The Deputy Secretary of Energy
Washington, DC 20585
September 8, 2010

RECEIVED
2010 SEP -8 PM 4:32
DNF SAFETY BOARD

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

Dear Mr. Chairman:

On August 6, 2010, you requested that the Department of Energy (DOE) respond to questions regarding plans and processes for the Waste Treatment and Immobilization Plant (WTP) being designed and constructed at the Hanford site. The DOE's responses to your questions are enclosed.

Enclosure 1 provides brief position papers on each of the five technical issues identified in your letter and the Federal Register Notice announcing the Public Meeting. Specifically, these papers address the following:

1) Changes in safety-related design criteria resulting from modification of the material at risk;
2) Changes in design strategy to address hydrogen in pipes and ancillary vessels;
3) Criticality safety concerns and other safety-related risks for the pulse jet mixing system;
4) Reclassification of safety-related systems, structures, and components; and
5) Safety-related design aspects of facilities or modifications of existing facilities needed to deliver high-level waste feed.

Enclosure 2 provides a crosswalk between these 5 issues and the individual questions of the 23 provided in the enclosure to your letter. In some cases a specific question may be listed under more than one of the five issues, since it supports multiple issues.

Enclosure 3 provides the following:

- Definitions of selected key terms (e.g., margin-of-safety, safety-related design risk) to ensure a common basis of understanding in the responses;
- Detailed responses to each of the 23 questions posed in your August 6 letter;
- Identification of each author, affiliation, and title of responses; and
- As needed, an opening/summary-level statement for selected question responses based on the need to establish the necessary framework or context for the response.

DOE will continue to provide additional support to the Board in preparation for the Public Meeting. If you have any further questions, please call me or Dr. Inés R.Triay, Assistant Secretary for Environmental Management, at (202) 586-7709.

Sincerely yours,

Daniel B. Poneman

Enclosures

cc: M. Campagnone, HS-1.1
I. Triay, EM-1

ENCLOSURE 1

Technical Issue

The Material-at-Risk (MAR) previously used for the Waste Treatment Plant (WTP) was based on a hypothetical "Super Tank" concept that assumed the simultaneous presence in the waste of the worst characteristics permitted by the WTP Contract even though such a waste stream did not exist at the Tank Farms. The MAR has now been revised to reflect:

1. Additional radioactive waste characterization studies conducted by the Tank Farms and incorporated into the approved Tank Farm safety basis in 2002;

2. Dynamic modeling of waste processing by the WTP Project to bound the changes that occur in waste characteristics for the range of processing methods being considered for use at WTP;

3. A better understanding of how the tank farm waste will be transferred to the Pre-Treatment Facility (PTF) to maximize treatment performance and reduce the overall life cycle; and

4. A commitment to provide a specific administrative control for WTP waste receipt to ensure that the assumed waste envelope will not be exceeded during facility operations.

New analyses were performed, incorporating the revised MAR, to estimate dose consequences to the on-site worker and the public from postulated accidents. The new analyses resulted in lower unmitigated accident dose consequences and the functional classification of some safety SSCs has been or can be reduced based on these results

Design/Safety Objective

The design and safety controls for the revised MAR ensure that:

1. Key safety class systems in the PTF (i.e., C-5 ventilation system, structural walls, and process vessel vent and process air systems) are retained to protect the large processing vessels from damage and, more importantly, to protect both workers and the public from any events that may occur inside the inaccessible waste processing cells.

2. WTP waste acceptance criteria will be established and waste that will be delivered by the Tank Farms to the WTP will meet the criteria.

Design/Safety Approach

A MAR task team was chartered by U.S. Department of Energy (DOE) in January 2009 to determine the appropriate waste feed characterization assumptions as they relate to the safety analysis. The team evaluated the original contract requirements of the "Super-Tank" concept compared with the actual Tank Farm waste characteristics to determine the best assumption for the MAR to be used in the safety analyses.

The MAR task team concluded that the project was using overly bounding process inventories and recommended revised acceptance criteria for waste feed to the WTP and reevaluation of selected assumptions and methods used in the accident analysis. The WTP Project accepted the task team recommendation to change the model used for radiological release accident analysis from GXQ to MACCS2, a DOE toolbox code used per applicable guidance including the 1 cm/s deposition velocity.

The WTP Project team implemented the recommendation of the task team and revised the MAR and ULD based on:

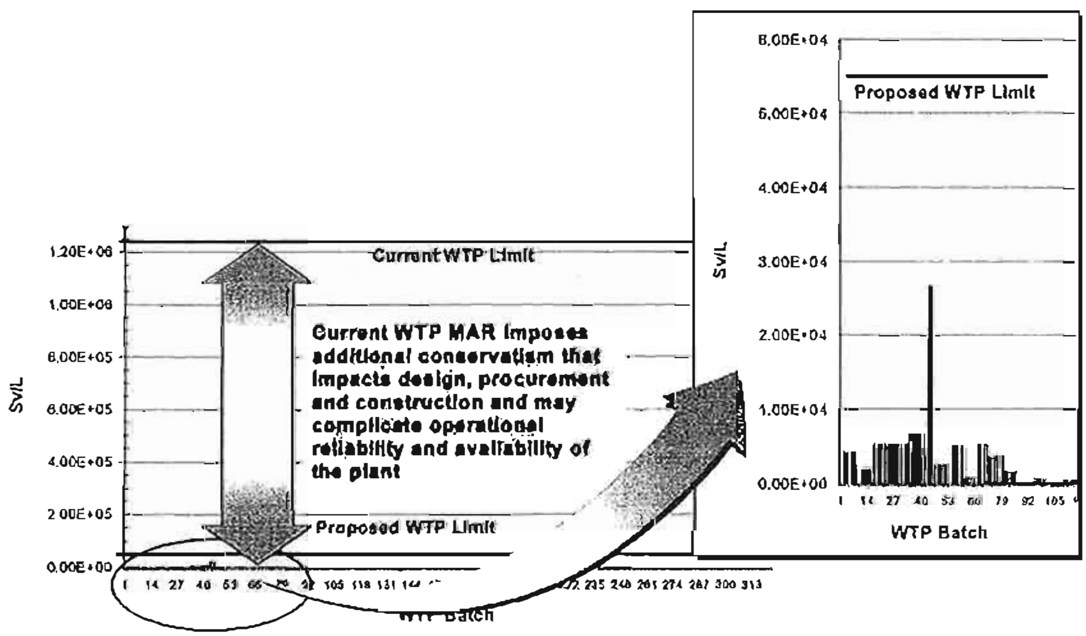
1. An assumption that the two worst case waste fractions in the Tank Farms would be combined at a design maximum weight percent solids, and

2. A recognition that facility controls would be in place to ensure that the Tank Farms verifies through sampling each feed batch transferred to the WTP. The Tank Farms must ensure that feed delivered meets the acceptance criteria and remains below the Unit Liter Dose (ULD) assumptions in the Safety Basis. WTP will perform trial processing of a waste sample to verify treatment plans and ensure understanding of the waste response.

   Any changes from previously evaluated process plans would be subject to review through the Unreviewed Safety Question process. In the event the waste cannot be accepted into WTP facilities as proposed, options to ensure acceptability are available such as blending the waste if necessary.

While the "Super Tank" MAR may have been necessary at the conceptual design stage for WTP, carrying its excessive conservatism through the preliminary design process was judged to be diverting design attention from the real issues posed by the waste that would be received.

The change in MAR and the remaining conservatism are illustrated in the following figure taken from the November 2009 DOE Safety Evaluation Report (SER) approving the MAR change.



Using the revised MAR and accompanying changes in analytic methodology, twenty-two bounding design basis events (DBEs) were analyzed. These events included spills, spray leaks, self-boiling in vessels, Pulse Jet Mixer overblows, electric load drops, Cesium Ion Exchange accidents, hydrogen explosions in vessels, and a bounding seismic event. The results of the analyses were used to re-evaluate the suite of controls selected to mitigate and prevent such events and resulted in revised safety classifications of many controls based on the reduced unmitigated dose consequences to the public and co-located workers. Based on the unmitigated dose consequences to the public for some of these accident scenarios and accounting for uncertainties in the accident analysis, DOE and WTP Project personnel judged that certain systems should remain with a safety-class designation. The new control strategy based on the new methodology was approved by DOE in November 2009.

The major elements of the revised strategy are:

1. The revised MAR is based on the two worst waste fractions in the Tank Farms that are combined at design maximum weight percent solids.

2. The tank farms ensure that feed delivered to WTP meets the acceptance criteria and remains below the MAR assumptions in the Safety Basis. Compliance with the WTP acceptance criteria is verified through a sampling program.

3. Any changes from previously evaluated process plans would be subject to review through the Unreviewed Safety Question process. In the event the waste cannot be accepted as proposed, options to ensure acceptability such as blending the waste are available.

4. The Project performs trial processing of a waste sample to verify treatment plans and ensure understanding of the waste response.

5. The key PTF safety-class systems, defined as the cell walls and C5 ventilation system serving the cells, are retained and afford robust mitigation for any postulated accidents.

6. Components, subcomponents, or support structures, systems, and components (SSCs) required for the credited function of these and other safety-class systems (such as the safety control system for overblow prevention), also remain classified safety-class.

Conclusion

Both DOE and Bechtel National, Inc. (BNI) have high confidence that the use of actual Tank Farm waste characteristics to determine the safety basis and control selection for the WTP, will yield a superior design for WTP that complies with DOE safety policies and ensures the operational reliability necessary for efficient achievement of the critical waste stabilization mission of the facility.

Technical Issue

Liquid high-level radioactive waste stored at the Hanford tank farm produces hydrogen by radiolysis and thermolysis. If a sufficient concentration of hydrogen accumulated in the WTP pipes or vessels and mixed in the right proportions with an oxidant, and an ignition source is present, the gas mixture would ignite. In some cases, the burning gas (deflagration) could transition to a more severe detonation event. Hydrogen gas hazards in vessels differ significantly from those in piping due to the vessel's much larger volumes and the usual presence of oxygen in the vessel headspace. The WTP design prevents hydrogen combustion events in vessels, including ancillary vessels like the pulse jet mixers, using active controls (purges and vents) that limit gas concentration below the lower flammability limit (LFL). Thus, this HPAV design issue is focused on the piping systems.

The postulated unmitigated effects of hydrogen combustion events (i.e., HPAV events) include various possible confinement piping system failure scenarios resulting in any of the leak accidents bounded by the safety analysis with initial control selection in accordance with DOE-STD-3009, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis*, to protect both the public and workers. The principal control to protect the public, workers, and the environment against the consequences of postulated confinement piping system failures is the safety-class C-5 boundary and C-5 ventilation system. This control is not being changed. Piping boundary failure in black cells or hard-to-reach areas would also jeopardize the facility mission due to the limited access for repair. A piping system failure in the hot cell is considered repairable, but frequent failures in the hot cell could also jeopardize the facility mission.

The Waste Treatment Plant (WTP) safety design strategy has been and remains based on design to assure that the piping and inline component primary confinement function is not adversely affected by postulated HPAV events. A previously accepted design approach to manage the accumulation of hydrogen in piping systems relied on (1) the passive pipe/component boundary where it could be shown that the resulting strain remained below the elastic strain limit, or (2) active controls (e.g., purge, flush, vent) where the HPAV event could cause the piping material to exceed the elastic strain limit.

The WTP Project is now revising this design approach to (1) modify the methodology for calculating the loads and strains resulting from an HPAV event for piping up to 4 inches (nominal pipe size [NPS]), (2) revise the allowable strain acceptance criteria to allow limited plastic deformation only for hot cell piping up to 4 inches NPS, and (3) always require active controls (i.e., eliminate the use of a strain criteria) for piping greater than 4 inches NPS. Also being incorporated into this revised design approach is the understanding that HPAV events in austenitic stainless steel piping do not have the potential to cause fragmentation, which could damage nearby components. The WTP safety design strategy continues to be based on design to assure that the piping and inline component primary confinement function is not adversely affected by postulated HPAV events.

Design/Safety Objective

The design of piping systems in WTP ensures the following:

1. An HPAV event in the piping will not adversely affect the ability of the piping or any nearby component to perform its intended safety function.

2. An HPAV event in the piping will not render the piping inoperable such that a difficult and expensive repair is required which could adversely impact the WTP mission.

3. The design approach should not introduce additional hazards/risks to workers or have significant adverse impact on WTP operations.

4. The design will facilitate efficient plant operations.

Design/Safety Approach

In 2002, the project initiated actions to address the lessons learned from the Nuclear Regulatory Commission (NRC) Information Notice 2002-15 "Hydrogen Combustion Events in Foreign BWR Piping." Actions included development of a safety design strategy to address the hydrogen hazard in piping and inline components. In the early stages of the facility design, it was apparent that sufficient data was not available to support a broad passive control strategy for HPAV that relied on the pipe capacity to withstand the event. In order to advance the design, active controls were developed that are intended to prevent the accumulation of hydrogen. In parallel, an extensive program of analysis and testing was initiated to gather sufficient data to support a broader passive control strategy.

The original design approach relied on deterministically defined active preventive controls for any piping system in which a conservatively defined "bubble of concern" could cause the piping to exceed the design code elastic limit. Given the conservatisms necessary due to a lack of sufficient data, active control systems were required for most HPAV affected piping routes. It was recognized during the design development that some of the controls would directly affect normal plant operations (e.g., interrupt waste transfers). Additionally, due to space limitations, some controls were located outside the hot cell creating worker hazards requiring additional protective measures.

In 2008, the U.S. Department of Energy (DOE) decided to re-evaluate the design control strategy that relied primarily on preventing the accumulation of combustible gasses. This review could now be informed by the completed active control design. The purpose of the evaluation was to determine if alternate design approaches for dealing with hydrogen would simplify the facility design, thus providing higher assurance of safe and reliable operations while protecting the long term availability of the facility. The WTP Project came to the conclusion that a combination of less reliance on the predominant original strategy to prevent gas accumulation and more reliance on engineered capacity to withstand HPAV events affords the most robust design and thus the best assurance of both safety and mission success. This conclusion was supported by the results of the extensive testing performed during the previous years.

The WTP Project has performed extensive testing involving deflagrations and detonations in piping systems to understand the applicable loading mechanisms and to support designs that could accommodate detonation without damage that would impair the confinement function. As a result, the Project has revised the piping system design approach to (1) modify the methodology for calculating the loads and strains resulting from an HPAV event for piping up to 4 inches NPS, (2) revise the allowable strain acceptance criteria for hot cell piping up to 4 inches NPS, and (3) always require active controls (i.e., eliminate the use of a strain criteria) for piping greater than 4 inches NPS. Also being incorporated into this revised design approach is the understanding that HPAV events in austenitic stainless steel piping do not have the potential to cause fragmentation which might damage nearby components.

Methods and criteria have been developed to implement this revised design approach, and are based on the following:

1. Extensive research and testing completed over the past three years to understand and characterize the physics and phenomena of potential HPAV events. This research and testing has enabled:

    a. Characterization of the event types (deflagration and detonation) including their time dependant evolution and behavior.

    b. Prediction of the response of the piping system to the events.

    c. Development of engineering code-based acceptance criteria (ASME B31.3, the Code of Record, does not explicitly address impulsive HPAV loads, but does provide guidance for designing for unusual service requirements such as HPAV loads).

    d. Development of tools to conservatively assess the frequency and severity of the HPAV events as a function of the unique characteristics of each WTP piping route.

2. Use of industry accepted models for prediction of piping response to dynamic loads.

3. Use of full scale tests to benchmark the methodology to assure adequate prediction of behavior.

4. Use of ASME Section VIII and ASME Section III in developing acceptance criteria to ensure safety factors comparable to those in the commercial nuclear industry for these types of events/loads.

On April 15, 2010, in a periodic report to Congress, the Board expressed concern "that many changes to the design of WTP are being approved by the Department of Energy (DOE) prior to the resolution of numerous outstanding technical issues."

In an effort to resolve these technical issues, the Board suggested a comprehensive, independent, expert-based review of the safety design strategy for control of hydrogen in pipes, similar in scope to the external flowsheet review completed in 2006. This led to the formation of the HPAV Independent Review Team (HPAV IRT).

The HPAV IRT concluded, based on the technical review, that the new design approach for HPAV piping and components is acceptable provided the WTP Project resolves the Findings which will improve the models, assumptions and methodology, and further stated that there is "*high confidence that*

- *The QRA approach is acceptable for defining loads to be used in design, and there is a low probability of exceeding either their frequency or their magnitude.*

- *The best estimate pipe stresses and strains, computed from the defined loads in the manner proposed by BNI, are not likely to be significantly exceeded.*

- *The combination of QRA load definitions, best estimate piping system response calculations and conservative acceptance criteria developed pursuant to the piping Code B31.3 provides a reasonable balance of probabilistic and deterministic elements appropriate for design of HPAV piping and components.*

The net result of this approach to design will be a low probability of pipe failure if hydrogen explosions occur."

Conclusion

Both DOE and Bechtel National, Inc. (BNI) have high confidence that the HPAV design approach will yield a superior design for WTP that not only complies with DOE safety policies but will also ensure the operational reliability necessary for efficient achievement of the critical waste stabilization mission of the facility.

Technical Issue

Successful operation of the WTP depends on the ability to mix liquids with suspended solids at varying concentrations and physical properties in process tanks (or vessels) located in the inaccessible black cell areas of the plant where the design has precluded locating items with moving parts, such as motors and rotating components.

The pulse jet mixers (PJMs) are the primary means used for mixing process fluids (liquids with suspended solids) in 38 process vessels in WTP (34 in the Pre-Treatment Facility [PTF] and 4 in the High Level Waste Facility [HLW]). The PJMs are long cylindrical vessels internal to the process tanks that draw in fluid by a vacuum and then pressurized with compressed air to eject the fluid back into the vessel to cause mixing; much like a baster draws in and expels fluid. These devices are very reliable and have no moving parts, thus eliminating the need for maintenance of this equipment over the life of the plant. The design of the WTP PJM mixing systems (number and power of PJMs) is based on the waste characteristics and the vessel size and geometry.

In 2006, the External Flowsheet Review Team (EFRT) reviewed the WTP designs and identified the following major issue associated with the vessels containing solids that were designated as Newtonian.

> *"Issues were identified related to mixing system designs that will result in insufficient mixing and/or extended mixing times. These issues include a design basis that discounts the effects of large particles and of rapidly settling Newtonian slurries. There is also insufficient testing of the selected designs."*

In response, the WTP prepared the *Issue Response Plan for Implementation of External Flowsheet Review Team (EFRT) Recommendations - M3, Inadequate Mixing System Design* which describes an approach for issue resolution and defines the issue closure criteria.

During the execution of the Issue Response Plan (IRP), technical reviews with the Defense Nuclear Facilities Safety Board (DNFSB), the Consortium for Risk Evaluation with Stakeholder Participation (CRESP), and other external teams have been conducted. Issues identified during these reviews have been documented and are being tracked to resolution. The primary issues are related to three potential safety concerns:

- The potential for inadvertent criticality due to the accumulation (collection) of fissile materials;
- The generation of hydrogen due to the accumulation of solids, and
- The potential for PJM overblows (discharge of air from the PJM) due to the inability to control the PJMs as a result of the accumulation of solids impacting the vessel level detection system.

Design/Safety Objective

The design/safety objective is to demonstrate through testing and analysis that PJM-mixed vessels meet their specific mixing requirements, including their safety related requirements. Specifically, the U.S. Department of Energy (DOE) and Bechtel National, Inc. (BNI) is committed to resolving the potential safety concerns associated with the accumulation of fissile materials, hydrogen generation, and performance of the vessel level control that could impact PJM operation (overblow events).

DOE also recognizes that some uncertainty will remain with respect to PJM performance until extensive experience has been gained through testing of large-scale prototypic PJM vessels and actual WTP operations. To reduce this uncertainty, vessel inspection and heel removal (solid/liquid slurry in a vessel below the normal operating level) is an important part of the defense in depth strategy to assure that excessive solids will not accumulate over the life of the facility. External reviews have documented that this capability is a prudent engineering design feature for vessels that are expected to be in service for many years. These features are viewed as defense-in-depth because the test results, analyses and vessel assessments do not predict conditions of solids accumulation.

Design/Safety Approach

The project will confirm the adequacy of the design by analysis, underpinned by testing. The overall strategy initiated in 2006, has been to employ a combination of analytical tools, modeling, existing experimental data, and new testing to evaluate the mixing performance of the WTP vessels. None of these methods are conclusive on their own; however, the combination of the independent tools employed and further small and large scale testing will be sufficient to support a strong overall conclusion. As additional information becomes available, the information is analyzed and vessel performance is reassessed/updated against the requirements.

The strategy to confirm the adequacy of the design is documented in the *Integrated PJM Mixed Vessel Design and Control Strategy*. This strategy document supplements the M3 Issue Response Plan (IRP) and serves as a roadmap for the disposition of remaining PJM-related technical issues. The strategy consists of three distinct phases.

- Phase 1 is the closure of the M3 EFRT issue and achievement of the targeted technology readiness level based on the IRP. It includes assessment of each PJM vessel against the vessel-specific mixing requirements and the definition of any required design changes to the vessel or supporting systems.

- Phase 2 is the closure of additional issues identified with the PJM control (bubblers), suction line design, and sampling systems. These issues will be closed in part by completion of large-scale prototypical tests of a Newtonian and Non-Newtonian vessel configuration. Additional technical issues identified by the DNFSB and CRESP external review groups related to aspects of the criticality control and gas release strategies will be resolved during this Phase.

- Phase 3 is the completion of the design change process to implement any required vessel or supporting system changes and confirm the design for the PJM-mixed vessels/systems.

Status

Phase 1: The closure criteria documented in the IRP related to inadequate PJM mixing were satisfied and the M3 EFRT issue was closed during August 2010. The Technology Steering Group (TSG) closure documentation identified potential risks and the following specific recommendations to mitigate the risks:

1) Updating design basis documentation;

2) Small-scale testing to support additional benchmarking of the Low Order Accumulation Model (LOAM) in Non-Newtonian vessel configurations;

3) Large scale testing to provide additional confidence in full scale vessel performance and support vessel operations, and

4) Completion of the verification and validation of the computational fluid dynamics models that will be used for confirmation of the design.

Closure of the M3 inadequate PJM mixing issue indicates sufficient resolution of the technical issues to continue with the design of the affected vessels. DOE and BNI are identifying the specific vessel fabrication and installation activities that will be placed on-hold if the required actions are not completed or do not support the vessel assessments.

The testing and analysis completed as part of Phase 1 also supported resolution of the potential safety issues associated with the accumulation of fissile material and the potential for criticality. The project's approach to addressing criticality safety is documented in a Criticality Safety Evaluation Report (CSER). With regard to mixing, the CSER addresses three main concerns: 1) differential settling that could allow potentially dense particles (i.e., those with fissile materials) to concentrate in the solids layer on the bottom of the tank, 2) inadequate mixing could allow an irretrievable layer of solids to form on the bottom of the tank with a potentially unacceptable concentration of fissile material, and 3) non-representative sampling.

Testing and analysis demonstrated that unacceptable accumulation or concentration of fissile material in the mixing vessel over the life of the project is not likely and that there is no unacceptable change in the particle size distribution as the material is removed from the vessel. To address the concern with non-representative sampling uncertainties, the WTP is currently evaluating the use of samples taken to demonstrate that the feed complies with the WTP Waste Acceptance Criteria (WAC). An update to the CSER is planned within the next year.

The testing and closure documentation for Phase 1 also included an assessment of the potential safety issue associated with the accumulation of solids due to insufficient mixing that could result in hydrogen generation. The assessment was performed for normal operations, as well as conditions in which PJMs are not operational following a design basis event. To support the assessment, testing was performed to ensure sediment mobilization to release gas and keep the vessel headspace from reaching the lower flammability limit following such an event.

The testing and analysis has determined that there is no accumulation of solids that could result in hydrogen build-up during normal operations. A principal test objective was to assure the ability to clear solids from the bottom of vessels under normal conditions. Any solids that settle to the vessel bottom during normal operations will be mobilized during the next PJM operational cycle (every 2 to 5 minutes). Following a design basis event, complete suspension of solids is not necessary to mitigate the retention of flammable gases. Testing and analysis determined the PJM operational sequence and mixing durations required to ensure that gas can be released from the settled solids layer.

Phase 2: Consistent with the overall *Integrated PJM Mixed Vessel Design and Control Strategy*, the need for large-scale integrated testing to support a variety of complex mixing, retrieval, transfer, and sampling needs has been recognized by DOE and was documented in the TSG closure documentation for Phase 1. The WTP project has also identified the need for system level testing of selected prototypic large scale vessels prior to cold commissioning of the WTP to further mitigate remaining PJM risks that at a high level include, but are not limited to, demonstration of:

- PJM operations over the range of fill conditions, including operation of a fully prototypic control systems;
- Sampler operations and data interpretation for process control and nuclear safety;
- High solids liquid Non-Newtonian slurry rheology control;
- Particle settling effect in low solids Non-Newtonian slurries;
- Large-scale, post-Design Basis Event (DBE) remobilization; and
- Vessel inspection and heel removal systems.

The combination of the large-scale testing (with realistic simulants) of a fully prototypic control system and previously performed PJM control system testing will be used to address the potential safety issue associated with the impact of settled solids on the level detection system and overall control of the PJMs. Previous testing has shown that the bubbler level and density measurements (level detection system) were repeatable, consistent, and provided acceptable system control. Testing of prototypic PJMs also demonstrated there were no overblows in over 9,000 PJM cycles, The PJMs operated predictably without an inadvertent overblow event, providing confidence in the reliability of the controls and predictability of the PJM operation.

The scope and schedule for the integrated large-scale testing is currently being developed. The test objectives and schedule are projected to be established at the end of calendar year 2010.

Phase 3: The design change process has been started based on the recommended design changes identified during the closure of Phase 1 (M3, Inadequate PJM Mixing). The vessel assessments and design studies (based on test results and data analysis) identified the following modifications:

- Adding additional PJMs to 3 vessels (HLP-VSL-00022 and UFP-VSL-00001A/B);

- Increasing PJM jet velocity for 5 vessels (FEP-VSL-00017A/B and FRP-00002B/C/D);

- Changing the PJM nozzle angle for 9 vessels (HLP-VSL-00022, UFP-VSL-00001A/B, FEP-VSL-00017A/B and FRP-00002B/C/D);

- Lowering the suction line to 3" off the vessel bottom for 9 vessels (FEP-VSL-00017A/B, UFP-00001A/B, HLP-VSL-00027A/B, HLP-VSL-00028, and UFP-VSL-00002A/B);

- Adding vessel inspection and heel removal capability with enhanced transfer capacity for 10 high-solids vessels (HLP-VSL-00022, FEP-VSL-00017A/B, UFP-00001A/B, HLP-VSL-00027A/B, HLP-VSL-00028, and UFP-VSL-00002A/B);

- Adjusting vessel operating limits to assure adequate mixing in 3 vessels (HLP-VSL-00022 and FEP-VSL-00017A/B), and

- Performing a decant of Low Activity Waste (LAW) feed in the Tank Farms and dedicating a transfer line for LAW feeds to minimize the potential for High Level Waste solids to enter LAW receipt vessels (FRP-VSL-00002A/B/C/D).

Conclusion

Both DOE and BNI have high confidence that the PJM Mixed Vessel design approach will yield a final design for WTP that not only complies with DOE safety policies but will also ensure the operational reliability necessary for efficient achievement of the critical waste stabilization mission of the facility. This confidence is collectively based on the program of testing and analysis performed, the identification of design limitations, risks, and uncertainties currently being addressed, and the independent oversight of the program.

Technical Issue

Recent project changes resulted in changes to the functional classification of safety-related systems, structures, and components (SSCs) in the Pretreatment (PTF) and High-Level Waste (HLW) Facilities of the Waste Treatment Plant (WTP). Key changes driving the reclassification included reduced material at risk (MAR), improved modeling of hydrogen generation in mixed vessels, and new criteria for hydrogen in piping and ancillary vessels (HPAV). The reclassification focused attention on both the functional classification criteria and the details of the accident analyses used by the Project to determine the functional classification of controls. The concern is to ensure that the Project appropriately identities SSCs required to perform a safety-related function, and procures and constructs SSCs with a safety-related function to the appropriate requirements and standards, ensuring that the final Documented Safety Analysis (DSA) will support startup and operation of the facilities. The current focus is on PTF, but the methodology is applicable to the HLW and Low-Activity Waste (LAW) facilities as well.

Design/Safety Objective

The WTP design will facilitate safe operations to protect public and worker health and safety, and protect the environment in accordance with DOE requirements. The design must also support timely treatment of radioactive waste currently stored in aging, underground storage tanks.

The analytical methods and the criteria applied for control selection and functional classification of WTP safety-related structures, systems, and components must comply with the set of nuclear safety requirements that provide the framework for DOE and its contractors to design nuclear facilities.

A key aspect of this process is the identification of SSCs that are relied upon to either prevent the occurrence of an accident or mitigate the consequences of an accident that could produce above guideline consequences to the public (safety-class SSCs) or significant radiological doses to workers (safety-significant SSCs).

Design/Safety Approach

The approach adopted by the Project to achieve the above objectives includes:

1. Adoption of functional classification and control selection criteria consistent with DOE-STD-3009, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis*, a safe-harbor methodology for compliance with 10 CFR 830. The criteria recognize that the Project predates DOE-STD-1189, *Integration Of Safety Into The Design Process*, and draws upon emerging practice across the DOE Complex while retaining historical conservatism where deemed appropriate (e.g., requiring consideration of collocated worker controls for predicted doses between 25 and 100 rem). Appropriate defense-in-depth is required.

2. Adoption of analytical methods based on applicable DOE guidance, including DOE-STD-3009 and DOE-HDBK-3010, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*. Providing justification when alternate methods are used.

3. Evaluation of comments on the chosen methodology, both to refine methods where appropriate and to address uncertainty pending resolution. When uncertainties are identified that must be resolved for the DSA, sensitivity studies are performed to ensure that the chosen control set would be adequate over the range of uncertainty. Key examples include:

    a. Deposition velocity – DOE guidance for the use of the DOE MELCOR Accident Consequences Code System (MACCS2) atmospheric dispersion model specifies a value for deposition velocity equal to 1.0 cm/sec. The Department's Chief of Nuclear Safety (CNS) evaluated this usage, found it to be acceptable, and documented in its use in the CNS Technical Paper, *Dry-Deposition Velocity Assumptions Used in Consequence Modeling at the Hanford Waste Treatment Plant.* Subsequently, the Board challenged the usage of a deposition velocity value of 1.0 cm/sec for the WTP, with its staff believing that a value between 0-0.3 cm/sec could be technically justified. (DNFSB letter to Under Secretary of Energy and Chief Health, Safety and Security Officer of May 21, 2010).

       The CNS re-evaluated its technical position in light of the Board's comments, researched the issue further, and still believes that the usage of a default deposition velocity of 1.0 cm/sec for the MACCS2 codes is technically defensible for reasonably conservative results in the case of unfiltered releases, given the level of uncertainty in the Gaussian Plume model used in MACCS2 analysis. CNS is revising its previous Technical Paper to incorporate additional information found in various U.S. Nuclear Regulatory Commission (NRC) publications and other technical studies. The CNS Technical Paper will be peer-reviewed by a nationally-recognized expert in radiological risk assessment and environmental analysis who is suitably qualified to peer-review the paper.

       Finally, it should be noted that sensitivity studies for the WTP indicate that equipment safety classification will not vary whether a deposition velocity of 0.1 cm/sec or 1.0 cm/sec is used in the calculation.

    b. Spray leak consequences – in response to comments and an expert conclusion that the DOE-HDBK-3010 model was based on glovebox conditions and not valid for WTP application, the Project has developed and documented a new spray leak model based on a review of literature correlations for validity based on available data for the relevant phenomenology. A broad range of residual uncertainty has been evaluated to test the adequacy of chosen controls.

    c. Material deposition in vessel headspaces – the Project agrees that the potential for accumulation of material deposited in vessel headspaces is difficult to quantify and has assumed sufficient material to be deposited and involved in a postulated unmitigated hydrogen explosion to cause the public evaluation guideline to be exceeded. This conservative assumption ensures that key safety-class systems to both prevent and mitigate explosions are identified for the PTF.

4. The Project has imposed requirements more stringent that those required for safety and non-safety SSCs at WTP where deemed appropriate for mission reliability. For example, all piping in black cells and hard-to-reach areas is being designed to the highest seismic requirements (SC-I).

All welds in black cells and hard-to-reach areas, as well as for HPAV affected piping in the hot cell require 100% volumetric inspection. These requirements afford added design margin.

5. With respect to seismic design, WTP has chosen the C5 boundary, an SC-I (PC-3) control, that ensures worker safety for sprays or spills initiated by a seismic event that can result in unmitigated calculated doses above 100 rem to the collocated worker. Such releases are postulated to occur in the PTF hot cell or black cells. These areas are inaccessible to workers. Releases of radioactive material in the PTF black cell and hot cells are confined within the C5 boundary. The components that make up this boundary include cell structures, ventilation fans, ducting, and filters, which are designated safety-class (SC-1). Additional protection (defense in depth) relative to detecting or confining leaks and spills is provided by the primary vessel and piping boundaries, seismic shutdown system, pump suction isolation valves, level detection in the vessel, stainless steel cell liner, leak detection system, and planned operating procedures (e.g., monitoring and spill response).

6. The Project recognizes that there are additional functional classification and control decisions that must be made to finalize the confinement design, but have not yet been incorporated into the PDSA. Examples and the actions taken to ensure safety in the interim include:

   a. Designation of portions of the primary waste boundary as a major contributor to defense in depth – the spray leak model update identified this as an appropriate change. All piping downgrades below safety significant are on hold per note 13 in Table 5 of the PDSA Addendum and this hold will not be lifted until a decision on the safety significant portion of the boundary is made.

   b. Designation of the high level waste suction line isolation valves as safety significant, SC-I, to ensure their operability when isolation is required -- the seismic design classification is a design requirement, but its designation as credited for safety has not yet been made in the PDSA.

