U.S. Department of Energy
P.O. Box 450, MSIN H6-60
Richland, Washington, 99352

JAN 3 0 2012

12-WTP-0039

The Honorable Peter S. Winokur
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, DC 20004-2901

TRANSMITTAL OF DEFENSE NUCLEAR FACILITIES SAFETY BOARD (DNFSB) RECOMMENDATION 2010-2 IMPLEMENTATION PLAN (IP) DELIVERABLE 5.5.3.4

Dear Mr. Chairman:

This letter provides you the deliverable responsive to Commitment 5.5.3.4 of the U. S. Department of Energy (DOE) plan to address Waste Treatment and Immobilization Plant (WTP) Vessels Mixing Issues; IP for DNFSB 2010-2.

The attached report identifies tank farm sampling and transfer capability test requirements to be documented in a test requirements document. This report provides input to separate IP deliverables for conduct of testing. Testing will 1) determine the range of physical properties of tank waste expected to be staged, sampled, and transferred to include uncertainties with waste properties, and 2) determine the capability of tank farm staging tank sampling systems to provide samples that will appropriately characterize the tank waste and be in compliance with the Waste Acceptance Criteria (WAC). These tests will reduce technical risk associated with overall mixing, sampling, and transfer of waste to WTP so that all WAC requirements are met. Testing will be completed with both small scale and full scale equipment at Hanford and off-site facilities.

Large-Scale Integrated Mixing System Expert Review Team review comments and resolution are also included with this transmittal.

If you have any questions, please contact me at (509) 376-6727 or your staff may contact Ben Harp, WTP Start-up and Commissioning Integration Manager at (509) 376-1462.

Sincerely,

Dale E. Knutson, Federal Project Director
Waste Treatment and Immobilization Plan

WTP:WRW

Attachments (2)

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ATTACHMENT 1
to
12-WTP-0039

TRANSMITTAL OF DEFENSE NUCLEAR FACILITIES SAFETY BOARD (DNFSB) RECOMMENDATION 2010-2 IMPLEMENTATION PLAN DELIVERABLE 5.5.3.4

- Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements, RPP-PLAN-41807, Rev 1A

(Total Number of Pages including coversheet: 32)

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RPP-PLAN-41807, Rev. 1A

Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements

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U.S. Department of Energy Contract DE-AC27-08RV14800

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Abstract: This plan addresses the general approach, test requirements, and overall schedule of the Mixing and Sampling Program to support waste feed delivery to the Waste Treatment and Immobilization Plant (WTP). The program will include activities to determine the range of waste physical properties that can be retrieved and transferred to WTP, based on testing and analysis. It will also determine the capability of the tank farm staging, tank sampling systems to obtain samples that can be characterized to assess the bounding physical properties important for the Waste Acceptance Criteria based on testing and analysis.

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1A TPM 01/24/12 RS	Page 1-3, Figure 1-1, was revised to include the following: changed the Test Requirements Final Gap Analysis Commitment number to 5.5.3.9, and changed LAW to low-activity waste in the Legend	Tamika Pirtle Moore Tamika Pirtle Moore 1/24/2012	Mike Thien Mike Thien 1/24/12

RPP-PLAN-41807
Rev. 1A

Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements

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Prepared for the U.S. Department of Energy
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Contractor for the U.S. Department of Energy
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EXECUTIVE SUMMARY

The primary purpose of the Tank Operations Contractor (TOC) Waste Feed Delivery (WFD) Mixing and Sampling Program is to mitigate the technical risks associated with the ability of the tank farms feed delivery systems to mix and sample high-level waste (HLW) feed adequately to meet the Waste Treatment and Immobilization Plant (WTP) Waste Acceptance Criteria (WAC). The TOC has identified two critical risks TOC-08-65 and TOC-12-64 per the TFC-PLN-39, *Risk and Opportunity Management Plan*, Rev. F-1. These two risks address emerging waste WAC and sampling method requirements. In addition, in November 2011, U.S. Department of Energy (DOE) issued the Implementation Plan (IP) for the Defense Nuclear Facility Safety Board Recommendation (DNFSB) 2010-2, DOE Rec. 2010-2, Rev. 0, *Implementation Plan for Defense Nuclear Safety Board Recommendation 2010-2*, which addresses safety concerns associated with the ability of the WTP to mix, sample, and transfer fast settling particles.

This document revises the previous plan to incorporate results to date and to include new requirements associated with DNFSB Recommendation 2010-2. This document satisfies DNFSB 2010-2 Sub-Recommendation 5, Commitment 5.5.3.4 and addresses the general approach, test requirements, and overall schedule of the WFD Mixing and Sampling Program to support WFD to the WTP including:

- Determine the range of waste physical properties that can be retrieved and transferred to WTP based on testing and analysis and
- Determine the capability of the tank farm staging, tank sampling systems to obtain samples that can be characterized to assess the bounding physical properties important for the WAC based on testing and analysis.

In order to meet the expanded TOC WFD Mixing and Sampling Program objectives identified above, test requirements have been established. Three major areas of testing will be executed during this Program:

- Limits of performance - determine the range of waste physical properties that can be mixed, sampled and transported under varying modes of operation.
- Solids accumulation - perform scaled testing to understand the behavior of remaining solids in a DST during multiple fill, mix, and transfer operations that are typical of the HLW feed delivery mission.
- Scaled performance - demonstrate mixing, sampling, and transfer performance using a realistic simulant representing a broad spectrum of Hanford waste to meet WTP WAC Data Quality Objective (DQO) sampling confidence requirements.

This work will be managed under the One System concept where TOC and WTP work scope will be integrated and managed under one management organization (RPP-54471, Rev. 0 and 24590-WTP-CH-MGT-11-008, *2020 Vision One System IPT Charter*). Waste Feed Delivery activities will be integrated and coordinated with the WTP Vessel Completion Team including Large-Scale Integrated Testing (LSIT) Program.

This document presents the foundation for the description of more detailed simulant and testing requirements that will define the TOC mixing and sampling program and satisfy additional DNFSB Recommendation 2010-2 Implementation Plan requirements.

CONTENTS

FIGURES

TABLES

TERMS

Abbreviations and Acronyms

ASME	American Society of Mechanical Engineers
DOE	U.S. Department of Energy
DNFSB	Defense Nuclear Facilities Safety Board
DST	double-shell tank
DQO	data quality objective
HLW	high-level waste
ICD	Interface Control Document
IP	Implementation Plan
LAW	low-activity waste
LSIT	Large-Scale Integrated Testing
M3	External Flowsheet Review Team Major Issue 3
MDT	mixing demonstration tank
MJP	mixer jet pump
ORP	Office of River Protection
PSDD	particle size density distribution
RPP	River Protection Project
RSD	Remote Sampler Demonstration
SRNL	Savannah River National Laboratory
SSMD	Small-Scale Mixing Demonstration
SST	single-shell tank
TOC	Tank Operations Contract
TPA	Tri-Party Agreement
TSD	Transfer System Demonstration
WAC	waste acceptance criteria
WFD	Waste Feed Delivery
WRPS	Washington River Protection Solutions, LLC
WTP	Waste Treatment and Immobilization Plant

Units

ft	feet
in	inch
gpm	gallons per minute

1.0 INTRODUCTION AND PURPOSE

1.1 INTRODUCTION

The U.S. Department of Energy (DOE), Office of River Protection (ORP) is responsible for management and completion of the River Protection Project (RPP) mission, which comprises both the Hanford Site tank farms operations and the WTP. The RPP mission is to store, retrieve, and treat Hanford's tank waste; store and dispose of treated wastes; and close the tank farm waste management areas and treatment facilities by 2047 in a safe, environmentally compliant, cost-effective, and energy-effective manner.

The *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) (aka Tri-Party Agreement [TPA]) requires DOE to complete the RPP tank waste treatment mission by September 30, 2047. A key aspect of implementing that mission is to construct and operate the WTP (ORP-11242, *River Protection Project System Plan*). The WTP is a multi-facility plant that will separate and immobilize the tank waste for final disposition. Tank Farm waste treatment is scheduled to be completed by 2047.

The RPP work scope is currently performed by two primary contractors: Washington River Protection Solutions, LLC (WRPS) (the TOC); and Bechtel National, Inc. (BNI), the WTP Construction and Commissioning Contractor. WRPS is responsible for the construction, operation, and maintenance activities necessary to store, retrieve, and transfer tank wastes; provide supplemental pretreatment for tank waste; and provide secondary low-activity waste (LAW) treatment, storage, and/or disposal of the immobilized product and secondary waste streams. BNI is responsible for the design, construction, and commissioning of a WTP Pretreatment Facility, two vitrification facilities (one for HLW and one for LAW), a dedicated analytical and radiochemical laboratory, and supporting facilities to convert radioactive tank wastes into glass for long-term storage or final disposal.

1.2 PURPOSE

One of the primary goals of the TOC is to provide waste feed to the WTP for treatment and immobilization. This goal will partially be met through the TOC Mixing and Sampling Program, which includes the following activities:

- Small-scale mixing demonstration (SSMD),
- Remote sampler demonstration (RSD),
- Savannah River National Laboratory (SRNL) scouting studies, and
- Future full-scale testing.

The primary purpose of the TOC Mixing and Sampling Program is to mitigate the technical risks associated with the ability of the tank farms WFD systems to mix and sample HLW feed adequately to meet the WTP WAC (24590-WTP-RPT-MGT-11-014, *Initial Data Quality Objectives for WTP Feed Acceptance Criteria)*. Consistent batch tank waste feed is desirable for efficient operations of the WTP. However, uniform feed is not achievable for the full complement of tank waste properties for the current WFD Mixing and Sampling baseline.

The TOC has identified two critical risks TOC-08-65 and TOC-12-64 per the TFC-PLN-39. These risks address emerging WAC and sampling method requirements. In addition, the WFD Mixing and Sampling Program will address system performance related to WTP safety issues raised by the Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2010-2 and the Implementation Plan submitted by DOE to resolve these issues (DOE Rec. 2010-2). TOC's responsibilities are only associated with Sub-recommendation 5 commitments of DOE Rec. 2010-2. Table 1-1 provides a summary of the DNFSB commitments that the TOC is either leading or participating with as a co-lead.

Table 1-1. Defense Nuclear Facility Safety Board Recommendation 2010-2 Commitments

Commitment No.	Due Date	POC	Commitment Description
5.5.3.1	12/31/2012	WRPS/BNI	Initial gap analysis between Waste Treatment and Immobilization Plant (WTP) waste acceptance criteria (WAC) and tank farm sampling and transfer capability
5.5.3.2	6/30/2012	WRPS	Evaluation of waste transferred to WTP
5.5.3.3	12 months after LSIT Testing Report complete	BNI	Update WAC Requirements based on WTP Large-Scale Integrated Testing results
5.5.3.4	1/31/2012	WRPS	Identification of tank farm sampling and transfer capability test requirements to be documented in a test requirements document
5.5.3.5	3/30/2012	WRPS	Definition of simulants for tank farm performance testing
5.5.3.6	5/31/2012	WRPS	Test plan to establish Tank Farm performance capability
5.5.3.7	3/31/2013	WRPS	Results from Tank Farm performance testing
5.5.3.8	12/31/2012	WRPS	Issue remote sampler test report
5.5.3.9	8/31/2014	WRPS/BNI	Complete Final Gap Analysis
5.5.3.10	5/31/2015	WRPS/BNI	Optimize WTP WAC Data Quality Objectives

The execution schedule including DNFSB Recommendation 2010-2, Sub-Recommendation 5 commitments is depicted in Figure 1-1.

In summary, the TOC will conduct tests to determine the range of waste physical properties that can be retrieved and transferred to WTP, and determine the capability of tank farm staging tank sampling systems to provide samples that will appropriately characterize the tank waste and determine compliance with the WAC. These tests will reduce the technical risk associated with the overall mixing, sampling, and transferring of HLW feed to WTP and ensure that all WAC requirements are met. Testing will be completed with both small-scale and full-scale equipment at Hanford and multiple off-site facilities.

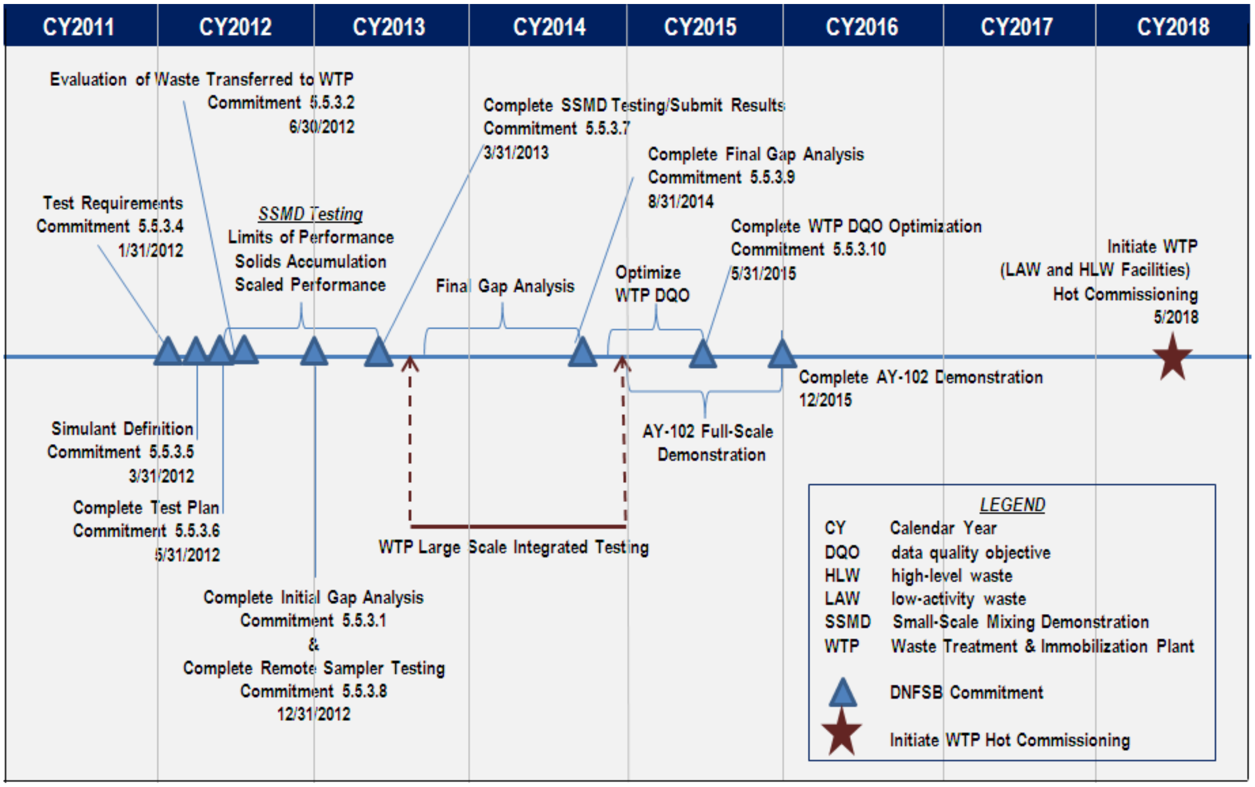

Figure 1-1. Mixing and Sampling Program Integrated Schedule

This document satisfies DNFSB Recommendation 2010-2, Commitment 5.5.3.4 and addresses the general approach, test requirements, and overall schedule of the Mixing and Sampling Program to support WFD to the WTP including:

- Determine the range of waste physical properties that can be retrieved and transferred to WTP based on testing and analysis
- Determine the capability of the tank farm staging tank sampling systems to obtain samples that can be characterized to assess the bounding physical properties important for the WAC based on testing and analysis

Additional information will be generated as part of parallel work that will further define test requirements. This parallel work includes Commitment 5.5.3.2, which estimates, based on current information, the range of waste physical properties that can be transferred to WTP and Commitments 5.7.3.1 and 5.7.3.4 which identify potential new WAC requirements based on preliminary documented safety analyses coupled with projections of potential WAC requirements based on recent assessments. Decisions on how to adjust test requirements based on these evolving requirements will be made and documented in updates to the issued WFD Mixing and Sampling Program Plan and Test Requirements.

