persulfate and combustion furnace[7]	80 – 120%	75 - 125%	≤ 20%
Wt% solids	Gravimetric	80 - 120%	N/A	≤ 30%
Viscosity				

TABLE 4.8. SUGGESTED ANALYTICAL METHODS AND QUALITY CONTROL REQUIREMENTS (3 SHEETS)				
Analyte (Measured in Solids)	Analytical Technique	QC Acceptance Criteria		
		LCS %Recovery [1]	Spike %Recovery [2]	Duplicate RPD [3]
Slurry density		N/A	N/A	N/A
Volume % settled solids	Visual observation	N/A	N/A	N/A
^{3}H	Separation/liquid scintillation	80 - 120%	N/A [4]	≤ 20%
^{14}C	Separation/liquid scintillation	80 - 120%	75 - 125%	≤ 20%
^{60}Co	GEA	80 - 120%	N/A [5]	≤ 20%
^{99}Tc	Separation/liquid scintillation	80 - 120%	70 - 130%	≤ 20%
^{90}Sr	Isotopic specific separation/beta count	75 - 125%	N/A [4]	≤ 20%
^{237}Np	ICP/MS	NP	75 - 125%	≤ 20%
^{238}Pu	Separation/AEA	NP	70 - 130%	≤ 20%
$^{239/240}Pu$	ICP/MS	NP	70 - 130%	≤ 20%
$^{241/242}Pu$	To be developed	--	--	—
^{241}Am	Separation/AEA	80 - 120%	N/A [4]	≤ 20%
$^{243+244}Cm$	Separation/AEA	NP	N/A [4]	≤ 20%
^{243}Am	ICP/MS	NP	75 - 125%	≤ 20%
^{137}Cs	GEA	NP	N/A [5]	≤ 20%
$^{153/154/155}Eu$	GEA	NP	N/A [5]	≤ 20%
^{125}Sb	GEA	NP	N/A [5]	≤ 20%
$^{233/235}U$	ICP/MS	NP	75 - 125%	≤ 20%
^{126}Sn	ICP/MS	NP	N/A [5]	≤ 20%
Total Alpha	Proportional counter	70 - 130%	70 - 130%	≤ 20%

TABLE 4.8. SUGGESTED ANALYTICAL METHODS AND QUALITY CONTROL REQUIREMENTS (3 SHEETS)				
Analyte (Measured in Solids)	Analytical Technique	QC Acceptance Criteria		
		LCS %Recovery [1]	Spike %Recovery [2]	Duplicate RPD [3]

Notes:

AEA = Alpha energy analysis
CVAA = cold vapor atomic absorption
GEA = gamma emission analysis
ICP/AES = Inductively coupled plasma/atomic emission spectroscopy
ICP/MS = ICP/mass spectrometry
N/A = Not applicable
NP = Not performed
TOC = total organic carbon

[1] LCS = Laboratory Control Standard. This standard is carried through the entire method. The accuracy of a method is usually expressed as the percent recovery of the LCS. The LCS is a matrix with known concentration of analytes processed with each preparation and analyses batch. It is expressed as percent recovery; i.e., the amount measured, divided by the known concentration, times 100.

[2] For some methods, the sample accuracy is expressed as the percent recovery of a matrix spike (MS) sample. It is expressed as percent recovery; i.e., the amount measured, less the amount in the sample, divided by the spike added, times 100. One matrix spike is performed/analytical batch samples are batched with similar matrices.

[3] RPD = Relative Percent Difference between the sample and duplicate results. Duplicates will be taken through preparation and analysis. Instrument analysis duplicates cannot be substituted except GEA which requires no preparation. Sample precision is estimated by analyzing duplicates. Acceptable sample precision is usually <20 percent RPD if the sample result is at least 10 times the instrument detection limit.

RPD = (|Result 1 - Result 2| /average result) x 100.