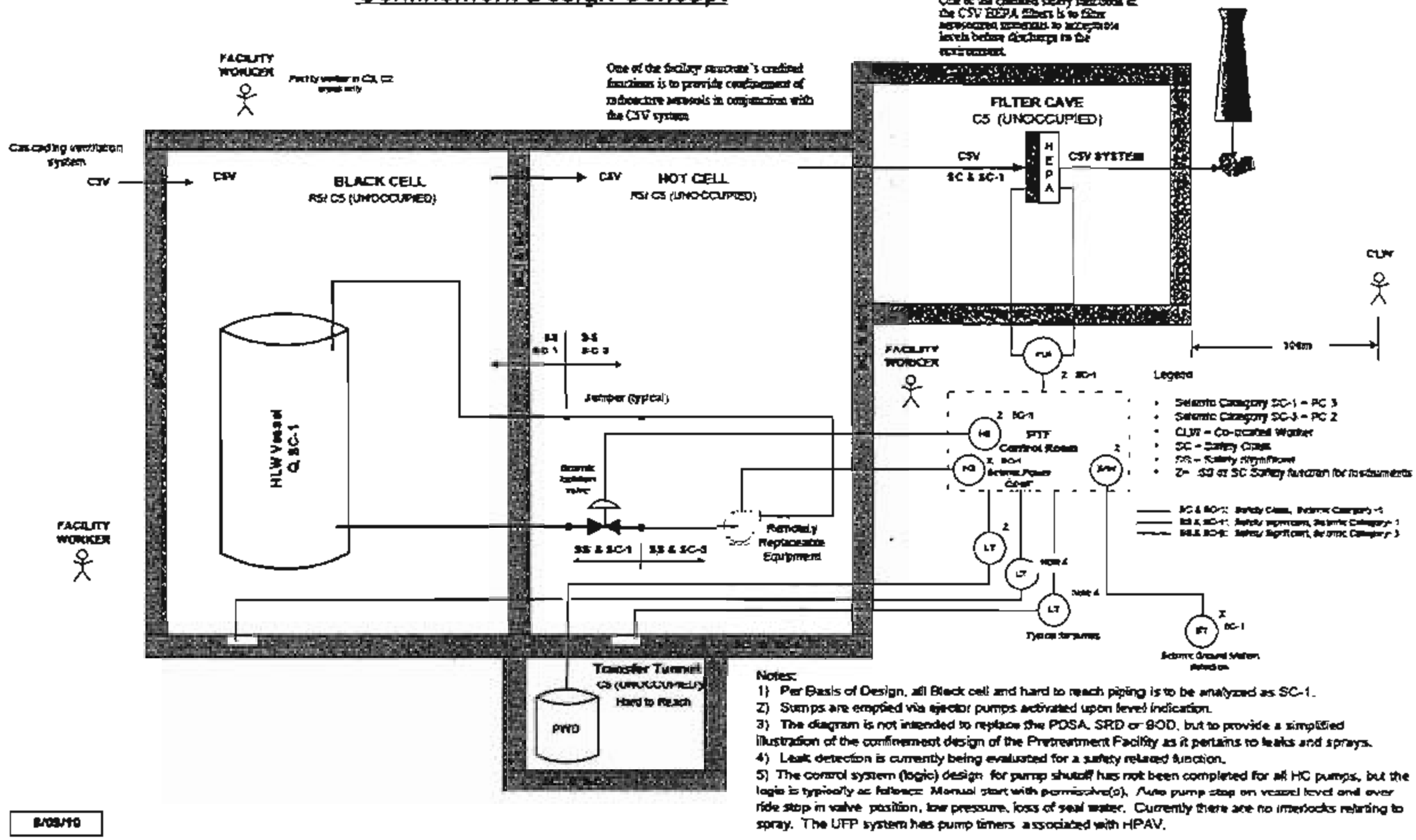
   c. Leak detection to ensure prompt action to stop a spray leak was identified as an option in the spray leak report. The Project is evaluating alternatives for using available engineered features that would support this function and could be added later in the design.

The effectiveness of these requirements is illustrated in the attached figure (see page 4) which depicts the many barriers afforded by the project's control strategy to protect workers outside the hot cell. This figure on page 4 provides a simplified depiction of the PTF confinement boundary.

Conclusion

The WTP is performing functional classification of safety-related SSCs in compliance with applicable DOE policy and guidance. Identified uncertainties are being evaluated in making control selection decisions. Both DOE and BNI have high confidence that the Project is procuring and constructing SSCs with a safety-related function to the appropriate requirements and standards, ensuring that the final Documented Safety Analysis (DSA) will support startup and operation of the WTP facilities as necessary for efficient achievement of their critical waste stabilization mission..

Pretreatment Facility
Confinement Design Concept



Notes:

1) Per Basis of Design, all Black cell and hard to reach piping is to be analyzed as SC-1.
2) Sumps are emptied via ejector pumps activated upon level indication.
3) The diagram is not intended to replace the PDSA, SRD or SOD, but to provide a simplified illustration of the confinement design of the Pretreatment Facility as it pertains to leaks and sprays.
4) Leak detection is currently being evaluated for a safety related function.
5) The control system (logic) design for pump shutoff has not been completed for all HC pumps, but the logic is typically as follows: Manual start with permissive(s). Auto pump stop on vessel level and over ride stop in valve position, low pressure, loss of seal water. Currently there are no interlocks relating to spray. The UFP system has pump timers associated with HPAV.

Technical Issue

Delivery of 55 million gallons of waste, currently stored as sludge, saltcake, and liquids in 177 underground storage tanks, to the Waste Treatment Plant (WTP) for treatment will require extensive facilities, infrastructure, and complex tank farm operations. Currently, much of the tank farm infrastructure is over 40 years old. Safe delivery of waste over the approximate 30 year operating life of the WTP will require modifications to existing facilities and the construction of new facilities to ensure that the Tank Farms waste feed delivery (WFD) systems are ready for WTP commissioning.

Design/Safety Objective

The WFD system design will facilitate timely treatment of radioactive waste currently stored in aging, underground storage tanks while ensuring safe operations to protect public and worker health and safety, and the environment in accordance with U.S. Department of Energy (DOE) requirements.

Design/Safety Approach

The Mission Analysis Report (documented in RPP-RPT-41742), also referred as to the River Protection Project - Mission Analysis Report (RPP-MAR), defines significant programmatic mission challenges (cost, schedule and technical adequacy) and provides a basis for a structured framework to evaluate and understand potential solutions to these challenges. The Tank Farm's hierarchy of documents related to design activities will control the design activities required to implement potential solutions and also facilitates development of appropriate safety-related structures, systems, and components (SSCs).

Title 10 CFR Part 830 requires contractors responsible for a hazard category 1, 2, or 3 DOE nuclear facility to establish and maintain a safety basis for the facility to ensure adequate protection to the public, workers, and the environment from nuclear hazards. Tank Operations Contractor (TOC) procedure TFC-ENG-SB-C-01, *Safety Basis Issuance and Maintenance*, describes the safety basis document development and maintenance process, including amendments to the current safety basis.

It is anticipated that some aspects of the double-shell tank (DST) Upgrades Project will require an amendment to RPP-13033, *Tank Farms Documented Safety Analysis*, to incorporate WFD activities and operations. As each project scope is defined and hazard analysis for that scope is completed to address the DOE-STD-1189-2008, *Integration Of Safety Into The Design Process*, major modification evaluation questions, the determination will be formalized. Once a nuclear safety basis is established, engineering supports maintenance of its integrity through implementation of the System Engineer Program in accordance with DOE O 420.1B, *Facility Safety*.

Inputs to the RPP-MAR include programmatic requirements from DOE, environmental laws, ORP-11242, *River Protection Project System Plan*, (also know as the *System Plan*) as the technical baseline, the waste feed interface control document (ICD-19), the TOC, and the TOC Performance Measurement Baseline (PMB). DOE and regulatory requirements are managed via the TOC and WTP contracts. The Authorization Basis is another key requirements source.

Deficiencies or challenges identified in the RPP-MAR are targeted for technology development, trade studies, and/or flowsheet evaluations. The end result of this planning is the scope definition of the projects necessary to complete the mission. The functions and requirements for each project are flowed down from the RPP-MAR and further developed in plans (e.g., RPP-40149, *Integrated Waste Feed Delivery Plan*) and project specifications.

Issue Background and Technical Status

The mission of the WFD system is to deliver waste feed to the treatment facilities.

- The ORP-11242 (the *System Plan*) establishes the baseline case that is used as the technical basis for the alignment of program costs, scope, and schedule, from upper tier contracts to individual operating plans. Strategic planning is ongoing; therefore, ORP-11242 will be revised periodically to reflect recent progress, current plans, responses to emergent issues, changes in the regulatory environment, and budgeting constraints.

- The *System Plan* also provides input to the RPP-40149, *Integrated Waste Feed Delivery Plan*, which outlines how the retrieved wastes will be staged and transferred to the WTP.

- The WFD functional requirements are listed in Appendix A-2.4 of the RPP-MAR (RPP-RPT-41742).

- Waste characterization activities shall enable certification that the Low Activity Waste (LAW) and High Level Waste (HLW) feed meets ICD-19 (documented in 24590-TP-ICD-MG-01-019).

Over 30 Hazard Category 2, Engineering Procurement, Construction, and Commissioning (EPCC) projects, organized by the Tank Farms operating contractor, are identified to construct and commission the systems required for using the 28 DSTs to deliver feed to the waste treatment facilities. The work scope, execution approach, schedule, and cost estimates for each project are described in RPP-40149. Technology needs are assessed and demonstration work, especially in the area of blending and characterization, are planned. Consistent with the ongoing approach for implementing single-shell tank retrieval projects, these projects have been identified as a series of discrete projects.

HLW feed qualification requires mixer pump operation, sample operation, and the necessary DST infrastructure and safety systems to support these two operations. Specific particle size and density screening and adjustments are currently not planned for HLW feed; all particle size/density related screening will be based on critical velocity measurements.

LAW feed qualification requires a sample system and the necessary DST infrastructure and safety systems to support this operation. LAW feed will be administratively controlled such that solids will have sufficient time to settle in the feed staging tanks prior to delivery to the WTP. LAW feed delivery systems will be configured such that settled solids are not likely to be entrained in the transfer system.

Feed staging will be planned based on staging WTP Waste Acceptance Criteria (WAC)-compliant feed tanks with solids concentrations below the prescribed acceptance limits. Feed certification sampling will confirm WAC compliance (includes critical velocity and rheological properties). If necessary to support feed certification, any final blending or diluting adjustments will be made. Representative samples of the LAW feed and HLW slurry will be collected from the feed staging tank a minimum of 210 days prior to planned feed delivery. The sample will be delivered to the WTP-identified laboratory for certification analysis. Requirements to ensure representative samples are gathered are currently undefined. These requirements will be defined through development of WTP Data Quality Objectives for feed certification.

The ability to adequately mix and sample waste to meet the WTP acceptance requirements is being evaluated and will need to be developed and demonstrated. This is detailed in RPP-PLAN-43988, *WRPS Technology Development Roadmap.* There may be blending and pretreatment processes that could be performed to optimize the feed to WTP but those are improvements and are not required to feed WTP.

Feeds sent to the Waste Receiver Facilities (WRFs) will be waste retrieved from single-shell tanks in B-Complex (B, BX and BY tank farms) and T-Complex (T, TX and TY tank farms). RPP-PLAN-40145, *Single-Shell Tank Waste Retrieval Plan,* describes the use of the WRFs. Single-shell tank saltcake will be dissolved to form supernatant which will then be used in the process to retrieve sludge wastes from the tanks. Periodically, the retrieved wastes will be transferred to the DST system to be staged for transfer to the WTP.

Conclusion

DOE and its contractors have systems in place to ensure that safety-related design activities associated with the Tank Farms waste feed delivery systems will be ready for WTP commissioning. The project's hierarchy of documents related to design activities also facilitates development of appropriate safety-related SSCs.

ENCLOSURE 2

CROSSWALK BETWEEN PRINCIPAL TECHNICAL ISSUES AND TWENTY-THREE SPECIFIC QUESTIONS[1]

Principal Technical Issues

(1) Changes in safety-related design criteria resulting from modifications of the material-at-risk.

Related specific questions – 1

(2) Changes in design strategy to address hydrogen in pipes and ancillary vessels.

Related specific questions – 3, 5, 6, 7, 8, 9, 10, 11, 12

(3) Criticality safety concerns and other safety-related risks for the pulse jet mixing system.

Related specific questions – 13, 14, 15, 16, 17, 18, 19, 20

(4) Reclassification of safety-related systems, structures, and components.

Related specific questions – 2, 3, 4

(5) Safety-related design aspects of new facilities or modifications of existing facilities needed to deliver high-level waste feed

Related specific questions – 16, 21, 22, 23

[1] Several questions cross-walked to multiple principal issues

ENCLOSURE 3

Responses to Defense Nuclear Facilities Safety Board Questions

September 8, 2010

List of Terms

AB	authorization basis
ABAR	authorization basis amendment request
APC	additional protection class
ARF	airborne release fraction
ARR	airborne release rate
ASME	American Society of Mechanical Engineers
BARCT	best available radionuclide control technology
BBR	broad base review
BBI	best basis inventory
BC	black cell
BNI	Bechtel National, Inc.
BOD	basis of design
BODCN	basis of design change notice
BOF	balance of facilities
BR	breathing rate
CCN	correspondence control number
CCPS	Center for Chemical Process Safety
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFD	computational fluid dynamics
CFR	Code of Federal Regulations
CIAR	critical items action report
CLUP	Comprehensive Land Use Plan
CPR	Construction Project Review
CRESP	Consortium for Risk Evaluation and Stakeholder Participation
CSER	Criticality Safety Evaluation Report
CSL	criticality safety limit
CSSG	Criticality Safety Support Group
DBE	design basis event
DCD	design criteria database
DEI	Dominion Engineering, Inc.
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy

List of Terms

DQO	data quality objectives
DSA	documented safety analysis
DST	double shell tank
E&NS	Environmental and Nuclear Safety
Ecology	Washington State Department of Ecology
EFRT	External Flowsheet Review Team
EQ	equipment qualification
FRP	waste feed receipt process system
FW	facility worker
GNNA	Global Nuclear Network Analysis
HC	hazardous condition
HGR	hydrogen generation rate
HPAV IRT	Hydrogen in Pipes and Ancillary Vessels Independent Review Team
HLW	high-level waste
HLP	HLW lag storage and feed blending process system
HPAV	hydrogen in piping and ancillary vessels
hr	hour
HSS	U.S. Department of Energy's Office of Health, Safety, and Security
HTF	Hanford Tank Farm
HTR	hard-to-reach
ICD	Interface Control Document
ICN	integrated control network
ISM	integrated safety management
ITS	important to safety
IX	ion exchange
JCDPI	justification for continued design, procurement, and installation
JRMT	Joint Risk Management Team
LAW	low-activity waste
LCO	limiting condition of operation
LFL	lower flammability limit
LOAM	Low Order Accumulation Model
M3	major issue 3
MAR	material at risk
MCE	Mid-Columbia Engineering

List of Terms

MR	material requisition
MRR	material requisition request
NDE	non-destructive examination
NRC	Nuclear Regulatory Commission
NPS	nominal pipe size
ORP	Office of River Protection
ORT	Operational Review Team
P&ID	piping and instrumentation diagram
PDBE	post design basis event
PDSA	preliminary documented safety analysis
PJM	pulse jet mixer
PMB	performance management baseline
PNNL	Pacific Northwest National Laboratory
PPJ	programmable protection system
PRA	probabilistic risk analysis
PRC-DDT	pressure reflected deflagration-to-detonation transition
PSC	Project Safety Committee
PTF	pretreatment facility
PVP	pretreatment vessel vent process system
Q	quality
QAM	Quality Assurance Manual
QRA	quantitative risk analysis
RCRA	Resource Conservation and Recovery Act
RF	release or respirable fraction
RPP	River Protection Project
SAB	safety authorization basis
SAC	special administrative control
SC	safety class
SC-	seismic category
SD	system description
sec	second
SER	safety evaluation report
SL	severity level
SRD	Safety Requirement Document

List of Terms

SRNL	Savannah River National Laboratory
SS	safety significant
SSC	structure, system, or component
SQP	software qualified procedure
SwRi	Southwest Research Institute
TOC	Tank Operations Contractor
TPOC	technical point of contact
TSG	Technology Steering Group
TSR	technical safety requirement
UD	unit dose
UFP	ultrafiltration process
ULD	unit liter dose
UST	underground storage tank
V&V	verified and validated
WAC	waste acceptance criteria
WDOH	Washington State Department of Health
WFD	waste feed delivery
WMA	waste management area
WPRS	Washington River Protection Solutions
WRF	Waste Retrieval Facility
WSGM	Waste Treatment Plan Site Ground Motion Spectra
WSMS	Washington Safety Management Solutions
WTP	Waste Treatment Plant
ZOI	zone of influence

1. Introduction

This attachment provides the written response to the Defense Nuclear Facility Safety Board Questions (DNFSB). Summary information is provided for select questions to provide additional details to the overall question set or information related to previous requests and interactions.

2. Definitions

This section provides standard definitions used by Waste Treatment Plant (WTP) personnel when responding to questions.

Margin-of-safety For the purpose of this question response package, the margin-of-safety means the difference between the design limit (e.g., code allowable, test limits, acceptance criteria) of a structure, system, or component (SSC) and the failure limit. As the project progresses, the margin-of-safety will evolve to include the basis for unreviewed safety question (USQ) determinations which will be the difference between the operating level (established in the basis of the technical safety requirements) and the level at which the credited SSC can not be assured to provide its intended safety function.

Safety-related Design Criteria means the requirements contained within the 24590-WTP-SRD-ESH-01-001-02, *Safety Requirements Document (SRD), Volume II.* These requirements include the safety criteria themselves which are identified in Sections 1 through 9, the implementing codes and standards identified in the safety criteria and associated tailoring in Appendix C, and the standards identified in Appendices A, B, and D through M of the SRD.

Safety-related Systems means the SSCs identified in the safety basis documentation (e.g., preliminary documented safety analysis [PDSA]), that are credited with providing a safety class (SC) or safety significant (SS) safety function.

Safety-related design risk as used in this question response package refers to the WTP project and/or technical risk associated with the implementation of a design that has not yet been confirmed to be capable of providing its intended safety function. This definition is used in the question response package for use with the following terms: "safety risk," and "safety-related risk."

3. Regulatory Construct

3.1. Current Safety Basis Document

The DNFSB questions include multiple questions related to the safety basis document for WTP facilities. This section identifies the current safety basis for each nuclear facility and discussion of the "in process" change for the Pretreatment facility (PTF).

The current safety basis documents for WTP facilities are identified in the table below:

Facility	Document Number	Title
General Information	24590-WTP-PSAR-ESH-01-002-01, Rev 4m	Preliminary Documented Safety Analysis to Support Construction Authorization; General Information
Balance of Facilities	24590-WTP-PSAR-ESH-01-002-05, Rev 4g	Preliminary Documented Safety Analysis to Support Construction Authorization; Balance of Facility Specific Information
Low Activity Waste	24590-WTP-PSAR-ESH-01-002-03, Rev 4l	Preliminary Documented Safety Analysis to Support Construction Authorization; LAW Facility Specific Information
Laboratory	24590-WTP-PSAR-ESH-01-002-06, Rev 4g	Preliminary Documented Safety Analysis to Support Construction Authorization; Lab Facility Specific Information
High Level Waste	24590-WTP-PSAR-ESH-01-002-04, Rev 4o	Preliminary Documented Safety Analysis to Support Construction Authorization; HLW Facility Specific Information
Pretreatment Facility	24590-WTP-PSAR-ESH-01-002-02, Rev 4m	Preliminary Documented Safety Analysis to Support Construction Authorization; PTF Facility Specific Information

The project initiated a change package for the PTF in July 2009 to update the material-at-risk (MAR) (i.e., radiological inventory for purposes of hazards and accident analyses) to align with the Tank Farm facility and update the design criteria for hydrogen in pipes and ancillary vessels (HPAV). The change package was approved by the U.S. Department of Energy (DOE) in November 2009 with four conditions of approval (COAs). WTP has completed the agreed to changes to close the COAs (e.g., modified the unmitigated consequence analysis, developed the WTP spray leak methodology) and revised the PDSA Addendum, 24590-WTP-PSARA-ENS-09-0001, Revision 2, *Preliminary Documented Safety Analysis – Control Strategy Changes for the PTF Facility* (PTF PDSA Addendum). While WTP was completing the required analyses and revisions, DOE transmitted a letter of direction to update the PTF PDSA Addendum (not yet approved) to eliminate the potential for fragmentation hazards that were postulated to occur as a result of an HPAV event. The directed changes and COA closure required changes will be submitted to DOE for review in September 2010. The response to DNFSB questions for PTF use this interim change package as the basis for the response.

Once DOE approves the revised change package, WTP will implement the change in accordance with established project procedures (i.e., authorization basis maintenance and engineering).

3.2. Path Forward for the Pre-Treatment Facility

In addition to the outstanding change package discussed above, WTP has identified the major technical issues for the PTF (e.g., mixing, design of the process vessel vent exhaust system, HPAV) that must be resolved to support the final design. A plan and schedule have been developed and implemented into project planning. The plan provides for a systematic review of the hazards analysis and update of the PTF design documents (e.g., process flow sheets, piping and instrument diagrams). The systematic evaluation will be used as the safety basis for the remaining design activities for PTF.

4. Responses to Questions

Responses to Question 1 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

Washington River Protection Solutions
Paul Rutland, Mission Analysis & Strategic Planning Manager

Contributing authors:

U.S. Department of Energy - Office of River Protection
Delmar Noyes, Deputy Assistant Manager, Waste Treatment and Immobilization Plant Project

U.S. Department of Energy - Richland Operations Office
Doug Shoop, Deputy Manager for the Richland Operations Office

Hanford Tank Waste Treatment and Immobilization Plant Project
Garth Duncan, Manager of Process Engineering and Technology
Dennis Hayes, Plant Operations Manager
Dan Herting, WTP Chief Process Chemist
George Matis, Commissioning Operations Manager

Washington River Protection Solutions
Chris Burrows, Manager, WTP Support

Question 1

Question 1. *Compare the Department of Energy's (DOE) most recent assessment to previous estimates of the MAR contained in the Hanford tank waste. Provide an introductory explanation of recent DOE activities as they relate to safety of the planned process, the site, future workers and the public.*

Response 1. The most recent assessment of the MAR in the Hanford tank wastes is the DOE approval of the current tank farm documented safety analysis in calendar year 2002. DOE initiated the MAR change to align the WTP with the tank farm to ensure an integrated solution to the retrieval, stabilization, and processing of the Hanford tank wastes.

The specific MAR assumptions were changed to replace the previous analysis that was based on a hypothetical "Super Tank" concept which assumed the simultaneous presence of the worst characteristics in the WTP contract (Specification 7) even though such a waste stream does not exist at the Tank Farms. The changes reflect:

- Additional radioactive waste characterization studies conducted by the Tank Farms and incorporated into the approved Tank Farm safety basis as of 2002;
- Dynamic modeling of waste processing at WTP to bound the changes that occur in the waste characteristics for the range of processing steps at WTP;
- A better understanding of how the tank farm waste will be transferred to the Pretreatment Facility to maximize treatment performance and reduce the overall treatment life cycle; and
- A commitment to provide a specific administrative control for WTP waste receipt to ensure that the assumed waste envelope will not be exceeded.

The changes to the estimated MAR result in changes to the calculated unit liter dose (ULD) values that are used to analyze dose consequences to the workers and the public. The revised MAR is based on the combination of the two worst tank waste fractions at design maximum weight percent solids. The strategy includes a recognition that project controls are in place to ensure that the Tank Farms verifies each feed batch before it is transferred to the WTP.

Prior to initiating this change, DOE chartered a MAR task team in January 2009 to determine the appropriate waste feed characterization assumptions as they relate to the safety analysis design criteria for the WTP. The team evaluated the assumptions and concluded that based on substantive uncertainties in characterization data the project was using overly bounding process inventories as the basis of design (BOD) of the WTP project. The MAR team recommended revised acceptance criteria for waste feed to the WTP and reevaluation of selected assumptions and methods used in the accident analysis for seismic and hydrogen phenomena related events.

Question 1.A *Provide a qualitative assessment of the variety and quantities of high level radioactive waste recipes currently isolated in the Hanford underground tanks, and provide an assessment of the relative challenges involved in stabilizing the various formulations.*

Response 1.A. See the response to question 1.A.1 for a discussion of the variety and quantity of waste types. At Hanford several spent nuclear fuel reprocessing technologies contributed to the waste stored in the tanks. The first of these was the bismuth phosphate process, which used two reprocessing facilities (B plant and T plant). Another process that just separated uranium was the uranium recovery process in the U Plant. To more efficiently separate plutonium and uranium, the reduction and oxidation solvent process was operated for approximately 15 years. An improved solvent extraction process called PUREX was then developed which used a different organic solvent and nitric acid, rather than aluminum nitrate in the liquid phase. Three in-tank processes were subsequently used for separating certain radionuclides. Ferrocyanide was used for this purpose in some tanks and in U Plant. Subsequent processes selectively removed cesium and strontium which were later converted to salts and stored separately onsite in a number of hastelloy material "capsules". The wastes, primarily salts and sludges, are stored in 149 single-shell tanks (SSTs) and most of the liquids, along with salts and sludges are stored in 28 double-shell tanks (DST).

From a MAR perspective, the most challenging waste is the contents of AZ-101 (PUREX) for solids and the complex concentrate waste contained in Tank AN-107 for liquids. There are a few other tanks with radioactive material concentrations that contribute to radiological dose resulting from inhalation, ULD values that are fractions of AZ-101; the rest of the tanks have ULDs at least an order of magnitude less than AZ-101. AZ-101 will be blended with other wastes before it is sent to the WTP. Our current estimate of the performance of the waste treatment mission for different waste types can be found in ORP-11242, Revision 4, *River Protection Project System Plan*. The System Plan addresses some challenges involved with treating various tank wastes. The System Plan addresses the waste based on the best basis inventory (BBI) in which blending of waste types are taken into account. Therefore, the challenges focus on waste constituents such as aluminum, chromium, phosphate, sodium, sulfate and zirconium as opposed to individual waste types.

The waste composition of feed delivered to the WTP will be compatible with WTP design calculations. Most challenges identified are associated with minimizing quantities of HLW and LAW glass that will be produced. This includes uncertainties such as waste composition, liquid-solid phase partitioning during retrieval or pretreatment, the degree of waste blending in DSTs and glass formulations. For example sodium and sulfate are challenges in LAW immobilization and aluminum, sulfate, chromium and zirconium are challenges in HLW immobilization. A few challenges not related to minimizing glass quantities are pretreatment of complexed waste in tanks AN-102 and AN-107 and properly managing waste with high phosphate concentrations to prevent plugging of piping and equipment.

Question 1.A.1 *For the purposes of this explanation, divide these wastes into process types and provide specific estimates as to the challenges and hazards of transporting them from the tank farms to the new waste treatment plant and any distinctions as to processing/stabilization. How has this changed from previous estimates? See also question 22 Waste Characterization in support of Waste Feed Delivery below.*

Response 1.A.1. The variety and quantity of waste types in the Hanford tank farm is documented in the best basis inventory and the tank characterization reports. The Tank Characterization Reports, with embedded best basis inventory for all 177 tanks including retrieved tanks, were provided to the DNFSB in the fall of 2009 (response to DNFSB Request #09-34(D), August, 2009). The estimate of the composition of the waste has evolved somewhat over time as new sample data is collected, but DOE and its tank farm contractors have had a reasonable understanding of the waste chemical properties for a long time. The estimate of the waste composition is updated quarterly to account for waste transfers and new sample data. In general, the best basis inventory divides the condensed phases into three phases called "sludge", "saltcake" and "supernatant". These three "phases" are further divided into waste types. RPP-8847, *The Best Basis Inventory Template Compositions of Common Tank Waste Layers* report divides the waste into 48 waste types for supernatants and 41 waste types for solids (saltcake + sludge). In addition, the tank farm contractor manages some wastes that are blends of these waste types in the DST system. The concept of waste type will become less and less relevant over time as waste is retrieved from the single shell tank system into the double shell tanks system and co-mingled with other waste. Most tanks at Hanford have more than one waste type and these waste types are blended together as the waste is retrieved. The variability in the waste types leads to variability in the glass formulations needed to vitrify the waste. To address this variability, glass formulation models have been developed to determine glass formulations used in mission planning analysis. The models indicate that the WTP can produce glass which meets contract technical requirements from all of the waste in the tank farm (ORP-11242).

Hazards associated with the transporting of wastes within Tank Farms and to the WTP are identified using the TFC-ENG-DESIGNC-35, Revision E, *Process Hazard Analyses Determination and Techniques Screening* procedure as new process designs are developed. A preliminary process hazard analysis was performed last year for the waste feed delivery (WFD) system and is documented in RPP-RPT-43205, *Preliminary Process Hazards Analysis of the Integrated Waste Feed Delivery Plan*. An update of this process hazard analysis is planned for FY2011.

Question 1.A.2 *Provide current planning estimates on processing (schedule and cost).*

Response 1.A.2 The current DOE tank farm baseline based on System Plan 4 completes the Hanford tank farm mission including waste treatment by 2047 and tank closure in 2050. The associated life cycle cost for this mission is approximately $61.5 billion. Tank Operations Contractor (TOC) is currently preparing System Plan 6 which will reflect advantages of mixing and blending capabilities, modifications to PTF and a more predictable waste feed delivery strategy. This may yield improvements to both life-cycle costs and schedule improvements.

Question 1.B *Based upon the most recent DOE assessment of the reduced material-at-risk what opportunities has DOE been able to capture in the Waste Treatment and Immobilization Plant (WTP) design and schedule? Specifically address modifications to the safety related design criteria.*

Response 1.B. Changes resulting from adjusting the WTP MAR to be consistent with that of the Tank Farms are documented in the PTF PDSA Addendum.

There were no changes to safety-related design criteria as a result of the MAR reduction. The functional classification of select process piping was changed from SC to SS due to the results of the postulated events with radiological consequences in the unmitigated consequence analysis (24590-PTF-Z0C-W14T-00036, Revision. 0B, *Severity Level Calculations for the Pretreatment Facility Based on Updated MAR*). The change in the functional classification would allow the design to consider elimination of redundant trains.

Question 1.C *With respect to emptying the tanks, completing the stabilization, and closing the legacy tank farms-what are the significant unresolved issues that remain unplanned/unfunded (e.g., additional vitrification; supplemental pre-treatment)? See also question 23 Design Status of Waste Feed Delivery system below.*

Response 1.C. The River Protection Project (RPP) includes a number of challenges that need to be addressed to reach the desired performance for the mission. These challenges are summarized along with potential mitigating actions and related details in ORP-11242, Section 7.0, *Key Issues and Uncertainties*. This section is divided topically in alignment with TFC-PLN-39, *WRPS Risk Management Plan*. Each key issue and uncertainty is linked to the associated assumption or assertion, potential mitigating actions, and current status.

Question 1.D *What are DOE's plans with respect to maintaining the site boundary and restricting access in the foreseeable future (e.g., until significant reductions in tank waste have occurred)?*

Response 1.D. The Hanford Site is approximately 586 square miles consisting of three major geographical components: (1) Hanford Reach National Monument, (2) River Corridor, and (3) Central Plateau. The 2015 Vision for the Hanford Site is a safe and effective cleanup that protects the Columbia River and includes reducing the active footprint of cleanup to 75 square miles (586 square miles to 75 square miles) as described in DOE/RL-2010-18, *Hanford Site Active Cleanup Footprint Reduction*. The Hanford Reach National Monument is protected by Presidential proclamation in 2000 and encompasses 290 square miles around the Hanford Site. The National Monument cleanup component is planned for completion in fiscal year 2011. The River Corridor component consists of approximately 220 square miles and is planned for clean up completion in fiscal year 2015. The Central Plateau component is approximately 75 square miles consisting of an outer area of 65 square miles and an inner area of 10 square miles. The outer area is planned for clean up completion in the 2015 to 2020 time period. The final 10 square miles, inner area, will be a long term waste management unit. The reduction of the footprint of active cleanup does not mean DOE intends to physically reduce the site boundaries or excess the land. However, it may result in making some areas available for DOE's reuse consistent with the existing *Hanford Comprehensive Land Plan Environmental Impact Statement* (HCP-EIS) and Record of Decision (ROD) (64 FR 61615), which established the *Comprehensive Land Use Plan* (CLUP). In the future, DOE may lease land for Energy Parks analogous to the lease currently in place with Energy Northwest to operate the commercial nuclear reactor on the Hanford Site. Consistent with the CLUP, any land lease for the purpose of establishing energy parks would be in the designated "industrial area" south of the Wye Barricade. As indicated in the DOE/RL-2010-18, *Hanford Site Active Cleanup Footprint Reduction* document and consistent with Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) ROD documents being developed, the Hanford Site will remain under Federal management and control for the foreseeable future and there are currently no plans to change the Hanford site boundaries or access.

Question 1.E *Describe the basis of current knowledge of Hanford tank waste, and where applicable, how and why confidence has increased in DOE's understanding of waste chemistry and process knowledge.*

Response 1.E. The basis of the knowledge and our understanding of tank waste radiological and chemical composition is documented in the *Best-Basis Inventory Template Compositions of Common Tank Waste Layers* report (See answer to Question 1.A.1). The change in the MAR was viewed as an opportunity to align the safety basis documents for the tank farm contractor and WTP while using the technical information available. The alignment with Tank Farms will facilitate an integrated authorization basis (AB) used at WTP facilities and was designed to be consistent with the MAR authorized and analyzed at the Tank Farms.

Question 1.F *What is the status of developing the cold (i.e., with simulants, no radioactive waste) testing plan and when is it expected to be fundamentally complete? How long does DOE expect to operate the WTP in a cold test mode before beginning to process tank waste?*

Response 1.F. The status of the cold commissioning plan is draft. A project approved draft is available (24590-WTP-PL-OP-05-0002, Revision 0B, *WTP Commissioning Plan Part B*) and was last updated to support closure of 24590-WTP-PL-ENG-06-0021, *Issue Response Plan for Implementation of External Flowsheet Review Team (EFRT) Recommendations - M9, Lack of Comprehensive Feed Testing in Commissioning.* Under the current project baseline, the WTP is scheduled to operate in a cold test mode from November 2016 - December 2017. The Commissioning Plan (24590-WTP-PL-OP-05-0002), WTP Contract Deliverable 5.1 (Table C.5-1.1, WTP Contract) is due 12 months prior to the start of cold commissioning. To bridge the gap between today and the issuance of the Commissioning Plan, the project has agreed to and accepted a May 2010 Construction Project Review (CPR) action item, CPR3-6, to produce a WTP commissioning strategy document.

Question 2. Waste Treatment and Immobilization Plant Safety Design Strategy

Responses to Question 2 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

Hanford Tank Waste Treatment and Immobilization Plant Project
Donna Busche, Environmental & Nuclear Safety Manager

Contributing authors:

Hanford Tank Waste Treatment and Immobilization Plant Project
Todd Allen, Safety Implementation Manager
Mike Delamare, Systems Engineering Manager
Ken Gibson, Safety Documents Lead
George Matis, Commissioning Operations Manager
Tom Patterson, Manager of Engineering
Dave Pisarcik, Engineering Design Support Manager

2.A Safety-related Design Criteria

The SRD provides formal documentation of the safety requirements and standards resulting from the WTP Project safety standards and requirements identification process. Structures, systems, and components (SSCs) that serve to provide reasonable assurance that the WTP facility can be operated without undue risk are classified as safety SSCs. Implementing codes and standards in the SRD are specified for SSCs in SC and SS applications.

In addition, the consensus codes and standards in the SRD used in the design of SSCs are linked to SRD Safety Criteria. This link is implemented through the Integrated Safety Management (ISM) process that is defined in the SRD Appendix A. These links are controlled to ensure that configuration management of the linkage to the SRD is maintained at all times.

A key feature of the SRD maintenance process is the ability to effect changes to the SRD (when such a change is appropriate). SRD changes may arise as a result of design evolution or may be identified through the hazard evaluation process. Changes of the first type occur when a proposed design position offers benefits (cost, safety, reliability) but is not in compliance with the SRD as written. Changes of the second type may result from newly identified accidents or off normal conditions. In either case, all activities are documented, and no change to the SRD is initiated without a formal review for compliance with the standards and requirements on which the SRD is based.

Question 2.A.1. *Describe the status of the safety-related design criteria (24590-WTP-SRD-ESH-01-001-02, Revision 5t, Safety Requirements Document, Volume II (SRD)).*

Response 2.A.1. 24590-WTP-SRD-ESH-01-001-02, Revision 5t, *Safety Requirements Document, Volume II (SRD)*, has been recently published as Revision 5u. At present, there is only one proposed change currently with DOE for review and approval. This change package was submitted to DOE for approval in letter CCN 216681, *Transmittal for Approval Authorization Basis Amendment Request 24590-WTP-SE-ENS-10-0017, Revision 0, Addition of ISA 67.04.01-2006 to the Safety Requirements Document Volume II.*

Question 2.A.1.a) *Describe each SRD change since October 1, 2008.*

Response 2.A.1.a). The following list identifies the changes made to the SRD since October 1, 2008. Of the eighteen changes listed in this table, eight involved code and standard changes resulting from design evolution, five were updates to bring requirements in line with DOE standards, three were process changes and two were changes in the hydrogen control strategy and acceptance criteria.