This work will be managed under the One System concept where TOC and WTP workscope will be integrated and managed under one management organization (RPP-51471, and 24590-WTP-CH-MGT-11-008, *2020 Vision One System IPT Charter*). Waste Feed Delivery activities will be integrated and coordinated with the WTP Vessel Completion Team including the Large-Scale Integrated Testing (LSIT) Program.

2.0 BACKGROUND

The ORP has defined the interface between the two major RPP contractors, BNI and TOC, in a series of interface control documents (ICDs). The primary waste interface document is 24590-WTP-ICD-MG-01-019, *ICD-19-Interface Control Document for Waste Feed* (ICD-19). Iterative updates to ICD-19 are anticipated as new information is generated. ICD-19 identifies a significant incompatibility between the TOC baseline equipment configuration and capabilities and the WTP baseline design and regulatory assumptions requirements for tank WFD to WTP. Section 2.3 states that the TOC baseline sampling plans and capabilities are not currently compatible with WTP sample and analysis requirements as described in 24590-WTP-PL-PR-04-0001, *Integrated Sampling and Analysis Requirements Document (ISARD)* (), the 24590-WTP-RPT-MGT-11-014, *Initial Data Quality Objectives for WTP Feed Acceptance Criteria* (), and the 24590-WTP-RPT-MGT-04-001, *Regulatory Data Quality Optimization Report*.

The WTP dynamic processing analysis and batch processing planning currently assumes each staged HLW feed tank is mixed and delivered in consistent feed delivery batches of 145,000 gallons (ICD-19). Consistent, as used here is intended to mean that the first 145,000 gallon batch has the same solids composition as the last 145,000 gallon batch. Small-scale testing completed to date (RPP-50557, *Tank Waste Mixing and Sampling Update* , Rev. 0b) concludes that the first feed tank (AY-102) can likely be sampled adequately using DST mixing systems, but that additional uncertainties related to data uncertainty, optimizing system performance, applicability to all feed tanks, and understanding emerging WTP solids handling risks still need to be addressed.

The SSMD project has focused on the first HLW planned for transfer to WTP, (AY-102) and now will apply knowledge gained to the remaining planned feed delivery DSTs. Double-Shell Tanks are 75 feet (ft) in diameter, and have an operating liquid height of up to 454 inches. The staged HLW feed tanks could have settled solids (sludge) heights of up to 70 in. The baseline configuration will include two, 400 horsepower mixer pumps, with opposing 6-inch diameter nozzles that will recirculate tank waste at approximately 5,200 gallons per minute (gpm) per nozzle. The mixer pumps have the ability to be rotated such that the nozzles can cover a full 360° of rotation. A slurry transfer pump will be installed near the center and bottom of the DSTs to transfer HLW slurry to the WTP up to 140 gpm.

The historical TOC baseline plan includes mixing of waste in a DST using slurry mixer pumps and then performing grab and core sampling for sludge and supernate feed waste acceptance analysis. A proposed alternative mixing and sampling concept based on a dynamic mixed tank includes a transfer pump driven recirculation and sampling loop, which allows remote sampling of the to-be-delivered feed stream during tank mixing and a real-time direct critical velocity measurement.

Work conducted over the past 5 years has introduced information that may result in new WAC requirements. This workscope includes mixing assessments that have indicated that:

- Controls on waste particles size and density may be required, and
- New controls on waste containing fissile material particles of larger size and density than previously assumed may be required.

The WFD Mixing and Sampling Program Plan and Test Requirements will be updated to address changes in the WAC. The evaluation of waste to be transferred to WTP, identified as Commitment 5.5.3.2, June 30, 2012, will define the preliminary range of physical properties of waste anticipated to be delivered to WTP.

2.1 WORK COMPLETED TO DATE

Initial SSMD Program results demonstrated that equivalent mixing performance, from a solids distribution perspective, can be achieved in two different scaled tanks. These results provide a foundation for beginning to explore other performance parameters that were investigated in the sampling and batch transfer phase. Reports identify a range of scaling factors (approximately 0.25 to 0.3) applicable to DST mixing (RPP-49740, *Small-Scale Mixing Demonstration Sampling and Batch Transfer Result Report*). The sampling and batch transfer testing results have indicated the feasibility of mixing the tanks adequately to provide a representative sample to the transfer system. The results indicated that more difficult and fastest settling particles can be delivered to the transfer system.

The RSD constructed at Monarch Machine and Tool in Pasco, Washington, includes a flow loop to allow testing of the Isolok® sampler and a PulseEcho ultrasonic measurement device to determine critical velocities. The flow loop is fitted with an Isolok®[1] sampler, and a Coriolis meter for measuring bulk density. The flow loop is currently configured to accept the PulseEcho system which will be installed later.

Initial work evaluated the ability of the Isolok to take a representative and repeatable sample based on analyte concentrations when compared to a known concentration. The data showed the Isolok® has a propensity to collect large and higher density particles over small and lower density particles. The cause of this bias is being evaluated.

Previous testing of the PulseEcho system at PNNL's PDL-East facility showed that the system is capable of measuring the point at which solids begin to fall out of solution, which is considered the onset of critical velocity. Various simulants were tested with similar results.

Appendix A presents a summary of the objective and outcome of testing results to-date and the five workshops conducted in chronological order, which provides a foundation for future work. While the initial work has demonstrated the concept functionality for the first feed tank, uncertainties remain that must be addressed. The remaining uncertainties to be resolved related to optimizing system performance include the applicability of data to all tank waste and understanding the emerging WTP solids handling risks.

2.2 MIXING PROGRAM ADJUSTMENTS

2.2.1 Defense Nuclear Facility Safety Board Recommendation 2010-2

DNFSB Recommendation 2010-2 has raised WTP safety issues related to tank farms ability to mix, sample, and transfer solids. In response, DOE developed an implementation plan to resolve these issues (DOE Rec. 2010-2). As discussed in Section 1.0, this program plan and test requirements document satisfies Commitment 5.5.3.4 of the Implementation Plan.

[1] Isolok® is a registered trademark of Sentry Equipment Corporation of Oconomowoc Wisconsin.

2.2.2 October 2011 Optimization Workshop Recommendations

During October 10 – 12, 2011, the TOC held their 5th Mixing and Sampling workshop in Richland, Washington (WRPS-1105293, *Small Scale Mixing Demonstration Optimization Workshop Meeting Minutes)*. The Mixing and Sampling Program has been augmented by internationally recognized mixing experts, National Laboratory and University experts, and TOC and WTP project subject matter experts. DNFSB technical staff was also present to observe the proceedings. Participants are listed in the minutes, WRPS-1105293. Over the past three years, the experts progressively evaluated the SSMD Project results to-date. During this workshop, the Expert Panel addressed a detailed list of outstanding key uncertainties including:

- Simulant Selection,
- Bounds of Equipment Performance,
- Scale-up,
- Solids Accumulation,
- Nozzle Performance, and
- Sparse Particle Detection,

The output from this workshop has been used to provide guidance in the development of this plan.

The primary output from the workshop was a group discussion of how to best prioritize the activities necessary to address the remaining uncertainties and to ensure that the work is appropriately integrated with the WTP LSIT activities. The group consensus identified the following path forward priorities in order of importance:

1. Bounds of Equipment Performance
   - Continue using the SSMD platform to determine the largest particles of two different representative densities that the system is capable of mixing, sampling, and transporting
   - Integral with above workscope, select appropriate complex simulants and accurate analytical techniques to characterize the material of interest
   - Integrate workscope with WTP simulant selection
2. Batch Accumulation Behavior
   - Initiate new phase of testing to understand the behavior of remaining solids in a DST during multiple fill, mix, and transfer operations that are typical of HLW WFD
3. Scale Up
   - Continue gathering data to enable the estimation of full-scale mixing, sampling, and solids transfer (but not as a specific test driver)
   - Scaled performance information can be gathered while testing for the two primary performance objectives; bounds of equipment performance and batch accumulation
4. Operational Improvements

- Evaluate parameters with less significant impact on mixing to confirm the significance impact to these parameters (e.g., capture velocity sensitivity, mixer pump rotation rate)

In addition, cold, full-scale mixing and sampling demonstration was recommended to be completed prior to demonstration in an actual DST, recognizing that sustained mixing test results from Tank AY-102 will not likely be available.

3.0 MIXING AND SAMPLING PROGRAM OBJECTIVES

The original objective of the Mixing and Sampling Program was to mitigate the technical risks associated with the ability of the tank farms WFD systems to mix and sample HLW feed adequately to meet the WTP WAC. Testing focused on the ability to achieve adequate mixing and representative sampling, minimizing variability between batches transferred to WTP. Testing to date (RPP-49740) has demonstrated the potential ability to adequately sample and deliver AY-102 simulated waste using currently planned DST mixing and transfer systems.

While several uncertainties remain regarding the ability to characterize DST waste adequately, larger mission uncertainties related to the compatibility of tank farms feed systems with the WTP receipt systems remain to be addressed. The current TOC Mixing and Sampling Program is being executed in a phased approach that will:

- Optimize requirements,
- Demonstrate the viability of systems to meet those requirements in a small-scale environment, and upon successful small-scale demonstration, and
- Exhibit system capability in a full-scale DST (i.e., DST which will be providing hot commissioning feed to WTP).

Upon successful demonstration of mixing and sampling in the first DST, a systematic evaluation of all HLW feed batches will be completed to identify any unique configurations or operating scenarios that may require additional demonstration activities.

This plan defines requirements for testing to address tank farm feed mixing, sampling, characterization and transfer system capability, which will support a gap analysis of capabilities to sample characterize and transfer waste to WTP that conforms with ICD-19. Testing may be accomplished through expansion of the Mixing and Sampling Program scope, including testing in conjunction with WTP large scale integrated testing, or by other means.

To ensure tank farms and WTP mixing and sampling systems are integrated and compatible (i.e., execution of the One System approach) and the uncertainties identified in RPP-50557 are addressed, the TOC Mixing and Sampling Program is being expanded to include:

- Define DST mixing, sampling, and transfer system limits of performance with respect to the ability to transfer waste to the WTP with varying physical properties, solid particulates sizes and densities, and under various modes of operation (i.e., defining the expected range of particle size and density and consideration of data uncertainty).
- Define propensity of solid particulates to build up, and the potential for concentration of fissile material over time in DSTs during the multiple fill, mix, and transfer operations expected to occur over the life of the mission.
- Define ability of DST sampling system to collect representative slurry samples and in-line critical velocity measurements from a fully mixed waste feed staging tank.
- Develop sufficient data and methodology to predict confidently full-scale DST mixing, sampling, and transfer system performance; such that a gap analysis against WTP feed receipt system performance can be adequately completed.

As described in Revision 0 of this plan, confirmation of full scale mixing performance is planned to be performed in conjunction with the installation and testing of the first mixer pumps in AY-102. This is scheduled to be completed well ahead of the first HLW feed delivery need date to allow for any operational adjustments that may be identified.

4.0 TESTING REQUIREMENTS

In order to meet the expanded TOC Mixing and Sampling Program objectives identified in Section 3.0, the following test requirements have been established. Three major areas of testing will be executed during this Program:

- Limits of performance,
- Solids accumulation, and
- Scaled performance.

Testing will be designed to bound system performance taking into account the uncertainty of known waste characteristics.

4.1 LIMITS OF PERFORMANCE

The objective of Limits of Performance activities is to determine the range of waste physical properties that can be mixed, sampled and transported under varying modes of operation. Integral with this activity is the selection of appropriately complex simulants, integrated with WTP simulant selection and supported by accurate analytical techniques to characterize the material of interest. Particle size and density are expected to be the most important solids properties. Particle shape is assumed to be less important but this will be confirmed by SRNL studies being done to support the WTP LSIT program and will be re-addressed, if necessary.

To meet this objective, the following specific activities, including inter-related sampling activities, are planned (the sequence of activities is not implied by this list):

- Use SSMD platform to test progressively larger particle size and density to identify the largest size and density of particles that can be mixed and transferred from the SSMD transfer system.
- Use a full-scale transfer system demonstration platform to define limits of particle size performance that cannot be tested with SSMD platform (i.e., physical size constraints of the scaled equipment).
- Evaluate the performance of Isolok® sampler to:
  - Collect representative and repeatable samples from the RSD loop over a range of simulant formulations representing potential HLW slurry conditions and
  - Identify particle size and density limitations of the Isolok® sampler in the RSD Loop.
- Evaluate the design of prototypic mechanical handling and conveyor systems (including placement and retrieval of a sample container from Isolok® sampler) and the placement of the sample bottle into a cask located on a motorized conveyor to assure that the sample bottle and shielded cask are compatible with the mechanical handling equipment used by the receiving laboratory.
- Determine the Isolok® sampler operating limits for temperature and pressure.
- Evaluate the performance of PulseEcho critical velocity detection instrument (developed by PNNL, PNNL-20350) over a range of simulant formulations representing potential HLW slurry conditions.

4.2 SOLIDS ACCUMULATION

The objective of Solids Accumulation activities is to perform scaled testing to understand the behavior of remaining solids in a DST during multiple fill, mix, and transfer operations that are typical of the HLW feed delivery mission. Testing will focus on accumulation of total solids over time and the propensity for simulated fissile material localized concentration to change over time. The following specific activities are planned to meet this objective:

- Use the SRNL mixing demonstration tank (MDT) platform to:
  - Perform scouting studies to evaluate remaining bulk material in a tank after a series of full MDT campaigns of feed tank pump-out and prototypic refill (similar to planned WFD campaigns to WTP) and
  - Determine what particles or materials remain in the MDT after a series of full tank pump out and prototypic refills (i.e., concentration and locations where the fastest settling particles accumulate in the tank heels).
- Use the SSMD platform to perform testing under NQA-1 requirements to:
  - Further refine SRNL demonstrated behavior of solids accumulation and simulated fissile material localized concentration and
  - Determine concentrations and locations of specific particles in the remaining tank heels.