[4] MS analyses are not required for this method because a tracer or carrier is used to correct for analyte loss during sample preparation and analysis. The result generated using the tracer accounts for an inaccuracy of the method on the matrix. The reported results reflect this correction.

[5] The measurement is a direct reading of the energy and the analysis is not affected by the sample matrix; therefore, an MS is not required.

[6] All samples must be digested using the appropriate method prior to metals analyses.

[7] This method or other comparable method should be used.

The minimum reportable quantities (MRQs) for HLW feed chemical and radionuclide analyses (See Tables 4.9 and 4.10) are specified in the interface control document for HLW feed (PHMC 1997). These values are considered to be minimum requirements for selected constituents in the LAW feed samples. The estimated quantitation limit (EQL) and minimum detectable activity (MDA) have been corrected for dilution associated with sample preparation. Measurements less than the EQL/MDA will be reported as "<" the EQL/MDA. The minimum reportable quantities (also called practical quantitation quantities) are, in general, a factor of three greater than the EQL/MDA. Measurements between the EQL/MDA and MRQ values will be reported as absolute values; however, the analytical error associated with these data may be large relative to data greater than the MRQ.

TABLE 4.9. MINIMUM REPORTABLE QUANTITIES FOR HLW FEED CHEMICAL ANALYSES (2 SHEETS)

Analyte	Estimated Quantitation Limits (EQL) μ g/g dried solids	Minimum Reportable Quantity (MRQ) μ g/g dried solids
Ag	5.0 E+01	9.0 E+02 1.4 E+01
Al	1.1 E+02	3.3 E+02
As	1.0 E+00	3.0 E+00
B	1.0 E+00	3.0 E+00
Ba	2.0 E+02	6.0 E+02
Be	1.0 E+00	3.0 E+00
Bi	2.0 E+03	6.0 E+03
Ca	6.2 E+01	1.8 E+02
Cd	4.0 E+00	1.1 E+01
Ce	2.0 E+00	6.0 E+00
Co	1.0 E+00	3.0 E+00
Cr	4.0 E+01	1.2 E+02
Cs	2.0 E+00	6.0 E+00
Cu	6.5 E+00	1.8 E+01
F	2.5 E+03	7.5 E+03
Fe	5.0 E+01	1.4 E+02
Hg	5.0 E-01	1.5 E+00
K	5.0 E+02	1.5 E+03
La	2.0 E+01	3.0 E+03 6.0 E+01
Li	1.0 E+01	3.0 E+01
Mg	1.8 E+02	5.4 E+02
Mn	1.0 E+02	3.0 E+02
Mo	2.0 E+00	6.0 E+00
Na	5.0 E+01	1.5 E+02
Nd	2.6 E+01	7.7 E+01
Ni	5.5 E+01	1.6 E+02
P	2.0 E +02	6.0 E+02
Pb	2.0 E+02	6.0 E+02
Pd	1.0 E+00	3.0 E+00
Pr	2.0 E+00	6.0 E+00
Pu	8.0 E+00	2.4 E+01
Rb	2.0 E+00	6.0 E+00
Rh	2.0 E+00	6.0 E+00
Ru	1.0 E+00	3.0 E+00
S	4.0 E+02	1.2 E+03
Sb	4.0 E+00	1.2 E+01
Se	1.0 E+02	3.0 E+02

TABLE 4.9. MINIMUM REPORTABLE QUANTITIES FOR HLW FEED CHEMICAL ANALYSES (2 SHEETS)