Changes to the SRD Since October 1, 2008

Rev	Date	Description
5d	10/16/08	Implementation of the WTP Site Specific Ground Motion Spectra into the SRD for Selective Use Reference: DOE Letter, 08-NSD-052, 24590-WTP-SE-ENS-08-0097, Revision 0 (CCN 187637)
5e	11/21/08	Removal of SDC/SDS/RRC from the SRD Reference: 24590-WTP-SE-ENS-08-0066, Revision 0

Changes to the SRD Since October 1, 2008

Rev	Date	Description
5f	12/30/08	• Removal of RL/REG-97 from the AB Reference: 24590-WTP-SE-ENS-08-0159, Revision 0 per DOE Letter 08-NSD-077 (CCN 191985) • Removal of SDC/SDS/RRC from the SRD Reference: 24590-WTP-SE-ENS-08-0066, Revision 0
5g	2/10/09	• SRD Change to Natural Phenomena Hazards Design Criteria Reference: DOE Letter 09-NSD-003, 24590-WTP-SE-ENS-08-0122, Revision 0 (CCN 193661) • Addition of Specific Administrative Controls into the AB Reference: 24590-WTP-SE-ENS-08-0163, Revision 0 • Removal of SDC/SDS/RRC from the SRD Reference: 24590-WTP-SE-ENS-08-0066, Revision 0
5h	3/12/09	New Safety Classification Process for the WTP Reference: 24590-WTP-SE-ENS-08-0154, Revision 1.
5i	4/10/09	Clarification of Use of AISC MO16-89, Manual for Steel Construction in the SRD Reference: DOE Letter 09-NSD-018, 24590-WTP-SE-ENS-08-0162, Revision 0 (CCN 196733)
5j	5/7/09	• Applicability of 10 CFR 50.49 and IEEE-323 on the WTP Project Reference: DOE Letter 09-NSD-030, 24590-WTP-SE-ENS-09-0013, Revision 0 (CCN 198340) • Removal of the Project Safety Committee (PSC) from the AB Reference: 24590-WTP-SE-ENS-09-0039, Revision 0
5k	8/28/09	Incorporation of DOE O 420.1B into the SRD Reference: DOE Letter 09-NSD-033, 24590-WTP-SE-ENS-08-0060, Revision 0 (CCN 204091)
5l	9/25/09	Clarification of Section VIII Division 1and Division 2 Requirements Reference: DOE Letter 09-NSD-050, 24590-WTP-SE-ENS-09-0023, Revision 0 (CCN 205736)
5m	10/9/09	Revision of the SRD to Tailor the Requirements to Implement Section 14 of DOE-STD-1066-97 Reference: 24590-WTP-SE-ENS-09-0019, Revision 0
5n	11/24/09	• Revisions to Hydrogen Control Strategy Requirements Reference: DOE Letter 09-NSD-044, 24590-WTP-SE-ENS-09-0089, Revision 0 (CCN 208458) • Implementation of Current Terminology of 10 CFR 835 into the SRD and PDSAs Reference: 24590-WTP-SE-ENS-09-0100, Revision 0
5o	1/20/10	Clarification of the SRD Introduction Reference: 24590-WTP-SE-ENS-10-0001, Revision 0
5p	2/24/10	Revisions to HPAV Acceptance Criteria Reference: DOE Letter 10-NSD-013, 24590-WTP-SE-ENS-09-0120, Revision 0 (CCN 214109)
5q	3/4/10	SRD Appendix H Cleanup Reference: DOE Letter 10-NSD-008, 24590-WTP-SE-ENS-06-0043, Revision 0 (CCN 214405)
5r	3/25/10	Editorial correction in Appendix C.26 changes "inaccessible" to "closed cell (black cell) and/or hard-to-reach" Reference: DOE Letter 10-NSD-008 (CCN 214405)
5s	4/8/10	Criterion 4.1-3 Interaction Requirements (Two over One Protection) Reference: DOE Letter 10-NSD-019, 24590-WTP-SE-ENS-09-0074, Revision 0 (CCN 216310)
5t	6/23/10	Clarification of Seismic Testing Requirements in SRD, Appendix C.2 Reference: DOE Letter 10-NSD-044, 24590-WTP-SE-ENS-10-0023, Revision 0 (CCN 220309)
5u	8/19/09	• AB Changes Regarding Safe State to Support the Elimination of DOE/RL-96-0006 from the WTP Contract Reference: DOE Letter 10-NSD-052, 24590-WTP-SE-ENS-09-0063, Revision 0 (CCN 222602) • Removal of DOE/RL-96-0003, DOE/RL-96-0004, DOE/RL-96-0005, and DOE/RL-96-0006 from the AB Reference: 24590-WTP-SE-ENS-09-0069, Revision 0 • Emergency Diesel Generators Reference: DOE Letter 10-NSD-043, 24590-WTP-SE-ENS-09-0084, Revision 0 (CCN 223544)

Question 2.A.1.a)(1) *Which SRD changes were needed to address major changes in the design (pulse jet mixing, control of hydrogen, changes to the process flowsheet to address solids precipitation, etc.)?*

Response 2.A.1.a)(1). There were two changes to the SRD since October 1, 2008 that were made to provide the safety design requirements for control of hydrogen as follows:

- SRD Revision 5n per 24590-WTP-SE-ENS-09-0089, *Revisions to Hydrogen Control Strategy Requirements;* and
- SRD Revision 5p per 24590-WTP-SE-ENS-09-0120, *Revisions to HPAV Acceptance Criteria.*

The purpose of authorization basis amendment request (ABAR) 24590-WTP-SE-ENS-09-0089 was to revise the SRD to align the requirements pertaining to control of hydrogen in piping and ancillary vessels (HPAV). These requirements, as they were documented in the SRD, were developed in the absence of the detailed analysis and testing needed to fully understand the behavior of facility SSCs that may be subject to HPAV events. In the absence of detailed analysis and testing the resulting control requirements were necessarily conservative. Analysis and testing conducted since the initial criteria were developed and documented in the SRD demonstrates that the original control strategies which had primarily active controls might be able to be replaced with passive controls.

The purpose of ABAR 24590-WTP-SE-ENS-09-0120 was to revise the criteria for hazardous conditions in facility piping and ancillary vessels to account for the results of testing and analysis that have been accomplished in the last three years.

Question 2.A.1.a)(2) *What was the technical basis for each change identified in (1) above?*

Response 2.A.1.a)(2). The technical basis for each change was documented in the safety evaluation that was completed for each change.

24590-WTP-SE-ENS-09-0089 - Analysis and testing resulted in a better understanding of the correct application of code requirements to HPAV events. DDT-PRC events are in most cases not possible for piping configurations typical to the WTP facilities (SwRI Project 18-14165, *HPAV Gaseous Deflagration, Detonation, and Deflagration to Detonation (DDT) Test Program* and C-6916-00-04, *Idealized PRC-DDT Pulse Shape Validation*), and show that failure modes for piping and ancillary vessels under HPAV loads do not include fragmentation (*Journal of Pressure Vessel Technology, Comparison of Fracture Response of Preflawed Tubes under Internal Static and Detonation Pressure Loading* and GNNA-09-004, *Fragment Generation from Hypothetical Gaseous Detonation Induced Explosive Rupture of HPAV Piping and Components*).

24590-WTP-SE-ENS-09-0120 - The criteria for identifying hazardous conditions in facility piping and ancillary vessels were revised to account for the results of testing and analysis that has been accomplished in the last three years and documented in WTP report 24590-WTP-RPT-ENG-07-011, *HPAV Analysis and Design Criteria.*

Question 2.A.1.a)(3) *What impact did each change identified in (1) above have on the Pretreatment Facility (PTF) margin-of-safety?*

Response 2.A.1.a)(3). The change in the HPAV acceptance criteria allows an increase in the acceptable level of deformation from events in hot cell piping. The revised criteria and methodology introduce higher load limits (limited localized strain) for piping in the PTF hot cell that preclude failure with reduced margin recognizing that piping could be repaired, if necessary. There was no change in the acceptance criteria, and no decrease in margin-of-safety, for black cell (BC) and HTR piping. See response to Question 5.E for additional detail.

Question 2.A.1.b) Why was each change necessary given the advanced state of the PTF design?

Response 2.A.1.b) In early stages of the facility design, it was apparent that sufficient data was not available to support a passive control strategy for HPAV. In order to advance the design active controls were developed. In parallel, an extensive program of analysis and testing was initiated to gather sufficient data to support an increased use of a passive control strategy. As the results of the testing and analysis program became available, it was determined that a passive control strategy could now be implemented into select portions of the design, even at the advanced state of the PTF design. SRD changes were generated to support future implementation of the passive control strategy.

Question 2.A.1.c) *What SRD changes are anticipated prior to startup (e.g., remaining unresolved safety issues)?*

Response 2.A.1.c) The SRD will be modified, as necessary, to address the findings in the recent report, 24590-CM-HC4-W000-00182-01-00001, *Hydrogen in Piping and Ancillary Vessels in the Pretreatment Facility of the Hanford Waste Treatment Plant.* At this time, there are no other anticipated or planned changes to the high-level safety design criteria defined in the SRD Safety Criteria in Sections 1.0 through 9.0; however, based on past Project history it can reasonably be expected that the implementing codes and standards documented in the SRD will undergo some level of modification to maintain required consistency with the design and selected control strategies. Currently, there are three proposed or anticipated changes to the SRD related to implementing codes and standards or clarification of methods. ABAR 24590-WTP-SE-ENS-10-0017, *Addition of ANSI/ISA 67.04.01-2006* to the SRD is at DOE pending approval. Additionally, ABARs 24590-WTP-SE-ENS-09-0126, *Combustible Loading Program*, and ABAR 24590-WTP-SE-ENS-10-0016, *Update API Standard 610 to the Latest Revision* and add ASME/ANSI B73.1 and B73.2 as Applicable Pump Standards, are currently under development and are expected to be formally transmitted to DOE for review and approval. These and future changes to the SRD that arise prior to start-up will be processed in accordance with established project procedures and approved by the appropriate authority prior to implementation and use.

Question 2.A.1.c)(1) *What is the technical basis for each anticipated change?*

Response 2.A.1.c)(1) For each proposed change to the SRD, a technical basis is developed and provided to DOE for their consideration during their review and approval of the proposed change to the SRD. DOE's approval of the change to the SRD via a safety evaluation report (SER) documents and affirms the adequacy of the technical basis for the proposed SRD change. This same process will be followed for any changes between now and start-up.

The technical basis for potential changes from the HPAV Independent Review Team (IRT) response plan will be developed when the complete change package is created. The technical basis for the remaining proposed changes are summarized below.

(ABAR) 24590-WTP-SE-ENS-10-0017 - The SRD does not provide a standard to develop the WTP for safety instrument setpoints. The addition of ANSI/ISA 67.04.01-2006 to the SRD was selected to provide a consistent methodology to develop WTP safety instrument setpoints.

(ABAR) 24590-WTP-SE-ENS-09-0126 - Calculation 24590-WTP-U1C-FPW-00005, *Combustible Loading Program*. Calculation 24590-WTP-U1C-FPW-00005 evaluated the largest identified fuel packages in each fire area for their potential thermal impact on the overall fire area. Each identified fuel package was analyzed to estimate a peak heat release rate associated with uncontrolled burning as a primary fuel package. The resultant peak upper layer temperatures were compared against a threshold of 300°C (upper layer temperatures in excess of 300°C are considered a high risk for flame spread and thermal damage to equipment based on ignition temperatures for various fuels [Society of Fire Protection Engineers (SFPE) Handbook of Fire Protection Engineering, Table 2-12.2, pg. 2-251]) and 500°C (upper layer temperatures in excess of 500°C are considered a high risk for structural damage [SFPE Handbook of Fire Protection Engineering]). The methodology presented in calculation 24590-WTP-U1C-FPW-00005 is an industry accepted practice and has been previously applied at DOE facilities and the WTP by industry experts, Hughes and Associates.

(ABAR) 24590-WTP-SE-ENS-10-0016 - 1) As pumps are manufactured to only the current and valid industry standards, it is increasingly difficult to procure pumps to the older version of the standard; therefore, it is proposed to replace the tailored 1995 version of API Standard 610 currently reflected in the SRD with the corresponding/applicable tailored 2004 version. 2) Addition of ASME/ANSI B73.1-2001 and ASME/ANSI B73.2-2003 as acceptable standards for pump confinement will allow for the procurement of standard industrial pumps for pump applications/areas that are expected to be changed out on dose limits rather than design life. To minimize high radiation exposure to plant personnel, when these pumps can no longer be operated due to a drop in efficiency or performance, they will be replaced with new pumps rather than maintained to replace worn out internal components.

Question 2.A.1.c)(2) *What impact will each anticipated change have on the PTF margin-of-safety?*

Response 2.A.1.c)(2) The additions of ANSI/ISA 67.04.01-2006 responded to a need for a consensus standard to address the definition of safety set points. The addition of the standard establishes the margin-of-safety for this activity.

The update to the latest version of API Standard 620 and addition ASME/ANSI B73.1 and B73.2 as Applicable Pump Standards will align the project with current industry practice and provides an appropriate margin-of-safety. The margin-of-safety provided by ASME/ANSI B73.1 and B73.2 may be lower than the margin-of-safety provided by API Standard 620, but is appropriate for pumps that will be replaced periodically.

The change to the combustible loading program was a change in the methodology used to assess fire temperatures. It did not change the acceptance criteria and therefore did not reduce the margin-of-safety.

Question 2.A.1.c)(3) *Describe the expected benefit of each anticipated change.*

Response 2.A.1.c)(3) The expected benefit for each anticipated change is provided below.

The expected benefit from resolution of the HPAV IRT findings (and resultant change to the SRD) is implementation of the HPAV design criteria into the design.

(ABAR) 24590-WTP-SE-ENS-10-0017 - The expected benefit is that the WTP for safety instrument setpoints will be developed consistently for each facility and in agreement with a national standard.

(ABAR) 24590-WTP-SE-ENS-09-0126 - The expected benefit is that many of the high radiation or high ambient temperature areas will not have a fire that challenges the boundaries or require the installation of suppression systems.

(ABAR) 24590-WTP-SE-ENS-10-0016 - The expected benefit of this change is a reduced radiation exposure to plant personnel by replacing pumps rather than maintaining the pumps and a reduced cost in procuring pumps designed to B73.1 and B73.2 rather than API 610.

2.A.2 Beginning in late 2008, DOE approved changes to the safety-classification methodology applied to the WTP design.

Question 2.A.2.a) *What changes were made and how did they affect the margin-of-safety?*

Response 2.A.2.a) The changes in classification methodology allow for the possibility of DOE accepting SS controls for events with consequences between 5 rem and 25 rem to the public and provide for the possibility of DOE accepting no safety controls for events with consequences between 25 rem and 100 rem to the collocated worker. Changes to the functional classification on this basis would require justification by the contractor and approval by DOE. This change in the classification methodology did not change the functional classification of any SSCs and future changes will require DOE approval. There has been no change in the margin-of-safety as a result of the changes in functional classification methodology.

Question 2.A.2.b) *Describe the intent of each change.*

Response 2.A.2.b) The new safety classification methodology was intended to better align the WTP methodology with DOE-STD-3009-94 and was a directed change from DOE documented in Letter 08-NSD-057, *Contract No. DE-AC27-07RV14136 - Direction to Implement New Safety Classification Process for the Waste Treatment and Immobilization Plant (WTP).*

Question 2.A.2.c) *Describe the technical basis for each change.*

Response 2.A.2.c) The revised safety classification types reflect the scheme documented in DOE-STD-3009-94.

Question 2.A.2.d) *Describe the consideration given to changes in DOE policy regarding the application of evaluation guidelines for the safety classification of components established in DOE Order 420.1B, Facility Safety, when modifying the safety classification system for protection of the collocated worker.*

Response 2.A.2.d) Final changes were made in the safety classification system for the protection of the collocated worker in conjunction with the PTF PDSA Addendum approved in the DOE SER (09-NSD-044, *Conditional Approval of Pretreatment Authorization Basis Control Strategy Change Package).* These changes aligned the WTP design and control selection process with established DOE requirements, completing the transition from the contemplated regulation by the Nuclear Regulatory Commission.

The change is compliant with DOE Order 420.1B, *Facility Safety,* including the defense in depth requirements and the need to identify major contributors to defense in depth as SS, governed by technical safety requirements (TSR). DOE's policy for WTP does not include Change 1 to DOE O 420.1B.

Specific criteria for selecting collocated worker protection controls included the 100 rem threshold that had emerged as the complex-wide practice, but also continued to require consideration of SS controls below this level (in the range 25-100 rem). In conjunction with the change from computer codes GXQ to MACCS2 for public dose analyses using the DOE guidance, a constant atmospheric dispersion coefficient χ/Q value of 3.5E-3 s/m^3 was directed for implementation in WTP analyses. This value is derived from NUREG-1140, *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees*, and is appropriate for large buildings like the WTP facilities. The decision not to apply the 100 rem criterion as a bright line for WTP is seen to make this choice even more appropriate, ensuring collocated worker protection in accordance with DOE policy.

Question 2.A.2.e) *Describe how unmitigated dose consequences to the collocated worker were calculated and evaluated.*

Response 2.A.2.e) The unmitigated consequences to collocated workers were calculated using methodology in DOE-HDBK-3010, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities.* The dose to the collocated worker is express as follows:

Dose = MAR x ARF(or ARR x t) x RF x χ/Q x BR x UD

where,

MAR	is the material-at-risk
ARF	is the airborne release fraction
ARR	is the airborne release rate
t	is the release duration (<= 8 hr consistent with DOE-STD-3009, Appendix A)
RF	is the fraction of the airborne release that is respirable
χ/Q	is the 95% atmospheric dispersion coefficient for a receptor at 100 meters
BR	is the breathing rate = 3.33E-4 m^3/sec
UD	is a unit dose factor consistent with the MAR.

Unmitigated consequences to the collocated worker are documented in severity level (SL) calculations, which provide input to the hazard analysis process and the basis for Section 3.4, *Accident Analysis,* of the WTP PDSAs. The unmitigated consequences in the severity level calculations are generic and may require adjustment to reflect specific accident scenarios. For example, spill consequences may need to be adjusted for the spill height assumed in a specific accident scenario; the consequences of an overblow event may need to be adjusted to reflect the number of devices involved in a specific scenario. The design basis events (DBE) calculations documented the evaluations of postulated accident sequences and consider mitigated consequences as well as unmitigated consequences. The DBE calculations are summarized and referenced in Section 3.4, *Accident Analysis,* of the facility PDSA. The unmitigated consequences reported in the design basis event calculations may be from the SL calculation or may be developed independently.

The PDSA submittals from 2003 through 2008 reported unmitigated consequences based on radiological inventories derived from the contract feed specifications, atmospheric dispersion coefficients that considered no depletion due to particle settling or building wake effects, and airborne release fractions and respirable fractions that were generally consistent with the recommendations of DOE-HDBK-3010. Calculation 24590-PTF-Z0C-W14T-00002, Revision. 0F, *Revised Severity Level Calculations for the Pretreatment Facility,* evaluated unmitigated consequences used in those submittals.

In early 2009, DOE made a decision to revise the radiological basis for the WTP safety analysis to align it with the basis used in the tank farm safety basis. DOE also directed that an atmospheric dispersion factor of 3.5×10^{-3} sec/m^3 be used to calculate collocated worker doses. 24590-PTF-Z0C-W14T-00036, Revision. 0A, *Severity Level Calculations for the Pretreatment Facility Based on Updated MAR,* calculated collocated worker consequences using the release fraction and respirable fraction values that were used in 24590-PTF-Z0C-W14T-00002 but incorporating the following changes:

- The unit dose factors and stream densities were changed to reflect the results documented in calculation 24590-WTP-Z0C-W14T-00020, *Design Basis Event Pretreatment Facility Drop of Radioactive Materials*;
- The χ/Q at the location of the collocated worker was changed to 3.5E-3 sec/m^3 as directed by DOE. This value is derived from NUREG-1140 for large structures (similar to WTP facilities); and
- Hydrogen consequences were evaluated on the basis of the amount of hydrogen generated in 1,000 hours rather than a stoichiometric hydrogen-air mixture in 50% of the vessel volume. This change was made for consistency with the time frames in SRD Appendix B, Section 2.1.3.

The DNFSB staff and DOE reviewers raised a number of issues related to the release fractions and models used in 24590-PTF-Z0C-W14T-00036, Revision. 0A, *Severity Level Calculations for the Pretreatment Facility Based on Updated MAR*. 24590-PTF-Z0C-W14T-00036, Revision 0B, incorporates changes responding to DNFSB staff and ORP comments. Specifically,

- The consequences of vessel headspace explosions in large vessels with significant solids content are evaluated to be > 25 rem to the public.
- The entrainment coefficients for boiling and steam/air overblow events are increased by a factor of 2 and a factor of 10, respectively.
- Spills are modeled to reflect bounding spill heights rather than a generic 3 meter spill height.
- The spray event airborne release are analyzed using the methodology described in 24590-WTP-RPT-ENS-10-001, *Methodology for Spray Leak Scenarios* (refer to the response to 4.A.2.).

Question 2.A.2.f) *What impact will each change to the safety classification system have on PTF safety-related systems, structures, and components (SSCs)? Describe which SSCs were affected by the changes in classification system including the impact on component quality level and safety-related design criteria.*

Response 2.A.2.f) At the time the change was implemented, a review of SC and SS SSCs was made and it was concluded that there would be no changes in classification due solely to the new safety classification system. There was no impact on the component quality levels. This review was documented in CCN 187620, *Impact of New Classification Scheme*. The changes in the safety classification system from DOE letter 08-NSD-057, *Direction to Implement New Safety Classification Process for the Waste Treatment and Immobilization Plant (WTP)* have been implemented at the WTP.

Question 2.A.3 *Describe the status of the Basis of Design (24590-WTP-DB-ENG-01-001).*

Response 2.A.3 The BOD identifies design criteria that serve as a design basis for the WTP. It addresses the process that converts waste to glass, environmental regulation, Hanford site characteristics, design requirements by engineering discipline, design codes and standards, and other requirements to be applied to the design. The BOD does not contain all WTP design criteria, but is used in conjunction with documents containing the nuclear safety requirements (such as the SRD), and other design criteria documents (e.g., environmental permits, interface control documents).

Changes to the BOD are processed using Basis of Design Change Notices (BODCN). The change process is controlled by procedure, and requires evaluation of all affected design organizations, the Environmental and Nuclear Safety (E&NS) organization and the DOE. The current version of the BOD is 24590-WTP-DB-ENG-01-001, Revision 1P, *Basis of Design*. There are two approved changes to the BOD that have not been incorporated as follows:

- 24590-WTP-BODCN-ENG-10-0006, *Use of Waste Treatment Project (WTP) Site-Specific Ground Motion (WSGM) for PTF Power Manipulator Cranes and Cable Reels*, dated May 27, 2010; and
- 24590-WTP-BODCN-ENG-09-0027, *Heat Tracing Remote Indication and Facility Network Infrastructure System (FNI) Fiber Optic Cable Laterals*, dated June 25, 2010.

Question 2.A.3.a) *Describe each change to the Basis of Design since October 1, 2008.*

Response 2.A.3.a) The BOD changes are normal and expected while design activities progress. Changes were made to clarify requirements update codes, apply specific seismic standards to selected equipment, address issues of design evolution, and to address specific issues (e.g., HPAV). The BODCNs made since October 1, 2008 are itemized in the table below.

Document Number	Approval Date	Purpose of Change
24590-WTP-BODCN-ENG-08-0008	10/2/08	*Revision of Black Cell and Hard-to-Reach Area NDE Requirements.* Modify Section 16 and 17-*Weld Nondestructive Examination [NDE] Requirements In Black Cell And Hard-To-Reach Areas* Requirements changed to reflect the necessity for Non-active Parts, components and non moving equipment parts in HTR areas to be welded and checked by non-destructive examination per ASME B31.3-1996(all welded construction shall be used for piping and vessels).
24590-WTP-BODCN-ENG-06-0007	10/7/08	SUPERCEDED - *Revise Welding Requirements In Black Cells And Hard-To-Reach Areas.* Modify Section 17 - Weld Nondestructive Examination Requirements in Black cells and Hard- to-Reach areas. Section 17 will be eliminated and BC and hard-to reach area nondestructive examination requirement will be Incorporated in Section 16.

Document Number	Approva l Date	Purpose of Change
24590-WTP-BODCN-ENG-08-0009	11/5/08	*Significant Design Requirements - Interim Approval for Implementation and* The following criteria shall replace the criteria outlined in Section 1.4 of reference 1 Definitions of Significant change of the WTP BOD • Design requirements cited in the Bechtel National, Inc. (BNI) Contract • Design requirements provided by DOE in writing • Environmental permitting requirements from State Law and Regulations, the Dangerous Waste Permit Application, Notices of Construction, Prevention of Significant Deterioration, etc • WTP site characteristics, including climatic, geotechnical, and natural phenomenon data • Allowable process and atmospheric temperatures, pressures, flow rates, for design conditions • Applicable codes and standards, regulations and guidelines • Any requirement that can alter the performance of safety of the WTP • Any requirement that is a result of or can alter a significant facility design change to the AB of the WTP The following BOD Sections are considered in their entirety • Section 4, Site data • Section 5, Safety • Section 7, Control Philosophy • Section 13, Fire protection • Section 14, Environmental • Section 16, Black Cell The following paragraph shall replace Section 1.5, *Interim Approval for Implementation (IAI)*
24590-WTP-BODCN-ENG-07-0016	11/17/08	*Environmental Basis of Design* CCN:184926 Updates references and removes revision numbers so that the reference will not become outdated. Updates the control technology equipment to match the requirements from the environmental permits Incorporates requirements from the permit for vaults (applicable for the Pretreatment facility outdoor process condensate tanks radioactive liquid waste disposal system) and double walled tanks (not currently in the design)
24590-WTP-BODCN-ENG-08-0011	11/17/08	*Allow Selected Vessels and Breakout Pots to Use WSGM.* Change incorporates coordinated references for the use of WSGM. The technical justification shall focus on the remaining design margins that will be provided if WSGM response spectra are used. Document lists the first set of components, some of the process vessels, for which it is beneficial to use WSGM
24590-WTP-BODCN-ENG-09-0001	1/8/09	*Correction to Steel Manual Reference.* Corrected title when referencing AISC M016
24590-WTP-BODCN-ENG-08-0013	3/13/09	*Allow Selected Components to Use WSGM.* Approval to use WSGM on selected components of CNP, FEP, TLP, HLP and UFP systems
24590-WTP-BODCN-ENG-08-0014	3/13/09	*Use of WSGM for PTF Hot Cell Equipment and Ancillary Jumpers/Equipment/Components* . The scope of approval includes all major PTF Hot Cell (room P-0123) equipment, ancillary equipment and components including piping, jumpers, support frames, mounting attachment, inline components, instruments, etc., between and including the hot cell embeds and the hot cell/BC pipe anchor locations (which define the qualification break between the hot cell and BC piping)
24590-WTP-BODCN-ENG-08-0007	5/4/09	*Treatment of Codes and Standards in the BOD* • Remove outdated references • Clarify discussion of the standards identification process and its basis and record documents • make uniform the disciplines presentation of their applicable codes and standards
24590-WTP-BODCN-ENG-09-0007	5/4/09	*Additional Hard-To-Reach Piping Details in Chapter 16.* Clarifies requirements for the outer pipe of dual containment pipe lines located in HTR areas within WTP

Document Number	Approva l Date	Purpose of Change
24590-WTP-BODCN-ENG-08-0012	5/28/09	*Implementation of Requirements from the Prime Contract Revision.* Replace the term "stress corrosion cracking" with "caustic stress corrosion cracking" on page 6.6, update maximum transfer rate for HLP-VSL-00027 A/B to 55 gpm in Table 6-2, and update Section 6.11.2 (G2 module run values) with the quantities of HLW waste and LAW waste in the feed vector.
24590-WTP-BODCN-ENG-09-0008.	5/28/09	*Clarify Light Switching Criteria and Common Path of Travel Egress Lighting Fixtures.* Clarifies the switching of lighting loads that will occur on a regular basis to be through the use of local light switches or rated circuit breakers, add IESNA standards, clarifies that Plant operations will determine location of switches, add battery backup.
24590-WTP-BODCN-ENG-09-0006	6/11/09	*Clarification of Description of Melter Cell Embeds in Chapter 6. Codes and Standards In Chapter 10.* Provides clarification to the requirements for Melter cell embeds in Chapter 6 and updates codes and standards in Chapter 10
24590-WTP-BODCN-ENG-09-0010	6/11/09	*Allow The Use of WTP WSGM for Mechanical Systems Equipment and Components .* Some equipment from CNP, CXP, DIW, FEP, HFP, HOP, HLP, NAR, PJV, PSA, PVP, PWD, RDP, PLD, SHR and UFP systems was approved for use of WSGM
24590-WTP-BODCN-ENG-08-0019	7/8/09	*Align BOD With Current WTP Alarm, Security Access And Waste Tracking Philosophy.* BODCN changes the requirement to annunciate Category 1 and Category 2 alarms on the Integrated Control Network operators control panel; they will be annunciated on individual panels within the control rooms (Main Control Room, Standby Control Room, and Facility Control Rooms) or though the public address system and other changes for alarm systems
24590-WTP-BODCN-ENG-09-0013	10/26/09	*NQA-1 Reference.* Proposed to remove ANSI/ASME NQA-1 FROM Revision10 of BOD. Section 1.8 of BOD refers to QAM, which includes NQA and applies to entire BOD, Citation of QAM in Chapter15 of BOD may cause confusion
24590-WTP-BODCN-ENG-09-0015	11/6/09	*Use of WSGM for HLW Power Manipulator Cranes and Cable Reels.* Allows the use of WSGM building response for the design of HLW crane Power Manipulators and Cable Reels
24590-WTP-BODCN-ENG-09-0012	11/17/09	*Minimum Conductor Size for Vendor Support Equipment, Removal of SC Switchgear Buildings and Updated egress Light Battery Size.* Smaller conductor size may be utilized as long as adequate over-current protection is provided.
24590-WTP-BODCN-ENG-09-0016	12/2/09	*Revision to Table 12-1 to Include PTF Control Building Compressor, Chilled Water Equipment, and HVAC Equipment Room Internal Conditions.* Clarified/specified temperature conditions if PTF chiller plant and control building.
24590-WTP-BODCN-ENG-09-0018	12/8/09	*Offgas Capacity Rated for 2 Melters.* Modify BOD so that the exhausters in the LAW can be downstream of all off gas abatement equipment
24590-WTP-BODCN-ENG-09-0022	12/15/09	*Instrumentation Signal and Power Supply Grounding.* Clarification of instrumentation installation requirements.
24590-WTP-BODCN-ENG-09-0019	1/7/10	*Revise References In Section 15.* Clarify requirements and requirement bases for melters
24590-WTP-BODCN-ENG-09-0014	1/21/10	*Mechanical Design Criteria for Diesel Fuel Oil Storage Tanks.* Reference to NFPA30 shall be changed to ANSI/UL 142. The BODCN updates the codes and standards used for design of diesel fuel oil storage tanks
24590-WTP-BODCN-ENG-09-0023	2/22/10	*Continuous Air Monitor (CAM) Locations* Clarification of the need for CAMs to be located inside of the rooms to get representative samples
24590-WTP-BODCN-ENG-09-0011	3/3/10	*Use of WSGM for Selected Pretreatment Facility (PTF) and High-Level Waste Facility (HLW) Heating, Ventilating, And Air Conditioning (HVAC) components.* Some HVAC equipment from PTF and HLW systems was approved for use of WSGM
24590-WTP-BODCN-ENG-09-0020	3/16/10	*Alignment of Piping Design Requirements With PDSA Addendum Revision for Seismic Changes.* Specifies the use of SC-I methods to evaluate pipe and certain isolation valves. Also specifies use of SC-III methods for certain SSCs recategorized from SC to SS.

Document Number	Approva l Date	Purpose of Change
24590-WTP-BODCN-ENG-10-0001	3/16/10	*HPAV Analysis and Design Criteria.* This BOCDN includes the detailed implementation of piping design criteria approved by Reference 1. In addition the request is made to close Condition of Approval (COA) No. 41 of ABAR requesL
24590-WTP-BODCN-ENG-09-0025	4/21/10	*DOE 1066 Equivalency and BOD Clarification* • Update of Section 12, Ventilation Basis of Design, to provide consistency with the DOE-STD-1066 Equivalent safety approach to High Efficiency Particulate Air Filter fire protection. • Exception is also needed in Section 16.4.1.1 regarding socket welding in lieu of full penetration welds for instrument connections to piping adjacent to remote HEPA filter housing in PTF and HLW, provided that 100% radiographic testing of the socket and weld is performed for additional assurance of the gap recommended by ASME B31.3
24590-WTP-BODCN-ENG-09-0026	4/21/10	*Steam/Condensate Isolation*. Section 11.6.6 shall be modified to read " Steam and condensate from steam used to heat radioactive process streams shall be contained in a secondary closed loop system whenever it is not consumed by a process stream
24590-WTP-BODCN-ENG-09-0028	4/26/10	*Bolted And Threaded Connections In the Black Cells For the Evaporators.* Update in black cell design requirements to support PTF facility evaporator demisted pad maintenance. Bullets in Section 16.4.1.1 shall be modified for clarity: all welded construction shall be used for piping and vessels.
24590-WTP-BODCN-ENG-10-0004	5/24/10	*Clarification of Outdoor Design Temperature.* The change is related to the applicability of the minimum and the maximum of ambient air temperatures identified in Table 4-4, Hanford Site Climatological Data.
24590-WTP-BODCN-ENG-09-0027	6/25/10	*Heat Tracing Remote Indication and Facility Infrastructure System (FNJ) Fiber Optic Cable Laterals.* Changes in electrical design criteria in BOD to agree with other requirements documents
24590-WTP-BODCN-ENG-10-0006	7/19/10	*Approval of the Use of WSGM and Concurrence on Basis of Design (BOD) Change Notice 24590-WTP-BODCN-ENG-10-0006, Use of the WSGM on Pretreatment Facility (PTF) Power Manipulator Cranes and Cable Reels.* Use of WSGM for design of PTF Power manipulator Cranes and Cable Reels.

Question 2.A.3.a)(1) *Which changes to the Basis of Design were needed to address major changes in the PTF design (e.g., pulse jet mixing, control of hydrogen)?*

Response 2.A.3.a)(1) One BODCN was needed and approved since October 1, 2008 to address the categories of interest (i.e. HPAV, MAR, Waste Feed). 24590-WTP-BODCN-ENG-10-0001, *HPAV Analysis and Design Criteria*, was approved on February 19, 2010. This change introduced methods and criteria to be applied to design when addressing HPAV. The methods and criteria previously in use were not contained in the BOD.

Question 2.A.3.a)(2) *Why was it necessary to make each of the changes identified in (1) above?*

Response 2.A.3.a)(2) 24590-WTP-BODCN-ENG-10-0001 was needed to update methods and acceptance criteria for HPAV analysis.

Question 2.A.3.a)(3) *What was the technical basis for each change identified in (1) above?*

Response 2.A.3.a)(3) The technical basis for this change to add Appendix C (new) is described in detail in the BODCN enclosure (1) (>500 pages). To summarize, the technical basis for the change was the analysis and testing completed over an approximate three year period as described in the BODCN enclosure.

Question 2.A.3.a)(4) *What impact did each Basis of Design change identified in (1) above have on the PTF margin-of-safety?*

Response 2.A.3.a)(4) The changes in 24590-WTP-BODCN-ENG-10-0001 had no impact on the margin-of-safety for BC and HTR piping. The change reduced the existing margin-of-safety for hot cell piping, but the margin-of-safety provided is consistent with the applicable design standards. The revised criteria and methodology introduce higher load limits (limited localized strain) for piping in the PTF hot cell that preclude failure with reduced margin recognizing that piping could be repaired, if necessary. The impact on margin-of-safety from the changes in HPAV criteria are addressed in detail in the response to question 5.E.