4.3 SCALED PERFORMANCE

While test data collected to date has provided some insight to mixing, sampling, and transfer performance (e.g. RPP-50557), more data is needed to confidently predict full-scale performance. The objective of Scaled Performance activities is to test at two scales, mixing and sampling; then transfer performance using a realistic simulant representing a broad spectrum of Hanford waste to meet WTP WAC DQO sampling confidence requirements. The following activities will be completed to meet this objective:

- Use the SSMD platform (43 inch and 120 inch tanks) to test at two or more mixing velocities to:
  - Evaluate the development of "mounds" and transfer behavior,
  - Define scaled test approaches to apply these test results at full scale, and
  - Develop a basis for confirming the velocities used for scaled testing.
- Use the RSD platform to define operational steps for the Isolok® sampler and describe functional requirement for supporting systems necessary for field deployment

5.0 SIMULANT PHILOSOPHY

DNFSB 2010-2Commitment 5.5.3.5 (due March 31, 2012) will define the simulants to be used for testing. The shift in testing philosophy away from demonstrating adequate performance in a conservative simulant (e.g. non-cohesive particulates in water) to a testing philosophy that defines limits of performance to support a gap analysis also requires a shift in simulant philosophy.

Successful completion of the TOC Mixing and Sampling Program depends upon the selection of appropriately complex simulants that are reflective of expected tank conditions, integrated with WTP simulant selection, and supported by accurate analytical techniques to characterize the material of interest. Testing will use increasingly complex simulants that are more representative of all Hanford tank waste.

The simulant that has been used in past SSMD activities, which consists of water and a five component particulate mix (PNNL 20637, *Comparison of Waste Feed Delivery Small Scale Mixing Demonstration Simulant to Hanford Waste*), is considered more challenging than AY-102 waste and waste composites except for particulates at the very high end of the size and density curve. The SSMD simulant, however, is not as challenging compared to the other HLW sludges that may be encountered in other DSTs. As much as 50% by volume of the HLW sludge waste particulate is more challenging than the SSMD simulant relative to properties such as settling velocity, pipeline transport, and Archimedes number (PNNL-20637). Therefore a simulant that is more representative of these more challenging tank wastes must be developed to support the TOC Mixing and Sampling Program objectives.

ASTM C1750-11 (*Standard Guide for Development, Verification, Validation, and Documentation of Simulated High-Level Tank Waste*) will be used for guidance on simulant selection. The guidelines will be used to help identify realistic simulants that envelope the complete range of physical properties for the high-level waste expected to be staged for WTP WFD.

The simulants developed and used for these testing activities will be integrated with WTP LSIT simulant development to ensure consistency in testing and will draw from the following experience and lessons learned:

- SSMD Program,
- WTP External Flowsheet Review Team Major Issue 3 (M3) Program, and
- SRNL mixing and sampling testing for both Savannah River and Hanford tank farm wastes.

Simulants will use non-hazardous materials except where hazardous components are required to produce a chemically representative simulant, in which case all safety requirements will be followed.

6.0 QUALITY ASSURANCE

Final testing with focused objectives will be done consistent with TOC's Quality Assurance Program that meets American National Standard American Society of Mechanical Engineers (ASME), NQA-1-2004, Quality Assurance Requirements for Nuclear Facility applications. The applicable version and addenda are identified in TFC-PLN-02, *Quality Assurance Program Description*. It is acceptable to perform scouting or development studies under commercial quality requirements. Data accuracy tolerances will be provided in the test plans.

7.0 REFERENCES

American Society for Testing and Materials C1750-11, *Standard Guide for Development, Verification, Validation, and Documentation of Simulated High-Level Tank Waste,* West Conshohocken, Pennsylvania.

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RPP-49740, Rev. 0, 2011, *Small Scale Mixing Demonstration Sampling and Batch Transfer Results Report*, Energy Solutions, Richland, Washington.

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APPENDIX A

MIXING AND SAMPLING PROGRAM WORK COMPLETED TO-DATE

The following table of historical results is drawn from RPP-50557, Rev. 0b, 2012, *Tank Waste Mixing and Sampling Update*. The descriptions of objectives and results are intended to summarize what is presented in the following documents and from workshop minutes as listed. The descriptions of results are subject to modification by more recent and future work.

Table A-1. Historical Mixing and Sampling Testing Results (5 Pages)

Objectives	Results
SRNL-STI-2009-0326 (April 2009) – *Demonstration of Internal Structures Impacts on Double Shell Tank Mixing Effectiveness*[a]	
To qualitatively demonstrate the mixing characteristics of AY-102.	Twelve test conducted: • Demonstrated the tanks are not homogeneously mixed • The air lift circulators do not impact the observed qualitative mixing behavior
Scaling Workshop (June 2009)	
Evaluated Savannah River National Laboratory (SRNL) Scouting Study workscope, identified SSMD scaling levels, and recommended the mixing and sampling program approach.	• Identified design and test basis for two scaling levels to be used and design and construction of a new testing demonstration platform in Pasco, Washington • Recommended to match SRNL 1/22 scale tank and design and construct a larger scale (~10 ft.) tank for demonstration platform • Recommended that computational fluid dynamics (CFD) modeling be focused on single phase velocity modeling first, and then build correlations to observed particle behavior.
SRNL-STI-2009-00717 (November 2009) – *Demonstration of Simulated Waste Transfers from Tank AY-102 to the Waste Treatment Plant*[b]	
Qualitatively demonstrate how well waste can be transferred out of a mixed DST and provide insights into the consistency between the batches being transferred.	For the twelve tests conducted: • Solids (gibbsite and silica carbide) transferred were consistent for the first five batches transferred regardless of mixing or batch transfer conditions • Increasing flow rate didn't change the consistency of batch transfers, however more solids were transferred out • Rotation rate within the tested range didn't have a large impact with batch transfers
SSMD Planning Workshop (December 2009)	
Review of SRNL Scouting Study and development of initial SSMD testing criteria and instrumentation to be used.	• Reviewed SRNL reviewed results of the qualitative scouting study of mixing and batch transfers • Introduced and evaluated instruments to be used to quantitatively measure mixing behavior in both tanks at Pasco Facility • Developed initial testing criteria • Agreed to perform testing in water to observe conservative performance of non-cohesive particles using various complex simulants modeled largely on Tank AY-102 waste
SSMD Initial Results Workshop (July 2010)	
Review RSD loop work plan and Phase 2 SRNL Scouting Study and CFD modeling results and recommend SSMD simulant improvements.	• Phase 2 - SRNL Scouting Study with focus on rotational rates – Cohesive particles could potentially impact batch transfers based on future studies due to the fact that cohesive particles may not mix as much at the bottom of a tank as at the

Table A-1. Historical Mixing and Sampling Testing Results (5 Pages)

Objectives	Results
	top – SSMD simulant selection, testing/tuning run matrices, and testing objectives • CFD Modeling Results: – Batch Transfer performance results are more significant than mixing performance results so correlations between the two are useful – CFD is valuable for exploring missing geometry effects • SSMD Results: – Current testing plan is an appropriate approach but data interpretation and correlation of scale-up estimates with batch transfer performance data needs additional understanding - V_{target} is a good point of data, but not as essential as originally envisioned – Demonstrated performance across a range of velocities is more useful in gaining scale up confidence • Program Recommendation – Complete recommendation on need for a dedicated Mixing and Sampling Facility by September 30, 2011
SRNL-STI-2010-00521 (Sept 2010) – *Demonstration of Mixer Jet Pump Rotational Sensitivity of Mixing and Transfers of AY-102 Tank*[c]	
Determine the impact on batch transfers when rotational parameters of the mixer jet pumps (MJPs) are varied.	Nineteen tests conducted: • Solids consistency variability (transferred batch tot batch) was very small for the first five batches transferred and was unaffected by the variations in MJP rotational characteristics • Lower rotational rates may support suspending solids that settle out faster
RPP-48055 (December 2010) – *Computational Fluid Dynamics Modeling of Scaled Hanford DST Mixing- Fiscal year 2010 Model Development Results*[d]	
Develop a DST mixing CFD model that predicts single-phase (fluid only) velocities that accurately mimic observed mixing performance in two SSMD platforms, develop scale-up correlations and estimate mixing performance in Hanford DST AY-102	• A functional single-phase CFD model was developed for the 43.2”, 120”, and full scale tanks • SSMD instrumentation difficulties prevented comparing model velocities with demonstration platform performance • Scale-up correlation for this model used the one/third power law factor
RPP-47557 (December 2010) – *Small Scale Mixing Demonstration Initial Results Report*[e]	
Demonstrate that comparable tank mixing behavior can be achieved in the two sizes of scaled tanks including: • Equipment performance and the ability of the scaled tanks to meet performance objectives	Test results showed: • Tank operating characteristics(V_{target}, $V_{lower,}$ and V_{upper}) were defined where similar performance was noted in the 43.2” and 120” tanks • Parameters are only indicators of mixing in the two scaled tanks and cannot be directly

Table A-1. Historical Mixing and Sampling Testing Results (5 Pages)

Objectives	Results
• Range of tank operating parameters that define the edges of mixing performance including mixer pump flow rate (nozzle velocity) and rotation rate (angular velocity), and provide the framework to move forward to the next phase of batch transfer and sampling testing (Phase 2)	used to derive scale-up correlations • Nozzle angular rotation (within the range tested) does not significantly affect the mixing in the tanks for the conditions tested, and the power law-based angular velocity should be used for all remaining testing • Repeatability tests have demonstrated that good reproducibility of data (within 10% for density) can be achieved in both tanks over repeated measurements
RPP-RPT-48233 (February 2011) -- *Independent Analysis of Small Scale Mixing Demonstration Testing*[f]	
Perform an independent, statistically based review of the tank performance data collected during Phase I of SSMD testing.	Statistical evaluation concluded: • Both scales of tanks have similar performance characteristics • Equivalent performance flow rates at 9 and102 gallon per minute (gpm) were defined for small and large tanks, respectively • Mixing plateaus can be defined where similar mixing is observed across a range of mixer pump velocities and below which mixing performance noticeably degrades
SSMD Sampling/Batch Transfer results workshop (March 2011)	
Review initial SSMD sampling and batch transfer results, examine statistical approach to data evaluation, review initial CFD modeling conclusions and Phase 2 SRNL Scouting Study results and recommend adjustments accordingly.	• Statistical approach to mixing using Coriolis Meter was used to build a regression model to find "equivalent" mixing and concluded: – Equivalent mixing flow rates – Small tank – 9 gpm – 23.4 ft/sec; Large tank – 102 gpm – 31.0 ft/sec – Velocity scale-up exponent on scale ratio of 0.32 – Degraded mixing flow rates – Small tank – 7.5 gpm – 19.5 ft/sec; Large tank – 80 gpm – 24.3 ft/sec – Mixing plateau – Small tank – (9-7.5)/9 = 17%; Large tank – (102-80)/102 = 22% • CFD modeling conclusions are consistent with SSMD observations (i.e., flowrate is more important than rotation rate and mixing performance improves [from a relative jet velocity sensitivity perspective] as scale increases) • SRNL Scouting Studies concluded that SSMD testing in water is conservative (i.e., water is a conservative fluid for transferring solids when compared to a liquid with a higher viscosity or a slurry with a yield stress and MJP cleaning radius is impacted by fluid rheology
24590-WTP-RPT-MGT-11-014, Rev. 0 (May 2011) – *Initial Data Quality Objectives for Waste Treatment Plant Feed Acceptance Criteria*[g]	
Describe type, quantity and quality of data required for WTP waste feed acceptance criteria to ensure that feed transfer and	• Evaluated all (in excess of 200) ICD-19 acceptance parameters and identified sixteen key WAC action limit parameters specific to safely and compliantly accepting waste at the

Table A-1. Historical Mixing and Sampling Testing Results (5 Pages)

Objectives	Results
receipt will not exceed WTP plant design, safety, and processing limits.	WTP • Identified initial data confidence requirements for action limit parameters
SRNL-STI-2011-00278 (July 2011) – *Demonstration of Mixing and Transferring Settling Cohesive Slurry Simulants in Tank AY-102*[h]	
Determine the impact of cohesive particle interactions in the simulants on tank mixing and batch transfer of seed particles. This testing is intended to provide supporting evidence to the assumption that (SSMD) testing in water is conservative.	• Testing results showed that water always transfers less seed particles, and is conservative by this metric when compared to fluids with a higher yield stress and/or higher viscosity at the same mixing/transfer parameters • Confirmed SSMD assumption that testing non-cohesive particles in water is conservative
***RPP-49845 (August 2011) – Computational Fluid Dynamics Modeling Sensitivity Study Result*[i]**	
Evaluate scale-up issues, study operational parameters and predict mixing performance at full-scale by: • Demonstrating that the modeled jet velocities are equivalent to the jet velocities measured in the SSMD 120-inch (in) tank • Evaluating the impact of the jet, in terms of its flow rate and rotational rate, on the mixing performance at each of the three tank scales -- 43.2-in, 120-in, and full-scale • Evaluating correlations that occur among the various tank scales for a defined particle suspension range of 0.2 to 0.4 meters per second (m/s), as well as impacts of these parameters on mixing performance	• Comparisons of the SSMD velocity measurements and the CFD model velocities were sufficient in the region exceeding 20 nozzle diameters, indicating that the CFD fluid velocities match those occurring in the SSMD tanks • Using the results from the complete sensitivity matrix across all scales, the effects of jet velocity and rotational rate have been studied. In all cases, a change in jet velocity has a much larger impact on mixing than changes in rotational rate • At each of the three tank scales, the mixing performance in terms of the velocity range of interest (0.2 to 0.4 m/s) was compared. As the tank scale increased, larger relative portions of the tank had velocity within the range of interest
Confidence Summit (August 2011)	
Technical working session with external experts to evaluate the data collected to date and identify remaining uncertainties in full-scale performance that could impact the decision on the need for a dedicated mixing and sampling facility.	• FY2011 draft Sample and Batch Transfer Test Report concluded: Scaled pre-transfer samples (using range of simulants) are boundingly representative, relative batch consistency of the simulated HLW slurry bulk density was within 10%; and pumping and sample collection system is adequate • Full Scale Performance: Small-scale test encompassed likely range of scaled down performance parameters and need to be documented in final Sample and Batch Transfer Test Report (to be published September 2011) • Simulant Representativeness/Characteristics: SSMD stimulant was bounding of Tank AY-102 waste and mostly bounding for average tank waste. Future testing needs to consider simulant modification to bound reasonable outliers • Confidence in DST sampling performance has been significantly improved but some uncertainties remain

Table A-1. Historical Mixing and Sampling Testing Results (5 Pages)