Analyte	Estimated Quantitation Limits (EQL) μ g/g dried solids	Minimum Reportable Quantity (MRQ) μ g/g dried solids
Si	1.0 E+03	3.0 E+03
Sr	1.0 E+02	3.0 E+02
Ta	2.0 E+00	6.0 E+00
Tc	2.0 E+00	6.0 E+00
Te	2.0 E+00	6.0 E+00
Th	2.0 E+02	6.0 E+02
Ti	5.0 E+01	1.5 E+02
Tl	2.0 E+02	6.0 E+02
U	2.0 E+02	6.0 E+02
V	2.0 E-02	6.0 E-02
W	2.0 E+00	6.0 E+00
Y	9.0 E+01	2.7 E+02
Zn	2.0 E+00	6.0 E+00
Zr	2.0 E+02	6.0 E+02
Cl	7.5 E+01	2.3 E+02
CO_3	1.0 E+01	3.0 E+01
NO_2^-	1.5 E+02	4.5 E+02
NO_3^-	1.5 E+02	4.5 E+02
TOC	2.0 E+01	6.0 E+01
CN	1.0 E+00	3.0 E+00
NH_3	2.0 E+01	6.0 E+01

TABLE 4.10 MINIMUM REPORTABLE QUANTITIES FOR HLW FEED RADIONUCLIDES (2 Sheets)

Radionuclide	Minimum Detectable Activity (MDA) μ Ci/g dried solids	Minimum Reportable Quantity (MRQ) μ Ci/g dried solids
^{3}H	5.0 E-03	1.5 E-02
^{14}C	6.0 E-04	1.8 E-03
^{60}Co	4.0 E-03	1.2 E-02
^{90}Sr	7.0 E+01	7.0 E+01
^{99}Tc	2.0 E+00 µg/g	6.0 E+00 µg/g
^{125}Sb	2.0 E+00	6.0 E+00
^{126}Sn	2.0 E-02	6.0 E-02

TABLE 4.10 MINIMUM REPORTABLE QUANTITIES FOR HLW FEED RADIONUCLIDES (2 Sheets)

Radionuclide	Minimum Detectable Activity (MDA) μ Ci/g dried solids	Minimum Reportable Quantity (MRQ) μ Ci/g dried solids
^{129}I	1.0 E+01 μg/g	3.0 E+01 μg/g
^{137}Cs	2.0 E-02	6.0 E-02
^{152}Eu	2.0 E+00	2.0 E+00
^{154}Eu	2.0 E-02	6.0 E-02
^{155}Eu	2.0 E-02	6.0 E-02
^{233}U	2.0 E+00 μg/g	6.0 E+00 μg/g
^{235}U	2.0 E+00 μg/g	6.0 E+00 μg/g
^{237}Np	6.0 E-01 μg/g	1.8 E+00 μg/g
^{238}Pu	2.0 E-05	6.0 E-05
^{239}Pu	2.0 E+00 μg/g	6.0 E+00 μg/g
^{241}Pu	4.0 E-01	1.2 E-06
^{241}Am	4.0 E-04	1.2 E-03
$^{243+244}Cm$	2.0 E-05	6.0 E-05

5.0 DEFINE THE STUDY BOUNDARIES

Characteristics of candidate HLW feed in Phase I tanks 241-AZ-101, 241-AZ-102, 241-C-106, 241-C-104, and 241-C-102 will be estimated from waste analyses and laboratory tests that simulate feed delivery operations and conditions. Physical, chemical, radiological, and rheological properties of the waste will be determined in a timely manner to support feed delivery decisions. Data will be obtained for each tank before waste transfer; thus, the decisions based on these data are applicable only to individual tanks.

Physical and chemical characteristics of the HLW feed are not expected to change much over a number of years (provided storage conditions remain the same). Radioactivity levels in the wastes will decrease due to radioactive decay. Radionuclide concentrations can be adjusted to account for radioactive decay as necessary. Therefore, data collected with this sampling effort will be applicable throughout the projected schedule for waste feed delivery and treatment.

Two constraints are likely to be encountered during collection of the HLW data. First, the tanks in which the wastes are stored were designed with limited access to the interior of the tanks (i.e., the number of risers). In some cases, the number and locations of samples will be predetermined by the tank configurations. Secondly, the cost of laboratory analysis for these samples will be high because of precautions necessary when dealing with highly radioactive materials. These constraints will be considered when a sampling design is developed for each tank.