Question 2.A.3.a)(4)(a) *Describe the impacts.*

Response 2.A.3.a)(4)(a) As indicated above in the response to Question 2.A.3.a)(4), the impacts on the margin-of-safety are described in detail in the response to question 5E. The new design approach is consistent with applicable codes and standards.

Question 2.A.3.a)(4)(b) *How was the impact, or lack of impact, determined?*

Response 2.A.3.a)(4)(b) The proposed changes were developed to ensure an adequate margin-of-safety. In the BC there was no change in the acceptance criteria, and therefore no impact on margin-of-safety. The allowance for permanent plastic deformation in the BCs is very low (0.2%). This strain is accepted as the elastic limit (yield stress) for the material. The BCs are the locations least likely to ever experience a hydrogen event since there are no operational components like pumps, valves or instruments that create potential sources of electrical or mechanical ignition. In addition, the possible ignition source due to thermal reactions is very low since the temperatures and pressures that WTP operates at are considerably lower than the critical conditions for auto-ignition.

In the hot cell the revised criteria provide a lower margin-of-safety against the failure limit. The allowance for permanent plastic deformation in the hot cells is higher but still maintains substantial margin to pipe failure. Also, the hot cells are remotely accessible for maintenance and jumper replacement should failure occur.

In order to develop the new criteria and methodology, BNI and DOE performed extensive testing and analysis over a three year period, as described in enclosure 1 to BODCN 24590-WTP-BODCN-10-0001. As explained in the enclosure, the testing and analysis showed that the piping could withstand multiple high-level events without deformation.

Question 2.A.3.a)(4)(c) *Describe why it was acceptable to proceed with the change (technical justification) in cases where the design change had the potential to adversely impact the PTF margin-of-safety?*

Response 2.A.3.a)(4)(c) In the hot cell the revised criteria provide a lower margin-of-safety against the failure limit. The revised criteria and methodology introduce higher load limits (limited localized strain) for piping in the PTF hot cell that preclude failure with reduced margin recognizing that piping could be repaired, if necessary.

In order to develop the new criteria and methodology, BNI and DOE performed extensive testing and analysis over a three year period, as described in enclosure 1 to BODCN 24590-WTP-BODCN-10-0001. As explained in the enclosure, the testing and analysis showed that the piping could withstand multiple high-level events without deformation.

Question 2.A.3.a)(5) *Why was each change identified in 3.a) above necessary given the advanced state of the PTF design? Describe the expected reduction in design and/or operational complexity from each change.*

Response 2.A.3.a)(5) In early stages of the facility design, it was apparent that sufficient data was not available to support a passive control strategy for HPAV. In order to advance the design active controls were developed. In parallel, an extensive program of analysis and testing was initiated to gather sufficient data to support a passive control strategy. As the results of the testing and analysis program became available, it was determined that a passive control strategy could now be implemented into select portions of the design, even at the advanced state of the PTF design. BOD changes were generated to support selective implementation of the passive control strategy.

Question 2.A.3.b) *What changes to the Basis of Design are anticipated prior to startup?*

Response 2.A.3.b) Anticipated changes are understood to be those that are currently proposed and being considered for approval as described in the Design Criteria procedure (24590-WTP-3DP-G04B-00001, *Design Criteria*). The table below itemizes the known anticipated changes at this time. Other changes, not yet identified, may be proposed and processed as controlled by procedure.

Anticipated Changes to the Basis of Design

Document Number	Initiation Date	Purpose of Change
24590-WTP-BODCN-ENG-08-0006	6/5/2008	*Design Criteria for Ambient Air (Temperature) - BOD Section 12, Section 12.4.1.1, Environmental Qualification External Air Temperature Requirement Addition* This change is necessary because: (1) The Environment Qualification (EQ) external air temperatures proposed by this BODCN are not currently in the Design Criteria Database; and (2) the EQ external air temperatures proposed by this BODCN need to be explicitly stated in the BOD for all disciplines to correctly apply design and qualification requirements.
24590-WTP-BODCN-ENG-08-0015	11/18/2008	*Fire Rated Seal Penetration Clarification* To align with the following requirements: • International Building Code, 2000 Edition, Section 712.3.1.2 through-penetration firestop system. Through penetrations shall be protected by an approved -penetration firestop system installed as tested in accordance with ASTM E 814 or UL 1479. • NFPA 801, Standard for Fire Protection For Facilities Handling Radioactive Materials, (2003 Edition) Section 5.6.3 Penetration seals provided for electrical and mechanical openings shall be listed to meet the requirements of ASTM E 814, Fire Tests of Through-Penetration Fire Stops, or UL 1479, Fire Tests of Through-Penetration Fire Stops
24590-WTP-BODCN-ENG-08-0026	8/20/2008	*Fire Rated Seal Penetration Clarification.* Same as 24590-WTP-BODCN-ENG-08-0015 • Update 13.6.2 Structural Fire Protection Criteria, 3rd Paragraph to align with the following requirements: • International Building Code, 2000 Edition, Section 712.3.1.2 through-penetration firestop system. Through penetrations shall be protected by an approved -penetration firestop system installed as tested in accordance with ASTM E 814 or UL 1479 • NFPA 801, Standard for Fire Protection For Facilities Handling Radioactive Materials, (2003 Edition) Section 5.6.3 Penetration seals provided for electrical and mechanical openings shall be listed to meet the requirements of ASTM E 814, Fire Tests of Through-Penetration Fire Stops, or UL 1479, Fire Tests of Through-Penetration Fire Stops.
24590-WTP-BODCN-ENG-09-0017	8/12/2009	*Impact of New Classification Scheme.* Update MS code information Clarify the types of documents listed, correct the titles of documents, and added guide for relief systems and standard for sealless pumps.
24590-WTP-BODCN-ENG-09-0024	11/5/2009	*Clarify Requirements For Decontamination - Eliminate High Pressure Steam and CO2 for Crane Decontamination.* Implements a change in decontamination requirements approved for the ORD.
24590-WTP-BODCN-ENG-10-0002	2/25/2010	*Incorporation of DOE O420.1B - Updates and Clarifies Fire Safety Requirements* 1) The updated DOE O 420.1B Facility Safety (instead of DOE O 420.1A) is required in the SRD 24590-WTP-SRD-ESH-01-001-02. 2) DOE Guide 420.1-3, Implementation Guide for DOE Fire Protection and Emergency Services for Use with DOE O-420.1B, Facility Safety shall replace DOE Guide 420.1/440.1, Implementation Guide for Use with DOE Orders 420.1 and 440.1 Fire Safety 3) Clarify fire safety requirements

Anticipated Changes to the Basis of Design

Document Number	Initiation Date	Purpose of Change
24590-WTP-BODCN-ENG-10-0003	3/26/2010	*As Received Waste Feed Particle Size And Density* Three of the External Flowsheet Review Team (EFRT) concerns were associated with the physical properties of the Hanford waste particle sizes and densities and how WTP designs would handle these wastes. The EFRT issues were: M1 - Plugging in Process Piping M2 - Mixing Vessel Erosion M3 - Inadequate Design of Mixing Systems The M1 and M2 issues have now been closed and the particle size and density to be used for closure of M3 has been defined. Hence, it is appropriate that the particle size and densities used in each of these closure packages, that were joint agreed to by WTP and DOE, be captured in the WTP *BOD*. Different bulk density values are used of design of pumping/line sizing and for mixing due to the different design methods/correlations used for each application. This formally documents the upper rheology bound for washed and leached waste used in the design of WTP.
24590-WTP-BODCN-ENG-10-0005	4/14/2010	*Drain Lines from PTF Control Building - C1 drain lines from PTF Control Bldg to C2 drain lines in PTF bldg.* Allow drain lines connection between C1 and C2 areas while providing adequate protection for cross contamination.
24590-WTP-BODCN-ENG-10-0007	5/6/2010	*Update: HPAV Analysis and Design Criteria.* P&IDs of the ASX, CHW, CNP, CRP, CXP, FEP, FRP, HPS, , HLP, NLD, PCW, PJV, PSA, PVP, PVV, PWD, RDP, RLD, TCP, TLP, & UFP may required design changes as each system is analyzed for the HPAV loads. Procurements Specifications for ASX, CHW, CNP, CRP, CXP, FEP, FRP, HPS, HLP, NLD, PCW, PJV, PSA, PVP, PVV, PWD, RDP, RLD, TCP, TLP, & UFP may need to be revised to add or remove items/requirements due to the new HPAV design criteria The intent of Appendix C was to limit its application to 4-inch (in) nominal pipe size (NPS) pipe and smaller. However it was never explicitly stated in the Appendix C BODCN. This change is meant to clearly communicate that intent. Provides instruction for using the deflagration pressure as the design pressure for HPAV affected systems with deflagration events. These events tend to be more numerous than the originally expected and therefore will be treated as occasional loads or operational loads depending on their frequency.
24590-WTP-BODCN-ENG-10-0008	5/10/2010	*Reinforcement Plates for Vessel Modifications - Addition of Reinforcing Pads for Black Cell and Hard to Reach Vessels.* 1) 16.4.2.1, first paragraph, Page 16-5, new bullet following current second bullet. Provide information regarding the design of internal attachments to the head and shell
24590-WTP-BODCN-ENG-10-0009	5/10/2010	*Seismic Interactions of Piping - Allow Use of WSGM for Certain Pipe.* Seismic wording on connection of piping and equipment and building structures update in Sections 7.3.711, Page 7-12; 10.2.15; 13.5.1.3, third paragraph, seventh bullet, Page 13-7; B.3
24590-WTP-BODCN-ENG-10-0010	5/10/2010	*Addition of Reinforcing Pads for Black Cell and Hard to Reach Vessels.* Same as 24590-WTP-BODCN-ENG-10-0008 16.4.2.1, first paragraph, Page 16-5, new bullet following current second bullet.//Provide information regarding the design of internal attachments to the head and shell
24590-WTP-BODCN-ENG-10-0011	5/25/2010	*Clarify Permit BARCT Requirements.* Sections 14.3.3 through 14.6 revised to clarify WTP established Best Available Radionuclide Control Technologies (BARCT) identified in the Radioactive Air Emissions Air Permit Approvals (WDOHa, WDOHb, WDOHc, WDOH 2007).

Of the anticipated changes, two are relevant to the topics of interest:

- 24590-WTP-BODCN-ENG-10-0003, *As Received Waste Feed Particle Size and Density*; and
- 24590-WTP-BODCN-ENG-10-0007, *Update: HPAV Analysis and Design Criteria* addressed the categories of interest (i.e. HPAV, MAR, Waste Feed). This change clarifies the previous BODCN (24590-WTP-BODCN-ENG-10-0001, *HPAV Analysis and Design Criteria)* by limiting the application of Appendix C to pipe of 4 in NPS and smaller and provides additional requirements for the Code design pressure by considering deflagration pressures as either normal or occasional pressures as defined by ASME B31.3, *Process Piping*. In addition, this change may be impacted by the findings in the recent report, 24590-CM-HC4-W000-00182-01-00001.

These anticipated changes are in draft. They will be subject to a review and approval process defined by 24590-WTP-3DP-G04B-00001. This process could result in alterations or denial of the change. Thus, the assessments below may be affected by the results of this process.

Question 2.A.3.b)(1) *What is the technical basis for each anticipated change?*

Response 2.A.3.b)(1) The technical basis for each anticipated change is summarized below.

<u>24590-WTP-BODCN-ENG-10-0003 (Particle Size/Density)</u>: The design basis particle size and density for the WTP feed is based on the currently available data. An initial analysis was conducted based on samples from seven waste tanks (AW-103, AY-101, AY-102, AZ-102, C-104, C-107, and SY-102) and reported in RPP-9805, *Values of Particle Size, Particle Density, and Slurry Viscosity to Use in Waste Feed Delivery Transfer System Analysis*. The approach for the study was to select a conservative (upper bound) solids density value and realistic values (best estimates) of particle sizes and slurry viscosities. As noted in the report, "The selection approach for these three waste properties is expected to support a reasonably conservative assessment for the waste feed delivery transport system."

Section 3 of the report (RPP-9805) describes the approach to developing the particle size analysis which is summarized in Table 3-2 for the mean, 95% upper (UL) and 95/95 tolerance limit (TL) particle size distributions. Section 6 of the report recommends the use of the Mean particle distribution and states that the 95/95 TL distribution was not recommended. The WTP has selected the 95% UL distribution as the design basis which provides additional conservatism when compared to the recommended Mean particle size distribution.

Section 4 of RPP-9805 describes the approach to developing a solids density based on the data from the seven tanks listed above as well as tank AZ-101. Section 6 then recommends "For particle density, in the absence of direct measurements of the agglomerated solid density, the value 2.9 g/ml is recommended." The WTP has selected the particle density of 2.9 g/ml which is conservative when agglomeration of the particles is considered.

In addition to RPP-9805, the report WTP-RPT-153 (24590-101-TSA-W000-0004-114-00021), *Estimate of Hanford Waste Insoluble Solid Particle Size and Density Distribution* has been reviewed. WTP-RPT-153 includes composite particle size distributions representing the waste in up to 19 Hanford waste tanks. The report (Section 5) also developed and evaluated four particle size and density distributions. Figure 1 in document 24590-WTP-ES-ENG-09-001, *Determination of Mixing Requirements for Pulse-Jet-Mixed Vessels in the Waste Treatment Plant*, compares these results for particle size to the particle size distribution (95% UL) from RPP 9805. In both cases (particle size and solids density), the RPP-9805 report bounded the WTP-RPT-153. As such, the design basis has remained based on the RPP-9805 report. However, the maximum particle size listed in RPP 9805 was a d99 particle of 310 microns for the 95%UL particle size distribution. Consistent with the data evaluation for the sonicated case (Table 5.0.1) in WTP-RPT-153, the d100 particle size was selected as 700 microns.

<u>24590-WTP-BODCN-ENG-10-0007 (HPAV):</u> The technical basis for this change to revise Appendix C was described in detail in the BODCN Enclosure (1) (24590-WTP-BODCN-ENG-10-0007, *Update to HPAV Analysis and Design Criteria)*. In summary, this is a change that clarifies the scope of Appendix C (limiting it to 4 inch NPS and smaller) and adds requirements for the design pressure based on the deflagration event (as required by B31.3). As described in the responses to 2.A.3.a), the technical basis for the Appendix C change is provided in 24590-WTP-BODCN-ENG-10-0001. *HPAV Analysis and Design Criteria*, summarizes the analysis and testing completed over a three year period . Other potential changes and associated bases may be developed after the findings of 24590-CM-HC4-W000-00182-01-00001.

Question 2.A.3.b)(2) *What are the potential impacts of each anticipated change on the PTF margin-of-safety?*

Response 2.A.3.b)(2) The technical basis for each anticipated change on the PTF margin-of-safety is summarized below.

<u>24590-WTP-BODCN-ENG-10-0003 (Particle Size/Density):</u> This BODCN documents parameters that were not previously defined in the BOD and are not defined in the current WTP contract. The maximum particle size and density used to close M3 is a significantly more conservative number than previously used for assessing pulse jet mixer (PJM) mixed vessels. The values in the BODCN have been agreed to with DOE as the appropriate values to use for design going forward.

This BODCN is expected to result in design changes that increase the margin-of-safety.

<u>24590-WTP-BODCN-ENG-10-0007 (HPAV):</u> As explained in 2.A.3.b)(1), the anticipated changes are:

- A limitation in the scope of Appendix C, which does not the affect margin-of-safety; and
- The addition of requirements to consider deflagration pressures when setting design pressure, which does not change the margin-of-safety as it relates to design margin, since it uses the B31.3 Code limit for static pressure.

Question 2.A.3.b)(2)(a) *Describe the potential impacts.*

Response 2.A.3.b)(2)(a) The technical basis for the potential impacts is summarized below.

24590-WTP-BODCN-ENG-10-0003 (Particle Size/Density): This BODCN will result in changes to vessel mixing systems, such as increased numbers of PJMs per vessel, increased PJM nozzle size, and changes to PJM orientation. (For more discussion, refer to the response for question 13.B.4.a). As indicated above in the response to Question 2.A.3.b)(2), these changes are expected to increase the margin-of-safety.

24590-WTP-BODCN-ENG-10-0007 (HPAV): As indicated above in the response to Question 2.A.3.b)(2), the anticipated BODCN has no impact on the margin-of-safety. The new design approach is consistent with accepted codes and standards.

Question 2.A.3.b)(2)(b) *How was the impact, or lack of impact, determined?*

Response 2.A.3.b)(2)(b) The impact, or lack of impact, is summarized below.

24590-WTP-BODCN-ENG-10-0003 (Particle Size/Density): As indicated above in the response to Question 2.A.3.b)(2), criteria were not previously defined. The resulting changes in design are expected to improve the margin-of-safety.

24590-WTP-BODCN-ENG-10-0007 (HPAV): The anticipated change limits application of Appendix C and sets design pressure in accordance with accepted codes and standards. As indicated above in the response to Question2.A.3.b)(2), there is no impact on the margin-of-safety. The new design approach is consistent with accepted codes and standards.

Question 2.A.3.b)(2)(c) *For each anticipated change, describe the justification to proceed with the change, in cases where there are potential adverse impacts to the PTF margin-of-safety?*

Response 2.A.3.b)(2)(c) The technical basis for justification to proceed with the change, in cases where there are potential adverse impacts to the PTF margin-of-safety is summarized below.

24590-WTP-BODCN-ENG-10-0003 (Particle Size/Density): As indicated above in the response to Question 2.A.3.b)(2), the change in criteria has no adverse impact to the margin-of-safety.

24590-WTP-BODCN-ENG-10-0007 (HPAV): As indicated above in the response to Question2.A.3.b)(2), in terms of design margin, there is no adverse impact on the margin-of-safety based on the anticipated change.

Question 2.A.3.b)(2)(d) *Why are the anticipated changes in the Basis of Design necessary given the advanced state of the PTF design? Describe the expected reduction in design and/or operational complexity from each change.*

Response 2.A.3.b)(2)(d) The reason the anticipated changes in the BOD are necessary given the advanced state of the PTF design, and the expected reduction in design and/or operational complexity is summarized below.

24590-WTP-BODCN-ENG-10-0003 (Particle Size/Density): The BOD changes were necessary at this stage of design due to the completion of the M3 mixing issue. The maximum particle size and density used to close M3 is a significantly more conservative number than previously used for assessing PJM mixed vessels. The values in the BODCN have been agreed to with DOE as the appropriate values to use for use in the design. This change is not expected to reduce either design or operational complexity.

24590-WTP-BODCN-ENG-10-0007 (HPAV): The BOD changes are necessary to: :

- limit the scope of Appendix C to 4 in NPS and smaller piping, consistent with the testing that has been done; and
- add requirements to consider deflagration pressures when setting design pressure, since deflagration has characteristics of a static pressure.

Question 3. Pretreatment Facility Safety

Responses to Question 3 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

Hanford Tank Waste Treatment and Immobilization Plant Project
Donna Busche, Environmental & Nuclear Safety Manager

Contributing authors:

U.S. Department of Energy - Office of River Protection
Vic Callahan, Director, Nuclear Safety Division

Hanford Tank Waste Treatment and Immobilization Plant Project
Todd Allen, Safety Implementation Manager
Russell Daniel, Production Engineering Manager
Mike Delamare, Systems Engineering Manager
Garth Duncan, Manager of Process Engineering and Technology
Dennis Hayes, Plant Operations Manager
John Hinckley, Integrated Safety Management Lead
Andy Larson, Safety Analysis Manager
George Matis, Commissioning Operations Manager
Mark Medsker, Pretreatment and High Level Waste Facilities Nuclear Safety Supervisor
Jeff Monahan, Project Engineering Manager, Pretreatment Facility
John Olson, Manager, Process Engineering Design
Tom Patterson, Manager of Engineering

Dave Simpson, Technical Issues Manager

<u>Washington River Protection Solutions</u>
Chris Burrows, Manager, WTP Support
Paul Rutland, Mission Analysis & Strategic Planning Manager

Question 3 deals with two subject areas. The first is reduction of design and operational complexity of the WTP, and the second is management of safety-related risk.

Application of safety controls is required to address hazards and accidents that can have unacceptable consequences to the public and to the workers who may be exposed to the consequences of these hazards and accidents. The analysis of the hazards and accidents and the subsequent identification of controls is, by necessity, a conservative process. Early in the project life-cycle when the design uncertainties are larger, more conservative analyses are performed. As the WTP design and the safety analysis has matured the design uncertainties have been reduced by testing and analysis. An initiative was undertaken to address existing conservatism in light of the maturing design, testing and analysis performed for the WTP, and knowledge of the waste that the WTP will receive for processing. An expected outcome of these initiatives was that the severity of the hazards and accidents at the WTP would be shown to be less than originally analyzed, allowing the number of required safety controls to be reduced. The reduction in the number of safety controls, or changes from active to passive safety controls would have a beneficial impact on the long-term operation of the WTP.

Due to the nature of the WTP project where design and construction are occurring in parallel, risks that can impact the design and construction need to be identified and a strategy developed to address the risks while allowing design and construction to continue.

Question 3.A *In late 2008, DOE began an initiative to reduce the complexity of the PTF design. Describe the basis for reducing the complexity of the PTF design, the results of this effort, and management controls necessary to prevent the final design from becoming too complicated to operate.*

Question 3.A.1 *When and how did Bechtel National, Incorporated (BNI) determine that the PTF design was overly complex?*

Response 3.A.1 In November 2008, BNI completed the incorporation of HPAV active controls into the committed design. The committed design raised concerns on the design/operational complexity (e.g., the number of controls, plant availability, initial understanding of the potential TSRs).

A committed design provides the design information needed by other disciplines to complete downstream design activities. The process is performed on a system basis and is considered completed for a system when the design information needed by the down-stream disciplines, including P&IDs (piping and instrumentation diagrams), component information system lists, and supporting committed calculations, is complete and supported by issued documentation. Committed design P&IDs may be utilized to support purchase of equipment and issuance of isometrics. Committed design typically will include "unverified assumptions" that are tracked to subsequent resolution, i.e., assumptions underpinning the design that will be confirmed before design completion.

A WTP sponsored technical issues review team (Letter No. CCN 192416, M. K. Robinson to Distribution, *Sensitive - WTP Project Technical Issues Review: November 19, 2008*) composed of off project URS and BNI personnel questioned assumptions driving controls and the impact of those controls on WTP. The team's review included pre-read packages of existing project information, presentations from issue resolution leaders, and follow-on discussions with key technical staff. Some of the controls were judged to impair operational reliability and introduce additional worker safety risk.

Question 3.A.2 *What three PTF systems were the most complex and how was this determined?*

Response 3.A.2 Reviews focused on representative systems with examples of the range of HPAV active controls being utilized and no attempt was made to determine which systems were the most complex.

Question 3.A.2.a) *Describe the details for each system, including a description of the overly complex aspects of these system designs, and how this was determined.*

Response 3.A.2.a) As an example, for the Operation Review Team (ORT) review (E-mail, CCN 201910, T. B. Ryan to Distribution, *Transmittal of Operational Review Team Final Report)*, the Ultrafiltration Process (UFP) system was selected by WTP because it included a range of HPAV controls that were proposed for installation in the Pretreatment Facility. A hard copy of the UFP sketches *(UFP Feed Preparation Loop, Post HPAV/MAR Study)* provided to the ORT are included in the references.

Question 3.A.2.b) *Describe the operational complexity that resulted from the original design.*

Response 3.A.2.b) As an example, for the ORT review (CCN 201910), the UFP system was selected by WTP because it included a range of HPAV controls . The WTP Project position in these discussions was that no single HPAV control was complex, but due to conservative assumptions for HPAV analyses, many controls for UFP would be required. The number of HPAV controls was viewed to represent an administrative burden on the PTF operating staff.

There are also cases where the design requirements drove design complexity, specifically related to the fragmentation phenomena. The UFP system has a power flush feature to flush the ultrafilters. The flush function became SC over the postulated concern that fragmentation of the SS UFP system could adversely impact the SC function of other systems (specifically other HPAV controls or the sparge lines at the top of the hot cell). To meet the single failure criterion for the operation of the flush valve, the design requirement was that the valve that supplied the flush required redundancy. This change required the valve that isolated the UFP system from the flush system to be redundant with a back-up air purge. It was not possible to keep these valves in the hot cell on a jumper due to space limitations, so the valve had to be relocated to bulges which are an expansion of the hot cell in an isolated structure intruding into an operating area. This led to a condition where the flush line would also contain waste creating a long dead leg where there was not one in the previous design. That dead leg became the basis for how often the system required flushing, limiting the operation of the filter loop.

Question 3.A.2.c) *Describe how BNI proposed to remove the complexity.*

Response 3.A.2.c) The WTP described the approach for addressing the MAR and HPAV initiatives in 24590-PTF-RPT-ENS-09-001, *Pretreatment Facility – Overview of the Approach to Update WTP Authorization Basis*. This document described the strategy and roadmap for updating the PTF safety basis. In general, the approach was to address maturation of system designs in the PTF, new information regarding HPAV that had been developed through additional testing and analysis, and a revised evaluation of material at risk with the expectation that some safety controls could be reclassified or removed. Once the evaluation was completed, the safety basis would be updated using established change control processes, which include approval by DOE.

Question 3.A.2.d) *Describe the potential impacts on operations from removing the overly complex aspects of the design (including changes in classification of safety-related SSCs).*

Response 3.A.2.d) Refer to response 3.A.1 for a discussion of complexity. The project will evaluate the potential to reduce the controls while still maintaining plant safety as its primary goal as described in response to Question 3.A.8. Removal of active controls demonstrated to be unnecessary can help simplify operations and enhance safety focus.

Question 3.A.2.d)(1) *Will operation of the PTF be more or less flexible due to changes in design? Describe the impact changes in design had on operational flexibility.*

Response 3.A.2.d)(1) Based on design progress to date and the expected changes, it does not appear that flexibility will be significantly affected. In some cases, operational efficiency for non-routine operations may be diminished, in order to realize a reduction in dead legs.

For example, the original design for the PTF hot cell envisioned the use of pump discharge manifolds with valves to allow a control room operator to switch from a routine transfer path to a alternate or non-routine transfer path. Although this allows a great deal of flexibility in facility operations, from an HPAV perspective it results in piping dead legs in front of the closed valves. The initial treatment of dead legs based on conservative assumptions required HPAV controls. In some cases, the design solution may be to remove the use of valves for alternate or non-routine transfer paths to eliminate the piping dead leg. To use an alternate or non-routine transfer path would require the removal and reinstallation of hot cell jumpers; which represents a manageable reduction in facility flexibility for non-routine operations. On the other hand, flexibility for routine operations would improve because of piping dead leg removal and the removal of line flushes for HPAV could eliminate flushes which would interrupt routine transfers. In this example there is an engineering decision to be made between facility flexibility and HPAV controls.

Question 3.A.2.d)(2) *Has the availability and maintainability of the systems changed? Describe the impact changes in design had on availability and maintainability.*

Response 3.A.2.d)(2) The original HPAV controls depicted on approved design documents have not been incorporated into the Operations Research (OR) model, which is the tool used to compute facility availability. The availability and maintainability of existing and future HPAV controls has not been assessed.

Question 3.A.2.d)(3) *Have there been changes in mean time to failure and mean time to repair? Describe the impact changes in design had on mean time to failure and mean time to repair.*

Response 3.A.2.d)(3) A change to mean time to failure or mean time to repair of individual components is not anticipated. However, it is observed that when the number of components increases, then so does the number of failures in a given interval of time. Consideration must be given to ensure that the allowed time to repair under potential TSRs is greater than the mean time to repair.

Question 3.A.2.d)(4) *Has there been an impact on the margin-of-safety? Describe each impact on the margin-of-safety.*

Response 3.A.2.d)(4) See the response to question 2.A.1.a)(3) above relating to the hot cell design criteria. Changes are evaluated prior to their implementation through existing processes to demonstrate that safety is maintained.

Question 3.A.3 *How did DOE determine that the PTF was too complex to operate?*

Response 3.A.3 DOE did not make a formal determination that the PTF was too complex to operate. In 2002, the project initiated actions to address the lessons learned from the commercial nuclear industry by implementing design improvements of the PTF to manage the accumulation of hydrogen in piping under such unusual conditions. The design approach relied on deterministically defined active preventive controls for any piping system in which a conservatively defined "bubble of concern,"and its subsequent ignition, could cause the piping to exceed the Code elastic limit. Given these conservatisms, active systems were required for most piping routes, including some active systems provided solely for combustible gas control, some that introduced potential operational errors (e.g., inadvertently open vent valves on pump suction lines leading to pump cavitations), some that add to the plant design a path for process waste to enter areas outside the thick walled cells meant to protect the workers (e.g., inadvertently open flush, vent or air purge lines), and some that required planned waste transfers to be interrupted mid-batch (pump timers). The number of safety controls in PTF grew between 2002 and 2008.

In 2008, DOE decided to re-evaluate the design control strategy that relied primarily on preventing the accumulation of combustible gasses in significant quantities. The purpose of the evaluation was to determine if alternate design approaches for dealing with hydrogen would simplify the facility, thus providing higher assurance of safe and reliable operations while protecting the long term availability of the facility. The Project came to the realization that a combination of the original strategy (to prevent gas accumulation) and a new strategy (to withstand some of those accumulation and ignition events) afford the most robust design and thus the best assurance of both safety and mission success.

To validate this new strategy for the project, DOE initiated a review of a passive option for a simpler design for more reliable operations as an alternative to the complex active system design. DOE chartered two task forces early in 2009 to determine whether alternate design approaches for dealing with hydrogen would simplify the facility, thus providing higher assurance of safe and reliable operations while protecting the long-term availability of the facility.

- The first expert task force assessed the design requirements for hydrogen, weighing whether the degree of conservatism being provided for safety unduly increased operational complexity of the facility, thereby decreasing operational reliability and safety. The team issued a report CCN 01897, *WTP – Control of Hazards Associated with Hydrogen Accumulation in Piping and Ancillary Vessels: Alternative Evaluation and Design Approaches.*

  The report concluded that "A substantial amount of testing and analysis has now been accomplished to understand HPAV-related phenomena allowing the project to implement the recommendations [of the report]...". The report included several recommendations to use the data gained through testing to re-evaluate and reduce the conservatisms in the analysis models to realize a change in control approach that could result in operational control reductions and design feature changes.

- The second task force assessed whether an overly conservative prescription of the MAR was causing the functional safety classification of systems to be inconsistent with the actual level of risk portended by the facility. The task force issued a report, *The Impact of Material at Risk (MAR) and Hydrogen in Piping and Ancillary Vessels (HPAV) Initiatives at the Waste Treatment Plant.*

  The report concluded "...that there are significant advantages in operability, maintainability, and constructability as a result of the proposed [MAR] changes."

Question 3.A.3.a) *When and how was the determination made?*

Response 3.A.3.a) See the response to question 3.A.3.

Question 3.A.3.b) *Describe the method/process/criteria used to make this determination.*

Response 3.A.3.b) See the response to question 3.A.3.

Question 3.A.4 *Describe actions taken by DOE and BNI to ensure that removing design complexity does not adversely impact the PTF margin-of-safety.*

Response 3.A.4 As stated in Section 2 of this document, for the purpose of this question, the margin-of-safety is interpreted to mean the difference between the design limit (e.g., code allowable, test limits, acceptance criteria) of a SSC and the failure limit. The processes are in place at the WTP to review changes to controls to assure that safety is maintained. A specific example of this is provided in the response to question 2.A.1.a)(3). This process includes review of the hazards and accidents associated with the change to identify the necessary controls and update of the AB, which includes DOE approval of control changes prior to implementing the change.

Question 3.A.4.a) *Did reducing the PTF design complexity require changes to the safety design strategy for the PTF (e.g., Hydrogen in Pipes and Ancillary Vessels [HPAV])?*

Response 3.A.4.a) Changes were made to the SRD to address the modified HPAV criteria (see response to Question 2.A.1.a)(1)). The changes to HPAV are a result of testing and research into the hydrogen phenomena as documented in 24590-WTP-ENG-07-011, *HPAV Engineering Analysis Methods and Criteria.*

Question 3.A.4.b) *Describe each of these changes and their impact on risk to the worker and public.*

Response 3.A.4.b) The revised HPAV criteria have been established based on new analysis and testing. Application of the criteria is through an established hazards and accident analysis process that evaluates the hazards and consequences of the hazards and establishes controls to address the hazards. Any changes resulting from application of the HPAV criteria will then be documented in accordance with the AB change control process, which includes approval by DOE. Specific changes are described in the response to Question 2.A.1.a)(1).

Question 3.A.5 *Describe the changes in the preliminary documented safety analysis (PDSA) necessary to support removal of design and/or operational complexity from the PTF design.*

Response 3.A.5 No changes were made to the PTF PDSA, 24590-WTP-PSAR-ESH-01-002-02, *Preliminary Documented Safety Analysis to Support Construction Authorization; PTF Facility Specific Information*, to directly address design or operational complexities. Changes to the PTF PDSA were made to address a reduction in MAR, HPAV analysis methods, and a small number of accident analysis methods, which are documented in an Addendum to the PTF PDSA, 24590-WTP-PSARA-ENS-09-0001, *Preliminary Documented Safety Analysis - Control Strategy Changes for the PTF Facility*. The changes made in the Addendum have been augmented by directed changes to the methodology of evaluating possible interaction effects from HPAV explosion events, as documented in DOE letter 10-NSD-055, *Directed Change to the Preliminary Documented Safety Analysis (PDSA) Affecting Hydrogen in Piping and Ancillary Vessels (HPAV) Control Strategy for Pretreatment (PTF) and High Level Waste (HLW) Facilities*. The net effect of the changes set the framework for the potential reclassification of some SC SSCs to SS or non-safety, resulting in the possible reduction of redundancy of safety SSCs and elimination of some safety SSCs no longer required. Since these changes were not targeted at reducing design or operational complexities, no evaluation has been performed regarding reduction of complexity.

Question 3.A.5.a) *Did any of the necessary changes to the PDSA impact the margin-of-safety for the PTF? If so, describe the impact.*

Response 3.A.5.a) See response to 2.A.1.a)(3).

Question 3.A.5.b) *Have changes to the PTF PDSA to reduce operational complexity impacted the complexity of the safety basis?*

Response 3.A.5.b) See response to 3.A.5. The changes to the PTF PDSA have not yet been incorporated so the final assessment on possible impacts to the complexity of the safety basis cannot be determined.

Question 3.A.5.b)(1) *Describe each change to the PTF PDSA needed to reduce operational complexity and its impact on the PDSA.*

Response 3.A.5.b)(1) See responses to question 3.A.5, 3.A.5.a, and 3.A.5.b, above.

Question 3.A.5.b)(2) *Are all of the necessary PDSA changes complete?*

Response 3.A.5.b)(2) See response to 3.A.5 above. PTF PDSA changes related to MAR and HPAV initiatives have not yet been approved by DOE or implemented. However, the framework for those changes exists in the PTF PDSA Addendum, pending closure of outstanding COAs and resolution of HPAV technical issues.

Question 3.A.5.b)(3) *If not, are the impacts to the PDSA known? Describe the potential impact(s).*

Response 3.A.5.b)(3) Not all impacts are known as some technical inputs are still being determined. Inputs from the Quantitative Risk Analysis (QRA) will have to be reviewed when the tool is complete to identify the initial conditions and assumptions that will need to be protected in accordance with DOE-STD-3009, Appendix A.

There are several major technical issues that have not yet been adequately addressed in the safety basis (and possible design basis) for the PTF. The hazards analyses of systems affected by resolution of major technical issues in PTF have been planned consistent with design development to ensure a systematic hazards analysis review of possible system upsets for the baseline system design as well as the proposed design changes. In the future, updated unmitigated and mitigated analyses will be incorporated in the PDSA, as needed, and the control strategy will be refined.