Objectives	Results
	• Future operational improvement testing should evaluate multiple transfer backfill cycles to understand accumulation and composition changes for heavy solids in the dead zone
PNNL-20637 (September 2011, Rev 0) -- *Comparison of Waste Feed Delivery Small Scale Mixing Demonstration Simulant to Hanford Waste*[j]	
Compare the size and density of the particulates comprising the five-part SSMD simulant to that of the characterized Hanford sludge waste particulates using a spectrum of metrics related to particle performance characteristics in slurries.	• As designed, the five-part SSMD simulant is typically more challenging than the Tank AY-102 waste except for the larger particulates of the most challenging particle size density distribution (PSDD) type, regardless of the metric considered • Results indicate that it is possible that up to of 43% by volume of the Hanford sludge undissolved solids particulate may be more challenging than that represented by the five-part SSMD simulant • SSMD simulant modification options were identified to provide a simulant more bounding of all Hanford wastes
RPP-49740 (October 2011, Rev 0) – *Small Scale Mixing Demonstration Sampling& Batch Transfer Results Report*[k]	
• Verify existing baseline tank pumping locations for sample collection suction inlets is adequate to provide a waste acceptance sample when tank is full and being mixed • Identify sample representativeness/uncertainty for samples collected at preferred location (using Coriolis, FBRM®, and particle size distribution and laboratory chemical composition) to ensure it is within 10% relative difference of initial tank contents and transferred tank contents with respect to solids concentrations • Demonstrate batch to batch variability is within 10% as scaled 150,000-gallon batches are transferred out of the tank during mixing • Identify the pump suction location, or locations, that allow for consistent batch transfers out of scaled mixing platforms • Identify expected batch to batch variability as tank contents are transferred to WTP • Examine effects of varying operational parameters such as mixer jet pump flow and transfer line flow velocity • Identify key/controlling parameters that affect batch transfer consistency	• Demonstrated pre-transfer sampling is boundingly representative of the fast settling particulates • Pre-transfer samples collected across a range of tank mixing conditions expected to match full scale baseline configuration showed the sample results to be within 36 % of the transferred batches and, in nearly all cases, bounded the amount of particulates transferred • Relative batch consistency of the simulated HLW slurry bulk density was within 10%. • Relative batch consistency of the individual particulate components ranged from 3% to 28% and was characterized by more consistency for the more populous, slower settling components and less consistency for the more sparse, faster settling components. The impact of these results is dependent on the sensitivity of WTP processing for the faster settling material. However, it is generally thought that because these faster settling particles represent a small fraction of the solids, specific operational adjustments will not be needed

[a] SRNL-STI-2009-0326, 2009, Demonstration of Internal Structures Impacts on Double Shell Tank Mixing Effectiveness, Savannah River National Laboratory, Aiken, South Carolina.
[b] SRNL-STI-2009-00717, 2009, Demonstration of Simulated Waste Transfers from Tank AY-102 to the Hanford Waste Treatment Facility, Savannah River National Laboratory.
[c] SRNL-STI-2010-00521, 2010, Demonstration of Mixer Jet Pump Rotational Sensitivity of Mixing and Transfers of AY-102 Tank, Savannah River National Laboratory.
[d] RPP-48055, 2010, Computational Fluid Dynamics Modeling of Scaled Hanford DST Mixing- Fiscal year 2010 Model Development Results, Washington River Protection Solutions, LLC, Richland, Washington.
[e] RPP-47557, 2010, Small Scale Mixing Demonstration Initial Results Report, Washington River Protection Solutions, LLC, Richland, Washington.
[f] RPP-RPT-48233, 2011, Independent Analysis of Small Scale Mixing Demonstration Testing (Daniel Greer), Washington River Protection Solutions, LLC, Richland, Washington.
[g] SRNL-STI-2011-00278, 2011, Demonstration of Mixing and Transferring Settling Cohesive Slurry Simulants in Tank AY-102, Savannah River National Laboratory, Aiken, South Carolina.
[h] 24590-WTP-RPT-MGT-11-014, Rev. 0, 2011, Initial Data Quality Objectives for Waste Treatment Plant Feed Acceptance Criteria, Bechtel National, Inc., Richland, Washington.
[i] RPP-49845 (August 2011) – Computational Fluid Dynamics Modeling Sensitivity Study Result, Washington River Protection Solutions, LLC, Richland, Washington.
[j] PNNL-20637, Rev. 0, 2011, *Comparison of Waste Feed Delivery Small Scale Mixing Demonstration Simulant to Hanford Waste*, Pacific Northwest National Laboratory, Richland, Washington.
[k] RPP-49740, Rev. 0, 2011, *Small-Scale Mixing Demonstration Sampling& Batch Transfer Results Report*, Washington River Protection Solutions, LLC, Richland, Washington.

ATTACHMENT 2
to
12-WTP-0039

TRANSMITTAL OF DEFENSE NUCLEAR FACILITIES SAFETY BOARD (DNFSB) RECOMMENDATION 2010-2 IMPLEMENTATION PLAN DELIVERABLE 5.5.3.4

- Large-Scale Integrated Mixing System Expert Review Team (ERT) Review Comments Letter (ERT-2011-6)
- WRPS ERT Review Comment Response Letter (WRPS-1200158/OS) including comment dispositions and Draft document
- ERT Comment Response Concurrence Letter (ERT-06 Feed Test Requirements) documenting ERT concurrence with comment responses

(Total Number of Pages including coversheet: 46)

Large-Scale Integrated Mixing System Expert Review Team

(L. Peurrung, chair; R. Calabrese, R. Grenville, E. Hansen, R. Hemrajani)

To: Tom Fletcher, Tank Farms Federal Project Director; Chuck Spencer, WRPS President and Project Manager, Tank Operations Contract

Cc: Ray Skwarek, One System IPT Manager; Rick Kacich, One System IPT Deputy Manager; Mike Thien, Scott Saunders, WRPS; ERT Members

Subject: Review of *Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements* (ERT-2011-6)

Date: January 3, 2012

The Large-Scale Integrated Mixing System Expert Review Team (ERT) was asked to review draft WRPS document RPP-PLAN-41807, *Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements*, Rev 0b (dated 12/13/11). The purpose of the document under review is to meet DNFSB 2010-2 Implementation Plan Commitment 5.5.3.4, "Identification of tank farm sampling and transfer capability test requirements to be documented in a test requirements document."

The ERT was asked to evaluate the test requirements and assess whether they and the document in general meet the intention of Commitment 5.5.3.4. The ERT considered the appropriateness of the test objectives and activities and whether the testing described will meet the overall objective of understanding the performance of the tank farm mixing system and its ability to deliver waste to WTP.

This is the first document that the ERT has formally reviewed for WRPS, the Tank Operations Contractor. It is also a high-level document that outlines areas of programmatic uncertainty and a plan to reduce that uncertainty rather than a detailed technical document on approach to testing. The ERT therefore has relatively few comments on the document. Some specific suggestions are offered on separate Review Comment Records where fresh eyes suggest that specific parts of the text may benefit from clarification. In general, within the ERT's understanding of the need for feed-related testing, the test objectives and activities do appear to be appropriate.

The ERT does have two general comments or questions. First, the test requirements document is focused on laying out a plan to understand and quantify what waste can be successfully mixed, sampled, and transferred to WTP. It is relatively silent on what is known and levels of uncertainty about the physical properties (and variability) of the waste that will be received into the feed vessels and their potential impact on mixing and sampling system performance. Presumably, there is another set of activities to better understand what might be received, which would need to be factored into future technical evaluations. This subject is likely to be revisited when the simulant basis for testing is developed, and it is one that the ERT would like to understand better. Second, Table A-1 in the Appendix states that prior testing indicated that "mixing performance improves as scale increases" and that (single phase) CFD modeling results reinforced this conclusion. This is somewhat counter to the members' experience where increased scale leads to increased segregation in multiphase systems. The ERT would like to understand the basis of this statement better.

The ERT looks forward to discussing the planned testing at higher levels of technical detail. We hope you find these comments helpful and look forward to your response per the ERT Charter.

Review Participants:

December 19, 2011: Rich Calabrese, Richard Grenville, Erich Hansen, Ramesh Hemrajani, Loni Peurrung, Mike Thien

December 27, 2011: Rich Calabrese, Richard Grenville, Ramesh Hemrajani, Loni Peurrung

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January 18, 2012 WRPS-1200158/OS

Mr. M. Kluse, Laboratory Director
Pacific Northwest National Laboratory
Post Office Box 999
Richland, Washington 99352-0999

Dear Mr. Kluse:

CONTRACT NUMBER DE-AC27-08RV14800 - ONE SYSTEM - TECHNICAL TEAM RESPONSE TO REVIEW OF WASTE FEED DELIVERY MIXING AND SAMPLING PROGRAM PLAN AND TEST REQUIREMENTS (ERT-2011-6)

Reference: Review of *Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements,* ERT-2011-6, prepared by the Large-Scale Integrated Mixing System Expert Review Team, dated January 3, 2012.

This letter responds to a review (Reference) performed by the Large-Scale Integrated Mixing System Expert Review Team (ERT) chaired by Dr. Loni Peurrung.

Washington River Protection Solutions LLC (WRPS) recognizes the short period of time the ERT had to become familiar with the tank farms mixing and sampling program necessary to meet the schedule for this Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2010-2 Implementation Plan Commitment document. WRPS and the One System Technical Team appreciate the ERT's review of the subject document (Enclosure 1).

The items below are the general comments or questions from your review letter followed by the One System response.

1. *The test requirements document is focused on laying out a plan to understand and quantify what waste can be successfully mixed, sampled, and transferred to WTP. It is relatively silent on what is known and levels of uncertainty about the physical properties (and variability) of the waste that will be received into the feed vessels and their potential impact on mixing and sampling system performance. Presumably, there is another set of activities to better understand what might be received, which would need to be factored into future technical evaluations. This subject is likely to be revisited when the simulant basis for testing is developed, and it is one that the ERT would like to understand better.*

The test requirements document is intended to lay out the high-level objectives of the tank farms mixing and sampling program and identify the test requirements to achieve those objectives. Subsequent program documents will address the more specific areas of waste physical properties and uncertainties and associated impacts on feed mixing, sampling, and transfer systems. Many of these documents are specifically identified in the DNFSB Recommendation 2010-2 Implementation Plan. In order to clarify your observation, we have added additional detail in the Purpose and Scope Section of the test requirements document that discusses these other documents and communicates how they are scheduled and integrated with each other.

2. *Table A-1 in the Appendix states that prior testing indicated that "mixing performance improves as scale increases" and that (single phase) CFD modeling results reinforced this conclusion. This is somewhat counter to the members' experience where increased scale leads to increased segregation in multiphase systems. The ERT would like to understand the basis of this statement better.*

   We agree with the ERT members' position that segregation in multi-phase systems tends to increase with increased scale. The statement that "mixing performance improves as scale increases" is a summary from the March 2011 mixing workshop discussions within the context of mixing sensitivity to relative jet velocity changes in the two test tank sizes. We have clarified this context in the final document. This statement was not intended to imply that mixing improves as scale increases; rather, it was intended to reflect test data that suggests mixing performance becomes less sensitive to relative changes in jet velocity as scale increases. This observation does not directly influence the mixing and sampling test requirements as it represents one of many considerations necessary to predict full scaled performance. As described in RPP-PLAN-41807, it is our objective to continue to collect scaled performance data as a specific test requirement. In order to facilitate a more thorough understanding of the evaluation and discussions leading to the workshop conclusion, WRPS will provide the primary data evaluation document (RPP-RPT-48233) and will support a question and answer session with the ERT and the primary document author, scheduled at the convenience of the ERT.

In addition to the specific responses highlighted above, the One System Technical Team has reviewed the ERT document suggestions and modified the DNFSB commitment document. The updated document incorporating comments received from all reviewers is enclosed (Enclosure 1), as well as the dispositions of the ERT Review Comment Records (Enclosure 2).

If you have any questions concerning this matter, please contact me at 372-9138, or Mr. M. G. Thien at 372-3665.

Sincerely,

C. G. Spencer
President and Project Manager

MGT:MES:MDE

Enclosures: 1. RPP-PLAN-41807, Rev. 0c, draft, "Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements" (29 pages)
2. Review Comment Record (8 pages)

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RPP-PLAN-41807
Rev. 0c

Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements

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

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-08RV14800

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RPP-PLAN-41807
Rev. 0c

Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements

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Key Words: Tank Farm Mixing and Sampling, Waste Feed Delivery, DNFSB Recommendation 2010-2

Abstract: This plan addresses the general approach, test requirements, and overall schedule of the Mixing and Sampling Program to support waste feed delivery to the WTP. The program will include activities to determine the range of waste physical properties that can be retrieved and transferred to WTP based on testing and analysis and determine the capability of the tank farm staging tank sampling systems to obtain samples that can be characterized to assess the bounding physical properties important for the WAC based on testing and analysis.

Release Approval	Date	Release Stamp

Tank Operations Contractor (TOC) RECORD OF REVISION		(1) Document Number: RPP-PLAN-41807	
(2) Title: Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements			
Change Control Record			
(3) Revision	(4) Description of Change – Replace, Add, and Delete Pages	Authorized for Release	
		(5) Resp. Engr. (print/sign/date)	(6) Resp. Mgr. (print/sign/date)
0	Initial release, titled, "Waste Feed Delivery Small Scale Mixing and Sampling Demonstration Plan"	Paul Townson, 8/27/2009	Dave Shuford, 8/27/2009
1	Revised to reflect some expansion of the program. Renamed, "Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements"		

EXECUTIVE SUMMARY

The primary purpose of the Tank Operations Contractor (TOC) Mixing and Sampling Program is to mitigate the technical risks associated with the ability of the tank farms feed delivery systems to adequately mix and sample HLW feed in order to meet the WTP Waste Acceptance Criteria (WAC). The TOC has identified two critical risks TOC-08-65 and TOC-12-64 per the TFC-PLN-39 (Risk Management Plan, Rev. F-1) which address emerging waste acceptance criteria (WAC) and sampling method requirements. In addition, in November 2011, U.S. Department of Energy issued the Implementation Plan (IP) for the Defense Nuclear Facility Safety Board Recommendation (DNFSB) 2010-2 (DOE Rec. 2010-2, Rev. 0, *Implementation Plan for Defense Nuclear Safety Board Recommendation 2010-2*) which addresses safety concerns associated with the ability of the Waste Treatment and Immobilization Plant (WTP) to mix, sample, and transfer fast settling particles.

This document revises the previous plan to incorporate results to date and to include new requirements associated with DNFSB Recommendation 2010-2. This document satisfies DNFSB 2010-2 Sub-Recommendation 5, Commitment 5.5.3.4 and addresses the general approach, test requirements, and overall schedule of the Mixing and Sampling Program to support waste feed delivery to the WTP including:

- Determine the range of waste physical properties that can be retrieved and transferred to WTP based on testing and analysis
- Determine the capability of the tank farm staging tank sampling systems to obtain samples that can be characterized to assess the bounding physical properties important for the WAC based on testing and analysis

In order to meet the expanded TOC Mixing and Sampling Program objectives identified above, the following test requirements have been established. Three major areas of testing will be executed during the execution of this Program:

- Limits of performance - determine the range of waste physical properties that can be mixed, sampled and transported under varying modes of operation.
- Solids accumulation - perform scaled testing to understand the behavior of remaining solids in a DST during multiple fill, mix, and transfer operations that are typical of the HLW feed delivery mission.
- Scaled performance - demonstrate mixing, sampling, and transfer performance using a realistic simulant representing a broad spectrum of Hanford waste to meet WTP WAC DQO sampling confidence requirements.