6.0 DEVELOP A DECISION RULE

To resolve the principal study questions, the statistical parameter of interest is the true mean of a waste property in a given feed batch or tank. The decision rules for this DQO can be stated as follow:

- If the true unknown means of chemical and radiological properties of HLW feed in Tank T are less than or equal to the feed envelope requirements (Tables 4.1 through 4.4), then these requirements are considered satisfied. Otherwise, negotiations for accepting out-of-specification feed must be conducted or another waste source must be selected.

- If the true unknown means of physical and rheological properties of the HLW feed are less than or equal to the waste transfer limits (Table 4.5), then these requirements are considered satisfied. Otherwise, actions must be taken to modify the waste characteristics, to select another waste, or to modify the limits.

- If the true unknown mean of the total mass of insoluble solids (grams of insoluble solids per liter of waste) in HLW feed is between 10 and 200 g/L, then this requirement is considered satisfied. Otherwise, actions must be taken to select another waste or modify the fraction of undissolved solids in the waste.

If the true unknown means of all interested properties are less than or equal to the associated requirements (or greater than or equal to a lower limit), then "*Tank T is confirmed as an appropriate feed source for HLW Feed Batch X.*" The true unknown mean of a given property is considered less than or equal to the associated requirement if the upper limit to an one-sided confidence interval about the estimated mean (or upper confidence level) is less than the requirement. The probability associated with the confidence interval for each property is specified in Section 7.0.

7.0 SPECIFY TOLERABLE LIMITS ON DECISION ERRORS

High-level waste in Phase I candidate feed tanks were generated from different spent-nuclear fuel reprocessing processes (e.g., PUREX, REDOX, etc.). Also, the types of spent fuels were different. It is expected that the waste properties vary significantly from tank to tank. Variation in properties within a given tank would be smaller. Variations in properties of candidate waste feed indicate the possibility of a significant decision error. For this reason, acceptable error levels for each decision (feed envelope, waste transfer, and quantity) have been established (Sections 7.1, 7.2, and 7.3, respectively).

7.1 ACCEPTABLE ERRORS FOR FEED ENVELOPE DECISION

The null hypothesis (H_o) for the feed envelope decision is that the chemical and radionuclide concentrations are outside the feed envelope limits, and the alternative hypothesis (H_a) is that the concentrations are within the limits. The null hypothesis presumes that the stated condition (i.e., waste concentrations exceed limits) is true in the absence of strong evidence to the contrary. Selection of the null hypothesis in this way provides a guard against concluding that HLW in Tank T satisfies the envelope limits when it does not. The hypotheses can be restated as follows:

H_o: $\mu >$ Upper Limit

H_a: $\mu <$ Upper Limit

Where μ is the true mean of an analytical or test property of interest.

The decision errors associated with the null and alternative hypotheses are as follows:

Type I Error (false positive): The data indicate that the properties are within the feed envelope when they are truly outside the envelope limits.

Type II Error (false negative): The data indicate that the properties are outside the envelope limits when they truly are within the envelope.

Potential consequences of the Type I error include:

- The waste could be transferred to the staging tank where the error is found through certification sampling. DOE would have to negotiate with the Privatization Contractor to accept out-of-specification feed. Negotiations conducted at that time may result in significant project delay.

- The error is found after treatment of HLW results in out-of-specification product. Resolution of the error may result in significant cost overrun and schedule delay.

- The error is never found. The treatment process is sufficiently robust to process slightly out-of-specification feed into acceptable product.

Potential consequences of the Type II error include:

- The waste could be transferred to the staging tank where the error is found. By then, negotiation for acceptance of out-of-specification feed would have taken place. Negotiation effort would be unnecessary but processing schedule would not be affected.

- The error is never found. DOE would have conducted unnecessary negotiation with the Privatization Contractor and possibly paid additional costs to the contractor for treating what was thought to be out-of-specification feed.