Potential impacts are unknown at this time.

Question 3.A.5.b)(4) *Did the PTF technical safety requirements (TSRs) change as a result of removing design and/or operational complexity? Describe the changes.*

Response 3.A.5.b)(4) There are no TSRs developed for the PTF. Preliminary TSRs were identified in Chapter 5, *Derivation of the Technical Safety Requirements* in 24590-WTP-PSAR-ESH-01-002-02, *Preliminary Documented Safety Analysis to Support Construction Authorization; PTF Facility Specific Information.*

WTP prepared an integrated change package to document the AB changes that aligned the MAR with the tank farm facility and updated the design requirements for hydrogen in pipes and ancillary vessels (HPAV). The safety basis portion of the change package was documented in the PTF PDSA Addendum This document updated the unmitigated analysis and associated changes to the control strategy. The impacts to future TSRs for the PTF were not addressed as part of that document. A direct page change to Chapter 5 of the PDSA was also provided in the integrated page change to communicate to users that Chapter 5 may have outstanding addenda that could affect the descriptions (e.g., controls, safety function, performance criteria, etc). The impact to the future TSRs will be evaluated when WTP implements the updated unmitigated analysis into the PTF PDSA. At that time, the accident analyses will be updated (as needed), the control strategy will be refined, and the derivation of TSRs will be updated accordingly. This method of handling potential TSR impacts is also described in the PTF PDSA Addendum, Section 3.2.

Question 3.A.5.b)(5) *Is the resulting set of TSRs more or less complicated than the set of TSRs that existed prior to removal of design and/or operational complexity?*

Response 3.A.5.b)(5) The level of complexity (e.g., number of limiting conditions for operation (LCO), specific administrative controls (SAC), etc.) of the future PTF TSRs is not known at this time. It is expected that as the systematic evaluation of hazards continues on the systems comprising the PTF, additional information will be gained that will provide insight into the level of complexity associated with the selected control suite. The schedule of system evaluations is being planned as part of the project planning.

Question 3.A.5.b)(5)(a) *How is this measured (e.g., number of TSRs, number of safety-related SSCs, number of administrative programs, or some other means of comparison)?*

Response 3.A.5.b)(5)(a) There have been no metrics established to track or monitor the complexity of the TSRs.

Question 3.A.5.b)(5)(b) *How have first of a kind design approaches to remove operational complexity (e.g., use of quantitative risk analysis [QRA]), impacted the complexity of the safety basis (i.e., TSRs)?*

Response 3.A.5.b)(5)(b) First of a kind design approaches such as the QRA have not impacted the complexity of the safety basis because they have not yet been evaluated using the criteria of DOE-STD-3009, Appendix A or used in the plant design. As such, any design solutions have not been evaluated through the established safety basis development process. It is expected that any first of a kind design approach that would potentially impact the safety basis would be incorporated into the appropriate safety basis developed process procedures and approved by the appropriate approval authority prior to Project use.

The new approaches are discussed in WTP report 24590-WTP-RPT-ENG-10-008, *Quantitative Risk Analysis of Hydrogen Events at WTP: Development of Event Frequency-Severity Analysis Model.* and 24590-WTP-RPT-ENG-07-011, *HPAV Engineering Analysis and Design Methods.* The new approaches have only re-enforced the importance of the system design processes of not only analyzing normal plant operating but systematically evaluating the upset or off-normal conditions that result in the accumulation of hydrogen.

Question 3.A.5.b)(5)(c) *If the impacts from using first of a kind design approaches on the safety basis are not yet known, when will they be known?*

Response 3.A.5.b)(5)(c) It is expected that any first of a kind design approach that would potentially impact the safety basis would be incorporated into the appropriate safety basis developed process procedures and approved by the appropriate approval authority prior to Project use. WTP is forecasting the QRA tool incorporate the HPAV IRT recommendations and be available for design use on January 2011. The full impact will not be known until each of the estimated 450 routes has been analyzed (24590-WTP-RPT-ENG-10-021, *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan*).

Question 3.A.5.b)(5)(d) *Describe the technical basis supporting the decision to reduce operational complexity?*

Response 3.A.5.b)(5)(d) In the early stages of system design for hydrogen events, conservative assumptions were established with regard to the accumulation of hydrogen, the structural response to hydrogen events and the progression of hydrogen events as deflagrations, detonations and/or the deflagration to detonation transitions. These conservative assumptions were used over the development of the current system design before the detailed analysis and testing information gained in the last several years was available. An example of the early conservatism is that all hydrogen that is generated in a pipe route, which is typically 200 - 300 feet long with multiple different high points, was assumed to accumulate in a single location and not at a high point, but at the lowest point of the system which establishes the highest starting pressure due to hydrostatic head of the fluids in addition to system pressure. These early conservatisms resulted in system design requirements that included multiple controls, which by themselves did not constitute operational complexity, but resulted in an operational burden due to the anticipated control set. An example of such a control set is a pump timer that has been included in the design on a batch transfer operation that requires the transfer to be secured and the system flushed multiple times before the entire contents of the vessel can be transferred from one tank to another in the process. This pump timer control increases the number of operations that Operations staff must conduct, increases the number of cycles the control valves will experience and requires more water in the processes. The compounding effects of these numerous controls is that the controls experience higher wear conditions and plant availability is reduced requiring a longer period of time to process waste.

Since the time when the early assumptions were made, additional testing was performed, expert elicitation was solicited and analysis methodologies have matured to allow unwarranted conservatisms to be revisited based on improved understanding of the phenomena and consequences of the hydrogen event.

Question 3.A.5.b)(6) *What has been the net effect on the technical aspects of the safety basis and the PDSA from removing design and/or operational complexity?*

Response 3.A.5.b)(6) No evaluation of the net effect on the technical aspects to the safety basis has been completed. The PTF PDSA Addendum implements MAR and HPAV changes. The technical inputs that changed in support of the PTF PDSA Addendum are:

- The source term for use in accident analysis has changed (24590-WTP-Z0C-W14T-00020, *Unit Dose Factors for Use in Updated MAR Accident Analysis*).
- The hydrogen generation rate (HGR) analysis has been revised (24590-WTP-M4C-V11T-00011, *Calculation of Hydrogen Generation Rates and Times to Lower Flammability Limit to Support Seismic and Severity Level Assessments*).
- The unmitigated consequence analysis has changed to reflect the revised source term and HGRs (24590-PTF-Z0C-W14T-00036, *Severity Level Calculations for the Pretreatment Facility Based on Updated MAR)*.
- The safety-related design criteria for HPAV events have been revised (24590-WTP-SRD-ESH-01-001-02.

- The safety classification of select SSCs has changed as a result of the unmitigated consequence analysis, as described below.
- The mixing requirements in select vessels have changed as a result of the revised hydrogen generation review, as described below.

It should be noted that further changes to the PTF PDSA Addendum and supporting documents are being made to address uncertainties identified in the preparation of the existing PTF PDSA Addendum.

Specific net changes are:

- Process Vessel Vent Exhaust System (PVV) / Pretreatment Vessel Vent Process System (PVP) system has been assigned an active SC function to provide an active vent path for vessel purges (24590-WTP-PSARA-ENS-09-0001, Table 2). The vessel vent high efficiency mist eliminatory (HEME) has been reclassified from SS to SC for confinement to support the PVV/PVP active function. (24590-WTP-PSARA-ENS-09-0001, Tables 2 and 5)
- SC mixing in seven vessels is now provided through a specific administrative control which includes engineered features rather than a dedicated SC mixing system (24590-WTP-PSARA-ENS-09-0001, Section 2.4.1). These vessels are FRP-VSL-00002A/B/C/D, PWD-VSL-00033, PWD-VSL-00043, and PWD-VSL-00044.
- The confinement function of selected vessels and piping up to and including the isolation valve has been reclassified from SC to SS. These vessels are: CNP-VSL-00003, CXP-VSL-00001, FEP-VSL-00017A/B, FRP-VSL-00002A/B/C/D, HLP-VSL-00022, HLP-VSL-00028, HLP-VSL-00027A/B, PWD-VSL-00015/16, PWD-VSL-00044, UFP-VSL-00001A/B, UFP-VSL-00002A/B, and UFP-VSL-0062A/B/C. (24590-WTP-PSARA-ENS-09-0001, Tables 2 and 5)
- The confinement function of the DOE HLW inner transfer pipe had been revised from SC to SS. (24590-WTP-PSARA-ENS-09-0001, Tables 2 and 5)

The complete set of SSC reclassifications and removal of controls has not been determined.

Question 3.A.5.b)(7) *Has reliance upon Specific Administrative Controls (SAC) increased or decreased as a result of reductions in complexity; has reliance upon engineered controls increased or decreased as a result of reductions in complexity? Are there any cases where engineered controls have been replaced with SACs?*

Response 3.A.5.b)(7) There was one new SAC imposed in the PTF PDSA Addendum (24590-WTP-PSARA-ENS-09-0001, Section 2.4.1) for mixing in seven vessels. The original control was that SC mixing was to be provided. During development of the PDSA Addendum, the time to lower flammability limit (LFL) in these vessels was determined to be substantially above 1,000 hours and the mixing function would be provided by a SAC, as allowed by the SRD Appendix B. The SAC will have provisions to agitate the waste within the calculated time to LFL. In support of the SAC, the PJM and piping to an out-cell connection point remain SC and SC-I. In this instance, there has been an increased reliance on a SAC and decreased reliance on engineered controls. Further, as the revised HPAV criteria are fully applied, identification of appropriate controls (e.g., engineered, administrative, passive design features, etc.) will be consistent with the control selection criteria established by the SRD Appendix B.

Question 3.A.5.c) *Describe the critical elements for DOE's system for maintaining control over the consistency of the design and safety bases. How are these elements intended to maintain consistency between the design and safety bases? Provide one example.*

Response 3.A.5.c) The process for maintaining the design and safety basis consistent is provided by the Contract implementing Standard 9 requiring BNI to follow ENS-ENG-IP-01, *WTP Authorization Basis Management.* This procedure requires the Safety Basis to be maintained current within 60 days of any design changes, whether approved by the contractor (Part 1 Safety Evaluation) or DOE ABAR. For the Part 1 Safety Evaluations, DOE is notified monthly of the previous months' contractor-approved changes and reviews the Part 1 Safety Evaluations and documents the results of the review in the Operational Awareness Database. For those changes approved by DOE, BNI notifies DOE by email that the changes have been incorporated within the 60 day time frame. Yearly assessments are performed to evaluate BNI performance to the BNI implementing procedures for maintaining the safety basis current/consistent with the design. The most recent assessment of the maintenance process associated with the BNI safety basis is captured by 10-NSD-051, *The U.S. Department of Energy, Office of River Protection (ORP) Assessment of Bechtel National, Inc. (BNI) Authorization Basis (AB) Maintenance Program.* There were no findings associated with this assessment but there were two observations regarding completeness of documentation.

Question 3.A.5.d) *Are the current PTF design and PDSA fully consistent?*

Response 3.A.5.d) The PTF is consistent with the PDSA. However, it is not consistent with the PDSA addendum, since an update to the document must be approved by DOE and implemented. Safety basis documents are "leading" design changes. Prior to release of specific design media, documents are required to align with the AB documents (which includes the PDSA).

Question 3.A.5.d)(1) *Has the project finalized the process flowsheet? For example, changes in the pulse jet mixing design potentially impacted the process flowsheet; have these impacts (or others) been fully incorporated into the design and safety bases?*

Response 3.A.5.d)(1) No. The project has developed the plan and schedule to systematically review the results of mixing tests to update process flowsheets, P&ID and the safety basis documents.

Question 3.A.5.d)(2) *Have the changes from revising the HPAV safety design strategy been fully incorporated into the safety and design bases? If not, what changes are required and when will these changes be complete?*

Response 3.A.5.d)(2) The SRD and the BOD have had some revisions to reflect the HPAV safety and design strategy. Changes made to these two criteria documents reflect a relaxation of the acceptable strain limit for replaceable piping, and a more detailed description of an acceptable method to determine what the strain would be in a postulated HPAV event. HPAV control strategy requirements documented in the PTF PDSA Addendum for the PTF remain essentially unchanged from their PDSA counterparts.

Some changes are expected to ultimately be made to the actual facility design, but no such changes have yet been made. These changes will arise from one of three sources:

- elimination of the fragmentation assumption;
- revisions to the severity levels of pipe sprays and leaks; and
- the results of application of the QRA.

Changes to the safety basis documentation are needed to update the PTF PDSA Addendum to show the final fragmentation criteria. The BOD will be evaluated for further changes based on the changes to the PTF PDSA.

Changes made as a result of elimination of the fragmentation assumption will be limited to reclassification of some -- but not all -- HPAV controls currently classified as SC to SS or non-safety. These controls have previously been classified as SC because of the assumption that fragmentation of the route piping or in-line components could disable vessel mixing and hydrogen purge systems, leading to a vessel explosion. DOE has provided a letter of direction to modify the PDSA Addendum to modify the previous accident analysis methodology (10-NSD-055, *Directed Change to the Preliminary Documented Safety Analysis (PDSA) Affecting Hydrogen in Piping and Ancillary Vessels (HPAV) Control Strategy for Pretreatment (PTF) and High Level Waste (HLW) Facilities*).

Changes made as a result of revisions to the severity level calculation may result in reclassification of some HPAV controls designated as SS to non-safety. It is expected that these changes will be limited to HPAV controls associated with the LAW piping and inline components. HPAV controls designated as non-safety that are found through the ISM process to present a significant worker exposure hazard from potential reverse flow from pressurized process piping into C3 area flush or vent piping will be eliminated from the design.

The QRA could be used to determine loads imposed on piping systems more accurately than deterministic methods. Prior to use of the QRA in that fashion, inputs and assumptions made to support the QRA will be thoroughly and systematically examined to determine the need for TSR or safety SSCs. Implementation of the HPAV IRT team findings and recommendations is documented in a response plan, 24590-WTP-RPT-ENG-10-021, Rev 0, *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan* which also establishes the timeframe for implementation.

3.A.5.e) If the PTF design and PDSA are not fully consistent:

Question 3.A.5.e)(1) *What remains to be done to align the PTF design and the PDSA?*

Response 3.A.5.e)(1) The PTF PDSA and the PTF PDSA Addendum, are continuing to evolve as the uncertainties identified in the original PTF PDSA Addendum are addressed and the revised HPAV design criteria are implemented. The process for bringing the PTF PDSA and the design into alignment requires that the hazards and accidents associated with the proposed changes be evaluated, the PTF PDSA updated and the design modified to reflect the updated PTF PDSA. The work necessary to bring the PTF PDSA and design into alignment is:

- Address uncertainties from the PTF PDSA Addendum and reissue the analysis that supports the PDSA (e.g., severity level calculation);
- Perform the hazards analysis of design changes committed in the PTF PDSA Addendum (i.e., PVV/PVP system);
- Complete the implementation of the revised HPAV design criteria;
- Revise the PTF PDSA to implement the PTF PDSA Addendum and supporting documents; and
- Issue the design implementing the approved changes to the safety basis document authorized for implementation (i.e., PTF PDSA or PTF PDSA Addendum

The AB maintenance process for the WTP does not allow design to be issued ahead of changing the AB, unless otherwise approved by DOE.

Question 3.A.5.e)(2) *When will the design and safety bases be fully consistent?*

> **Response 3.A.5.e)(2)** As part of the ongoing project planning update process, the schedules for completing the work to bring the PDSA and design into alignment are being developed.

Question 3.A.5.e)(3) *Which PTF system designs are not consistent with the current PDSA? Describe why the system design is not consistent with the current PDSA and provide the basis for each inconsistency.*

> **Response 3.A.5.e)(3)** The design of the PVP/PVV system is not consistent with the credited safety function in the PDSA Addendum.
>
> The AB which includes the PTF PDSA and the PTF PDSA Addendum leads the design in that the design or changes to the design may not be issued unless the design is in alignment with the AB. In cases where design has already been issued, changes in the PDSA may introduce inconsistencies between the PDSA and the issued design. In these cases, the inconsistency is identified, documented and resolved. The process to control implementation of AB requirements (new or modified) is described in procedure 24590-WTP-3DP-G04B-00001.

Question 3.A.5.e)(4) *For the PTF systems that are not consistent with the current safety basis, is BNI authorized to continue to procure safety related SSCs?*

> **Response 3.A.5.e)(4)** New design documentation and procurements can only be issued if DOE approval is received (the current mechanism for requesting DOE approval is the justification for continued design, procurement and installation (JCDPI)) or the conflict in the upper level documents (PDSA, SRD or BOD) is resolved. Where changes impact existing procurements, the affects are addressed on a case by case basis.

Question 3.A.5.e)(5) *For the systems that are not consistent with the current safety basis, which have components in fabrication?*

Response 3.A.5.e)(5) The PVP/PVV system is consistent with the current PDSA requirements for a passive vent path. However, once the PDSA addendum is approved and implemented, the PVP/PVV system will be inconsistent with requirements that changed the safety function from SS to provide an active vent path for vessel purges and to provide confinement and filtration of PVP/PVV exhaust during normal and upset conditions (24590-WTP-PSARA-ENS-09-0001, Section 3.2, Table 3). The PVP scrubber (PVP-SCB-02) has been partially fabricated. There are a number of items already delivered. They are:

- Scrubber Recirculating Pumps (PVP-PMP-01A/01B)
- HEME Drain Collection Vessel (PVP-VSL-01)
- HEME Drain Vessel Pumps (PVP-PMP-02A/02B)

Other components such as filters/housings, fans and other inline components have not yet been procured.

Question 3.A.5.e)(5)(a) *Does the lack of consistency impact component design criteria?*

Response 3.A.5.e)(5)(a) Yes. The requirements cannot be implemented into the system design as originally conceived when the requirements were established.

Question 3.A.5.e)(5)(b) *~~If~~ the lack of consistency impacts component design criteria has the fabrication of these components been placed on "hold" until the safety basis and design are consistent?*

Response 3.A.5.e)(5)(b) The PVP scrubber is the only major component that is awarded and not delivered. The fabrication is not progressing and is on hold for other design issues (revised ground motion (RGM) analysis) and due to other higher WTP project priorities with the supplier. WTP is working to develop an alternate safety strategy and also working with the supplier to develop a design solution. The components which have been delivered are not anticipated to be impacted.

Question 3.A.5.e)(6) *If a decision is made to proceed at risk (prior to assuring design and PDSA are consistent) with fabrication and/or installation, describe how that risk is quantified (in terms of schedule and cost) and communicated to DOE.*

Response 3.A.5.e)(6) Procedure 24590-WTP-GPP-SREG-002, *E&NS Screening and Authorization Basis Maintenance*, Section 3.2 requires quality affecting (i.e., Q) engineering design media (e.g., calculations, drawings), material requisitions, specifications, and supplier submittals to be consistent with the approved AB (i.e., safety basis documents and the SRD). Section 3.1.2 of the procedure itemizes the WTP AB documents and Appendix 2 of the procedure lists documents required to be screened for consistency.

In the event the document being screened is not consistent with the AB, Section 3.2 of the procedure requires the documents to be reconciled.

If the documents cannot be reconciled in time to support the project baseline, the procedure allows the preparation of a justification for continued design, procurement, and installation (JCDPI) in advance of the documents being reconciled. Performance of a JCDPI is the current process for requesting permission from DOE to proceed with design, procurement, or installation activities in advance of a formal safety basis change. 24590-WTP-GPP-SREG-002, Section 3.12 describes the JCDPI process.

The risk associated with moving forward with the design is not typically quantified in terms of cost and schedule. Only the schedule imperative (24590-WTP-GPP-SREG-002, Appendix 6, questions 3, 4, and 5) for moving design ahead of the PDSA and an evaluation of the consequences of moving forward are normally addressed by the established process.

If the risk of moving forward with the design exceeds the project threshold of $1 million as defined in paragraph 4.2.2, procedure 24590-WTP-GPP-PTF-003, *Project Risk Assessment and Management*, then the risk will be managed under the project risk management program as described in the same procedure. This process is illustrated on figure 7-4 of 24590-WTP-GPP-PTF-003.

Question 3.A.6 *Does the current PDSA meet all the requirements of 10 Code of Federal Regulations (CFR) Part 830? If not, describe the requirements that are not met and what is being done to address these deficiencies? It there are cases where the requirements are ambiguous or poorly defined, provide details of how the ambiguities affect the project?*

Response 3.A.6 The PTF PDSA and the PTF PDSA addendum are compliant with the requirements of 10CFR830, Subpart B, *Documented Safety Analyses*. Both documents present the safety basis for the PTF. The PDSA was prepared in accordance with the Rule required safe harbor methodology, DOE-STD-3009, *Preparation Guide for U.S. Department of Energy Nonreactor Facility Documented Safety Analyses*. The PTF PDSA Addendum (and supporting calculations) were prepared consistent with the safe harbor methodology. However, it has not been implemented into the PTF PDSA. This practice is acceptable and governed by procedure.

Implementation of the QRA tool will be consistent with the Rule required safe harbor methodology. Nuclear safety will review the QRA when release for use to identify the initial conditions and assumptions required to be protected by TSRs as specified in DOE-STD-3009, Appendix A.

WTP has prepared procedures to govern the development and maintenance of the Authorization Basis as required by 10CFR830, Subpart A, *Quality Assurance Requirements*. The PTF has planned and scheduled an effort to complete the systematic evaluation of the mixing results. That activity will lead to updates of the process flowsheets, P&IDs, model runs and complete the systematic evaluation of hazards. This process is required by 10CFR830, Subpart B. Given the significance level of the change, WTP will be developing a temporary process to use in lieu of existing procedures. The procedures as written would not allow release of an updated flowsheet, P&ID, etc without an update to the safety basis documents. The hazards analysis can not be completed without the revised process flow diagram and P&ID. The temporary process will modify existing WTP procedures and outline the requirements to govern the resolution of major technical issues. The PDSA will undergo one revision at the end of the resolution of the major technical issues.

If the Project needs to procure or install SSCs prior to the updated PDSA being reviewed and approved by DOE, a JCDPI will be prepared in accordance with established procedures (and 10CFR830.206) and submitted to DOE for approval.

Question 3.A.7 *Describe how BNI determined the resulting impact on operational complexity from changing the PTF design.*

Response 3.A.7 See the response provided to question 3.A.2.c).

Question 3.A.7.a) *Which operating procedures have been developed for the PTF?*

Response 3.A.7.a) No operating procedures for PTF have been completed at this time. The WTP is early in the process of developing operating procedures for the PTF . Currently, Plant Operations staff are performing noun naming and preliminary task analysis for PTF systems. The task analysis, when completed, will identify the specific activities required to operate the system. In the future, procedure sections will be developed from the task analysis.

Question 3.A.7.b) *Provide a list of these procedures and describe the design basis.*

Response 3.A.7.b) See response provided to question 3.A.7.a). The current approved design is used to perform the task analysis. Documents used to perform the task analysis include: safety basis documents, process flow diagrams, mechanical flow diagrams, mechanical handling diagrams, piping and instrumentation diagrams, ventilation and instrumentation diagrams, main electrical single line diagrams, plot plans, architectural drawings, general arrangement drawings, engineering specifications, system descriptions, vendor manuals and documents, and logic drawings.

Question 3.A.7.c) *Describe the degree of complexity in the current procedures.*

Response 3.A.7.c) As stated in the response to question 3.A.7.a), no operating procedures have been developed yet; however, when procedures are developed, DOE-STD-1029-92, *Writers Guide for Technical Procedures,* will be used to minimize complexity.

Question 3.A.8 *Based on the current state of procedure development, is the PTF too complicated to operate? Describe how this was determined. Describe steps taken by BNI and DOE to ensure that the final design is not too complicated to operate.*

Response 3.A.8 In 2002, the project initiated actions to address the lessons learned from the commercial nuclear industry by implementing design improvements of the PTF to manage the accumulation of hydrogen in piping under such unusual conditions. The Project has not yet developed operating procedures for PTF. Based on the current issued design with active HPAV controls, there is an administrative burden on the operating facility staff that is being addressed as described in the response to question 3.A.3.

At a senior management level, the WTP project has established a Safety Input Review Committee (SIRC) in accordance with 24590-WTP-GPP-SANA-011, *Safety Input Review Committee*, to review significant proposed changes to the safety basis.

Plant Operations staff are integrated with the design review process per 24590-WTP-3DP-G04T-00913, *Review of Engineering Documents*, 24590-WTP-3DP-G04T-00913. Plant Operations line management participates in review and approval of operating procedures as described in 24590-WTP-CPRO-ADM-0001, *Operations Procedure Administration*.

The design guide that defines the processes that will be used to determine what HPAV controls are necessary is 24590-WTP-GPG-M-0065, *Quantitative Risk Analysis Data Collection Process*. From the results of the system analysis that provides results on the frequency and severity of potential hydrogen events, the piping is then analyzed in accordance with design guide 24590-WTP-GPG-ENG-0143, *HPAV Stress Analysis Design Guide*. These processes still require a multi-disciplinary team to evaluate the design, operations, fault conditions and recovery plans for each HPAV-affected pipe route when evaluating the impact of accumulating hydrogen.

As the design matures and procedures are completed to support TSR surveillances and normal operations, Plant Operations Line Management review of each watch station duties and responsibilities will confirm control strategies. Simulator drills will validate Line Management decisions on watchstander duties and responsibilities.

In summary, to ensure the final design is not too complicated to operate:

- The SIRC provides senior management review of significant proposed changes to the safety basis.
- Plant Operations staff are integrated with the design review process.
- Plant Operations management reviews and approves operating procedures.
- A multi-disciplinary team evaluates each HPAV-affected pipe route.
- Plant Operations management reviews watchstation duties and responsibilities.

Simulator drills will be used to validate management decisions on watchstander duties and responsibilities.

Question 3.A.8.a) *What metrics are in place to monitor the effectiveness of management controls necessary to prevent the final design from becoming too complicated to operate? When were the metrics developed and implemented?*

Response 3.A.8.a) No quantitative metrics are in place. See 3.A.8 for programs and processes being used to monitor the effectiveness of management controls to ensure that the final design is appropriately informed by an operations perspective.

Question 3.A.8.b) *Describe each metric, how the metric is tracked, and the measured effectiveness of each (if known).*

Response 3.A.8.b) See response provided to question 3.A.8.a).

Question 3.A.8.c) *What actions are taken in response to unacceptable metrics?*

Response 3.A.8.c) Actions are not taken in response to quantitative metrics. Actions are taken in response to the identification of complexity during normal work processes.

As previously noted:

- The SIRC provides senior management review of significant proposed changes to the safety basis.
- Plant Operations staff are integrated into the design review process.
- Plant Operations management reviews and approves operating procedures.
- A multi-disciplinary team evaluates each HPAV-affected pipe route.
- Plant Operations management reviews watchstation duties and responsibilities.

One of the following options or a combination of these options would be considered to address a complexity challenge:

- Additional resources or redistribution of watchstander duties
- Automation
- Revision of the control strategy
- Changes to the design
- Changes to procedures.

Question 3.A.9 *Has DOE documented the lessons learned resulted from the design being too complex to operate?*

Response 3.A.9 No, there has not been a Lessons Learned submitted to the official Lessons Learned program.

Question 3.A.9.a) *Describe each lesson learned.*

Response 3.A.9.a) No, there has not been a Lessons Learned submitted to the official Lessons Learned program.

Question 3.A.9.b) *Describe what was done to communicate these lessons learned to other Department of Energy-Environmental Management projects and other DOE organizations.*

Response 3.A.9.b) No, there has not been a Lessons Learned submitted to the official Lessons Learned program.

3.B Management of Safety-related Risk.

BNI and DOE have a number of processes in place to manage technical and project risks. Describe these processes, their intended objectives, and the methods of managing technical and safety risk.

The WTP management of Risk is defined in two project documents: 24590-WTP-PL-PR-01-003, *Risk Management Plan*, and 24590-WTP-GPP-PTF-003, *Project Risk Assessment and Management*. A brief summary of each is provided here:

- 24590-WTP-PL-PR-01-003, *Risk Management Plan*
  This Risk Management Plan (RMP) describes the strategic approach for assessing and managing threats and opportunities (both referred to as risk in this plan) for the WTP in accordance with DOE O 413.3A, *Program and Project Management for the Acquisition of Capital Assets* and the associated manual DOE M 413.3-1, *Project Management for the Acquisition of Capital Assets.*

  The objective of the RMP is to provide a systematic process for BNI to maximize the probability and consequences of positive impacts while minimizing the probability and consequences of adverse events. The risk management process described in this plan is implemented by procedure 24590-WTP-GPP-PTF-003, *Project Risk Assessment and Management.*

- 24590-WTP-GPP-PTF-003, *Project Risk Assessment and Management*
  This procedure implements the RMP and contains the minimum requirements for assessing and managing threats and opportunities (both referred to as risks in this procedure) for the WTP project in accordance with DOE O 413.3A, *Program and Project Management for the Acquisition of Capital Assets* and DOE M 413.3-1.

WTP does not identify or manage risk on the basis of safety function and therefore does not use the term safety-related in association with Risk. See the response to question 3.B.1.

Question 3.B.1 *Describe the processes in place for the management of WTP critical safety-related design risk.*

Response 3.B.1 WTP manages the cost and schedule risk to the project associated with the implementation of a compliant design that meets the design and safety requirements. In assessing that risk it is taken in context with a design that has not yet been confirmed to be capable of providing its intended safety function.

Procedure 24590-WTP-GPP-PTF-003, *Project Risk Assessment and Management* describes the process for the identification and management or risk on WTP. Risks are classified on the basis of their probability of occurrence and consequence impact level (cost). Procedure section 4.2 and Table 4-3 Risk Level Determination explain how risks are classified on WTP. Risks with an overall risk level determination of High are automatically selected as Critical risks to be managed. Moderate risks included in the top contributing threats to 80% of risk realization are also selected as Critical risks. However, other risks may be selected as Critical risks by the Project Risk Manager or Joint Risk Management Team (JRMT) for additional management attention based on additional criteria such as:

- Is the scope of the risk significant to the project?
- Does the risk require high priority mitigating actions that require Senior Management involvement?
- Are the mitigation activities for the risk significant (e.g. scope, cost, schedule)?
- Is the potential consequence of the risk event near-term?

Procedure Section 4 describes the processes to Identify (4.1), Quantify (4.2), Risk Handling (4.3), Define Impacts (4.4), and Monitoring, Reporting, and Closure (4.5).

Question 3.B.1.a) *Describe the process to manage critical design risks and the need to develop, when required, alternate designs for risk mitigation.*

Response 3.B.1.a) As described in the response to Question 3.B.1, the process to manage design risk is described in procedure 24590-WTP-GPP-PTF-003, Section 4.2 describes the processes for identifying critical risks. Procedure Section 4.3 describes the process for selecting a risk handling strategy, which includes Avoid, Mitigate, or Accept. When the expectation is that the Probability of occurrence cannot be eliminated, the focus of the risk handling approach is to reduce or mitigate the impact of the risk occurring. This does not mean that the likelihood of occurrence cannot be reduced. Rather, it is recognized that the likely outcome is that the risk cannot be prevented from occurring. Based on this determination, the risk handling strategy and Risk Response Plan (RRP) scope is to focus on elimination and/or minimization of the impact if the risk occurs. If appropriate to the risk handling strategy, the risk response plan may include the use of an engineering study to evaluate alternate solutions to an engineering problem and formulate mitigation methods. Engineering studies on WTP are performed in accordance with procedure 24590-WTP-3DP-G04B-00016, *Engineering Studies.* The performance of the study and results would be tracked on the Risk Sheet as Actions with assigned Action Lead and Forecast finish dates. See *Project Risk Assessment and Management* Section 4.3.2.

Procedure Section 4.5 describes the processes for Monitoring, Reporting, and Closure of a risk. Risk tracking ensures that RRPs are effectively implemented and executed. The assigned Risk Lead is responsible for tracking individually assigned risks from identification to final resolution and closure. Key (critical or otherwise selected by the JRMT) risks are reviewed at least monthly during Area Project Reviews and/or Integrated Project Team (IPT) review meetings.

Question 3.B.1.b) Is BNI currently carrying alternate designs forward as a means of risk mitigation?

Response 3.B.1.b) No alternate designs are currently being pursued as a means of risk reduction. For all current risks, alternate designs may have been studied as a risk mitigation action, but a single design solution is selected and carried forward for risk mitigation.

The risks that propose design changes as a means of risk mitigation for PTF systems, structures or components include:

- ENG-048, Capital and Schedule Risk for DOE Standard 1066 Compliance
- ENG-130, Revised Safety Strategy based on MAR and HPAV Evaluations

- ENG-136, Decontamination Issues Associated with Relocating Equipment in R3/C3 Areas
- ENG-137, Ash Fall Design Impact
- ENG-143, PTF Control Building ITS Chilled Water and Support Systems
- ENG-151, PVP-PVV Impacts from M3, Solids Entrainment, etc.
- ENG-156, Mixing System Design Implementation (under development)
- PET-127, "Technical Maturation of CNP/CXP is Inadequate"
- DOE-047, "Technical Maturation of CNP/CXP is Inadequate – Equipment Option"

Question 3.B.1.b)(1) *If yes, describe each design alternative and the risks these alternatives are intended to mitigate.*

Response 3.B.1.b)(1) See response to question 3.B.1.b).

Question 3.B.1.b)(2) *For each alternative design, what information (e.g., tests, evaluations) is required to determine which design alternative to pursue?*

Response 3.B.1.b)(2) See response to question 3.B.1.b).

Question 3.B.1.b)(3) *When will all the decisions related to these design risks be complete?*

Response 3.B.1.b)(3) See response to question 3.B.1.b).

Question 3.B.1.b)(4) *What is the likely impact on each part of the high-level waste treatment system (i.e., waste retrieval, waste feed qualification, pretreatment, and vitrification) from implementing alternate designs later in the project?*

Response 3.B.1.b)(4) It is expected that there will be no impact on WTP's ability to meet contract requirements to receive, pre-treat, vitrify and qualify waste products resulting from implementing the design changes proposed for risk mitigation. See response to question 3.B.1.b).

Question 3.B.2 *Describe the parts of the PTF design that have the greatest safety-related design risk.*

Response 3.B.2 See response to 3.B.1. WTP does not identify or manage risk on the basis of safety function and therefore does not use the term safety-related in association with design risk. The design risks associated with safety-related systems is managed in the overall risk management program as described in the response to 3.B and in 24590-WTP-GPP-PTF-003.

The projects risks with the greatest design risks that are associated with safety-related systems include:

- ENG-130, Revised Safety Strategy based on MAR and HPAV Evaluations
- DOE-001, Design Authority Hydrogen In Pipe and Ancillary Vessels (HPAV) Case not accepted
- ENG-151, PVP-PVV Impacts from M3, Solids Entrainment, etc.
- ENG-137, Ash Fall Design Impact
- ENG-156, Mixing System Design Implementation (currently under development)

Question 3.B.2.a) *Describe the impact and the safety-related risks resulting from the revised HPAV safety design strategy and the resolution of pulse jet mixing design issues on each part of the high-level waste treatment system.*

Response 3.B.2.a) Since the implemented design will be consistent with the safety basis, there is no risk directly related to safety. The impact of the project risks are detailed in individual Risk Assessment Sheets per 24590-WTP-GPP-PTF-003. Refer to the response to question 3.B.2 for a list of the design risk sheets that pose the greatest impact on PTF cost/schedule.

Question 3.B.2.b) *Describe the impact safety-related risks have on plant operability. How were these impacts determined and how are they being managed?*

Response 3.B.2.b) See response to Question 3.B.2. WTP does not identify or manage risk on the basis of safety function and therefore does not use the term Safety-related in association with design risk.