This document presents the foundation for the description of more detailed simulant and testing requirements which will define the TOC mixing and sampling program and satisfy additional DNFSB Recommendation 2010-2 Implementation Plan requirements.

CONTENTS

FIGURES

TABLES

TERMS

Abbreviations and Acronyms

ASME	American Society of Mechanical Engineers
DOE	U.S. Department of Energy
DNFSB	Defense Nuclear Facilities Safety Board
DST	double-shell tank
DQO	data quality objective
FY	Fiscal Year
HLW	high-level waste
ICD	Interface Control Document
LAW	low-activity waste
LSIT	Large-Scale Integrated Testing
M3	External Flowsheet Review Team Major Issue 3
MDT	mixing demonstration tank
MJP	mixer jet pump
ORP	Office of River Protection
PSDD	particle size density distribution
RPP	River Protection Project
RSD	Remote Sampler Demonstration
SRNL	Savannah River National Laboratory
SSMD	Small-Scale Mixing Demonstration
SST	single-shell tank
TOC	Tank Operations Contract
TPA	Tri-Party Agreement
TSD	Transfer System Demonstration
WAC	waste acceptance criteria
WRPS	Washington River Protection Solutions, LLC
WTP	Hanford Waste Treatment and Immobilization Plant

Units

ft	feet
in	inch
gpm	gallons per minute

1.0 INTRODUCTION AND PURPOSE

1.1 INTRODUCTION

The U.S. Department of Energy (DOE), Office of River Protection (ORP) is responsible for management and completion of the River Protection Project (RPP) mission, which comprises both the Hanford Site tank farms operations and the Hanford Waste Treatment and Immobilization Plant (WTP). The RPP mission is to store, retrieve and treat Hanford's tank waste; store and dispose of treated wastes; and close the tank farm waste management areas and treatment facilities by 2047 in a safe, environmentally compliant, cost-effective and energy-effective manner.

The Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement [TPA]) requires DOE to complete the RPP tank waste treatment mission by September 30, 2047. A key aspect of implementing that mission is to construct and operate the WTP (ORP-11242, *River Protection Project System Plan*). The WTP is a multi-facility plant that will separate and immobilize the tank waste for final disposition. Tank waste treatment is scheduled to be completed by 2047.

The RPP work scope is currently performed by two primary contractors: Washington River Protection Solutions, LLC (WRPS), the Tank Operations Contractor (TOC); and Bechtel National, Inc. (BNI), the WTP Construction and Commissioning Contractor. WRPS is responsible for the construction, operation, and maintenance activities necessary to store, retrieve, and transfer tank wastes; provide supplemental pretreatment for tank waste; and provide secondary low-activity waste (LAW) treatment, storage, and/or disposal of immobilized product and secondary waste streams. BNI is responsible for the design, construction, and commissioning of a WTP Pretreatment Facility, two vitrification facilities (one for high-level waste [HLW] and one for low-activity waste [LAW]), a dedicated analytical and radiochemical laboratory, and supporting facilities to convert radioactive tank wastes into glass for long-term storage or final disposal.

1.2 PURPOSE

One of the primary goals of the TOC is to provide waste feed to the WTP for treatment and immobilization. This goal will partially be met through the TOC Mixing and Sampling Program which includes the following activities:

- Small-scale mixing demonstration (SSMD)
- Remote sampler demonstration (RSD)
- Savannah River National Laboratory (SRNL) scouting studies
- Future full-scale testing

The primary purpose of the TOC Mixing and Sampling Program is to mitigate the technical risks associated with the ability of the tank farms feed delivery systems to adequately mix and sample HLW feed in order to meet the WTP Waste Acceptance Criteria (WAC) (24590-WTP-RPT-MGT-11-014, *Initial Data Quality Objectives for WTP Feed Acceptance Criteria).* Consistent batch tank waste feed is desirable for efficient operations of the WTP. However, uniform feed is not achievable for the full complement of tank waste properties for the current Mixing and Sampling baseline.

The TOC has identified two critical risks TOC-08-65 and TOC-12-64 per the TFC-PLN-39 (*Risk Management Plan*, Rev. F-1) which address emerging WAC and sampling method requirements. In addition, the Mixing and Sampling Program will address system performance related to WTP safety issues raised by the Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2010-2 and the Implementation Plan submitted by DOE to resolve these issues (DOE Rec. 2010-2, Rev. 0, *Implementation Plan for Defense Nuclear Safety Board Recommendation 2010-2*). TOC's responsibilities are only associated with Sub-recommendation 5 commitments of DOE Rec. 2010-2. A summary of the DNFSB commitments that TOC is either leading or participating as a co-lead is given in Table 1-1.

Table 1-1. Defense Nuclear Facility Safety Board Recommendation 2010-2 Commitments

Commitment No.	Due Date	POC	Commitment Description
5.5.3.1	12/31/2012	WRPS/BNI	Initial gap analysis between Waste Treatment and Immobilization Plant (WTP) waste acceptance criteria (WAC) and tank farm sampling and transfer capability
5.5.3.2	6/30/3012	WRPS	Evaluation of waste transferred to WTP
5.5.3.3	12 months after LSIT Testing Report complete	BNI	Update WAC Requirements based on WTP Large-Scale Integrated Testing results
5.5.3.4	1/31/2012	WRPS	Identification of tank farm sampling and transfer capability test requirements to be documented in a test requirements document
5.5.3.5	3/30/2012	WRPS	Definition of simulants for tank farm performance testing
5.5.3.6	5/31/2012	WRPS	Test plan to establish Tank Farm performance capability
5.5.3.7	3/31/2013	WRPS	Results from Tank Farm performance testing
5.5.3.8	12/31/2012	WRPS	Issue remote sampler test report
5.5.3.9	8/31/2014	WRPS/BNI	Complete Final Gap Analysis
5.5.3.10	5/31/2015	WRPS/BNI	Optimize WTP WAC Data Quality Objectives

The execution schedule including DNFSB Sub-Recommendation 5 commitments is depicted in Figure 1-1.

In summary, the TOC will conduct tests to determine the range of waste physical properties that can be retrieved and transferred to WTP and determine the capability of tank farm staging tank sampling systems to provide samples that will appropriately characterize the tank waste and determine compliance with the WAC. These tests will reduce technical risk associated with the overall mixing, sampling, and transferring of HLW feed to WTP so that all WAC requirements are met. Testing will be completed with both small scale and full scale equipment at Hanford and multiple off-site facilities.

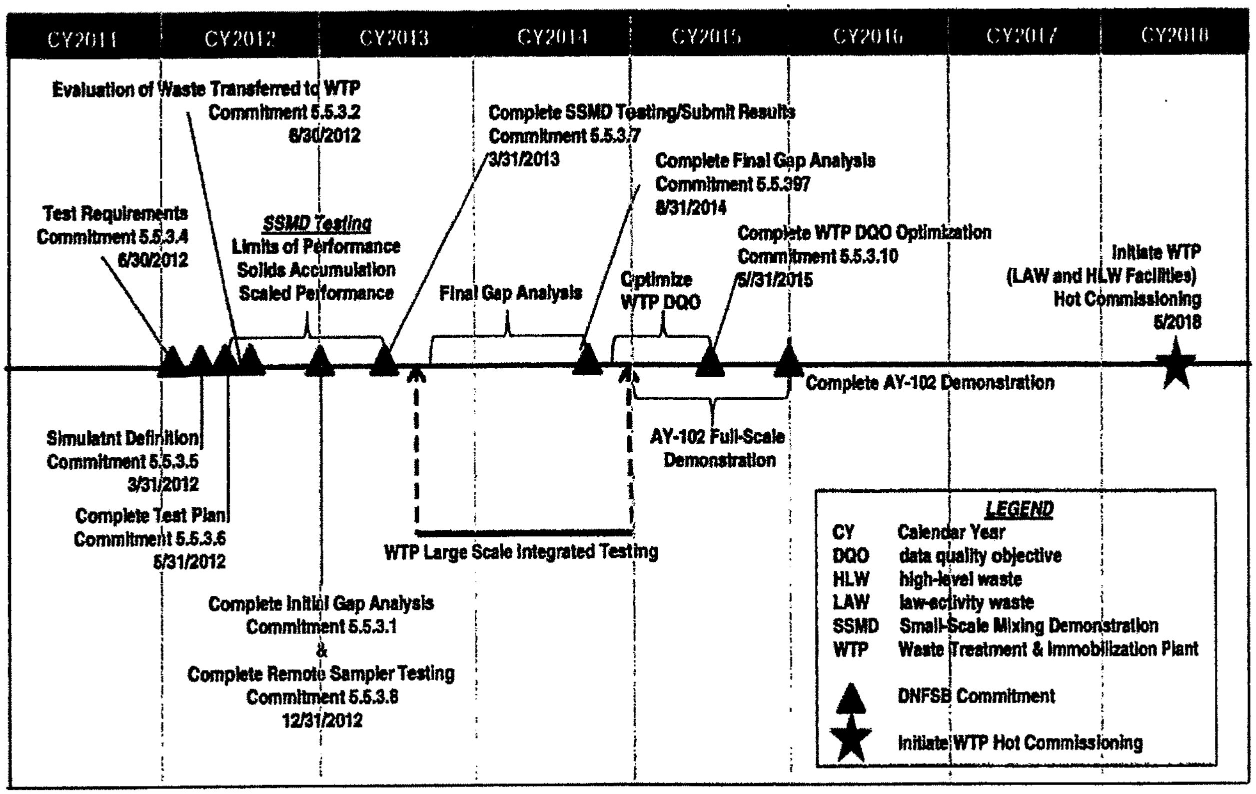

Figure 1-1. Mixing and Sampling Program Integrated Schedule

This document satisfies DNFSB Sub-Recommendation Commitment 5.5.3.4 and addresses the general approach, test requirements, and overall schedule of the Mixing and Sampling Program to support waste feed delivery to the WTP including:

- Determine the range of waste physical properties that can be retrieved and transferred to WTP based on testing and analysis
- Determine the capability of the tank farm staging tank sampling systems to obtain samples that can be characterized to assess the bounding physical properties important for the WAC based on testing and analysis

Additional information will be generated as part of parallel work that will further define test requirements. This parallel work includes Commitment 5.5.3.2 which estimates, based on current information, the range of waste physical properties that can be transferred to WTP and Commitments 5.7.3.1 and 5.7.3.4 which identify potential new WAC requirements based on preliminary documented safety analyses coupled with projections of potential WAC requirements based on recent assessments. Decisions on how to adjust test requirements based on these evolving requirements will be made and documented in updates to the issued Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements.

This work will be managed under the One System concept where TOC and WTP workscope will be integrated and managed under one management organization (RPP-54471, Rev. 0 and 24590-WTP-CH-MGT-11-008, *2020 Vision One System IPT Charter*). Waste Feed Delivery activities will be integrated and coordinated with the WTP Vessel Completion Team including Large-Scale Integrated Testing (LSIT) Program.

2.0 BACKGROUND

The ORP has defined the interface between the two major RPP contractors, BNI and TOC, in a series of interface control documents (ICDs). The primary waste interface document is 24590-WTP-ICD-MG-01-019, *ICD-19-Interface Control Document for Waste Feed* (ICD-19). Iterative updates to ICD-19 are anticipated as new information is generated. ICD-19 identifies a significant incompatibility between the TOC baseline equipment configuration and capabilities and the WTP baseline design and regulatory assumptions requirements for tank waste feed delivery to WTP. Section 2.3 states that the TOC baseline sampling plans and capabilities are not currently compatible with WTP sample and analysis requirements as described in *Integrated Sampling and Analysis Requirements Document (ISARD)* (24590-WTP-PL-PR-04-0001), the *Initial Data Quality Objectives for WTP Feed Acceptance Criteria* (24590-WTP-RPT-MGT-11-014), and the *Regulatory Data Quality Optimization Report* (24590-WTP-RPT-MGT-04-001).

The WTP dynamic processing analysis and batch processing planning currently assumes each staged HLW feed tank is mixed and delivered in consistent feed delivery batches of 145,000 gallons (ICD-19). Consistent, as used here is intended to mean that the first 145,000 gallon batch has the same solids composition as the last 145,000 gallon batch. Small scale testing completed to date (RPP-50557, *Tank Waste Mixing and Sampling Update* , Rev. 0a) concludes that the first feed tank (AY-102) can likely be adequately sampled using DST mixing systems, but that additional uncertainties related to data uncertainty, optimizing system performance, applicability to all feed tanks, and understanding emerging WTP solids handling risks still need to be addressed.

The SSMD project has focused on the first HLW planned for transfer to WTP, (AY-102) and now will apply knowledge gained to the remaining planned feed delivery DSTs. DSTs are 75 feet (ft) in diameter, and have an operating liquid height of up to 454 inches (in). The staged HLW feed tanks could have settled solids (sludge) heights of up to 70 in. The baseline configuration will include two, 400 horsepower mixer pumps, with opposing 6-in diameter nozzles that will recirculate tank waste at approximately 5200 gallons per minute (gpm) per nozzle. The mixer pumps have the ability to be rotated such that the nozzles can cover a full 360° of rotation. A slurry transfer pump will be installed near the center and bottom of the DSTs to transfer HLW slurry to the WTP up to 140 gpm.

The historical TOC baseline plan includes mixing of waste in a DST using slurry mixer pumps and then performing grab and core sampling for sludge and supernate feed waste acceptance analysis. A proposed alternative mixing and sampling concept based on a dynamic mixed tank includes a transfer pump driven recirculation and sampling loop, which allows remote sampling of the to be delivered feed stream during tank mixing and a real-time direct critical velocity measurement.

Work conducted over the past 5 years has introduced information that may result in new WAC requirements. This workscope includes mixing assessments which have indicated that:

- Controls on waste particles size and density may be required
- New controls on waste containing fissile material particles of larger size and density than previously assumed may be required

The Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements will be updated to address changes in the WAC. The evaluation of waste to be transferred to WTP, identified as Commitment 5.5.3.2, June 30, 2012, will define the preliminary range of physical properties of waste anticipated to be delivered to WTP.

2.1 WORK COMPLETED TO DATE

Initial SSMD Program results demonstrated that equivalent mixing performance, from a solids distribution perspective, can be achieved in two different scaled tanks. These results provide a foundation for beginning to explore other performance parameters which were investigated in the sampling and batch transfer phase. Reports identify a range of scaling factors (approximately 0.25 to 0.3) applicable to DST mixing (RPP-49740, *Small-Scale Mixing Demonstration Sampling and Batch Transfer Result Report*). The sampling and batch transfer testing results have indicated the feasibility of mixing the tanks adequately to provide a representative sample to the transfer system. The results indicated that more difficult and fastest settling particles can be delivered to the transfer system.

A Remote Sampler Demonstration (RSD) flow loop was constructed at Monarch Machine and Tool in Pasco, Washington to allow testing of the Isolok® sampler and a PulseEcho ultrasonic meter to determine critical velocities. Initial work evaluated the ability of the Isolok to take a representative and repeatable sample based on analyte concentrations when compared to a known concentration. The data showed the Isolok® has a propensity to collect large and higher density particles over small and lower density particles. The cause of this bias is being evaluated.