Overall, the consequences of the Type I error could be very high. Hence, the tolerable limit, alpha (α), is set at 0.05 (for an one-sided 95% confidence level) to guard against this type of error. The potential consequences for Type II error are slightly lower; thus, the corresponding tolerable limit, beta (β), is set at 0.1.

7.2 ACCEPTABLE ERROR LIMITS FOR WASTE TRANSFER DECISION

The null hypothesis (H_o) for the waste transfer decision is that the physical properties exceed the waste transfer limits, and the alternative hypothesis (H_a) is that the properties are under the limits. The null hypothesis presumes that the stated condition (i.e., waste properties exceed limits) is true in the absence of strong evidence to the contrary. Selection of the null hypothesis in this way provides a guard against concluding that HLW in Tank T satisfies waste transfer limits when it does not. The hypotheses can be restated as follows:

H_o: μ > Upper Limit

H_a: μ $\leq$ Upper Limit

Where μ is the true mean of an analytical or test property of interest.

The decision errors associated with the null and alternative hypotheses are as follows:

Type I Error (false positive): The data indicate that the properties are below the waste transfer limits when they are truly above the limits.

Type II Error (false negative): The data indicate that the properties are above the limits when they truly are below.

Potential consequence of the Type I error: The error is discovered during waste transfer to a staging tank. Waste transfer operations could be delayed to conduct engineering evaluation or additional process testing. Feed delivery schedule may be adversely affected.

Potential consequence of the Type II error: Unnecessary engineering studies and/or process tests may be conducted to modify waste transfer properties.

The consequences of these types of decision errors could be significant. A tolerable limit of 0.1 is set for both alpha and beta (for an one-sided 90% confidence level).

7.3 ACCEPTABLE ERROR LIMITS FOR QUANTITY DECISION

The null hypothesis (H_o) for the quantity decision is that the mass of insoluble solids in the HLW feed is outside the acceptable range, and the alternative hypothesis (H_a) is that the property is within the limits. The null hypothesis presumes that the stated condition (i.e., waste property is outside the limits) is true in the absence of strong evidence to the contrary. Selection of the null hypothesis in this way provides a guard against concluding that HLW in Tank T satisfies the quantity limits when it does not. The hypotheses can be restated as follows:

H_o: μ > Upper Limit or P < Lower Limit

H_a: Low Limit $\leq \mu \leq$ Upper Limit

Where μ is the true mean of an analytical or test property of interest.

The decision errors associated with the null and alternative hypotheses are as follows:

Type I Error (false positive): The data indicate that the property (mass of insoluble solids in unit volume of waste) is within the acceptable range when it is truly outside the limits.

Type II Error (false negative): The data indicate that the property is outside the limits when it is truly within the acceptable range.

Consequence of the Type I error: If the mass of insoluble solids exceeds the upper limit (200 g/L), then the waste may be diluted as needed. If it is below the lower limit, the number of canisters of HLW glass that can be produced for the feed batch may be less than expected. Also, DOE will not satisfy a feed delivery condition specified in the Privatization contract.

Consequence of the Type II error: Efforts may be made unnecessarily to bring the waste property within the acceptable range. These attempts will increase costs and may cause delays in the feed delivery schedule.

The consequences of these types of decision errors could be significant. A tolerable limit of 0.1 is set for both alpha and beta (for an one-sided 90% confidence level).

8.0 OPTIMIZE THE DESIGN FOR DATA COLLECTION

Data will be collected for HLW in a number of tanks under the direction provided in this DQO. The waste characteristics and storage conditions are unique for each tank. Also, the quantity and quality of existing data for waste in these tanks are different. For these reasons, a sampling design applicable for all HLW feed tanks is not possible. Rather, direction for designing a sample scheme that provides sufficient data to satisfy the needs for each tank is provided. Optimized sampling designs will be developed for individual tanks based on this DQO and will be included in tank-specific sampling and analysis plans (SAPs).