The projects risks with the greatest design risks that are associated with safety-related systems include:

- ENG-130, Revised Safety Strategy based on MAR and HPAV Evaluations
- DOE-001, Design Authority Hydrogen In Pipe and Ancillary Vessels (HPAV) Case not accepted
- ENG-151, PVP-PVV Impacts from M3, Solids Entrainment, etc.
- ENG-137, Ash Fall Design Impact
- ENG-156, Mixing System Design Implementation (currently under development)

Question 3.B.2.c) *Describe the potential impact these safety-related risks have on the feed delivery system. How are these impacts determined and how are they managed?*

Response 3.B.2.c) See response to Question 3.B.2. WTP does not identify or manage risk on the basis of safety function and therefore does not use the term Safety-related in association with design risk.

Potential impacts from a revised safety strategy are not expected. Controls are still required for sampling to verify compliance with waste feed acceptance criteria.

Potential impacts to the design of the feed delivery system from the pulse jet mixing design are not anticipated. The current WTP design has the ability to dilute the feed stream or modify the rheology of the feed stream once it is transferred to the WTP. The only potential impact is on the number of batch transfers that may be required.

Question 3.B.2.d) *Describe the potential cost and schedule impacts on each part of the high-level waste system resulting from safety-related risks in the PTF design.*

Response 3.B.2.d) The *Risk Management Plan,* 24590-WTP-PL-PR-01-003, defines the WTP risk program which estimates commercial costs and schedule impacts associated with implementing the project plan, including major technical risks. Because the implemented design will be consistent with the safety basis, there is no risk directly related to safety. The forecasted realization value for the design risks is included on the Risk Assessment Sheets in the individual risks under the Residual Forecast. Refer to the response to question 3.B.2 for a list of the design Risk Sheets with the greatest impact on PTF cost/schedule.

Question 3.B.2.e) *Describe any safety-related design risks that will not be resolved until "cold" commissioning.*

Response 3.B.2.e) At present no safety-related design risks, other than some aspects of PJM mixing as discussed below, have been identified that would require cold commissioning to close the risk.

The potential risks associated with the pulse jet mixing systems have been documented in the Technical Steering Group (TSG) M-3 Issue Closure records. The specific safety-related design risks are associated with limiting solids accumulation, release of gas, and the control strategies for criticality and hydrogen mitigation.

- CCN 208996, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package CXP-VSL-00026a/B/C), Inadequate Mixing System Design*
- CCN 214951, *Technology Steering Group -Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 2, Solids Free And Resin Storage Vessels), Inadequate Mixing System Design*
- CCN 221575, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 4, Low Solids Containing Vessels), Inadequate Mixing System Design*
- CCN 204767, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume- 5, PWD-VSL-00033/43/44), Inadequate Mixing System Design*
- CCN 220452, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 6, FRP-VSL-00002A/B/C/D), Inadequate Mixing System Design*
- CCN 220453, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 7, UFP-VSL-00001 A/B), Inadequate Mixing System Design*
- CCN 220454, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 8, HLP-VSL-00022), Inadequate Mixing System Design*

- CCN 220455, *Technology Steering Group -Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 9, FEP-VSL-00017A/B), Inadequate Mixing System Design*
- CCN 211816, *Technology Steering Group -Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Packaging Volume 10, RLD-VSL-00007), Inadequate Mixing System Design*

These closure records also document the recommendations to mitigate the identified risks. Specifically, these closure records recommend that a large scale test be performed prior to cold commissioning. With the conduct of this test, the remaining risks that can not be closed until cold commissioning will be associated with the integration of all 38 PJM mixed vessels with the control of the facility support systems (e.g., air and vent systems). Scaled testing prior to cold commissioning can not be utilized to minimize these risks.

Question 3.B.2.e)(1) *What are the potential cost and schedule impacts from carrying these safety related design risks into cold commissioning? For example, consider the Pulse Jet Mixing System:*

Response 3.B.2.e)(1) Potential cost and schedule impacts range from no impact due to improved performance during cold commissioning, to requiring in-place modifications of the impacted vessels and potentially the support systems. WTP is mitigating the potential risks associated with PJM mixing systems with the conduct of large scale testing and using a heel removal system and access ports to further mitigate the risk associated with PJM mixing systems. In addition, process control strategies are being evaluated to further mitigate the risks associated with the PJM mixing systems.

Question 3.B.2.e)(1).a *If large-scale pulse jet mixing tests were delayed until cold commissioning and the pulse jet mixing design did not perform as anticipated-what are the potential cost and schedule impacts from carrying these risks to that time?*

Response 3.B.2.e)(1).a Based on the potential impacts identified in the response to question 3.B.2.e)(1), WTP does not plan to delay the large scale pulse jet mixing tests until cold commissioning.

Question 3.B.2.e)(1).b *What is the range of potential impacts to the PTF if the Pulse Jet Mixing System design does not perform as anticipated?*

Response 3.B.2.e)(1).b The recommended pulse jet mixing system design is based on the best available knowledge of waste currently in the Tank Farms. In addition, the current design and operation of the WTP will control the pertinent waste conditions as it is received through pre-qualification and as it is processed through the WTP. The potential impacts if the PTF does not perform as anticipated range from being able to process the waste at higher concentrations than currently projected (improved performance and through-put rates) to requiring additional time to adjust (such as heel dilution / cleanout) for a limited amount of feed, expected to be less than 5% of the total batches (decreased performance), see the response to question 21.A.2 b). In all cases, the potential impacts are associated with process requirements (plant through-put) and will not impact the safety-related functions.

Question 3.B.2.e)(1).c *What is the range of potential impacts on the ability to vitrify tank farm wastes, consistent with the current plan, if the Pulse Jet Mixing System design does not perform as anticipated?*

Response 3.B.2.e)(1).c No impacts on the ability to vitrify tank farm waste have been identified due to the pulse jet mixing system design. As discussed above, potential impacts (e.g., improved or decreased performance) are associated with the PTF through-put.

Question 3.B.2.e)(1).d *What is the range of potential impacts on the feed delivery system from the pulse jet mixing design not performing as anticipated?*

Response 3.B.2.e)(1).d Potential impacts to the design of the feed delivery system from the PJM design are not anticipated. The current WTP design has the ability to dilute the feed stream or modify the rheology of the feed stream once it is transferred to the WTP. The only potential impact is on the number of batch transfers that may be required.

Question 3.B.2.e)(2) *What alternate means are available to resolve these safety-related design risks earlier?*

Response 3.B.2.e)(2) As discussed above, the use of large scale testing prior to cold commissioning has been recommended by the Technical Steering Group to mitigate technical risks associated with the M3 Issue closure. In addition, the completion of the computational fluid dynamics (CFD) verification and validation (V&V) and the completion of the vessel performance calculations to support the confirmation of the pulse jet mixed vessel design will mitigate the potential risks.

Question 3.B.2.f) *For those areas of the design with the greatest safety-related risk, how closely coupled is design and construction (duration between approval of the confirmed design and construction).*

Response 3.B.2.f) At present no safety-related design risks, other than some aspects of PJM mixing, as discussed previously, have been identified that would require cold commissioning to close the risk. The implementation of the additional PJMs, as recommended from M3 issue closure, puts the vessel analysis and design of the changes, fabrication, and vessel delivery/installation closely coupled, on or near the critical path.

Question 4. Waste Treatment and Immobilization Plant Safety Analysis

Responses to Question 4 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

Hanford Tank Waste Treatment and Immobilization Plant Project
Donna Busche, Environmental & Nuclear Safety Manager

Contributing authors:

U.S. Department of Energy - Headquarters
Richard (Chip) Lagdon, Chief of Nuclear Safety for Energy

Hanford Tank Waste Treatment and Immobilization Plant Project
Todd Allen, Safety Implementation Manager
Brad Erlandson, Environmental Manager
Andy Larson, Safety Analysis Manager
Mark Medsker, Pretreatment and High Level Waste Facilities Nuclear Safety Supervisor
John Minichiello, Vessels and Piping Technical Manager
Tom Patterson, Manager of Engineering

Question 4.A Accident Analysis Calculations

Question 4.A.1 *What value will be used for deposition velocity in calculating unmitigated dose calculations? Provide the technical basis for this value that justifies its use as being representative of the Hanford Site and WTP-specific conditions?*

Response 4.A.1 The value used in the WTP safety analysis for dry deposition is 1 cm/sec.

The revised WTP transport analysis uses the DOE MELCOR Accident Consequences Code System (MACCS2) atmospheric dispersion model default transport value for deposition velocity equal to 1.0 cm/sec. The Department's Chief of Nuclear Safety (CNS) evaluated this usage, found it to be acceptable, and documented in its use in the CNS Technical Paper, *Dry-Deposition Velocity Assumptions Used in Consequence Modeling at the Hanford Waste Treatment Plant.* Subsequently, the Board challenged the usage of a deposition velocity value of 1.0 cm/sec for the WTP, with its staff believing that a value between 0 – 0.3 cm/sec could be technically justified. (DNFSB letter to Under Secretary of Energy and Chief Health, Safety and Security Officer of May 21, 2010)

The CNS re-evaluated its technical position in light of the Board's comments, researched the issue further, and still believes that the usage of a default deposition velocity of 1.0cm/sec for the MACCS2 codes is technically defensible for reasonably conservative results in the case of unfiltered releases, given the level of uncertainty in the Gaussian Plume model used in MACCS2 analysis. CNS is revising its previous Technical Paper to incorporate additional information found in various NRC publications and other technical studies. The CNS Technical Paper will be peer-reviewed by a nationally-recognized expert in radiological risk assessment and environmental analysis who is suitably qualified to peer-review the paper.

Finally, it should be noted that sensitivity studies for the WTP indicate that equipment safety classification will not vary whether a deposition velocity of 0.1 cm/sec or 1.0 cm/sec is used in the calculation.

Question 4.A.2 *Discuss the technical basis for the WTP-specific methodology for spray leak scenarios.*

Response 4.A.2 The WTP specific methodology for spray releases was developed based on literature reviews and subject matter expert review. The details are provided in Sections 1 through 3 of 24590-WTP-RPT-ENS-10-001.

Question 4.A.2.a *Describe the technical basis supporting the WTP-specific methodology.*

Response 4.A.2.a The WTP specific methodology for spray releases was developed based on literature reviews and subject matter expert review. The details are provided in Sections 1 through 3 of 24590-WTP-RPT-ENS-10-001.

Question 4.A.2.b *What are the results from the DOE requested review of the WTP-specific methodology for spray leaks by DOE's Office of Health, Safety, and Security (HSS). If the results are incomplete, when will the HSS review be completed?*

Response 4.A.2.b The Office of Nuclear Safety Policy and Assistance (HS-21) within the Office of Health, Safety and Security (HSS) has been performing a review of the WTP-specific methodology for spray leaks utilizing the support of consultants from the nuclear industry including experts from the Information Systems Laboratories (a company which provides technical support to the U.S. Nuclear Regulatory Commission).

A draft technical analysis supporting an Information Notice to the DOE complex has been developed and is under initial stages of HS-21 management review. The analysis and Information Notice should be completed by the end of October 2010.

Question 4.A.3 *What specific accident analysis research would improve the accuracy and certainty of the WTP Safety Analysis and provide the worker and the public greater confidence in the calculations?*

Response 4.A.3 The calculations that support the WTP safety analyses have been reviewed to be accurate and consistent with the chosen methodology. WTP has identified several additional tests/research that would provide a higher confidence in the postulated consequences.

- Spray events. The correlations available to predict aerosol production from sprays are based on experiments with spray nozzles of various configurations using pure liquids. The experimental conditions are not representative of breaches that might be induced in process piping/vessels carrying WTP wastes. As discussed in 24590-WTP-RPT-ENS-10-001, the correlation selected for use in the WTP safety analysis was judged to be conservative. Testing could confirm this judgment and provide a basis for predicting the consequences from spray events at WTP that is based on conditions that are representative of WTP conditions.
- Waste entrainment from sparger airflow or fluidic device overblows. There are uncertainties related to entrainment coefficients appropriate for WTP wastes. This uncertainty has been addressed by adopting conservative entrainment coefficients derived from experiments with relatively dilute solutions. These results may not be representative of entrainment from WTP waste. Additional testing could provide a basis for entrainment coefficients derived from liquid more representative of WTP wastes and justify removing unnecessary conservatism in the safety analysis.

4.B PTF Primary Confinement Design

Question 4.B.1 *Describe the safety design strategy for the PTF confinement boundary.*

Response 4.B.1 The confinement strategy for the PTF follows the SRD, Appendix A, Section 5.1 by providing primary confinement including vessels, piping, and a dedicated vessel ventilation (system PVP/PVV). The design intent is that the primary confinement systems prevent and mitigate potential releases from waste processing activities. However, PTF design does not rely solely on the primary confinement systems. For events that could challenge the primary confinement systems, secondary confinement is provided by the C5 boundary and the C5V ventilation system.

Question 4.B.2 *Describe the active and passive features of the PTF primary confinement credited for safety purposes.*

Response 4.B.2 The features credited for nuclear safety are described in the PTF PDSA Addendum, 24590-WTP-PSARA-ENS-09-0001, in Tables 2 and 3. The SSCs that contribute directly to a confinement function are listed in Tables A and B (see below). Note that support systems, such as electrical power to exhaust fans, were not listed but should be considered as indirectly contributing to the confinement function. Tables A and B indicate whether the SSC is considered primary or secondary confinement, the functional classification of the SSC as presented in the PTF PDSA Addendum, and whether the SSC is active or passive.

Question 4.B.3 *Describe the safety classification and quality levels for each credited safety feature.*

Response 4.B.3 The safety classification of credited features that are part of the PTF primary confinement boundary are described in the PTF PDSA Addendum and reiterated Tables A and B below. The items identified as SC and SS features are designated Q, per procedure 24590-WTP-3DP-G04T-00905, *Determination of Quality Levels.*

The tables below present the results from the PDSA Addendum.

DNFSB Question 4 Table A:
Primary and Secondary Confinement SSCs Listed in Table 2 of the PTF PDSA Addendum

SC System (Major Components)	Credited Safety Function	Primary or Secondary	Functional Classification	Active or Passive
Facility structures including cells, filter cave, pit, and tunnels	Provide secondary confinement of radioactive materials.	Secondary	SC	Passive
C5V ductwork, stack and stack structural frame	Provide secondary confinement of aerosols and vent path.	Secondary	SC	Passive
C5V HEPA filters	Provide filtration of radioactive materials.	Secondary	SC	Passive
C5V fans and safety controls to transfer to standby fan	Provide secondary confinement of aerosols. Provide air for cell purge to prevent hydrogen accumulation during large hot/BC spill.	Secondary	SC	Active
C5 filter High dp alarm	Warn plant operators to allow actions to be taken to protect filters from rupture caused by high dp.	Secondary	SC	Active
Vessel headspace purge air piping, flow instruments, and PVP/PVV piping, collection header and in-bleed piping, and vent connections to C5 vessels including C3/C5 isolation valves	Provide pathway for air purge, dilution, and venting of Newtonian vessel headspace to prevent H_2 accumulation.	Primary (vessel vent portion)	Varies according to vessel serviced - see Table 5 of Addendum	Passive (vessel vent portion)
CNP and FEP Evaporator Separator Condensers Shells and Piping	Prevent post seismic disruption of H2 vessel purge air pathways, spread of contamination into C3 areas from PVP blowback.	Primary	SC	Passive
CNP Rectifier Shell and Piping	Prevent post seismic disruption of H2 vessel purge air pathways, spread of contamination into C3 areas.	Primary	SC	Passive

**DNFSB Question 4 Table A:
Primary and Secondary Confinement SSCs Listed in Table 2 of the PTF PDSA Addendum**

SC System (Major Components)	Credited Safety Function	Primary or Secondary	Functional Classification	Active or Passive
High Active Process Vessels and Isolation Valves, including piping between vessels and the valves CNP-VSL-00003 CXP-VSL-00001 FEP-VSL-00017A/B FRP-VSL-00002A/B/C/D HLP-VSL-00022 HLP-VSL-00027A/B HLP-VSL-00028 PWD-VSL-00015/16 PWD-VSL-00044 UFP-VSL-00001A/B UFP-VSL-00002A/B UFP-VSL-00062A/B/C	Prevent spills of large quantities of high activity process liquid into the Hot Cell.	Primary	Varies according to vessel - see Table 5 of Addendum	Passive (vessels and piping) Active (valves)
DOE HLW Inner Transfer Pipe	Provide confinement of high activity process liquids.	Primary	See Table 5 of Addendum	Passive
Vessel vent primary and secondary HEPA filters, and piping to the filter cave wall (section of piping necessary to protect the C5V boundary)	Provide confinement, and filtration of vessel aerosols. Provide PVP/PVV vent path for hydrogen mitigation.	Primary	SC	Passive
Vessel vent HEPA filter high dP alarm	Protect vessel vent HEPA filters from rupture caused by high dP.	Primary	SC	Active
PJV piping, flue, and HEPA filters, in-line component housings including primary and secondary filters, and demisters	Provide a flow path and filtration for fluidics exhausts.	Primary	SC	Passive
Vessel ventilation system fans, vent path, control systems, electrical power, and other necessary support SSCs (excludes portions of the system that can be bypassed or is not necessary for the function)	Provide active vent path for vessel purges	Primary	SC	Active
CNP evaporator separator waste confinement boundary CNP-EVAP-00001	Prevent evaporator piping rupture and sudden air intrusion, resulting in burp, or waste carryover to the Cs evaporator nitric acid rectifier.	Primary	SS	Passive
DOE HLW Outer Transfer Pipe	Capture leaks from inner pipe and direct them to PTF Hot Cell Drain SSCs.	Secondary	SS	Passive

DNFSB Question 4 Table A:
Primary and Secondary Confinement SSCs Listed in Table 2 of the PTF PDSA Addendum

SC System (Major Components)	Credited Safety Function	Primary or Secondary	Functional Classification	Active or Passive
High Active Process Piping and Valves CNP-VSL-00003 CXP-VSL-00001 FEP-VSL-00017A/B FRP-VSL-00002A/B/C/D HLP-VSL-00022 HLP-VSL-00027A/B HLP-VSL-00028 PWD-VSL-00015/16 PWD-VSL-00044 UFP-VSL-00001A/B UFP-VSL-00002A/B UFP-VSL-00062A/B/C	Prevent spills of large quantities of high activity process liquid into the Hot Cell.	Primary	Varies according to vessel - see Table 5 of Addendum	Passive
PVP/PVV piping and components inside the C5 areas from the vessel vent HEME housing inlet to the vessel vent primary HEPA inlet, piping and components downstream of the filter cave wall through the secondary	Provide confinement and filtration of PVP/PVV exhaust during normal and upset conditions. Maintain integrity of C5V boundary. Provides vent path for forced air purge of vessels.	Primary	SC	Passive
Vessel vent HEME boundary and element	Provide confinement and filtration of PVP/PVV exhaust during normal and upset conditions. Maintain integrity of PVP boundary. Provides vent path for forced air purge of vessels.	Primary	SS (element) SC (boundary)	Passive
Shield doors, SPADs, bulk shielding, and shielded hatches	Provide shielding for protection from direct radiation. Protect facility confinement function.	Secondary	SS	Passive
Vessel overflow piping for SS process streams	Provide confined pathway for vessel overflows to the ultimate overflow vessel to minimize aerosol generation.	Primary	SS	Passive
High Active Process bulge enclosures, drain and ventilation piping (i.e., PVP-BULGE-00001 PVP-BULGE-00002 PVP-BULGE-00014 CRP-BULGE-00001 ASX-SMPLR-00015 ASX-SMPLR-00017 ASX-SMPLR-00019 ASX-SMPLR-00020 ASX-SMPLR-00025)	Protect workers from a direct radiation and inhalation hazard by routing leaks from bulges to C5 areas.	Secondary	SS	Passive
Cs IX Columns (H_2 Hazards) (SS)	Provide primary confinement of process materials and to maintain an intact connection with the CXP hydrogen mitigation collection piping, and dilution systems.	Primary	SS	Passive

DNFSB Question 4 Table A:
Primary and Secondary Confinement SSCs Listed in Table 2 of the PTF PDSA Addendum

SC System (Major Components)	Credited Safety Function	Primary or Secondary	Functional Classification	Active or Passive
Cs ion exchange feed cooler and UFP Heat exchangers	Provide primary confinement of process liquids, the release of which to CHW system could exceed radiation exposure standard (RES) to facility workers.	Primary	SS	Passive
CNP and FEP evaporator separator reboiler tubes	Prevent process fluids from leaking into the steam condensate systems, and causing a direct radiation hazard in occupied areas.	Primary	SS	Passive
Hot cell berm, scupper drains, high active vessel overflow and drain piping to ultimate overflow vessel, and HLW effluent transfer vessel and sealpot	Direct liquid spills and vessel overflows in hot cell to the ultimate overflow vessel, and HLW effluent transfer vessel to minimize aerosol generation and control gross flooding of hot cell.	Secondary	SS	Passive

DNFSB Question 4 Table B:
Primary and Secondary Confinement SSCs Listed in Table 3 of the PTF PDSA Addendum

SS System (Major Components)	Credited Safety Function	Primary or Secondary	Functional Classification	Active or Passive
CNP evaporator separator waste confinement boundary CNP-EVAP-00001	Prevent evaporator piping rupture and sudden air intrusion, resulting in burp, or waste carryover to the Cs evaporator nitric acid rectifier.	Primary	SS	Passive
DOE HLW Outer Transfer Pipe	Capture leaks from inner pipe and direct them to PT Hot Cell Drain SSCs.	Secondary	SS	Passive
High Active Process Piping and Valves CNP-VSL-00003 CXP-VSL-00001 FEP-VSL-00017A/B FRP-VSL-00002A/B/C/D HLP-VSL-00022 HLP-VSL-00027A/B HLP-VSL-00028 PWD-VSL-00015/16 PWD-VSL-00044 UFP-VSL-00001A/B UFP-VSL-00002A/B UFP-VSL-00062A/B/C	Prevent spills of large quantities of high activity process liquid into the Hot Cell.	Primary	Varies according to vessel - see Table 5 of Addendum	Passive
PVP/PVV piping and components inside the C5 areas from the vessel vent HEME housing inlet to the vessel vent primary HEPA inlet, piping and components downstream of the filter cave wall through the secondary	Provide confinement and filtration of PVP/PVV exhaust during normal and upset conditions. Maintain integrity of C5V boundary. Provides vent path for forced air purge of vessels.	Primary	SC	Passive

DNFSB Question 4 Table B:
Primary and Secondary Confinement SSCs Listed in Table 3 of the PTF PDSA Addendum

SS System (Major Components)	Credited Safety Function	Primary or Secondary	Functional Classification	Active or Passive
Vessel vent HEME boundary and element	Provide confinement and filtration of PVP/PVV exhaust during normal and upset conditions. Maintain integrity of PVP boundary. Provides vent path for forced air purge of vessels.	Primary	SS (element) SC (boundary)	Passive
Shield doors, SPADs, bulk shielding, and shielded hatches	Provide shielding for protection from direct radiation. Protect facility confinement function.	Secondary	SS	Passive
Vessel overflow piping for SS process streams	Provide confined pathway for vessel overflows to the ultimate overflow vessel to minimize aerosol generation.	Primary	SS	Passive
High Active Process bulge enclosures, drain and ventilation piping (i.e., PVP-BULGE-00001 PVP-BULGE-00002 PVP-BULGE-00014 CRP-BULGE-00001 ASX-SMPLR-00015 ASX-SMPLR-00017 ASX-SMPLR-00019 ASX-SMPLR-00020 ASX-SMPLR-00025)	Protect workers from a direct radiation and inhalation hazard by routing leaks from bulges to C5 areas.	Secondary	SS	Passive
Cs IX Columns (H_2 Hazards) (SS)	Provide primary confinement of process materials and to maintain an intact connection with the CXP hydrogen mitigation collection piping, and dilution systems.	Primary	SS	Passive
Cs ion exchange feed cooler and UFP Heat exchangers	Provide primary confinement of process liquids, the release of which to CHW system could exceed RES to facility workers.	Primary	SS	Passive
CNP and FEP evaporator separator reboiler tubes	Prevent process fluids from leaking into the steam condensate systems, and causing a direct radiation hazard in occupied areas.	Primary	SS	Passive
Hot cell berm, scupper drains, high active vessel overflow and drain piping to ultimate overflow vessel, and HLW effluent transfer vessel and sealpot	Direct liquid spills and vessel overflows in hot cell to the ultimate overflow vessel, and HLW effluent transfer vessel to minimize aerosol generation and control gross flooding of hot cell.	Secondary	SS	Passive

Question 4.B.4 *Describe the unmitigated dose consequences to the public and collocated workers from radioactive releases postulated to occur from a breach in the primary confinement boundary.*

Response 4.B.4 The unmitigated dose consequences for breaches in the primary confinement boundary for bounding streams are presented in Table 1 of the PTF PDSA Addendum. The development of the consequences and the consequences for the bounded streams are discussed in calculation 24590-PTF-Z0C-W14T-00036, Revision 0A. Note t hat this calculation (24590-PTF-Z0C-W14T-00036) is being revised to address DOE and DNFSB comments. Consistent with the response to Question 4.B.2, the primary confinement boundary is comprised in vessels, piping, and the dedicated vessel ventilation system. The events in Table 1 of the PTF PDSA Addendum that represent breaches of that boundary are included in this response as Table C.

Question 4.B.4.a) *What initiating events can result in a breach of the primary confinement boundary?*

Response 4.B.4.a) In the unmitigated analysis, failure of the primary confinement boundary is postulated to occur due to a number of events. Such events include mechanisms internal to the primary boundary such as corrosion, erosion, and HPAV explosions, as well as forces external to the primary boundary, such as a seismic event or adverse interaction with another system. Initial controls have been identified to address each of these failure mechanisms.

Question 4.B.4.b) *What are the unmitigated dose consequences from breaches in the primary confinement boundary?*

Response 4.B.4.b) The unmitigated dose consequences for breaches in the primary confinement boundary for bounding streams are presented in Table 1 of the PTF PDSA Addendum. The development of the consequences and consequences of bounded streams is discussed in calculation 24590-PTF-Z0C-W14T-00036, Revision 0A. The results are summarized in the PTF PDSA Addendum and in Table C below. Note that this calculation (24590-PTF-Z0C-W14T-00036) is being revised to address DOE and DNFSB comments.

Question 4.B.4.c) *Which accident scenarios result in unmitigated dose consequences above the evaluation guidelines?*

Response 4.B.4.c) The unmitigated dose consequences for bounding accident scenarios are presented in Table 1 of the PDSA Addendum, 24590-WTP-PSARA-ENS-09-0001, Revision 2. The public exposure guideline is exceeded for hydrogen explosions in vessels. The collocated worker exposure guideline is exceeded for vessel spills, pipe leaks, self boiling, PJM overblow, hydrogen explosions in vessel, and ion exchange (IX) column reactions events. Both exposure guidelines are exceeded for seismic hydrogen explosions and the colocated worker exposure guideline is exceeded for seismic spills. Safety controls are provided to prevent or mitigate events with unmitigated consequences that exceed the guidelines. The functional classification, SC or SS, of these controls is based on the unmitigated consequence of the event and the function of the control in accordance with SRD Appendix A. The safety controls are assigned natural phenomena hazard (NPH) categories in accordance with SRD Safety Criterion 4.1-3.

Question 4.B.5 *Describe the strategy for meeting defense-in-depth requirements from DOE Order 420.1B, as applied to the design of the PTF primary confinement.*

Response 4.B.5

According to DOE Order 420.1B, Section I-3.b.(2), defense in depth must include all of the following

(a) choosing an appropriate site;
WTP is situated on the Hanford site as close as practical to the waste to be retrieved and treated. The WTP site is also as remote from public populations as possible and will be under Hanford Site support services and infrastructure.

(b) minimizing the quantity of MAR;
Waste volumes have been selected to provide only enough margin to meet mission goals of a 40-yr lifetime for the facilities to process the specified Tank Farms wastes.

(c) applying conservative design margins and quality assurance;
The WTP is designed to consensus codes and standards. The design codes and standards selected for Safety SSCs are listed in the SRD. These codes and standards provide conservative design margins. The quality assurance provisions on WTP are graded in accordance with an item's importance to safety and mission in accordance with the project 24590-WTP-QAM-QA-06-001, *Quality Assurance Manual.*

(d) using successive physical barriers for protection against radioactive releases;
The PTF design provides multiple confinement boundaries: a primary confinement boundary consisting of process vessels, piping, and vessel ventilation system; a secondary confinement boundary consisting of the process cells and C5V exhaust system; and a tertiary confinement boundary consisting of the area surrounding the process cell and the C3V exhaust system.

The PTF design incorporates provisions that protect the primary and secondary boundaries from events that could challenge their integrity. Examples include the following:

- Provisions to control accumulations of flammable gases in process vessels and piping
- Provisions to relieve pressure transients in vessels and piping
- Provisions to assure that the waste received at WTP is consistent with the facility design bases
- Provisions to control reagents added to the waste
- Provision of multiple sources of power and working fluid for critical active systems

(e) *using multiple means to ensure critical safety functions needed to —*
1 control processes,
2 maintain processes in safe status, and
3 confine and mitigate the potential for accidents with radiological releases;

The WTP will be operated by trained personnel in accordance with written procedures. The WTP design includes engineered control systems to support its operation. WTP uses normal control measures in the integrated control network (ICN) to provide oversight of systems and processes. The ICN includes automatic and operator control provisions along with oversight interlocks and alarms to provide reliable control. ICN monitoring and alarms afford the opportunity for early warning to halt deviations from normal operations. Also, the programmable protection system (PPJ) provides independent safety oversight of parameters and conditions in the event that the ICN fails to properly regulate the system or process being monitored. The PPJ system has complete override capability over the ICN and takes action to place the system or process into a safe status and maintain that safe status, ensuring waste material is confined and accidents prevented or mitigated. The PPJ system is SC, with fully redundant trains to meet the single failure criteria.

As noted under item (d) above, WTP incorporates multiple confinement boundaries which include provisions to mitigate the consequences of releases into the facility.

(f) using equipment and administrative controls that:
1 restrict deviation from normal operations,
2 monitor facility conditions during and after an event, and
3 provide for response to accidents to achieve a safe condition;

In addition to the ICN control system, operator actions to maintain normal operating conditions, and PPJ oversight discussed above, provisions for post accident monitoring are required for WTP systems and processes to ensure sufficient information is available to operators in the control room to ensure that a safe condition has been achieved and can be maintained.

(g) providing means to monitor accident releases as required for emergency response; and
Post-accident monitoring and a dedicated incident command post within the main control building, as well as a dedicated standby control room, ensures acceptable monitoring and response capability.

(h) establishing emergency plans for minimizing the effects of an accident.
WTP will have a general emergency response plan in addition to facility-specific emergency response and alarm response procedures. Commitment to an emergency response program is expected to be identified as a general programmatic administrative control in the TSRs.

Question 4.B.6 *What requirements are applicable to the PTF design for the detection of leaks from the primary boundary?*

Response 4.B.6 The requirements that are applicable are contained in 24590-WTP-DB-ENG-01-001, Section 14.10.1.2, *General Secondary Containment System Design Requirements and Performance Standards* for a dangerous waste tank system. BOD requirements are derived from Washington State Dangerous Waste Regulations, (WAC) 173-303-640(4), *Tank Systems, Containment and Detection of Releases*. The PTF PDSA and Addendum do not credit leak detection as a SC or SS function.

Table C Bounding Unmitigated Accident Consequences for PTF

Hazard/Accident	Bounding Source Term	Public Receptor		Collocated Worker		Primary Credited Control Strategies[4]	
		dose (rem)	PSL	dose (rem)	CSL	SSC[4]	Classification
Radioactive Material Drops	Waste drum or Contaminated Object	9.00E-02	PSL-5	8.60E+01	CSL-2	Waste drum cask C5V confinement	SS
Vessel Spills	HLP-VSL-00028	2.40E-01	PSL-4	2.24E+02	CSL-1	Vessel confinement[7]	SS
Vessel Sprays	CNP-EVAP-00001 (collocated worker) HLP-VSL-00028 (public)	9.83E-04	PSL-5	1.02E+00	CSL-4	Vessel confinement[7]	SS
Pipe Sprays	HLP-VSL-00028	1.12E-02	PSL-5	1.04E+01	CSL-3	C5V confinement	SS
Pipe Leaks	150 gpm for 8 hours	1.38E-01	PSL-4	1.28E+02	CSL-1	C5V confinement	SS
Self-boiling	HLP-VSL-00028	2.51E-01	PSL-4	2.35E+02	CSL-1	Vessel vent confinement	SS
[1,4]One PJM Overblow in Mode 1	UFP-VSL-00002B times 6 PJMs	1.78E-01	PSL-5	1.66E+02	CSL-1	Vessel vent confinement	SS
[1,4]One PJM Overblow in Mode 2	HLP-VSL-00028 times 8 PJMs	2.14E-01	PSL-5	2.00E+02	CSL-1	Vessel vent confinement	SS
One RFD overblow	CNP-VSL-00003	1.59E-03	PSL-5	3.25E+00	CSL-4	Vessel vent confinement	SS
Sparger overblow	HLP-VSL-00028	9.29E-02	PSL-5	8.67E+01	CSL-2	Vessel vent confinement	SS
Steam Ejector Overblow	CNP-EVAP-00001 (Collocated worker) UFP-VSL-00002B (Public)	5.45E-02	PSL-5	6.54E+01	CSL-2	Vessel vent confinement	SS
[1]Crush/Impact of PJM/RFD HEPA filter	25 filters	2.00E-03	PSL-5	1.83E+00	CSL-4	C5V confinement	SS
[1]Crush/Impact of Vessel Vent HEPA filter	5 filters	5.75E-04	PSL-5	5.05E-01	CSL-4	C5V confinement	SS
[1]Crush/Impact of PJM/RFD HEME unit	2 HEME units	8.06E-04	PSL-5	7.36E-01	CSL-4	C5V confinement	SS
[1]Crush/Impact of Vessel Vent HEME unit	2 HEME units	2.48E-03	PSL-5	2.18E+00	CSL-4	C5V confinement	SS
Hydrogen Explosion in Vessel	HLP-VSL-00028	>25.00E+00	PSL-1	>1.00E+02	CSL-1	Hydrogen mitigation Vessel vent exhaust[8]	SC
Ion Exchange Column Runaway REDOX Reaction	CXP-IXC-00001 (loaded resin bed)	2.35E-01	PSL-4	4.33E+02	CSL-1	Emergency elution	SS
Ion Exchange Column Fire	CXP-IXC-00001 (loaded resin bed)	2.13E-02	PSL-5	4.33E+01	CSL-2	Emergency elution	SS
Ion Exchange Column Hydrogen Explosion	CXP-IXC-00001 (loaded resin bed)	1.07E-03	PSL-5	1.92E+00	CSL-4	Hydrogen mitigation	SS
Spent Resin Vessel Spill	RDP-VSL-00002A (resin from one un-eluted column is accidentally transferred to the vessel and then spilled)	2.19E-04	PSL-5	4.47E-01	CSL-4	Vessel confinement[7]	SS
Seismic Spill	Total spill of all vessels	1.05E+00	PSL-4	9.93E+02	CSL-1	Vessel confinement[7]	SS
Seismic Hydrogen Explosion	Hydrogen explosion in vessels at 1,000 hours post earthquake	>25.00E+00	PSL-1	>1.00E+02	CSL-1	Hydrogen mitigation Vessel vent exhaust[8]	SC

1. For the PJM [pulse jet mixer] overblow and filter crush/impact scenarios, the SLA doses are presented on a per PJM or per filter basis and are multiplied by the number of PJMs or filters/units involved in the event as indicated in the following list. For other types of overblows, the SLA calculation presents a total system overblow that accounts for all units in the vessel.
- UFP-VSL-00002B has 6 PJMs per 24590-PTF-M6-UFP-00010007
- HLP-VSL-00028 has 8 PJMs per 24590-PTF-M6-HLP-00006007
- PJM/RFD [reverse flow diverter] (system PJV) number of HEPA filter is 25 per PTF PDSA Section 3.4.2.1
- Vessel vent (system PVV) number of HEPA filters is 5 per PTF PDSA Section 3.4.2.1
- PJM/RFD (system PJV) number of HEME filters (actually demisters) is 2 per PTF PDSA Section 3.4.2.1
- Vessel vent (system PVV) number of HEME filters is 2 per PTF PDSA Section 3.4.2.1

2. This column identifies the primary control strategy to meet functional classification requirements for the bounding event. In all cases, at least two physical barriers are provided: primary confinement provided by the vessels and piping, and secondary confinement provided by the facility ventilation systems with at least one barrier credited as SS.
3. Radioactive material drop events were not covered in the SLA calculation. The consequences presented are taken from the existing Design Basis Event sections of the PTF PDSA and do not incorporate any of the revised accident analysis inputs.
4. The two PJM modes refer to different air flows depending on the height of waste in the vessel. If the waste level is high, for example, greater pressure is needed in the PJM to achieve the same exit velocity through the nozzles. The two cases evaluated cover the range of PJM operation.
5. Deleted
6. Note that the C5V system and boundary are not credited for events that would require them to be SC. However, they are designated as SC for confinement to address uncertainty in the spray leak analyses as described in Section 2.7.
7. Vessel confinement includes process piping out to and including the seismic isolation valve.
8. Active function of the vessel vent system (PVP/PVV) is credited to provide a vent path for vessel purges.