Appendix A presents a summary of the objective and outcome of testing results to-date and the five workshops in chronological order which provides a foundation for future work. While the initial work has demonstrated the concept functionality for the first feed tank, uncertainties remain that must be addressed. Uncertainties remain to be resolved related to optimizing system performance, the applicability of data to all tank waste, and understanding emerging WTP solids handling risks.

2.2 MIXING PROGRAM ADJUSTMENTS

2.2.1 Defense Nuclear Facility Safety Board Recommendation 2010-2

DNFSB Recommendation 2010-2 has raised WTP safety issues related to tank farms ability to mix, sample, and transfer solids. In response, DOE developed an implementation plan to resolve these issues (DOE Rev. 0 2010-2). As discussed in Section 1.0, this program plan and test requirements document satisfies Commitment 5.5.3.4 of the Implementation Plan.

2.2.2 October 2011 Optimization Workshop Recommendations

During October 10 – 12, 2011, the TOC held their 5th Mixing and Sampling workshop in Richland, Washington (WRPS-1105293, *Small Scale Mixing Demonstration Optimization Workshop Meeting Minutes)*. The Mixing and Sampling Program has been augmented by internationally recognized mixing experts, National Laboratory and University experts, and TOC and WTP project subject matter experts. DNFSB technical staff was also present to observe the proceedings. Participants are listed in the minutes, WRPS-1105293. Over the past three years, the experts have progressively evaluated the SSMD Project results to-date. During this workshop, the Expert Panel addressed a detailed list of outstanding key uncertainties which includes:

- Simulant Selection
- Bounds of Equipment Performance
- Scale-up
- Solids Accumulation
- Nozzle Performance
- Sparse Particle Detection

The output from this workshop has been used to provide guidance in the development of this plan.

The primary output from the workshop was a group discussion of how to best prioritize the activities necessary to address the remaining uncertainties and to ensure the work is appropriately integrated with the WTP LSIT activities. The group consensus identified the following path forward priorities in order of importance:

1. Bounds of Equipment Performance
   - Continue using the SSMD platform to determine the largest particles of two different representative densities that the system is capable of mixing, sampling, and transporting
   - Integral with above workscope, select appropriate complex simulants and accurate analytical techniques to characterize the material of interest
   - Integrate worksope with WTP simulant selection
2. Batch Accumulation Behavior
   - Initiate new phase of testing to understand the behavior of remaining solids in a DST during multiple fill, mix, and transfer operations that are typical of HLW WFD
3. Scale Up
   - Continue gathering data on full scale estimation (but not as a specific test driver)
   - Scaled performance information can be gathered while testing for the two primary performance objectives; bounds of equipment performance and batch accumulation
4. Operational Improvements
   - Evaluate parameters with less significant impact on mixing to confirm the significance impact to these parameters (e.g., capture velocity sensitivity, mixer pump rotation rate)

In addition, cold, full-scale mixing and sampling demonstration was recommended to be completed prior to demonstration in an actual DST, recognizing that sustained mixing test results from Tank AY-102 will not likely be available.

3.0 MIXING AND SAMPLING PROGRAM OBJECTIVES

The original objective of the Mixing and Sampling Program was to mitigate the technical risks associated with the ability of the tank farms feed delivery systems to adequately mix and sample HLW feed in order to meet the WTP WAC. Testing focused on the ability to achieve adequate mixing and representative sampling, minimizing variability between batches transferred to WTP. Testing to date (Jackson, 2011) has demonstrated the potential ability to adequate tank mixing and delivery for waste sampling of AY-102 simulated waste using currently planned DST mixing and transfer systems.

While several uncertainties remain regarding the ability to adequately characterize DST waste, larger mission uncertainties related to the compatibility of tank farms feed systems with the WTP receipt systems remain to be addressed. The current TOC Mixing and Sampling Program is being executed in a phased approach which will:

- Optimize requirements
- Demonstrate the viability of systems to meet those requirements in a small-scale environment, and upon successful small-scale demonstration
- Exhibit system capability in a full-scale DST (i.e., DST which will be providing hot commissioning feed to WTP)

Upon successful demonstration of mixing and sampling in the first DST, a systematic evaluation of all HLW feed batches will be completed to identify any unique configurations or operating scenarios that may require additional demonstration activities.

This plan defines requirements for testing to address tank farm feed mixing, sampling, characterization and transfer system capability, which will support a gap analysis of capabilities to sample characterize and transfer waste to WTP that conforms with ICD-19. Testing may be accomplished through expansion of the Mixing and Sampling Program scope, testing in conjunction with WTP large scale integrated testing, or by other means.

To ensure tank farms and WTP mixing and sampling systems are integrated and compatible (i.e., execution of the one-system approach) and the uncertainties identified in RPP-50557 are addressed, the TOC Mixing and Sampling Program is being expanded to include:

- Define DST mixing, sampling, and transfer system limits of performance with respect to the ability to transfer waste to the WTP with varying physical properties and solid particulates sizes and densities and under various modes of operation (i.e., defining the expected range of particle size and density and consideration of data uncertainty)
- Define propensity of solid particulates to build up and potential for concentration of fissile material over time in DSTs during the multiple fill, mix, and transfer operations expected to occur over the life of the mission
- Define ability of DST sampling system to collect representative slurry samples and in-line critical velocity measurements from a fully mixed waste feed staging tank
- Develop sufficient data and methodology to confidently predict full scale DST mixing, sampling, and transfer system performance such that a gap analysis against WTP feed receipt system performance can be adequately completed

As described in revision 0 of this plan, confirmation of full scale mixing performance is planned to be performed in conjunction with the installation and testing of the first mixer pumps in AY-102. This is scheduled to be completed well ahead of the first HLW feed delivery need date to allow for any operational adjustments that may be identified.

4.0 TESTING REQUIREMENTS

In order to meet the expanded TOC Mixing and Sampling Program objectives identified in Section 3.0, the following test requirements have been established. Three major areas of testing will be executed during the execution of this Program:

- Limits of performance
- Solids accumulation
- Scaled performance

Testing will be designed to bound system performance taking into account the uncertainty of known waste characteristics.

4.1 LIMITS OF PERFORMANCE

The objective of Limits of Performance activities is to determine the range of waste physical properties that can be mixed, sampled and transported under varying modes of operation. Integral with this activity is the selection of appropriately complex simulants, integrated with WTP simulant selection and supported by accurate analytical techniques to characterize the material of interest. Particle size and density are expected to be the most important solids properties. Particle shape is assumed to be less important but this will be confirmed by SRNL studies being done to support the WTP LSIT program and will be re-addressed, if necessary

To meet this objective, the following specific activities, including inter-related sampling activities, are planned (the sequence of activities is not implied by this list):

- Use SSMD platform to test progressively larger particle size and density to identify largest size and density particle that can be mixed and transferred from the SSMD transfer system
- Use a full-scale transfer system demonstration platform to define limits of particle size performance that cannot be tested with SSMD platform (i.e., physical size constraints of the scaled equipment)
- Evaluate performance of Isolok® sampler to:
  - Collect representative and repeatable samples from the RSD loop over a range of simulant formulations representing potential HLW slurry conditions
  - Identify particle size and density limitations of the Isolok® sampler in the RSD Loop
- Evaluate design of prototypic mechanical handling and conveyor systems (including placement and retrieval of a sample container from Isolok® sampler) and placement of the sample bottle into a cask located on a motorized conveyor to assure that sample bottle and shielded cask are compatible with the mechanical handling equipment used by the receiving laboratory
- Determine Isolok® sampler operating limits for temperature and pressure
- Evaluate performance of PulseEcho critical velocity detection instrument (developed by PNNL, PNNL-20350) over a range of simulant formulations representing potential HLW slurry conditions

4.2 SOLIDS ACCUMULATION

The object of Solids Accumulation activities is to perform scaled testing to understand the behavior of remaining solids in a DST during multiple fill, mix, and transfer operations that are typical of the HLW feed delivery mission. Testing will focus on accumulation of total solids over time and the propensity for simulated fissile material localized concentration to change over time. The following specific activities are planned to meet this objective:

- Use the SRNL mixing demonstration tank (MDT) platform to:
  - Perform scouting studies to evaluate remaining bulk material in a tank after a series of full MDT campaigns of feed tank pump-out and prototypic refill (similar to planned WFD campaigns to WTP)
  - Determine what particles or materials remain in MDT after a series of full tank pump out and prototypic refills (i.e., concentration and locations where the fastest settling particles accumulate in the tank heels)
- Use the SSMD platform to perform testing under NQA-1 requirements to:
  - Further refine SRNL demonstrated behavior of solids accumulation and simulated fissile material localized concentration
  - Determine concentrations and locations of specific particles in the remaining tank heels

4.3 SCALED PERFORMANCE

The objective of Scaled Performance activities is to demonstrate mixing, sampling, and transfer performance using a realistic simulant representing a broad spectrum of Hanford waste to meet WTP WAC DQO sampling confidence requirements. The following activities will be completed to meet this objective:

- Use the SSMD platform to test at two or more mixing velocities to:
  - Evaluate the development of "mounds" and transfer behavior
  - Define scaled test approaches to apply these test results at full scale
  - Develop a basis for confirming the velocities used for scaled testing
- Use the RSD platform to define operational steps for the Isolok sampler and describe functional requirement for supporting systems necessary for field deployment

5.0 SIMULANT PHILOSOPHY

DNFSB 2010-2 Commitment 5.5.3.5 (due March 31, 2012) will define the simulants to be used for testing. The shift in testing philosophy away from demonstrating adequate performance in a conservative simulant (e.g. non-cohesive particulates in water) to a testing philosophy that defines limits of performance to support a gap analysis also requires a shift in simulant philosophy.

Successful completion of the TOC Mixing and Sampling Program depends upon the selection of appropriately complex simulants that are reflective of expected tank conditions, integrated with WTP simulant selection, and supported by accurate analytical techniques to characterize the material of interest. Testing will use more complex simulants that are more representative of all Hanford tank waste.

The simulant that has been used in past SSMD activities, which consists of water and a five component particulate mix (PNNL 20637, *Comparison of Waste Feed Delivery Small Scale Mixing Demonstration Simulant to Hanford Waste*), is considered more challenging than AY-102 waste and waste composites except for particulates at the very high end of the size and density curve. The SSMD simulant, however, is not as challenging compared to the other HLW sludges that may be encountered in other DSTs. As much as 50% by volume of the HLW sludge waste particulate is more challenging than the SSMD simulant relative to properties such as settling velocity, pipeline transport, and Archimedes number (PNNL-20637). Therefore a simulant that is more representative of these more challenging tank wastes must be developed to support the TOC Mixing and Sampling Program objectives.

ASTM C1750-11 (*Standard Guide for Development, Verification, Validation, and Documentation of Simulated High-Level Tank Waste*) will be used for guidance on simulant selection. The guidelines will be used to help identify realistic simulants that envelope the complete range of physical properties for the high-level waste expected to be staged for WTP WFD.

The simulants developed and used for these testing activities will be integrated with WTP LSIT simulant development to ensure consistency in testing and will draw from the following experience and lessons learned:

- SSMD Program
- WTP External Flowsheet Review Team Major Issue 3 (M3) Program
- SRNL mixing and sampling testing for both Savannah River and Hanford tank farm wastes

Simulants will use non-hazardous materials except where hazardous components are required to produce a chemically representative simulant, in which case all safety requirements will be followed.

6.0 QUALITY ASSURANCE

Final testing with focused objectives will be done consistent with TOC's Quality Assurance Program that meets American National Standard American Society of Mechanical Engineers (ASME), NQA-1-2004, Quality Assurance Requirements for Nuclear Facility applications. The applicable version and addenda are identified in TFC-PLN-02, *Quality Assurance Program Description*. It is acceptable to perform scouting or development studies under commercial quality requirements. Data accuracy tolerances will be provided in the Test Plans.

7.0 REFERENCES

American Society for Testing and Materials C1750-11, *Standard Guide for Development, Verification, Validation, and Documentation of Simulated High-Level Tank Waste,* West Conshohocken, Pennsylvania

American Society of Mechanical Engineers (ASME), NQA-1-2004, *Quality Assurance Requirements for Nuclear Facility Applications*, New York City, New York.

24590-WTP-ICD-MG-01-019, 2011, *ICD 19 – Interface Control Document for Waste Feed,* Rev. 5, Bechtel National, Inc., Richland, Washington.

24590-WTP-RPT-MGT-04-001, 2004, *Regulatory Data Quality Optimization Report,* Rev. 0, Bechtel National, Inc., Richland, Washington.

24590-WTP-RPT-MGT-11-014, 2011, *Initial Data Quality Objectives for WTP Feed Acceptance Criteria*, Rev. 0, Bechtel National, Inc., Richland, Washington.

24590-WTP-PL-PR-04-0001, *Integrated Sampling and Analysis Requirements Document (ISARD)*, Rev. 1, Bechtel National, Inc., Richland, Washington.

DNFSB Rec. 2010-2, Rev. 0, November 10, 2011, *Department of Energy Plan to Address Waste Treatment and immobilization plant Vessel Mixing Issues – Implementation Plan for the Defense Nuclear Safety Board Recommendation 2010-2*, U.S. Department of Energy, Washington D.C.

ORP-11242, Rev. 6, *River Protection Project System Plan*, Washington River Protection Solutions, Richland, Washington.

PNNL-18327, 2009, *Estimate of the Distribution of Solids within Mixed Hanford Double-Shell Tank AZ-101: Implications for AY-102*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-18688, 2009, *Hanford Tank Farms Waste Certification Flow Loop Strategy Plan*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-20350, 2011, *Hanford Tank Farms Waste Certification Flow Loop Phase IV: PulseEcho Sensor Evaluation*, Pacific Northwest National Laboratory, Richland, WA

PNNL-20637, 2011, *Comparison of Waste Feed Delivery Small Scale Mixing Demonstration Simulant to Hanford Waste*, Pacific Northwest National Laboratory, Richland, Washington.

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RPP-49740, Rev. 0, 2011, *Small Scale Mixing Demonstration Sampling and Batch Transfer Results Report*, Energy Solutions, Richland, Washington.

RPP-50557, Rev 0B, *Tank Waste Mixing and Sampling Update*, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-51471 and 24590-WTP-CH-MGT-11-008, *2020 Vision One System IPT Charter*, Washington River Protection Solutions, LLC and Bechtel National, Inc., Richland, Washington

SRNL-STI-2009-00326, 2009, *Demonstration of Internal Structures Impacts on Double Shell Tank Mixing Effectiveness,* Savannah River National Laboratory, Savannah River Nuclear Solutions, Aiken, South Carolina.

TFC-PLAN-02, Quality Assurance Project Description, Rev. XX Washington River Protection Solutions, LLC, Richland, Washington.

TFC-PLAN-39, 2011, *Risk Management Plan*, Rev. F-1, Washington River Protection Solutions, LLC, Richland, Washington.