The type and quantity of data required to support each of the three DQO decisions are different. The number of samples will be determined separately for each decision. The total number of samples taken from each tank would be the highest calculated value. However, not all required analyses and tests will be performed on every sample. Direction for determining the right quantity of data to address each DQO decision is provided in the next three sections.

8.1 OPTIMIZE SAMPLING DESIGN FOR FEED ENVELOPE DECISION

The number of samples needed to support the feed envelope decision, n_1, will be calculated using the following equation (EPA 1994):

$$n_1 = \frac{\sigma^2 \left(Z_{1-b} + Z_{1-\alpha}\right)^2}{\Delta^2} + 0.5 {Z_{1-\alpha}}^2 \qquad \text{(Equation 1)}$$

where:

n_1 = minimum number of samples required
σ^2 = estimated variance in measurements
Z = the Z value of the standard normal distribution (from standard statistical table)
Δ = the difference between the action level and the estimated mean.

As discussed in the Decision Rule, action levels are the feed envelope limits (Tables 4.1 through 4.4). The mean concentrations for the feed envelope properties can be estimated from existing analytical data and results of previous waste mixing and/or dilution tests.

The variance for each property would be calculated if sufficient data are available. If data are insufficient, a rough estimate of the variance (or standard deviation) can be determined based on analytical results of a similar tank or based on the expected degree of mixing prior to and during waste transfer. The acceptable error levels specified in Section 7.1 will be used to obtain the appropriate Z values from a standard statistical table. Using this method, n_1 can be calculated for all feed envelope properties. The largest value calculated for n_1 is the minimum number of samples that must be taken to allow the decision to be made in accordance with the established rule. Additional samples may be obtained for contingency purpose.

Variability in tank waste such as different phases and layers, if it exists, must be addressed by the sampling scheme so that analytical results may be used to describe the whole content of the tank. Each sample must contain sufficient solids to perform the required mixing (and dilution if necessary) process tests. The undissolved solids will then be analyzed for properties listed in Tables 4.1 through 4.4 of this DQO.

8.2 OPTIMIZE SAMPLING DESIGN FOR THE WASTE TRANSFER DECISION

The number of samples needed to support this decision, n_2, will be calculated using a method similar to that described in Section 8.1. The action levels and the acceptable error levels are specified in Table 4.5 and Section 7.3, respectively. If one or more action levels were exceeded, process tests would be performed to determine the target dilution necessary to bring the waste characteristics within the acceptable criteria. The samples would be diluted at the target dilution ratio, mixed, and the properties re-measured.

8.3 OPTIMIZE SAMPLING DESIGN FOR THE WASTE QUANTITY DECISION

The number of samples needed to support this decision, n_3, will also be calculated using Equation 1. However, the action level could be the upper (200 grams of insoluble solids per liter of waste) or lower limit (10 g/L) of the acceptable range. The limit to be used will be the one closest to the estimated mean. The acceptable error levels are specified in Section 7.3. Sample preparation is similar to that discussed in Section 8.2. The total mass of undissolved solids in each sample will be measured.

In addition, a minimum of two samples each will undergo aqueous and caustic washes as described in Specifications 12.2.2 and 12.2.3 of the TWRS Privatization contract. The aqueous and caustic insoluble solids will then be analyzed for components listed in Table 4.7. (Note: As stated in Section 4.3, the minimum concentrations of waste components in HLW glass are not applicable to feed delivery; thus, the number of samples cannot be calculated. At least two samples are needed to allow statistical analysis of the data).

9.0 SUMMARY

A DQO process was conducted to assure appropriate data would be collected to "confirm Tank T is acceptable for HLW feed." The DQO identified three decision statements that require data to resolve:

- Determine whether or not HLW feed composition exceeds the envelope limits specified in the TWRS Privatization contract.
- Determine whether or not physical and rheological properties of the waste exceed established waste transfer criteria.
- Determine whether or not the quantity of HLW in Tank T is below the minimum requirement for a feed batch as required in the contract.