NOTE: Table 1 represents summary level information on bounding consequences, overall control strategies, and minimum functional classifications. Detailed consequences are presented in the SLA calculation and actual functional classifications of SSCs are presented in Tables 2, 3, 4, and 5, below. In some cases, actual SSC functional classifications might be higher than listed in Table 1 because of uncertainties.

Question 4.B.6.a) Describe the performance characteristics of the PTF leak detection system from the Basis of Design.

Response 4.B.6.a) BOD Section 14.10.1.2 contains the following requirement: "Provide a leak-detection system that will detect the failure of primary tank system or the secondary containment system, the presence of any release of mixed or dangerous waste, or accumulated liquid in the secondary containment system within 24 hours of a leak (WAC 173-303-640[4][c][iii]). Note: Ecology has interpreted this requirement to mean the detection of 0.1 gallons per hour based on dangerous waste permit condition III.10.E.9.e.ii."

WAC 173-303-640[4][c][iii] does not identify a leak rate to be detected in 24 hours. Ecology used a underground storage tank (UST) tightness testing requirement as the basis (40 CFR 280.43(c)) for 0.1 gallons/hour permit condition.

There are no nuclear safety functional requirements for the PTF leak detection system.

Question 4.B.6.b) *Given the non-Newtonian character of some fluids in the PTF, what is the technical basis supporting the as-designed leak detection system's ability to meet the Basis of Design requirements for leaks involving these fluids?*

Response 4.B.6.b) The PTF leak detection system is not specifically credited to prevent or mitigate postulated consequences from liquid loss of confinement events (i.e., leaks). The facility structure and liner in the BCs and hotcell are credited for confinement of liquid spills.

Question 4.B.6.c) *What other features of the PTF design, relative to detecting or containing leaks and spills, serve a defense-in-depth function?*

Response 4.B.6.c) Defense in depth relative to detecting or confining leaks and spills is provided by the primary vessel and piping boundaries, seismic shutdown system, pump suction isolation valves, level detection in the vessel, stainless steel cell liner, leak detection system, operating procedures (e.g., monitoring and spill response), and secondary confinement provided by the C5V system and C5 boundary.

Question 4.B.6.d) *What are the performance requirements of these features?*

Response 4.B.6.d) There are no nuclear safety performance requirements specified for the leak detection system. The stainless steel cell liner has recently been credited to provide a confinement function in a working ISM.

The remaining features identified do have defined nuclear safety performance requirements described in Chapter 4 of the PDSA. The established functions will be updated to reflect the PDSA Addendum at the next revision.

Question 4.B.7 *Describe the consideration given DOE policy for design of the confinement boundary established in DOE Order 420.1B, in the current seismic design specification for piping and vessels for protection of collocated workers.*

Response 4.B.7 Chapter I, 3.b.(4) requires that hazard category 1, 2, and 3 nuclear facilities with uncontained radioactive material must have the means to confine the uncontained radioactive materials to minimize their potential release in facility effluents during normal operations and during and following accidents. Confinement design considerations must include

(a) for a specific nuclear facility, the number, arrangement, and characteristics of confinement barriers as determined on a case-by-case basis;

(b) consideration of the quantity, form, and conditions for dispersing the radioactive material in the confinement system

(c) use of engineering evaluations, tradeoffs, and experience to develop practical designs that achieve confinement system objectives;

(d) the adequacy of confinement systems to perform required functions as documented and accepted through the PDSA and DSA.

The PTF design provides multiple confinement barriers as described above in the response to question 4.B.5

The WTP hazard and accident analyses consider the quantity, form, and conditions for dispersing the radioactive material in the confinement system as evidenced in calculations 24590-PTF-Z0C-W14T-00036, 24590-PTF-Z0C-W14T-00002, and the accident analyses described in Section 3.4 of the PDSA.

The design of the WTP confinement systems is still evolving but it is informed by engineering evaluations, and experience and will achieve confinement system objectives.

Chapters 3 and 4 of the approved WTP PDSA demonstrates the adequacy of the confinement systems to perform their required functions.

The NPH categorization of SSCs on WTP is as specified in SRD Safety Criterion 4.1-3. The provisions of Safety Criterion 4.1-3 comply with the requirements of DOE O 420.1B, Chapter IV, and are consistent with the guidance in DOE-STD-1021-93 Chapter 2.0.

DOE G 420.1-2 states that *"When safety analyses determine that local confinement of high-hazard materials is required for worker safety, PC-3 designation may be appropriate for the SSCs involved."*

The WTP design is consistent with this statement. Releases of highly radioactive material may occur in the PTF hotcell or BCs. These areas are inaccessible to workers. Releases of radioactive material in the PTF BC and hot cells are confined within the C5 boundary. The components that make up this boundary include cell structures, ventilation fans, ducting, and filters, which are designated SC (24590-WTP-PSARA-ENS-09-0001). In addition, for added protection, WTP has committed to designing all piping and vessels inside the BCs to the SC-I requirements (BOD, Sections 16.4.2.1 and 16.4.2.7), and to designing the hot cell pump suction isolation valves for the vessels listed in

Appendix B.4 of the BOD to the SC-I requirements. Designing these SSCs as SC-I provides additional assurance of confinement in SC-I events.

The policies established in the April 15, 2009 memorandum from James Owendoff,, Chief Operations Officer for Environmental Management, *Implementation of DOE-STD-1189, Integration of Safety into the Design Process in Environmental Management Activities* do not apply to WTP per Attachment 2 to that memorandum.

Question 4.B.7.a) *For those piping systems, inline components, and vessels that are currently designated with a lower seismic design requirement, what consideration was given to revising the seismic design requirements to be consistent with DOE's stated expectations (i.e., a higher seismic design requirement when needed for collocated worker protection)?*

Response 4.B.7.a) The applicable DOE criteria and expectations are described above in response 4.B.7, and the WTP design is consistent with those criteria and expectations. The WTP design protects the worker with an SC-I barrier: the physical structure (walls, slabs) of the cells and the C5V exhaust System.

The design philosophy for WTP has always been to locate passive elements of the primary confinement in an inaccessible BC and to place active in-line components that form part of the primary confinement boundary in a hot cell where they are accessible only via remote maintenance. This maintenance philosophy dictates the use of jumpers in the hot cell to allow removal of inline components. A worker is not permitted in either the BC or hot cell areas. The functional classification of the confinement function of the hot cell piping has always been SS, or lower. Consistent with safety criterion 4.1-3, these features are designated SC-III (PC-2) or lower. This, coupled with the SC-I barriers noted above, provides adequate protection for the workers and the public and achieves the DOE expectations for local confinement of high hazard materials.

Question 4.B.7.a)(1) *Describe the expectations from DOE policy and how they are addressed.*

Response 4.B.7.a)(1) The expectations from DOE policy that apply to WTP are discussed in the response to 4.B.7. These include the suggestion that a PC-3 designation may be appropriate for local confinement. As further discussed in the response to 4.B.7.a) above, the WTP design addresses this expectation with an SC-I confinement barrier and a commitment to design to SC-I requirements all BC vessels and piping, and the high activity vessel pump suction valves.

Question 4.B.7.a)(2) *Describe the technical basis for determining that a higher seismic design requirement was not needed to protect collocated workers.*

Response 4.B.7.a)(2) As explained in the response to question 4.B.7. protection of the worker is consistent with DOE G 420.1-2. by providing an SC-I (PC-3) barrier between the worker and the hazard. In addition, for added protection, WTP has committed to designing all piping and vessels inside the BCs to the SC-I requirements (24590-WTP-DB-ENG-01-001, Sections 16.4.2.1 and 16.4.2.7), and to designing the hot cell pump suction isolation valves for the vessels listed in

Appendix B.4 of the *Basis of Design* to the SC-I requirements. Designing these SSCs as SC-I provides additional assurance of confinement in SC-I events.

Question 4.B.7.b) *If the unmitigated dose from an accidental release of radioactive material to the collocated worker is above the established evaluation guidelines what consideration was/is being given to revising the seismic design requirements for those components?*

Response 4.B.7.b) As explained in the response to question 4.B.7., protection of the worker is consistent with DOE G 420.1-2. by providing an SC-1 (PC-3) barrier between the worker and the hazard, which prevents the dose from being above the established guideline. In addition, for added protection, WTP has committed to designing all piping and vessels inside the BCs to the SC-I requirements (24590-WTP-DB-ENG-01-001, Sections 16.4.2.1 and 16.4.2.7), and to designing the hot cell pump suction isolation valves for the vessels listed in 24590-WTP-DB-ENG-01-001, Appendix B.4 to the SC-I requirements. Designing these SSCs as SC-I provides additional assurance of confinement in SC-I events.

Question 4.B.7.c) *In the PTF hot cell, describe design alternatives being developed to address the release of radioactive material due to a seismic event.*

Response 4.B.7.c) There are no additional design alternatives necessary to address release of radioactive material in the hot cell resulting from seismically induced damage. See the response to questions 4.B.7 above.

Question 4.B.7.c)(1) *Describe the critical performance characteristics of these design alternatives.*

Response 4.B.7.c)(1) As noted above there are no additional design alternatives under consideration. The performance requirements for the existing provisions are to isolate the high activity vessels in a timely fashion and to accommodate the aerosols released in the event. The detailed requirements are still being developed.

Question 4.B.7.c)(2) *Does the design alternative provide an equivalent margin-of-safety as would be provided by a higher seismic design requirement when needed for worker protection?*

Response 4.B.7.c)(2) As noted above there are no additional design alternatives under consideration.

Question 4.B.7.c)(3) *Describe the results of the analysis to determine that the design alternative provides an equivalent margin-of-safety.*

Response 4.B.7.c)(3) As noted above there are no additional design alternatives under consideration. Therefore, no such analysis exists.

Question 5. Hydrogen in Pipes and Ancillary Vessels

Responses to Question 5 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

Hanford Tank Waste Treatment and Immobilization Plant Project
Greg Ashley, Project Technical Director

Contributing authors:

U.S. Department of Energy - Office of River Protection
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration
Greg Jones, Nuclear Safety Specialist

CH2M HILL Plateau Remediation Company
Steve Additon, DOE Consultant

California Institute of Technology
Dr. Joseph Sheperd, DOE Consultant

Questions 5 through 12 are related to the WTP safety design strategy to assure that piping and ancillary vessels are not adversely affected by postulated hydrogen events (deflagrations and detonations). These events are referred to as "HPAV" events. The WTP safety design strategy for HPAV events has been, and continues to be, the provision of engineered features based on two options: 1) conservative design of the primary process fluid boundary to withstand HPAV events without compromise (passive accommodation); or 2) the addition of active systems designed to limit the accumulation of hydrogen to levels where the piping is not challenged by HPAV events. In either case, the goal is to provide high confidence of low probability of failure of the primary process fluid boundary due to an HPAV event.

The questions refer to the "revised HPAV safety design strategy" that is being implemented now to make passive accommodation practical in pipes up to 4 inches (nominal pipe size [NPS]) in diameter (approximately 80% of pretreatment piping affected by HPAV events). The responses are based on the DOE approved SRD, the BOD, and other supporting documents as noted in the individual responses. The revised HPAV safety design strategy is the result of insights gained through extensive testing and analysis performed by the Project to first understand and then to conservatively quantify the effects of an HPAV event on the WTP piping systems. The revised criteria and methodology are significantly more rigorous than previous requirements, including the requirement to consider: 1) potential for multiple events over the plant life, 2) multiple classes of events, and 3) previously unrecognized load components such as high frequency pressure oscillation. The revised criteria and methodology also introduce higher load limits (limited localized strain) for piping in the PTF hot cell that preclude failure with reduced margin recognizing that piping could be removed and repaired, if necessary. In the event of a leak or spray in the hot cell, the confinement design, including the C5 ventilation, ensures that the public and the worker are adequately protected. The revised HPAV criteria and methodology provide required assurance that the primary process fluid boundary is protected without requiring installation of additional active engineered controls that are judged to impair operational reliability and introduce additional worker safety risk.

Question 5.A *Describe the current (revised) HPAV safety design strategy, and describe the anticipated changes prior to cold start up.*

Response 5.A The Waste Treatment Plant falls under the provisions of DOE Order 420.1B, *Facility Safety*. This Order amplifies and supports the overarching requirements of 10 CFR 830, *Nuclear Safety Management*. Specifically, the safety case for WTP is required to integrate safety with design to "include multiple layers of protection to prevent or mitigate the unintended release of radioactive materials to the environment, otherwise known as defense in depth." Designers implement defense in depth by using multiple barriers to prevent the release of radioactivity to the environment and by designating a set of SC structures, systems and components (SSCs) and other hazard controls to protect the public. SC SSCs are coupled with a set of SS SSCs and other hazard controls to protect workers and reinforce defense in depth. For HPAV the facility most affected by any revisions to the design strategy is the Pre-Treatment Facility (PTF). PTF piping, components and vessels comprise a first barrier to release of radioactivity, while the confinement building and associated systems for controlling and filtering releases offer a second barrier.

With the outer boundary of PTF having been chosen as a SC control as the predominant barrier of defense in depth, DOE has determined the PTF safety case to be consistent with this guidance. The outer or predominant means of mitigating uncontrolled releases consists of the building structure, including the cell structure (BCs and hot cell), and the C5 ventilation system. The C5 ventilation system would channel airborne particulate release within the cell structure to a common exhaust header where contamination would be removed by two stages of high efficiency particulate air filtration. Both the cell structure and the C5 ventilation system are designated as SC SSCs for ultimate confinement. The hazards being addressed by the HPAV occur within this SC confinement boundary.

As for the safety-related design objectives of HPAV piping and components in particular, DOE has determined that these piping and components are to be designated SS for defense in depth. The WTP safety design strategy is based on design to assure that the piping and inline component primary confinement function is not adversely affected by postulated HPAV events. The functional requirements and performance criteria for design of HPAV piping and components involve: 1) conservative design of the primary process fluid boundary to withstand HPAV events without compromise (passive accommodation); or 2) the addition of active systems designed to limit the accumulation of hydrogen to levels where the piping is not challenged by HPAV events; or 3) a combination of 1) and 2). Selection among the two approaches or some combination of the two is guided by engineering analysis, operating experience and DOE guidance that exhibits a preference for preventive over mitigative controls and passive over active controls.

The revised safety design strategy is implemented through the *Basis of Design*, 24590-WTP-DB-ENG-01-001, Appendix C, Revision 1p, which includes the use of a QRA tool to objectively evaluate options for hydrogen hazard management on an individual pipe-route basis. The QRA was not developed by BNI to justify the "as is" safety of an existing facility or to support the selection of events for consideration in the safety analysis. Rather, it is a design tool used to assess options for assuring compliance with the safety and reliability functions and performance criteria for piping and components potentially subject to the accumulation of explosive hydrogen mixtures.

It is anticipated that the piping analysis may show a current pipe route design does not meet the *Basis of Design* criteria. For example, a schedule 40 pipe may need to be increased to schedule 80, or a pipe support may require a heavier structural member. It is also anticipated that as the analyses demonstrate that certain piping runs meet the design criteria, active controls (piping, valves, instrumentation, and bulges) will be removed from the design. These are the types of changes anticipated in the design prior to cold startup.

Question 5.B *To what extent, if any, has DOE determined that gaseous deflagrations/detonations within the WTP primary confinement barrier (process piping systems and components) are acceptable in the WTP design? Describe the basis supporting this determination and the extent to which it will be incorporated into the WTP design. Is this a change from the pre-2008 design acceptance criteria, and if so, why was this change necessary?*

Response 5.B DOE approved HPAV functional performance requirements in the Preliminary Documented Safety Analysis Addendum with a SER issued November 2, 2009 that determined gaseous deflagrations/detonations within the WTP Pretreatment Facility process piping systems and components are acceptable if specified functional performance criteria are met. The pre-2008 design acceptance criteria also determined that gaseous deflagrations/detonations within the process piping systems and components were acceptable if specified functional performance criteria were met, and allowing deflagrations/detonations under certain conditions is not a change to the pre-2008 design acceptance criteria. However, there have been changes made to the specified functional performance criteria.

The pre-2008 design acceptance criteria stipulated a functional performance criterion of no significant piping system deformation (i.e., less than 0.2% strain). The revised BC/HTR functional performance criteria remain consistent with the pre-2008 practice with two clarifications: (1) certain loads need not be combined absolutely if it can be shown they are not simultaneously imposed, and (2) appropriate strain rate dependent yield stress may be used with justification. The approval of these changes is attributed to insights from the HPAV testing program.

For the hot cell remotable piping, the functional performance criteria has been changed to allow for a 50% load increase in the vicinity of a detonation (permits up to an estimated strain of 2.5%-2.8%). The approval of this change was based on maintaining appropriate margin to piping failure, the estimated improbability of cumulative damage from events occurring in a single location (large margins remained after a single event), and the fact that remotable piping in the hot cell is designed to be replaceable.

These changes were considered necessary because the insights gained from the experimental program indicated that the pre-2008 criteria were overly conservative and biased the design process inappropriately toward requiring active preventive systems in instances where passive accommodation would be adequate and preferable.

In a second SER issued February 15, 2010 (10-NSD-013), DOE approved substantially revised HPAV piping design criteria proposed for inclusion in the SRD following their review and acceptance by outside experts in the ASME B31.3 code and its application in the nuclear industry. These criteria implemented the functional performance requirements adding significant necessary sophistication to pre-2008 methods, which used overly simplified the loading mechanisms and neglected fatigue, for example.

Question 5.C *Identify other defense nuclear facilities that allow gaseous deflagrations/detonations in process piping systems that form the primary confinement boundary. If known, what is the safety design strategy for these facilities?*

Response 5.C Defense Waste Processing Facility (DWPF) and H Canyon designs at the Savanna River Site, have been evaluated to allow for gaseous deflagration/detonations in process piping. The safety design strategies for these facilities have not been provided as part of this response. Additionally, Los Alamos National Laboratory (LANL) DYNEX, with which the DNSFB is very familiar, is specifically designed to maintain its pressure boundary when subjected to repeated deflagrations/detonations. Criteria developed for these facilities provided important insights/guidance to inform the WTP.

Question 5.D *DOE approved the HPAV safety design strategy allowing permanent plastic deformation of piping (bulging) in the PTF hot cell. Why is this design approach preferable?*

Response 5.D BNI recommended this allowance for the hot cell anticipating that it would affect the practical capacity of some piping routes to passively accommodate potential hydrogen combustion loads. This recommendation recognized the inherent ductile capacity of the design and materials of construction utilized for the hot cell piping and components coupled with the low probability of the postulated HPAV events. In accepting this recommendation, DOE concluded that meeting the revised functional performance criteria that allowed limited deformation in the hot cell would preclude failure. In addition, any incremental risk of piping failure due to allowing this limited deformation in the hot cell, where repair was clearly possible, was warranted if it obviated active preventive systems on that route. Neither BNI nor DOE knows yet whether there are any such examples. As of the writing of this response, the specific analyses to identify these situation have not been performed.

It is not necessarily the case that allowing limited deformation in the hot cell represents any increased risk of piping failure. Review by external experts has noted that when the reliability of active controls is considered, designing piping to passively withstand the HPAV event may reduce the risk of piping failure. Given the conservatism in the HPAV design criteria, DOE views the trade-off as one between an extremely unlikely need for a readily accomplished repair, versus an additional active system with the potential both to disrupt operations significantly and to require additional equipment to be installed in enlarged bulges, posing some increase in worker hazards.

Question 5.E *Describe the safety-related benefits from allowing permanent plastic deformation to piping systems from gaseous detonations. What impact on the margin-of-safety resulted from allowing this design approach? How was the change in the margin-of-safety justified?*

Response 5.E "Safety-related benefits" cannot be ascribed to one particular element of a design criteria. The design criteria "in total" are developed to meet specific safety, functional and performance objectives. Engineering design must be based on an understanding of the safety hazards and operational goals of the plant and then must apply codes and standards as required. As discussed in the response to questions 7.A and 7.A.1, the design provisions that allow for plastic deformation of piping are consistent with the guidance provided in the ASME code for unusual circumstances and events. One aspect of the change in approach is to determine if the project can replace an active control or barrier with a passive control or barrier, which is the preferred method of control. The preference of passive design over active controls is defined as DOE in DOE-G-420.1-1, Section 2.1.1, and DOE-STD-3009 page A-8. The proposed changes were developed to ensure an adequate margin-of-safety. In the BC there was no change in the acceptance criteria, and therefore no impact on margin-of-safety. The allowance for permanent plastic deformation in the BCs is very low (0.2%). This strain is accepted as the elastic limit (yield stress) for the material. The BCs are the locations least likely to ever experience a hydrogen event since there are no operational components like pumps, valves or instruments that create potential sources of electrical or mechanical ignition. In addition, the possible ignition source due to thermal reactions is very low since the temperatures and pressures that WTP operates at are considerably lower than the critical conditions for auto-ignition.

In the hot cell the revised criteria provide a lower margin-of-safety against the failure limit. The allowance for permanent plastic deformation in the hot cells is higher but still maintains substantial margin to pipe failure. Also, the hot cells are remotely accessible for maintenance and jumper replacement should failure occur.

In order to develop the new criteria and methodology, BNI and DOE performed extensive testing and analysis over an approximate three year period, as described in enclosure 1 to BODCN 24590-WTP-BODCN-10-0001. As explained in the enclosure, the testing and analysis showed that the piping could withstand multiple high-level events without deformation.

There are still numerous conservatisms in the new analysis and design criteria that ensure adequate design margin as discussed in 24590-WTP-RPT-ENG-07-011, *HPAV Engineering Analysis and Design Methods*, Appendix I. Appendix I is not an exhaustive listing of conservatisms, but those considered major items in ensuring that sufficient margin exists for the hydrogen events that could be potentially encountered during the operational life of WTP. Added confidence is ensured by the use of a Q-designated quality level for material being used in HPAV-affected piping and components and all welds receiving full volumetric inspections.

Question 5.F *What alternatives did DOE evaluate prior to deciding to allow permanent plastic deformation?*

Response 5.F. DOE has considered the design options consistent with the safety design strategy described in 5.A. The specific design alternatives are: 1) conservative design of the primary process fluid boundary to withstand HPAV events without compromise (passive accommodation); or 2) the addition of active systems designed to limit the accumulation of hydrogen to levels where the piping is not challenged by HPAV events; or 3) a combination of 1) and 2). The criteria established are consistent with the necessary understanding of the safety, functional and performance requirements of the design. Selection among the approaches is guided by engineering analysis, operating experience and DOE guidance that exhibits a preference for preventive over mitigative controls and passive over active controls.

Question 5.G *Does DOE anticipate the possibility of leakage out of the primary confinement barrier as a result of a boundary breach resulting from gaseous deflagrations/detonations, and if so how will the leakage be confined and mitigated? What alternatives were considered?*

Response 5.G Yes, there is a low probability for leakage out of the primary confinement barrier, but design criteria for HPAV in 24590-WTP-DB-ENG-01-001, *Basis of Design*, Section C, provide adequate assurance that a breach due to a gaseous deflagration/detonation will not occur. Section 16 of the BOD provides added assurance that a breach will not occur in the BC/HTR areas and includes more stringent requirements above those in ASME B31.3 for all welding, and examination of BC/HTR piping.

Any leakage that does occur will be confined within the boundary of the C5 area (essentially the non-manned areas of the facility) and mitigated through the design of the structure and ventilation system including filters.

Other alternatives, such as double-walled piping would not mitigate other potential causes such as a leak from a PUREX connector in the hot cell. Confinement within the boundary of C5 provides for the safety of the collocated worker as well as public safety.

Question 5.H *From a safety perspective, why were the other alternatives inferior to allowing permanent plastic deformation or leakage of the primary confinement barrier?*

Response 5.H As stated in 5.F above, DOE has considered the design options consistent with the safety design strategy described in 5.A. The specific design alternatives are: 1) conservative design of the primary process fluid boundary to withstand HPAV events without compromise (passive accommodation); or 2) the addition of active systems designed to limit the accumulation of hydrogen to levels where the piping is not challenged by HPAV events; or 3) a combination of 1) and 2). The criteria established are consistent with the necessary understanding of the safety, functional and performance requirements of the design. Selection among the approaches is guided by engineering analysis, operating experience and DOE guidance that exhibits a preference for preventive over mitigative controls and passive over active controls.

DOE concluded that meeting the revised functional performance criteria that allowed limited deformation in the hot cell would preclude failure. Any incremental risk of piping failure due to allowing this limited deformation in the hot cell, where repair was clearly possible, was warranted if it obviated the need for active preventive systems on that route. As of early September, the specific analyses to identify such situation have not been performed. It is not certain that allowing limited deformation in the hot cell represents any increased risk of piping failure. Review by external experts have noted that when the reliability of active controls are considered, designing piping to passively withstand the HPAV event may have reduced the risk of piping failure. Given the conservatism in the HPAV design criteria, DOE views the trade-off as one between an extremely unlikely need for a readily accomplished repair versus an additional active system with the potential both to disrupt operations significantly if mis-operated and to force additional equipment to be installed in enlarged bulges posing some increase in worker hazards.

Question 6. Potential Impacts on the WTP Mission from Hydrogen Explosion in WTP Piping

Responses to Question 6 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

Hanford Tank Waste Treatment and Immobilization Plant Project
Greg Ashley, Project Technical Director

Contributing authors:

Hanford Tank Waste Treatment and Immobilization Plant Project
Dennis Hayes, Plant Operations Manager
George Matis, Commissioning Operations Manager
Jeff Monahan, Project Engineering Manager, Pretreatment Facility
Tom Patterson, Manager of Engineering
Mike Wentink, Technical Issues Manager, HPAV & 1066

Question 6.A *Describe the design features capable of detecting deflagrations/detonations in process piping and inline components in the PTF (e.g., black cell and hot cell)?*

Response 6.A There is no plan to add design features specifically dedicated to detecting hydrogen events in process piping and inline components in the PTF. Certain features in the design may provide indication of a possible hydrogen event such as pressure detectors, level detection systems and weepage of liquids at jumper connections (detected by remote cameras); however, these types of events (e.g., pressure spikes, jumper leaks in the hot cell) are expected to occur during plant operations and could be unrelated to hydrogen events.

Question 6.B Recovery from leaks and spills from process piping

Question 6.B.1 *What design features aid in the recovery from a leak in the black cell (e.g., the ability to isolate process piping in the black cell, existence of redundant flow paths)?*

Response 6.B.1 BCs contain sumps with level detection to support waste removal should a leak occur significant enough to communicate fluid to the sump. Sumps also include a provision to allow video examination of the sump contents to aide in determination of the leak source. Provisions are made to provide access points into BCs should unforeseen maintenance or plant improvements become necessary. Such entrance points would not be designed for routine operations or maintenance, and would be used only in extraordinary circumstances and would involve robotics, not personnel entry (CCNs: 100140, 117871, 091022 and 24590-WTP-DB-ENG-01-001, *Basis of Design*).

The design of piping in the BCs includes requirements (24590-WTP-DB-ENG-01-001 Section 16) that minimize the potential for a leak. Potential actions required for recovery have not been developed at this time because the circumstances would be extraordinary.

BC vessels have piping that runs to wall nozzles in the hot cell. This provides some capability to reconfigure transfer paths to and from the vessel using jumpers to allow limited operations (or bypassing the vessel) depending on the need.

The project determined that redundancy for all vessels has not been a facility functional or design requirement. However certain vessels/unit operations, such as ultrafiltration, ion-exchange, feed receipt evaporation, HLW product storage, LAW feed receipt have a level of redundancy as part of the overall flexibility in the design. It should be noted that potential impacts on facility throughput have not been evaluated if these alternated flow path were utilized.

Question 6.B.1.a) *What design features restrict the amount of process fluids released from the primary confinement boundary following a leak from a black cell pipe?*

Response 6.B.1.a The design features that could be utilized to restrict the amount of process fluid released from the BC primary confinement boundary (vessels and pipe) are the vessel level indication and the sump and sump level indication. These level indications could be used to terminate transfer of process fluids to a vessel in a cell with a high sump level indication. The sump would then be used to return the process fluid to the Plant Wash and Disposal (PWD) system. A leak that includes sludge could result in solids settled on the BC floor after liquid removal by the installed sump. The method of solid removal and wash down of the liner plate would be determined in recovery planning. The cell design and C5 ventilation (both SC) provide assurance that the consequences of the leak are mitigated and that there are no unacceptable consequences to the public, the environment and the collocated worker. The design for piping in the BC (24590-WTP-DB-ENG-01-001 Section 16 for BC piping and Appendix C for HPAV criteria) minimize the potential for a leak in the BC by limiting the maximum strain allowed and designed using all welded, fully volumetrically examined, connections on process piping. No additional design features are deemed necessary.

Question 6.B.1.b) *What are the immediate recovery actions necessary to isolate and limit the loss of material from the primary confinement boundary?*

Response 6.B.1.b) Though not formally documented at this time, immediate recovery actions could be taken upon receipt of a high sump level indication/alarm and/or an abnormal vessel level indication inconsistent with expected vessel level. These actions would include termination of transfers (stop specific pumps), isolation of vessels using the hot cell isolation valves and initiating transfers away from the suspected leak. Once the leak is isolated, the waste would be directed to the sumps and ejected to the PWD system. A leak that includes sludge could result in solids settled on the BC floor after liquid removal by the installed sump. The method of solid removal and wash down of the liner plate would be determined in recovery planning.

Question 6.B.1.c) *What is the potential maximum volume of radioactive material that could be released from the primary confinement boundary?*

Response 6.B.1.c) The project has not developed an estimate at this time of the maximum volume of material that could leak from the primary boundary (vessels and piping) prior to completion of recovery actions to isolate and limit the leakage of material. Bounding assumptions have been made in the PTF safety basis for the unmitigated consequences of loss of primary confinement. These assumptions form the basis for selection of safety-related controls (the control strategy) for the PTF facility to assure that the public, the environment, and the worker are protected from the consequences of a failure of process vessels or piping

Question 6.B.2 *What is the estimated cost and process interruption required to fully recover from a pipe leak in the black cell (e.g., the repair of damaged equipment and a return to operations)?*

Response 6.B.2 The design requirements for piping in the BC (24590-WTP-DB-ENG-01-001 Section 16 and Appendix C for HPAV criteria) are intended to provide reasonable assurance that leaks will not occur. Therefore, estimates of costs and process interruptions associated with BC pipe leaks have not been developed.

Question 6.B.2.a) *Describe the potential actions required in recovery (e.g., spill clean-up, repair of piping, inspection of impacted components).*

Response 6.B.2.a) Recovery actions and procedures have not been documented at this stage of the project. Specific recovery actions would be determined contingent on the BC event and would be evaluated for consistency with the safety basis through the application of the Unreviewed Safety Question process. General initial actions would likely include: declaration of an event; notifications; assessment of event consequences; and system stabilization. Inspections could be conducted remotely with robotics, borescopes, cameras and use of the hot cell in-cell bridge crane with power manipulator to view from the hot cell side of the BC. Failure of piping or vessels is not expected. Access to the BCs is limited and is discussed in 6.B.1 and 6.B.2.b. The design requirements for piping in the BC (24590-WTP-DB-ENG-01-001 Section 16 and Appendix C for HPAV criteria) are intended to provide reasonable assurance that leaks will not occur.

Question 6.B.2.b) *Describe restrictions on recovery posed by the limited accessibility to a black cell (e.g., limited inspection capability, congestion, potentially high radiation dose).*

Response 6.B.2.b) BCs are closed cells where access is not planned during facility operation or scheduled shutdown periods (BOD, Section 16.2). They are located in WTP operating facilities which require a 40-year design life (Contract, C.7.(a)(1)). Provisions are made, however, to provide access points into BCs should unforeseen maintenance or plant improvements become necessary. Such entrance points would not be designed for routine operations or maintenance, and would be used only in extraordinary circumstances and would involve robotic, not personnel entry (CCNs: 100140, 117871, 091022 and 24590-WTP-DB-ENG-01-001).

Question 6.B.2.c) *Describe the results of DOE's evaluation of the cost and operational impacts from recovery.*

Response 6.B.2.c) The potential range of operational events that may require recovery actions has not been developed yet. Therefore, DOE has not performed an evaluation of the costs and operational impacts from such events.

Question 6.B.2.d) *What are the potential hazards for workers attempting to conduct repairs in a black cell (e.g., potential radiological exposures)?*

Response 6.B.2.d) As described in the response to 6.B.2.c) there has been no formal evaluation. However, if a repair in a BC were required, the repair work would be done remotely (e.g., robotics, manipulators, etc) without operator entry to ensure worker protection from radiological hazards.

Question 6.B.2.e) *How were potential worker hazards factored into DOE's approval of the HPAV safety design strategy? Describe the rationale for accepting the potential hazards to workers.*

Response 6.B.2.e) The basis for DOE's approval of the HPAV safety design strategy is contained in two SERs. The SER attached to DOE letter 09-NSD-044 (CCN 208458) in November 2009 provided conditional approval of the HPAV control strategy. Pages xviii, 37, and 38 of the SER contain DOE's consideration of potential worker hazards. A subsequent SER on the topic issued in February 2010, which was attached to DOE letter 10-NSD-013 (CCN 214109) and approved changes to the BOD, contains text associated with consideration of potential worker hazards on page 16.

Question 6.C *If a hydrogen detonation significantly damaged a hot cell pipe or component (e.g., the component is no longer operable, or a breach of primary confinement occurs) describe the worst case consequences to facility operations.*

Response 6.C The worst case consequences to facility operations are judged to be similar to those that would be encountered for normal equipment failures. The design requirements for HPAV piping and components are to ensure primary confinement. Some components may also be required to perform an active function, such as valve closure. Designing the piping and components in accordance with the HPAV criteria defined in the SRD and the BOD will preclude a breach of primary confinement and component inoperability (if that is a required function).

Question 6.C.1 *Describe the potential actions required in recovery (e.g., spill clean-up, repair of piping, inspection of impacted components).*

Response 6.C.1 As expected, recovery actions and procedures have not been documented at this stage of the project. However, hot cell recovery actions are expected to be consistent with those necessary to perform normal maintenance of failed hot cell equipment. Hot cell maintenance is designed for remote operations. Specific recovery actions would be determined contingent on the hot cell event and would be evaluated for consistency with the safety basis through the application of the Unreviewed Safety Question process.