WRPS-1105293, *Small Scale Mixing Demonstration Optimization Workshop Meeting Minutes*, November 16, 2011, Washington River Protection Solutions, Richland, Washington.

APPENDIX A

MIXING AND SAMPLING PROGRAM WORK COMPLETED TO-DATE

The following table of historical results is drawn from RPP-50557, Rev. 0a, 2011, *Tank Waste Mixing and Sampling Update.* The descriptions of objectives and results are intended to summarize what is presented in the following documents and from workshop minutes as listed. The descriptions of results are subject to modification by more recent and future work.

Table A-1. Historical Mixing and Sampling Testing Results (5 Pages)

Objectives	Results
SRNL-STI-2009-0326 (April 2009) – *Demonstration of Internal Structures Impacts on Double Shell Tank Mixing Effectiveness*[a]	
To qualitatively demonstrate the mixing characteristics of AY-102.	Twelve test conducted • Demonstrated the tanks are not homogeneously mixed • The air lift circulators do not impact the observed qualitative mixing behavior
Scaling Workshop (June 2009)	
Evaluated Savannah River National Laboratory (SRNL) Scouting Study workscope, identified SSMD scaling levels, and recommended the mixing and sampling program approach.	• Identified design and test basis for two scaling levels to be used and design and construction of a new testing demonstration platform in Pasco, Washington • Recommended to match SRNL 1/22 scale tank and design and construct a larger scale (~10 ft.) tank for demonstration platform • Recommended that computational fluid dynamics (CFD) modeling be focused on single phase velocity modeling first, and then build correlations to observed particle behavior.
SRNL-STI-2009-00717 (November 2009) – *Demonstration of Simulated Waste Transfers from Tank AY-102 to the Waste Treatment Plant*[b]	
Qualitatively demonstrate how well waste can be transferred out of a mixed DST and provide insights into the consistency between the batches being transferred.	For the twelve tests conducted: • Solids (gibbsite and silica carbide) transferred were consistent for the first five batches transferred regardless of mixing or batch transfer conditions • Increasing flow rate didn't change the consistency of batch transfers, however more solids were transferred out • Rotation rate within the tested range didn't have a large impact with batch transfers
SSMD Planning Workshop (December 2009)	
Review of SRNL Scouting Study and development of initial SSMD testing criteria and instrumentation to be used	• Reviewed SRNL reviewed results of the qualitative scouting study of mixing and batch transfers • Introduced and evaluated instruments to be used to quantitatively measure mixing behavior in both tanks at Pasco Facility • Developed initial testing criteria • Agreed to perform testing in water to observe conservative performance of non-cohesive particles using various complex simulants modeled largely on Tank AY-102 waste
SSMD Initial Results Workshop (July 2010)	
Review RSD loop work plan and Phase 2 SRNL Scouting Study and CFD modeling results and recommend SSMD simulant	• Phase 2 - SRNL Scouting Study with focus on rotational rates – Cohesive particles could potentially impact batch transfers based on future studies due

Table A-1. Historical Mixing and Sampling Testing Results (5 Pages)

<table>
<tr><th>Objectives</th><th>Results</th></tr>
<tr><td>improvements</td><td>to the fact that cohesive particles may not mix as much at the bottom of a tank as at the top
– SSMD simulant selection, testing/tuning run matrices, and testing objectives
• CFD Modeling Results
– Batch Transfer performance results are more significant than mixing performance results so correlations between the two are useful
– CFD is valuable for exploring missing geometry effects
• SSMD Results:
– Current testing plan is an appropriate approach but data interpretation and correlation of scale-up estimates with batch transfer performance data needs additional understanding - V_{target} is a good point of data, but not as essential as originally envisioned
– Demonstrated performance across a range of velocities is more useful in gaining scale up confidence
• Program Recommendation – Complete recommendation on need for a dedicated Mixing and Sampling Facility by September 30, 2011</td></tr>
<tr><td colspan="2">SRNL-STI-2010-00521 (Sept 2010) – Demonstration of Mixer Jet Pump Rotational Sensitivity of Mixing and Transfers of AY-102 Tank[c]</td></tr>
<tr><td>Determine the impact on batch transfers when rotational parameters of the mixer jet pumps (MJPs) are varied</td><td>Nineteen tests conducted:
• Solids consistency variability (transferred batch tot batch) was very small for the first five batches transferred and was unaffected by the variations in MJP rotational characteristics
• Lower rotational rates may support suspending solids that settle out faster</td></tr>
<tr><td colspan="2">RPP-48055 (December 2010) – Computational Fluid Dynamics Modeling of Scaled Hanford DST Mixing- Fiscal year 2010 Model Development Results[d]</td></tr>
<tr><td>Develop a DST mixing CFD model that predicts single-phase (fluid only) velocities that accurately mimic observed mixing performance in two SSMD platforms, develop scale-up correlations and estimate mixing performance in Hanford DST AY-102</td><td>• A functional single-phase CFD model was developed for the 43.2", 120", and full scale tanks
• SSMD instrumentation difficulties prevented comparing model velocities with demonstration platform performance
• Scale-up correlation for this model used the one/third power law factor</td></tr>
<tr><td colspan="2">RPP-47557 (December 2010) – Small Scale Mixing Demonstration Initial Results Report[e]</td></tr>
<tr><td>Demonstrate that comparable tank mixing behavior can be achieved in the two sizes of scaled tanks including:</td><td>Test results showed:
• Tank operating characteristics(V_{target}, V_{lower}, and V_{upper}) were defined where similar performance was noted in the 43.2" and 120" tanks</td></tr>
</table>

Table A-1. Historical Mixing and Sampling Testing Results (5 Pages)

Objectives	Results
• Equipment performance and the ability of the scaled tanks to meet performance objectives • Range of tank operating parameters that define the edges of mixing performance including mixer pump flow rate (nozzle velocity) and rotation rate (angular velocity), and provide the framework to move forward to the next phase of batch transfer and sampling testing (Phase 2)	• Parameters are only indicators of mixing in the two scaled tanks and cannot be directly used to derive scale-up correlations • Nozzle angular rotation (within the range tested) does not significantly affect the mixing in the tanks for the conditions tested, and the power law-based angular velocity should be used for all remaining testing • Repeatability tests have demonstrated that good reproducibility of data (within 10% for density) can be achieved in both tanks over repeated measurements
RPP-RPT-48233 (February 2011) – *Independent Analysis of Small Scale Mixing Demonstration Testing*	
Perform an independent, statistically based review of the tank performance data collected during Phase I of SSMD testing	Statistical evaluation concluded: • Both scales of tanks have similar performance characteristics • Equivalent performance flow rates at 9 and102 gallon per minute (gpm) were defined for small and large tanks, respectively • Mixing plateaus can be defined where similar mixing is observed across a range of mixer pump velocities and below which mixing performance noticeably degrades
SSMD Sampling/Batch Transfer results workshop (March 2011)	
Review initial SSMD sampling and batch transfer results, examine statistical approach to data evaluation, review initial CFD modeling conclusions and Phase 2 SRNL Scouting Study results and recommend adjustments accordingly	• Statistical approach to mixing using Coriolis Meter was used to build a regression model to find "equivalent" mixing and concluded: – Equivalent mixing flow rates – Small tank – 9 gpm – 23.4 ft/sec; Large tank – 102 gpm – 31.0 ft/sec – Velocity scale-up exponent on scale ratio of 0.32 – Degraded mixing flow rates – Small tank – 7.5 gpm – 19.5 ft/sec; Large tank – 80 gpm – 24.3 ft/sec – Mixing plateau – Small tank – (9-7.5)/9 = 17%; Large tank – (102-80)/102 = 22% • CFD modeling conclusions are consistent with SSMD observations [i.e., flowrate is more important than rotation rate and mixing performance improves (from a scaled jet velocity sensitivity perspective) as scale increases] • SRNL Scouting Studies concluded that SSMD testing in water is conservative (i.e., water is a conservative fluid for transferring solids when compared to a liquid with a higher viscosity or a slurry with a yield stress and MJP cleaning radius is impacted by fluid rheology
24590-WTP-RPT-MGT-11-014, Rev. 0 (May 2011) – *Initial Data Quality Objectives for Waste Treatment Plant Feed Acceptance Criteria*[5]	

Table A-1. Historical Mixing and Sampling Testing Results (5 Pages)

Objectives	Results
Describe type, quantity and quality of data required for WTP waste feed acceptance criteria to ensure that feed transfer and receipt will not exceed WTP plant design, safety, and processing limits	• Evaluated all (in excess of 200) ICD-19 acceptance parameters and identified sixteen key WAC action limit parameters specific to safely and compliantly accepting waste at the WTP • Identified initial data confidence requirements for action limit parameters
SRNL-STI-2011-00278 (July 2011) – *Demonstration of Mixing and Transferring Settling Cohesive Slurry Simulants in Tank AY-102*[t]	
Determine the impact of cohesive particle interactions in the simulants on tank mixing and batch transfer of seed particles. This testing is intended to provide supporting evidence to the assumption that (SSMD) testing in water is conservative.	• Testing results showed that water always transfers less seed particles, and is conservative by this metric when compared to fluids with a higher yield stress and/or higher viscosity at the same mixing/transfer parameters • Confirmed SSMD assumption that testing non-cohesive particles in water is conservative
***RPP-49845 (August 2011) – Computational Fluid Dynamics Modeling Sensitivity Study Result*[i]**	
Evaluate scale-up issues, study operational parameters and predict mixing performance at full-scale by: • Demonstrating that the modeled jet velocities are equivalent to the jet velocities measured in the SSMD 120-inch (in) tank • Evaluating the impact of the jet, in terms of its flow rate and rotational rate, on the mixing performance at each of the three tank scales -- 43.2-in, 120-in, and full-scale • Evaluating correlations that occur among the various tank scales for a defined particle suspension range of 0.2 to 0.4 meters per second (m/s), as well as impacts of these parameters on mixing performance	• Comparisons of the SSMD velocity measurements and the CFD model velocities were sufficient in the region exceeding 20 nozzle diameters, indicating that the CFD fluid velocities match those occurring in the SSMD tanks • Using the results from the complete sensitivity matrix across all scales, the effects of jet velocity and rotational rate have been studied. In all cases, a change in jet velocity has a much larger impact on mixing than changes in rotational rate • At each of the three tank scales, the mixing performance in terms of the velocity range of interest (0.2 to 0.4 m/s) was compared. As the tank scale increased, larger relative portions of the tank had velocity within the range of interest
Confidence Summit (August 2011)	
Technical working session with external experts to evaluate the data collected to date and identify remaining uncertainties in full-scale performance that could impact the decision on the need for a dedicated mixing and sampling facility	• FY2011 draft Sample and Batch Transfer Test Report concluded: Scaled pre-transfer samples (using range of simulants) are boundingly representative, relative batch consistency of the simulated HLW slurry bulk density was within 10%; and pumping and sample collection system is adequate • Full Scale Performance: Small-scale test encompassed likely range of scaled down performance parameters and need to be documented in final Sample and Batch Transfer Test Report (to be published September 2011) • Simulant Representativeness/Characteristics: SSMD stimulant was bounding of Tank AY-102 waste and mostly bounding for average tank waste. Future testing needs to consider

Table A-1. Historical Mixing and Sampling Testing Results (5 Pages)

Objectives	Results
	simulant modification to bound reasonable outliers • Confidence in DST sampling performance has been significantly improved but some uncertainties remain • Future operational improvement testing should evaluate multiple transfer backfill cycles to understand accumulation and composition changes for heavy solids in the dead zone
PNNL-20637 (September 2011, Rev 0) – *Comparison of Waste Feed Delivery Small Scale Mixing Demonstration Simulant to Hanford Waste*	
Compare the size and density of the particulates comprising the five-part SSMD simulant to that of the characterized Hanford sludge waste particulates using a spectrum of metrics related to particle performance characteristics in slurries	• As designed, the five-part SSMD simulant is typically more challenging than the Tank AY-102 waste except for the larger particulates of the most challenging particle size density distribution (PSDD) type, regardless of the metric considered • Results indicate that it is possible that up to of 43% by volume of the Hanford sludge undissolved solids particulate may be more challenging than that represented by the five-part SSMD simulant • SSMD simulant modification options were identified to provide a simulant more bounding of all Hanford wastes
RPP-49740 (October 2011, Rev 0) – *Small Scale Mixing Demonstration Sampling& Batch Transfer Results Report*	
• Verify existing baseline tank pumping locations for sample collection suction inlets is adequate to provide a waste acceptance sample when tank is full and being mixed • Identify sample representativeness/uncertainty for samples collected at preferred location (using Coriolis, FBRM®, and particle size distribution and laboratory chemical composition) to ensure it is within 10% relative difference of initial tank contents and transferred tank contents with respect to solids concentrations • Demonstrate batch to batch variability is within 10% as scaled 150,000-gallon batches are transferred out of the tank during mixing • Identify the pump suction location, or locations, that allow for consistent batch transfers out of scaled mixing platforms • Identify expected batch to batch variability as tank contents are transferred to WTP • Examine effects of varying operational parameters such as	• Demonstrated pre-transfer sampling is boundingly representative of the fast settling particulates • Pre-transfer samples collected across a range of tank mixing conditions expected to match full scale baseline configuration showed the sample results to be within 36 % of the transferred batches and, in nearly all cases, bounded the amount of particulates transferred • Relative batch consistency of the simulated HLW slurry bulk density was within 10%. • Relative batch consistency of the individual particulate components ranged from 3% to 28% and was characterized by more consistency for the more populous, slower settling components and less consistency for the more sparse, faster settling components. The impact of these results is dependent on the sensitivity of WTP processing for the faster settling material. However, it is generally thought that because these faster settling particles represent a small fraction of the solids, specific operational adjustments will not be needed

Table A-1. Historical Mixing and Sampling Testing Results (5 Pages)

Objectives	Results
mixer jet pump flow and transfer line flow velocity • Identify key/controlling parameters that affect batch transfer consistency	

[a] SRNL-STI-2009-0326, 2009, Demonstration of Internal Structures Impacts on Double Shell Tank Mixing Effectiveness, Savannah River National Laboratory, Aiken, South Carolina.

[b] SRNL-STI-2009-00717, 2009, Demonstration of Simulated Waste Transfers from Tank AY-102 to the Hanford Waste Treatment Facility, Savannah River National Laboratory.

[c] SRNL-STI-2010-00521, 2010, Demonstration of Mixer Jet Pump Rotational Sensitivity of Mixing and Transfers of AY-102 Tank, , Savannah River National Laboratory.

[d] RPP-48055, 2010, Computational Fluid Dynamics Modeling of Scaled Hanford DST Mixing- Fiscal year 2010 Model Development Results, Washington River Protection Solutions, LLC, Richland, Washington.

[e] RPP-47557, 2010, Small Scale Mixing Demonstration Initial Results Report, Washington River Protection Solutions, LLC, Richland, Washington.

[f] RPP-RPT-48233, 2011, Independent Analysis of Small Scale Mixing Demonstration Testing (Daniel Greer), Washington River Protection Solutions, LLC, Richland, Washington.