These decisions will be addressed for individual tanks because waste characteristics and storage conditions are unique for each tank. Also, quantity and quality of existing data for wastes in these tanks are different. For these reasons, an optimized sampling design for each HLW feed tank is needed. Direction for optimizing tank-specific sampling design is provided in Section 8.0. The number of samples (n_1, n_2, or n_3) that would be required for each decision regarding a given HLW tank will be calculated as described in Sections 8.1, 8.2, and 8.3, respectively. The largest value (plus a contingency) is the number of samples that would be taken from the tank. Sampling methods must be selected appropriately to assure the samples are representative of the waste.

Material from at least two samples will be used to study waste behavior during mixing. Also, if dilution were necessary to bring the HLW feed to within acceptable transfer criteria, then dilution process tests would be needed. A target dilution ratio would be determined for the waste.

All samples collected will be mixed and diluted, if necessary, at the target dilution ratio. Undissolved solids from each of the n_1 samples will be analyzed for properties listed in Tables 4.1 through 4.4. Physical properties (Table 4.5) of the sample mixture from each of the n_2 samples will be measured. The mass of undissolved solids from each of the n_3 samples also will be determined. In addition, a minimum of two samples each will be washed with aqueous and caustic solutions as described in Section 4.3 and the resulting insoluble solids will be analyzed for properties listed in Table 4.7. The overall test and analysis scheme is summarized in Table 9.1. Many of these tests can be combined to minimize laboratory cost. Also, existing information may already be sufficient to address a number of the tests and analyses. Optimization of the tests/analyses including deviations (omissions or additions) from the DQO requirements will be documented in tank-specific sampling and analysis plans and/or process test plans.

It should be noted that the DQO process is meant to be iterative. Data collected will be evaluated to determine if the decision rule is satisfied. Samples collected for contingency purpose may have to be analyzed as needed.

TABLE 9.1. OVERALL DATA COLLECTION SCHEME

Input Requirements	Process Tests To Prepare Samples for Analysis	Quantity of Data
• Fraction of solids that dissolve during mixing • Solids dissolution rate (or total dissolution time) • Solids settling rate after mixing • Physical properties of undissolved solids (before and after mixing) including particle size and density. • Visual inspection of soluble fraction for a separate organic layer.	Mixing (Samples will be mixed to simulate tank mixing prior to transfer)	A minimum of 2 measurements [1,2]
If dilution is necessary, then dilution and mixing tests (instead of the mixing tests described above) will be conducted and the data need includes: • The five input requirements above • Target dilution ratio	Dilution and mixing	A minimum of 2 measurements [1,2]
Undissolved solids will be analyzed for HLW feed envelope properties listed in Tables 4.1.0 to 4.4	Mixing (or dilution at target ratio and mixing, if necessary)	n_1 measurements [2]
Waste mixture containing both liquid and solids will be analyzed for properties listed in Table 4.5	Mixing (or dilution at target ratio and mixing, if necessary)	n_2 measurements [2]
Mass of undissolved solids per liter of waste mixture	Mixing (or dilution at target ratio and mixing, if necessary)	n_3 measurements [2]
Insoluble solids resulting from aqueous washes will be analyzed for properties listed in Table 4.7	• Mixing (or dilution at target ratio and mixing, if necessary) • Aqueous-wash	A minimum of 2 measurements [2]
Insoluble solids resulting from caustic washes will be analyzed for properties listed in Table 4.7	• Mixing (or dilution at target ratio and mixing, if necessary) • Caustic-wash	A minimum of 2 measurements [2]

[1] At this time, there are no acceptance limits (or action levels) associated with mixing or dilution properties, thus the number of samples for these properties cannot be calculated. These properties will be measured from at least 2 samples to allow statistical analysis of the data.

[2] Each measurement shall come from a separate original tank waste sample.

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