[g] SRNL-STI-2011-00278, 2011, Demonstration of Mixing and Transferring Settling Cohesive Slurry Simulants in Tank AY-102, Savannah River National Laboratory, Aiken, South Carolina.

[h] 24590-WTP-RPT-MGT-11-014, Rev. 0, 2011, Initial Data Quality Objectives for Waste Treatment Plant Feed Acceptance Criteria, Bechtel National, Inc., Richland, Washington.

[i] RPP-49845 (August 2011) – Computational Fluid Dynamics Modeling Sensitivity Study Result, Washington River Protection Solutions, LLC, Richland, Washington.

[j] PNNL-20637, Rev. 0, 2011, *Comparison of Waste Feed Delivery Small Scale Mixing Demonstration Simulant to Hanford Waste,* Pacific Northwest National Laboratory, Richland, Washington.

[k] RPP-49740, Rev. 0, 2011, *Small-Scale Mixing Demonstration Sampling& Batch Transfer Results Report*, Washington River Protection Solutions, LLC, Richland, Washington.

REVIEW COMMENT RECORD (RCR)

	1. Date: 1//2/2012	2. Review No. ERT-2011-6
	3. Project No.	

5. Document Number(s)/Title(s)	6. Program/Project/Building Number	7. Reviewer	8. Organization/Group	9. Location/Phone
RPP-PLAN-41807, Revision 0b, draft for review, 12/13/11	**Tank Mixing and Sampling**	**Ramesh Hemrajani, Richard V. Calabrese, Loni Peurrung, Erich Hansen**	LSIMS ERT	NJ / 908-647--0185

17. Comment Submittal Approval:	10. Agreement with indicated comment disposition(s)	11. CLOSED
Organization Manager (Optional)	Date Reviewer/Point of Contract Author/Originator	Date Reviewer/Point of Contact Author/Originator

12. Item	13a. Comment(s)	13b. Basis	13c. Recommendation	14. Reviewer Concurrence Required	15. Disposition (Provide Justification is NOT accepted)	16. Status
(RH-1) p.4 Section 1.	It is targeted to meet WTP WAC which is yet to be defined. Therefore it is difficult to appropriately define the scope. It is also mentioned that uniform feed is desirable. This may be overly stringent recognizing that some segregation can be expected in the transfer pipeline. In addition, it would be difficult to target uniform slurry during pumpout when the mixer (Twin-Jets) will be rotating at 5-20 minute cycles.	Experience and Engineering judgement	Re-evaluate uniform slurry concentration requirement.		Accepted – reworded to clarify	
(RH-2) p.5-6 Section 2.1	Background – Information on characteristics of all waste material in all storage tanks seems to be missing. I understand that only limited samples have been collected from few storage tanks. It is difficult to develop a good simulant and test plan without complete knowledge of properties of all the waste materials.	Discussions with WTP folks and review of reports.	It would help to collect more samples and/or review history of materials when they were stored.		Added the statement, "The evaluation of waste to be transferred to WTP, identified as Commitment 5.5.3.2, June 30, 2012, will define the preliminary range of physical properties of waste anticipated to be delivered to WTP."	

REVIEW COMMENT RECORD (RCR)

1. Date	2. Review No.
3. Project No.	4. Page 2 of 8

(RH-3) p.6 Section 2.2	Work Completed – Large amount of valuable work has been carried out, and perhaps further detailed analysis may be helpful. For example, data of Cleaning Radius vs. Nozzle Velocity to define "Critical Velocity for Suspension" on Slide K-14 of Adamson/Steeper presentation. These data can be further worked up using literature correlations for Jet Velocity Decay, Rate of Jet Propagation, and Settling Rate of particles.	Experience with sludge suspension in crude oil storage tanks.			Acknowledged – the work mentioned will be used to define specific flow velocities in specific test plans.	
(RH-4) p.7 Section 2.3.2	Determining bounds by selecting largest particles and highest density may be overly conservative. Typically settling velocity characterizes mixing requirement for suspension.	Industrial experience with mixing tanks for solids suspension.			Acknowledged – Overly conservative properties are being used for initial testing to define bounds.	
(RH-5) p.9	Solids Accumulation – While this issue can be important, it is assumed that all particles are suspended and homogenized for transfer. Therefore accumulation should not be allowed.				DST mixing will not suspend all particles, thus the need for evaluating solids accumulation.	
(RH-6) p.10	Simulant Philosophy – It is stated that 50% of Hanford waste is more challenging than the SSMD simulant. What is the basis of this estimate, especially when waste material in all storage tanks has not been sampled and analyzed.		Initiate a dialogue on this point while developing an appropriate simulant.		Added reference	
(RH-7) p.18 Table A-1	Testing in Water is Conservative – While settling velocity of particles in water would be higher than in viscous/yield stress liquid, suspending particles from rest could be more difficult with viscous/yield stress liquids.		Perhaps limited bench scale testing would resolve this issue.		The testing described did address this.	

REVIEW COMMENT RECORD (RCR)	1. Date	2. Review No.
	3. Project No.	4. Page 3 of 8

(RH-8) General	1. It would help to provide details of how waste material will be tranferred from SSTs to DST Staging Tank, and what will be added before pumping to DST Waste Feed Preparation Tank. Also any feed treatments are anticipated.				Added description	
	2. I carried out limited scoping calculations of velocity requirement for solids suspension using data from 43" and 120" tanks. The results appear to be consistent for providing equivalent solids suspension. Similar data analysis can help understand mixing requirements.				Acknowledged	
	3. It is mentioned that mixing quality improves on scale-up. While some limited data seem to indicate this conclusion, it may not be true for all waste materials, especially yield stress fluids.				Accepted – reworded the statement to say, "flowrate is more important than rotation rate and mixing performance is less sensitive to velocity changes as scale increases"	
	4. Scaled Performance Testing – should be carried out at 4 or more jet velocities to cover a range of scaling exponent from 0.18 to 0.33. For example for 43" tank jet velocity range of 22-35 ft/s and for 120" tank jet velocity range of 30-45 ft/s.				The number of velocities used is a trade off with cost/schedule. Past experience allows focusing on two velocities. This will be considered further as test plans are developed.	

REVIEW COMMENT RECORD (RCR)

1. Date	2. Review No.
3. Project No.	4. Page 4 of 8

	5. I understand that WTP is planning to use 30Pa/30cP rheological properties of simulant for testing. Perhaps same properties should be considered for this testing as well.				The 30Pa/30cP rheological properties are following WTP pretreatment and are not applicable to feed delivery.	
(RVC-1) pp.5-6 Sect 2.1	WAC is discussed but there is no mention as to what extent PSDDs are known in the SSTs.	Inadequate knowledge of tank farm properties may impact success criteria and simulant selection.	Please discuss briefly.		Added the statement, "The evaluation of waste to be transferred to WTP, identified as Commitment 5.5.3.2, June 30, 2012, will define the preliminary range of physical properties of waste anticipated to be delivered to WTP."	pp.5-6 Sect 2.1
(RVC-2) p.5 Sect 2.1 Last para.	The words following "*to adequately suspend and homogenously distribute*" imply that the criteria for success are a completely uniform and homogeneous PSDD throughout the tank. Is this possible to achieve and really necessary?	Complete homogeneity and uniformity may not be achievable, and may not be necessary for success in sampling and transfer to WTP.	Please clarify.		Deleted the word "homogeneously"	p.5 Sect 2.1 Last para.
(RVC-3) pp.8-10 Sect 4	There is considerable mention of scaling and scaled performance, but no discussion in the main body of the report on the ability to predict full scale performance. Is there a demonstrated scaling exponent?	Several test facilities (SSMD, MDT, RSD, etc.) will be employed and it is implicitly assumed that the results can be used to predict full scale performance.	Briefly discuss scalability of test facilities in this section or in an earlier section.		Added statement, "Reports identify a range of scaling factors (approximately 0.25 to 0.3) applicable to DST mixing (Jackson, 2011)."	pp.8-10 Sect 4
(RVC-4) p.10 Sect 5 Last para.	The description of the "current simulant" needs more context than is provided.	Strengths/limitations of "current simulant, as described, are difficult for a novice to follow/comprehend.	Please clarify assuming document is to be seen by a less informed public.		Changed to, "The simulant that has been used in SSMD activities"	p.10 Sect 5 Last para.
(RVC-5) Table A-1 General	This is Table 2-1 of RPP-50557, and summarizes a large amount of work. It would benefit from Introduction and Reference sections.	Document will be released outside of DOE. Table contains too much information, taken out of context.	Provide an overview of the Table and a list of References.		Added an introductory statement and list of references.	Table A-1 General

REVIEW COMMENT RECORD (RCR)

1. Date	2. Review No.
3. Project No.	4. Page 5 of 8

(RVC-6) General	There are minor grammatical mistakes, awkward phrases, typos and cut & paste errors throughout the document.	Examples: Section 1 begins on p.4. Table A-1 is 6 pages (not 5). It is 5 pages in RPP-5057.	Give a "hard read" before it is released.		Accepted	General
(LMP-1)	Section 4, page 10, first bullet, i.e. the description of the first activity to determine scaled performance: this description is unclear, in part because it lacks detail.	Unclear to the outside reader what is planned.	Add detail and/or clarity to description.		Revised to read, "Use the SSMD platform to test at two or more mixing velocities to evaluate the development of "mounds" and transfer behavior, define scaled test approaches to apply these test results at full scale, and develop a basis for confirming the velocities used for scaled testing."	
(EKH-1	Section 2.1, page 5, "WTP dynamic processing analysis and batch processing planning currently assumes each staged HLW feed tank is homogeneous…"		Provide reference to this statement.		Accepted - Referenced ICD-19	1
(EKH-2)	Section 2.1, page 5. The last paragraph goes into describing ideal mixing conditions (homogeneity), which does not seem to be the case for the present DST mixer configuration and simulant (fast settling) basis. Should it be made clear in this section that the previous testing to date did not provide a homogenous distribution of solids in the DST due to the nature of the simulant (in the case, assume fast) tested? Testing using non-Newtonian simulant and mixing were also performed and their behavior on mixing performance should also be added. This is part of the history.	For completeness and clarity on type of mixing performance that was observed for different fluid conditions.	Add detail and/or clarity to description.		Accepted - Removed use of the term "homogeneous" and have added clarity to introduction.	2
(EKH-3)	Section 2.1, page 6, This section provides description of the	For completeness.	Add detail and/or clarity to description.		Accepted – added paragraph to summarize proposed sampling	3

	mixing/pumping equipment. Is there information about the sampling pump/sampling system?				method.	
(EKH-4)	Section 2.2, page 6, "The sampling and batch transfer testing results have indicated the feasibility of the sampling concept with results showing the more difficult and fastest settling particles can be sampled in a manner that is representative of the bounding feed transferred to the WTP." What is the meaning of "representative of the bounding feed"?	This statement is not clear.	Add detail and/or clarity to description.		Accepted – deleted the confusing phrase	4
(EKH-5)	Section 2.2, page 6, This section discusses sampling. In the WTP waste prequalification program, a single sample will be obtained for analysis to determine processing steps and operating knowledge for the campaign. Questions may arise to know batch to batch variability in a single campaign as compared to the pulled sampled. Are there plans for such activities of batch to batch variability? If batch to batch is performed, will the variability in both scales be compared?	This provides a better understanding of feed variability going to the WTP.	Provide details if such activities will take place or not to make it clear a position has been taken.		This section discusses past work. Testing objectives and requirements are addressed in sections 3 and 4. The intention is to gather batch to batch variability during the scaled performance testing	5
(EKH-6)	Section 4, Limits of Performance, page 9, 3rd burger dot. Makes reference to a "…representative and repeatable samples…" What is your definition of "representative" and what is it compared against?	This is related to item 3 above.	Add detail and/or clarity to description.		This will be defined in the test plan to follow.	6
(EKH-7)	Section 5, page 10, can you provide the composition of the SSMD simulant that is being discussed.	Provides clarity to this section.	Add detail and/or clarity to description.		Added brief description and reference	7

REVIEW COMMENT RECORD (RCR)

1. Date	2. Review No.
3. Project No.	4. Page 7 of 8

(EKH-8)	Table A-1 Hard to comment on this section, since this the authors summary of events with individual who have performed this work or were involved in reviewing the work. Hence the following are just questions to improve this section. 1 - Page 15, Nov. 2009, 3rd burger dot. Were more solids transferred at a higher or lower flow rate (not clearly specified)? 2. Page 16, July 2010, 1st burger dot. Once particles were removed from the bottom of the tank in the cohesive simulant, were they better suspended as compared to the non-cohesive simulant? If so, should this be stated? 3. Page 16, Sept. 201, 1st burger dot. What does solids consistency variability mean? What was the consistency basis (visual, weight, eg) 4. Page 16, Sept. 201, 2nd burger dot. Interesting comment. I need to look at the report. 5. Page 17, Dec. 2010, 4th burger dot. Is +/- 10% of density good? Let's assume your average is 15 wt% , water is the carrier fluid, and one can use volume additivity (not a bad assumption, since these solids are not soluble) For solids having an average density of 2.7, the wt% would range between 7.4 to 21.8 wt%. For a 4 s.g average particle density, the wt% of solids in the slurry would range between 8.8 to 20.6 wt%. From a wt% solids concentration value, this	Experience in dealing with non-Newtonian and heterogeneous slurries processes and characterization.	Adds detail.		This section is a direct excerpt from an issued report (RPP-50557) which provides a high level summary of each of the referenced documents. Further details can be found in each referenced document. An introduction to Appendix A has been added to clarify this point. Separate ERT question and answer sessions are planned to help the ERT members understand the history and interpretation behind the referenced reports.	8

	10% change in density provides very large swings in the wt%. (continue on next page) Hard to convince me that +/- 10 % in density is a good indicator. I might have to read this report to get a better understanding. As well as others on how this is being used. 6 - Page 18, Aug 2011, 1st burger dot. How were the velocities measured in the field?					

WTP Large-Scale Integrated Mixing System Expert Review Team

(L. Peurrung, chair; R. Calabrese, R. Grenville, E. Hansen, R. Hemrajani)

To: Mike Thien, WRPS

Subject: Concurrence on response to ERT Review of *Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements* (ERT-06 Feed Test Reqmts[1])

Date: January 24, 2012

Dear Mr. Thien:

The Large-Scale Integrated Mixing System Expert Review Team (ERT) concurs with WTP's disposition of ERT comments documented in our review ERT-06, "Waste Feed Delivery Mixing and Sampling Program Plan and Test Requirements" (dated January 3, 2012) as described in your response letter dated January 18, 2012. It is our mutual understanding that the ERT's review of the document was not intended to and does not constitute a review of or agreement with the conclusions of the previous work described in the appendix, which was the basis for the second comment in our review. We appreciate the clarification of your intent to continue to emphasize the development of a scaling basis for waste feed mixing systems. We would also be happy to receive document RPP-RPT-48233. Since we have not been asked to formally review it at this time, we will work with you to determine whether it should be part of a future discussion.

This letter closes review ERT-06 Feed Test Reqmts.

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[1] Under previous review numbering system, ERT-2011-6