Inspections could be conducted with the multiple cameras located on the in-cell bridge crane with power manipulator or robotic devices to verify equipment status, leakage, and damage to hot cell components. Damaged components could be flushed, removed, and transported to decontamination and maintenance locations for repair/disposal. Spare jumpers may not be available in every case. New jumpers could be fabricated based on dimensional record information.

Following removal and replacement of the equipment necessary to resume operation, it is expected that the equipment will be decontaminated to allow inspection necessary to determine the cause of failure. Failure of piping or vessels is not expected.

Question 6.C.2 *Describe restrictions on recovery posed by the limited accessibility to the hot cell (e.g., inspection capability, congestion, potentially high radiation dose).*

Response 6.C.2 Personnel access to the Pretreatment hot cell is not planned due to its classification as a C5/R5 area. Equipment within the hot cell is designed for remote access and recovery (BOD, Section 11.8.3.3). Recovery actions are described in the response to question 6.C.1.

Question 6.C.3 *Describe the existing capability to remotely repair piping and components in the hot cell.*

Response 6.C.3 Remotable hot cell jumpers which contain piping and components would first be removed from the hot cell with the hot cell crane. Once a jumper is removed remote decontamination and repair or replacement would then occur in the decontamination maintenance cave (Room P-0123A). The hot cell maintenance area contains maintenance stands, manipulators, a decontamination soak tank, size reduction equipment, viewing windows, tooling, and a separate 5-ton bridge crane to support decontamination and remote repair/replacement of components in the hot cell. Equipment in some case may be able to be decontaminated sufficiently for transportation to a glovebox for maintenance. This concept is similar to capabilities that have been successfully incorporated and used in the DWPF, a high-level waste vitrification facility at the Savannah River Site.

There is limited installed capability to maintain HTR piping in the hot cell. For this reason piping in the hot cell that is defined as HTR will meet the same design criteria as BC piping as defined per 24590-WTP-DB-ENG-01-001 Section 16.2.

Question 6.C.3.a) *What functional design requirements specifically support the repair, and mitigate the effects of damage to piping and components in resulting from an explosion in the hot cell?*

Response 6.C.3.a) 24590-WTP-DB-ENG-01-001 contains requirements in sections 9, 11 and 15. The *Operational Requirements Document*, 24590-WTP-RPT-OP-01-001 Section 9 and 14 also contains requirements on maintenance of hot cell equipment.

Question 6.C.3.b) *What is the range of the planned PTF repair capability of piping and components damaged by the effects of explosions?*

Response 6.C.3.b) Planned PTF repair capability is limited to remotable components. Please refer to Question 6.C.3 for a discussion of the existing capability to remotely repair/replace piping and components in the Pretreatment hot cell.

Question 6.C.4 *Does the planned repair capability specifically address deformation of piping and components?*

Response 6.C.4 Piping and components will be repaired when they no longer meet their functional requirements. As discussed in 6.C. conditions that warrant maintenance/repair are judged to be similar to those that would be encountered for normal equipment failures. As discussed in 6.C.1, following removal and replacement, the component will be inspected to determine the cause of failure. Inspection will include unexpected deformation, which could be an indication of an unexpected or unusual event.

Question 6.C.4.a) *What is the current capability to replace piping and repair or replace inline components that have been deformed by a hydrogen detonation?*

Response 6.C.4.a) See response to question 6.C.4.

Question 6.C.4.a)(1) *If an inline component damaged by a hydrogen detonation cannot be removed from the hot cell, what will be the capability to repair components in-place?*

Response 6.C.4.a)(1) The hot cell is designed such that jumpers (containing components and piping) are removed from their installed location and taken to the decontamination maintenance cave (Room P-0123A) at the far end of the hot cell for repair or replacement. Failure of a jumper that would preclude its removal is not anticipated. Therefore a remotable jumper that experienced a HPAV event would be removed and replaced or repaired. Please refer to the response provided to Question 6.C.3 for a discussion of the existing capability to remotely repair/replace remotable jumper (containing piping and components) in the Pretreatment hot cell.

Question 6.C.4.a)(2) *If an inline component damaged by a hydrogen detonation cannot be removed or repaired in-place, what alternatives are incorporated in the design to bypass the damaged component?*

Response 6.C.4.a)(2) Inability to remove a failed remotable jumper (containing piping and components) is not anticipated. See 6.C.4.a)(1). Remotable jumpers (containing inline components) in the Hot Cell have been designed to be repaired or replaced. BC and HTR piping will meet the criteria in 24590-WTP-DB-ENG-01-001, Appendix C.2.2.1, which are intended to preclude their failure.

Question 6.C.4.b) *Describe the results of DOE's evaluation of the cost and operational impacts.*

Response 6.C.4.b) Piping that has the potential to experience detonation events will either be designed to withstand the event or will be designed with active controls to prevent the event, thus there is no cost or operational impact associated with the detonation event for the piping. Damage from a detonation to an in line component (seal or seat leakage) may require replacement of the component; however, that replacement is expected to be no different from the replacement due to normal service life. Replacing/repairing jumpers and components will be a normal maintenance activity.

Question 6.C.4.c) *If manned entry were required, what is DOE's assessment of the hazards, particularly estimated radiological exposures, for workers entering the hot cell to conduct repairs?*

Response 6.C.4.c) See response to question 6.C.2.

Question 6.C.4.c)(1) *Describe DOE's assessment methods and results.*

Response 6.C.4.c)(1) See response to question 6.C.2.

Question 6.C.4.c)(2) *How did DOE's evaluation of the potential worker hazards impact the decision to approve the revised HPAV safety design strategy?*

Response 6.C.4.c)(2) The HPAV strategy is not based on manned entry into the hot cells. Hot cell piping is designed to withstand the event or will be designed with active controls to prevent the event. See response to question 6.C.2 for additional information on the WTP Hot Cell operational strategy.

Question 6.C.4.c)(3) *Describe the rationale for accepting the potential hazards to workers.*

Response 6.C.4.c)(3) See response to question 6.C.2.

Question 7. Discuss the Use of ASME Design Codes

Responses to Question 7 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

Hanford Tank Waste Treatment and Immobilization Plant Project
Greg Ashley, Project Technical Director

Contributing authors:

U.S. Department of Energy - Office of River Protection
Brad Eccleston, Mechanical Safety System Oversight Engineer

Hanford Tank Waste Treatment and Immobilization Plant Project
John Minichiello, Vessels and Piping Technical Manager
Tom Patterson, Manager of Engineering

Question 7.A *Is DOE relying upon ASME B31.3, Process Piping, provisions for the design of piping systems to withstand gaseous deflagrations/detonations? If not, then upon what consensus design code is DOE relying?*

Response 7.A DOE is using ASME B31.3 (1996) and ASME B31 Code Case 178 for the design of piping systems to withstand gaseous deflagrations (WTP Report 24590-WTP-RPT-ENG-07-011, Revision 3, Sections 7.1.4.1 and 7.1.4.3). Pending resolution of the HPAV Independent Review Team (HPAV IRT) comments, stress combination criteria more conservative than ASME B31.3 Code Case 178 may be used for deflagration stresses.

DOE is relying on the ASME B31.3 (1996) provisions noted in paragraphs 300(c)(3) and 300(c)(5) for the design of piping systems to withstand gaseous detonations:

(3) Engineering requirements of this Code, while considered necessary and adequate for safe design, generally employ a simplified approach to the subject. A designer capable of applying a more rigorous analysis shall have the latitude to do so, but must be able to demonstrate the validity of that approach.

(5) The engineering design shall specify any unusual requirements for a particular service. Where service requirements necessitate measures beyond those required by this Code, such measures shall be specified by the engineering design. Where so specified, the Code requires that they be accomplished.

ASME B31.3 does not address the highly impulsive pressure loading due to a detonation event, for which the peak lasts milliseconds. Since this is an unusual requirement, B31.3 requires the designer to address it and permits the use of a more rigorous approach, provided the validity of that approach is justified. This is also consistent with DOE Order 420.1B, Section 4b, which states in part:

> All new construction, as a minimum, must comply with national consensus industry standards and the model building codes applicable for the state or region, supplemented in a graded manner with additional safety requirements for the associated hazards in the facility that are not addressed by the codes.

Question 7.A.1 *What is the maximum plastic deformation allowed ASME B31.3?*

Response 7.A.1 ASME B31.3 does not specifically limit or address plastic deformation. However, it contains design provisions that allow for plastic strain. As stated in Paragraph 319.2.3(a) of ASME B31.3:

> (a) In contrast with stresses from sustained loads, such as internal pressure or weight, displacement stresses may be permitted to attain sufficient magnitude to cause local yielding in various portions of a piping system.

Because detonation loading is not addressed in B31.3, as noted in response 7.A, the provisions of paragraph 300(c)(3) and 300(c)(5) are used to develop a set of acceptance criteria for the event. Independent Code experts reviewing this approach specifically noted in their report that the Code allows for this situation.

Question 7.A.2 *What is the maximum plastic deformation allowed by the DOE approved HPAV safety design strategy?*

Response 7.A.2 The current DOE approved plastic strain limit in the BC/HTR piping areas is 0.2% through wall average strain (WTP Report 24590-WTP-RPT-ENG-07-011, Revision 3, Section 7.1.4.1, and the SRD, Appendix C, Section 26). Outside the BC/HTR piping areas, as indicated in the cited references, the current limit is a load limit that results in plastic strains on the order of 2.5% - 2.8%.

Based on the HPAV Independent Review Team Report, Finding F4-5, BNI will be changing the acceptance criteria outside the BC/HTR to be a plastic strain limit of 2.8% through wall average strain in any single event, with a further limitation that the cumulative plastic strain from multiple events not exceed 8.4%. This will be documented in changes to SRD Appendix C-26, the BOD Appendix C, and the PDSA.

Question 7.A.3 *Does the ASME design code require periodic inspection in piping systems that allow permanent plastic deformation? If yes, how does DOE propose to perform these inspections?*

Response 7.A.3 The Code does not address requirements for in-service inspections, as indicated in paragraph 300(c)(2), ASME B31.3 (1996), which states:

(2) This Code is not intended to apply to the operation, examination, inspection, testing, maintenance, or repair of piping that has been placed in service.

However, the Project anticipates there will be in-service inspections of all piping (except in the BC/HTR areas, which are not accessible) and is evaluating the type and periodicity of these inspections.

Question 7.A.4 *How will DOE determine if permanent plastic deformation has occurred?*

Response 7.A.4 DOE does not plan to determine if plastic deformation has occurred. The operating contractor will establish a maintenance program to ensure SSCs are maintained to provide the required safety and operability functions. At this time the project does not expect to monitor plastic deformation. The control strategy is to design HPAV SSCs to prevent release of material and protect the primary boundary.

Question 7.B *DOE has approved the use of strain-rate-dependent material properties for the WTP piping design.*

Question 7.B.1 *Does ASME B31.3 explicitly allow the use of strain-rate-dependent material properties?*

Response 7.B.1 No, B31.3 does not explicitly provide design guidance for highly impulsive pressure loading for which strain-rate dependent material properties more accurately represent the piping behavior. However, as discussed in 7.A.1, B31.3 does recognize that unusual requirements for a particular loading may not be addressed by the Code. The Code provides for applying more rigorous analysis, such as the use of strain-rate dependent material properties, provided the validity of the approach is demonstrated.

Question 7.B.2 *If yes, under what conditions?*

Response 7.B.2 As noted above, B31.3 does not provide explicit guidance on this topic . However, the Code provides for applying more rigorous analysis, such as the use of strain-rate dependent material properties, with the condition that the validity of the approach is demonstrated.

Question 7.B.3 *Does DOE's allowed use of strain-rate-dependent material properties require the same conditions?*

Response 7.B.3 Yes, in that the project's use of strain-rate dependent material properties meets the B31.3 requirements for applying rigorous analysis for unusual requirements and then demonstrating the validity of the approach.

Question 7.C *Has DOE submitted a code case to the ASME regarding revised HPAV safety design strategy?*

Response 7.C DOE does not intend to submit a Code Case. As indicated in the response to question 7.A, ASME B31.3 provides the Owner and Designer latitude to develop methods and criteria where the Code does not provide them in provisions noted in paragraphs 300(c)(3) and 300(c)(5):

(3) Engineering requirements of this Code, while considered necessary and adequate for safe design, generally employ a simplified approach to the subject. A designer capable of applying a more rigorous analysis shall have the latitude to do so, but must be able to demonstrate the validity of that approach.

(5) The engineering design shall specify any unusual requirements for a particular service. Where service requirements necessitate measures beyond those required by this Code, such measures shall be specified by the engineering design. Where so specified, the Code requires that they be accomplished

Review by an independent code expert noted that a code case request is unnecessary. The expert noted that "*One answer that could be expected from the B31.3 Committee to that inquiry would be a standard response that the B31.3 Committee does not provide consulting. On the other hand, if the analysis and design methods were developed into a set of requirements, with the research presented as background, a code case (a published set of alternate rules) could be developed but it is my opinion that such an effort is unnecessary and essentially duplicates what is already permitted by B31.3 paras. 300(c)(3) and 300(c)(5).*"

Question 7.C.1 *If yes, describe the code case.*

Response 7.C.1 Not applicable/

Question 7.C.2 If not, does DOE intend to submit a code case?

Response 7.C.2 DOE does not intent to submit a code case.

Question 7.C.3 If DOE does not intend to submit a code case, describe the basis for this decision.

Response 7.C.3 See response above..

Question 8. Testing in Support of the Revised Safety Design Criteria for Pipes and Inline Components

Responses to Question 8 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

Hanford Tank Waste Treatment and Immobilization Plant Project
Greg Ashley, Project Technical Director

Contributing authors:

Hanford Tank Waste Treatment and Immobilization Plant Project
Tom Patterson, Manager of Engineering
Mike Wentink, Technical Issues Manager, HPAV & 1066

Question 8.A *Describe the test plan to verify that all inline components can withstand the effects of detonation. For example, describe the test plans for pumps, PUREX connectors, valves, and safety-related instrumentation.*

Response 8.A The test plan for components is scheduled to be complete by November 30, 2010. The plan will detail the required testing for each component along with the acceptance criteria to be used as defined in the *Basis of Design*, 24590-WTP-DB-ENG-01-001, Revision 1P which states:

Components such as jumper connectors, valves, jet pump pairs, etc. whose function cannot be demonstrated by analysis alone may be qualified by a combination of analysis and test as follows:

1. *Analyses per the criteria above as applicable for the component boundary.*
2. *Demonstrate other significant design aspects such as leak tightness of jumper connectors or valve operability, closure function and stem leakage by performing a bounding impulsive load test.*

The test plan shall include at a minimum:

- *Descriptions of the components, or class of components, being tested.*
- *Test acceptance criteria similar to those that would be used for the same functions in a seismic test.*
- *Specification of the criteria by which a tested item will be judged to have passed. These criteria shall be quantitative (e.g., no more than xx% plastic strain as measured by strain gauges installed on the most limiting parts of the component). However, for in-line components, such as valves, the criteria may be qualitative (e.g., no more than several drops per minute through failed packing, no visible damage to packing or gasket material, etc.).*

- *Damage to soft goods of a component, such as packing materials and seals are acceptable for limited leak rates that at normal system pressure do not result in spray or spill consequences that approach the limiting case DBE values.*
- *Qualitative criteria of no visible damage (i.e. cracking) of the major structural pieces of the component, that provide pressure boundary integrity, is allowed. Where visual inspection of the component surfaces is not possible, use of non-destructive testing will be employed.*
- *For replaceable components (i.e. instruments), potential failure to function properly after a PRC-DDT is acceptable*, unless they are required to operate to meet a safety requirement.

The HPAV testing conducted over the last three years and current experience with the QRA (model is defined in *Quantitative Risk Analysis of Hydrogen Events at WTP Development of Event Frequency-Severity Analysis Model*, 24590-WTP-RPT-ENG-10-008, Revision 1) has provided a basis for the loads that each component must be qualified for. The test specification will identify test conditions that bound, with margin, the frequency, and severity of the loads necessary to demonstrate that the component can perform its intended safety function (e.g. close to provide isolation) subsequent to repeated hydrogen events that are postulated to occur during the its operating life. Individual route QRA results will be checked to verify that equipment test conditions have bounded the demand on the piping route and associated components intended safety function.

The testing will be conducted under NQA-1 at a nationally recognized test facility similar to the HPAV testing conducted at Southwest Research Institute, and will be a part of the WTP environmental and seismic testing program. This test program will be developed and conducted in compliance with ANSI/IEEE Std 323-1983, if necessary for the particular type of component, as required by the WTP SRD.

Question 8.B *Describe the design criteria applied to each component.*

Question 8.B.1 *Will the current criteria from the WTP Basis of Design be used; if not, then what specific design criteria will be used?*

Response 8.B.1 As discussed in 8.A, components may be qualified by analysis, by test or by a combination of analysis and test. The criteria in the WTP *Basis of Design* (24590-WTP-BD-ENG-01-001) were developed explicitly for the WTP piping systems. More general requirements are provided for components qualification.

Criteria for components qualified by test will depend on the individual component and the component's safety function. For example, a particular size and type valve may be subjected to five (5) detonations at a maximum detonation pressure of 800 psi as part of the type testing qualification program, which includes margin on the expected severity and frequency of hydrogen events shown by the QRA. The QRA results may show this valve will actually be subject to two detonations at a maximum detonation pressure of 400 psi over the life of the plant. Assume the safety function of this valve is to provide primary confinement of the waste and it has no other safety function. The acceptance criteria for this particular valve would be that the valve body remains intact with minimal permanent deformation, but the soft goods, such as the valve packing, may fail. Test Acceptance Criteria would require that the primary confinement boundary remain intact, via leak rate testing and visual examination. After testing it would be documented for the specific system that the valve was tested for five (5) events of severity 800 psi and is only subject to two (2) events at 400 psi. Thus, the valve is acceptable for use in the system, because the testing envelopes the intended system function.

As mentioned above valves are installed on jumpers. Jumpers are attached to each other and to the permanent plant piping using remote handled mechanical connections. These connections are qualified for bulk confinement. The acceptance criteria for the valve would be consistent with that of the jumper it is installed on. Minor leakage may be present through failed soft goods such as the stem packing seal, but the valve body, bonnet, and stem disc/ball assembly remain in intact and qualified for bulk confinement of the waste.

As a second example, the valve discussed above now has an additional safety requirement to close and isolate the waste after the HPAV event. An additional acceptance criterion will be that the valve functions (fails closed) after the five (5) detonation test loadings. It may still exhibit minor leakage past the seats, but it must remain functional such that is can be opened and closed.

In either case, it would be documented for the specific system that the valve was tested for five (5) events of severity 800 psi and is only subject to two (2) events at 400 psi. Thus, the valve is acceptable for use in the system, since the testing envelopes the intended system conditions.

For components qualified by analysis, WTP has developed loading models of all the potential HPAV events and those loads can be used to analyze components in a finite element model to determine resulting strain or deformation on the component. The acceptance criteria will be consistent with the criteria for piping, i.e., Code or Standard limits for deflagration loading and strain criteria for detonation and higher loading. It is expected that this would be applied to simple in-line components where maintaining the pressure boundary is the required safety function.

Specific requirements for all components will be documented as part of component qualification. -

Question 8.B.2 *For those current criteria that are qualitative, explain why qualitative criteria are adequate.*

Response 8.B.2 Qualitative acceptance criteria (e.g. "no visible damage") will not be the sole means of acceptance of a component's post test functionality and serviceability. Qualitative criteria are complimentary to quantitative measurements such as strain, leakage rate, and displacement. Test acceptance of a specific performance requirement will not be based solely on qualitative criteria.

Question 8.C *Which components will be verified by analysis, and which will be verified by testing?*

Response 8.C A complete list showing which components will be verified by analysis and those that will be verified by testing will be available by November 30, 2010. Those that will require testing include complex components such as valves having an active safety function. Components having simple geometries and safety functions may be qualified by analysis. See *Basis of Design*, 24590-WTP-DB-ENG-01-001, Appendix C.

Question 8.D *What is the schedule for completing the testing or analysis to qualify inline components? Will testing and evaluation be completed before components intended for plant installation begin fabrication?*

Response 8.D The tentative schedule will be to complete all testing of inline components by early 2012. Testing and evaluations will be completed before components intended for plant operation are procured for delivery and installation. (See response to 8.B.1 above).

Question 8.E *What alternatives exist if a component cannot be qualified by testing or analysis?*

Response 8.E Two alternatives exist if a component cannot be qualified by testing or analysis:

1) An alternate component will be selected that can be qualified to meet the requirements, or

2) Implement a design feature, such as a flush or vent piping and associated components, to prevent the accumulation of hydrogen and thereby reduce the risk of a hydrogen event

Question 8.F *Discuss the results of the detonation tests performed on the 4 inches plug valve at the Southwest Research Institute.*

Response 8.F As indicated in *Phase II HPAV Gaseous Deflagration, Detonation, and Deflagration to Detonation Transition (DDT) Test Program Final Report*, sections 4.4 and 5.3, this test series consisted of a limited number of PRC-DDT experiments using a valve and pipe spool assembly. The objective was to evaluate whether the valve body and pipe spool would fragment under internal gas detonation conditions. Functional failure of the valve (i.e., damage to seals and internal components) was anticipated. The valve used in this test was a custom Flowserve Durco Mach® 1 4-inch diameter plug valve with the valve body and internal plug modified to allow for remote extraction of the plug and seal assemblies. It had been used in previous environmental tests conducted in 2005 that included seismic testing and end-of-life radiation exposure for seals and packing gland materials.

Experiments were conducted at an elevated initial pressure in an attempt to produce significant plastic strain in the pipe spool and/or valve. The goal was to demonstrate that the valve and pipe do not fail catastrophically (fragment) during the event, potentially resulting in loss of containment or damage to neighboring components. To verify the level of plastic strain achieved, diametrical measurements were made at five locations upstream of the valve. Measurements were taken before the start of experiment and immediately after each test.

Although internal damage to the 4-inch Flowserve valve plug and seal materials was observed during the Valve PRC-DDT experiments at three atmospheres initial pipe pressure, which resulted in a peak pressure on the order of 13,000 psi, neither the valve nor the pipe spool displayed evidence indicating the onset of fragmentation. In fact, the maximum strain observed in the piping was on the order of 0.33%.

Question 8.F.1 *What was the evaluation criteria used? Are these criteria the same that have been included in the basis of design?*

Response 8.F.1 This test was a demonstration test and not a component qualification test. The evaluation criteria were qualitative and were based primarily on observation and qualitative inspection.

Question 8.F.2 *What was the extent of damage to the valve in this test?*

Response 8.F.2 As indicated in *Phase II HPAV Gaseous Deflagration, Detonation, and Deflagration to Detonation Transition (DDT) Test Program Final Report*, sections 4.4 and 5.3, four PRC-DDT experiments were conducted on the 4-inch Flowserve Mach 1 plug valve and pipe spool provided by BNI. Experiments were conducted at 3 atmospheres initial pressure using gas mixtures ranging from 13.5% to 16% H_2. The gas mixture was varied with the goal of achieving a PRC-DDT condition at a location corresponding to approximately 90% of the pipe length. Although detonations were achieved on all tests, the maximum transition distance observed was only 77% of pipe length. Some damage to the plug and plug seal materials was sustained on the first two experiments, but damage induced during the third experiment was severe enough to prevent further testing (a pre-test vacuum could not be maintained). The observed damage included melting of the polymeric seal material along with deformation of the plug and valve seals. In an effort to continue testing, equivalent parts (plug and plug seals) were extracted from a new off-the-shelf valve (purchased from Flowserve with similar but not identical parts) and placed in the original valve body. On the fourth experiment the new plug and plug seal materials sustained similar damage resulting in termination of the test series. No damage to the valve body or production of fragments was observed in any of the four experiments. All valve materials and components remained attached to the valve or inside the pipe spool. Neither the valve nor the pipe spool displayed evidence indicating the onset of fragmentation and there was no visible sign of any bulging.

The cumulative permanent strain measured in the pipe after the four experiments ranged from 3333 μstrain (0.33%) to 889 μstrain (0.09%). Consistent with observations on the valve body, the pipe spool displayed no evidence indicating onset of fragmentation and there were no visible signs of any bulging.

Question 8.F.3 *Did the test achieve the desired maximum loading, i.e., a pressure reflected deflagration-to-detonation transition (PRC-DDT)?*

Response 8.F.3 Yes. Four PRC-DDTs occurred in this series of tests. The goal of achieving the PRC-DDTs at 90% of the pipe length, however, was not met due to termination of the tests. The four PRC-DDTs occurred at 54%, 68%, 65%, and 77% of the pipe length, resulting in maximum (peak) pressures on the order of 13,000 psi.

Question 8.F.4 *Will this valve design be used in the PTF in HPAV-affected piping systems?*

Response 8.F.4 The Flowserve Durco Mach® 1 plug valve design will not be used in HPAV affected piping systems. Project personnel have tentatively selected all metal seated ball valves. The reason this valve was tested is that it was readily available at a time no other typical components were available and because our primary focus was to study the possibility of fragmentation of the valve body, not the survivability of the internals. The Flowserve Durco Mach® 1 valve had been previously subjected to seismic and radiation aging before being used in the HPAV testing.

Question 8.G *The basis of design does not limit the use of the HPAV safety design strategy to pipes of 4 inches or less in diameter, yet the HPAV test program only tested pipes up to 4 inches in diameter.*

Response 8.G Approximately 95% of the HPAV-affected piping is 4 inch NPS and smaller. The intent of the BOD (24590-WTP-DB-ENG-01-001, Revision 1p) was to only apply the design criteria for qualification of piping for postulated HPAV events to piping 4 inch NPS at the Savanna River Site, and smaller in diameter. A BODCN has been prepared to clearly identify that the criteria are applicable to piping 4 inch NPS and smaller.

While the intent of the BOD is to only apply the design criteria for qualification of piping for postulated HPAV events to piping 4 inch NPS and smaller, it is important to note that the materials of construction of the larger piping are also austenitic stainless. Though there will be no attempt to qualify this piping for the postulated HPAV events (it will be protected with active controls), it is not credible to assume that this piping fail in a non-ductile manner (fragment) if subjected to an HPAV event. The HPAV IRT (*Hydrogen in Piping and Ancillary Vessels in the Pretreatment Facility of the Hanford Waste Treatment Plant - Report by an Independent Review Team for Bechtel National Inc. August 11, 2010)*, concluded that:

This supplemental independent assessment has found nothing in the open literature that would suggest fragmentation has ever occurred in any austenitic stainless steel pipes or tubes for HPAV operating conditions. Field experiences with pressure vessels and piping failures that have resulted in fragmentation have typically been in carbon and low alloy steels. The typical cause of these failures was very low fracture toughness, resulting in brittle failure. This independent assessment did not identify any problems with prior studies leading to the BNI conclusion to discount fragmentation in HPAV austenitic stainless steel piping (including the cold-worked bends) or in similar materials used in cast valve bodies.

Question 8.G.1 *Will the HPAV safety design strategy apply to pipes greater than 4 inches in diameter?*

Response 8.G.1 The HPAV analysis and design criteria for qualification of piping for postulated HPAV events will not be applied to pipes greater than 4 inch NPS as discussed in response to question 8.G above.

Question 8.G.2 *Does the project anticipate additional testing on pipes greater than 4 inches in diameter? If yes, when will this testing be done?*

Response 8.G.2 No additional testing is planned for piping greater than 4 inch NPS as discussed in responses to questions 8.G and 8.G.1 above.

Question 9.

Responses to Question 9 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

Hanford Tank Waste Treatment and Immobilization Plant Project
Greg Ashley, Project Technical Director

Contributing authors:

Hanford Tank Waste Treatment and Immobilization Plant Project
Tom Patterson, Manager of Engineering
Mike Wentink, Technical Issues Manager, HPAV & 1066

Question 9 *What specific research remains to be done to fully evaluate the HPAV effects to provide greater confidence in the worker and the public accident analysis calculations (e.g., explosion limits for small volumes of explosive gases embedded in waste; response of piping systems partially filled with waste; strain rate effects in structural response; estimates of rupture and fragmentation thresholds; dispersion resulting from gaseous explosion; standardized analysis methods for safety studies; code cases and guidelines for ASME Boiler and Pressure Vessel code and B31.3 piping code)?*

Response 9 Additional research is being planned to respond to the HPAV Independent Review Team (IRT) Findings. The additional research and analysis that will be performed is documented in the response plan, 24590-WTP-RPT-ENG-10-021, *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan.* The results of the additional research will be incorporated into the existing calculations. No new testing (other than component/equipment qualification) is anticipated at this time and the testing accomplished in the last three years is considered adequate to provide the confidence necessary to support analysis of HPAV events for design. The HPAV IRT concluded, based on the technical review, that the new design approach for HPAV piping and components is acceptable provided BNI resolves the findings which will improve the models, assumptions and methodology, and further stated that there is "*high confidence that*

- *The QRA approach is acceptable for defining loads to be used in design, and there is a low probability of exceeding either their frequency or their magnitude.*

- *The best estimate pipe stresses and strains, computed from the defined loads in the manner proposed by BNI, are not likely to be significantly exceeded.*
- *The combination of QRA load definitions, best estimate piping system response calculations and conservative acceptance criteria developed pursuant to the piping Code B31.3 provides a reasonable balance of probabilistic and deterministic elements appropriate for design of HPAV piping and components.*
- The net result of this approach to design will be a low probability of pipe failure if hydrogen explosions occur.

Question 10. Quantitative Risk Analysis

Responses to Question 10 were developed by:

Primary authors:

<u>U.S. Department of Energy - Office of River Protection</u>
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

<u>Hanford Tank Waste Treatment and Immobilization Plant Project</u>
Greg Ashley, Project Technical Director

Contributing authors:

<u>U.S. Department of Energy - Office of River Protection</u>
Greg Jones, Nuclear Safety Specialist

<u>Hanford Tank Waste Treatment and Immobilization Plant Project</u>
Donna Busche, Environmental & Nuclear Safety Manager
Dennis Hayes, Plant Operations Manager
George Matis, Commissioning Operations Manager
Tom Patterson, Manager of Engineering
Grant Ryan, Documented Safety Analysis Integration Manager
Mike Wentink, Technical Issues Manager, HPAV & 1066

<u>CH2M HILL Plateau Remediation Company</u>
Steve Additon, DOE Consultant

10 Quantitative Risk Analysis

Question 10.A *DOE does not have a policy or a standard for the use of QRA.*

Response 10.A DOE submitted and DNFSB accepted an Implementation Plan (Letter, A. Wallo, DOE, to P. Winokur, DNFSB, *Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2009-1, Risk Assessment Methodologies at Defense Nuclear Facilities*) to respond to DNFSB Recommendation 2009-1. Both the Board recommendation and DOE's response address the limited policy and standard guidance available for risk applications for nuclear safety purposes, the bases for their use today, and plans underway to assess the need for further guidance.

Question 10.A.1 *What DOE direction and guidance was provided for allowing the use of QRA Probabilistic Risk Analysis as a design tool at the WTP in the absence of a DOE approved standard?*

Response 10.A.1 A DOE sponsored HPAV Assessment Team Report (February 2009) recommended using QRA to determine the likelihood of events and the relative importance of hazards for each pipe route. Direction was given to BNI to proceed with determining the methodology and criteria on how the QRA was to be used as a design tool by approving Trends 24590-06-03317, 06-04210, and 06-04806. BNI proposed to use the QRA model to determine the potential combustion loads (severity and frequency) for each pipe route susceptible to deflagrations or detonations. Over the following year progress resolving the HPAV technical issue, including QRA development, received significant DOE oversight and was tracked monthly. DOE approved criteria for use of QRA for the Pretreatment Facility as a design tool in February 2010 (10-NSD-013). The approved criteria stipulated that maximum waste characteristics were to be used, that an ignition probability of one was to be assumed at maximum bubble size, that limiting events could not be probabilistically excluded, that structurally insignificant events could be omitted, and that complete model documentation was required. As discussed in the SER, these criteria imposed deterministic constraints on the QRA to ensure adequacy for its intended design purpose.

As part of DOE's response to DNFSB Recommendation 2009-1, a Risk Assessment Technical Expert Working Group (RWG) was established to assist in the review or development of methodologies for risk assessments. Through this group, DOE-HSS sponsored a Peer Review of the QRA to assess the available standards, the model and modeling assumptions, the data and uncertainties, and the QRA development process. Feedback and recommendations from this review were provided to WTP in a final report, *Peer Review of Waste Treatment Plant Quantitative Risk Assessment of Hydrogen Events in Piping and Vessels, dated May 28, 2010.*

Question 10.A.1.a) *If direction and guidance was provided, at what level was it approved and how and when was it documented?*

Response 10.A.1.a) See response to question 10.A.1.

Question 10.A.1.b) *What were the major concerns identified by DOE that necessitated the need to provide direction and/or guidance?*

Response 10.A.1.b) At the time the SRD criteria were being finalized and the SER was being prepared, the HPAV QRA was not a fully mature tool. DOE sought to differentiate those aspects of the model and its use that warranted approval by DOE as distinct from the many implementation details that were appropriately the purview of BNI as the design authority. The Project's HPAV experimental program provided strong evidence that piping systems could be made capable of withstanding more severe postulated hydrogen combustion loads. DOE judged it appropriate for piping systems that were to be relied upon to withstand such loads, however, to be specifically designed for them. Thus, several of the approved criteria serve to ensure that such loads are conservatively determined and that credible loads are not eliminated either through application of probabilistic techniques (showing them to be low in probability) or through any misapplication of such techniques. Drawing upon early WASH-1400 experience (Rasmussen Reactor Safety Study), documentation sufficient to ensure a scrutable product was also judged to be important. The SER (10-NSD-013) documents the basis for acceptance of the criteria.

Because no DOE standard or guidance currently exists that directly applies to the use of the QRA, the Peer Review sponsored by DOE-HSS was aimed at ensuring the QRA effort appropriately took guidance from process industry developed guidance and good practices.

Question 10.A.1.c) *Has QRA been used as a design tool in other nuclear applications?*

Response 10.A.1.c) One of the actions in the DOE IP in response to DNFSB 2009-1 is to evaluate DOE's present use of risk assessment tools in nuclear safety-related decision-making and identify any opportunities for improvement. The study is to be completed the end of September 2010. DOE will share the results with the DNFSB as part of the IP process.

Question 10.A.1.d) *Compare and contrast DOE QRA guidance to Nuclear Regulatory Commission guidance on PRA/QRA?*

Response 10.A.1.d) The HPAV IRT reviewed the QRA procedure for consistency with NRC guidance. This comparison is documented in the HPAV Independent Review Team Report, *Hydrogen in Piping and Ancillary Vessels in the Pretreatment Facility of the Hanford Waste Treatment Plant*, Section 2.2.2.

Question 10.A.2 *Did DOE evaluate the potential conflicts between the use of QRA at WTP and other DOE standards? Describe the results of this evaluation.*

Response 10.A.2 DOE has evaluated the potential conflicts between the use of QRA at WTP and other DOE standards in the development of the *DNFSB Recommendation 2009-1 Implementation Plan*, dated March 2010, which was accepted by the DNFSB. Specifically, see Section 2 of the 2009-1 IP where DOE notes that "DOE's predominant approach to managing safety relies on hazard-based deterministic analyses that are required by DOE nuclear safety directives and rules." DOE also points out "as identified in the Board's letter, the Department, in some cases, does utilize elements of risk assessment techniques as part of the development of safety bases for nuclear facilities..." but it "does not have a policy or requirements specifically focused on the use of the QRA for nuclear safety applications..." DOE-Standard (STD)-3009, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis, (the "safe harbor" for compliance with Code of Federal Regulations (CFR) Title 10, Part 830, Nuclear Safety Management, Subpart B), provides clear direction on the analyses that are required to support safety basis decisions and plainly states that the Department's approach does not require or expect the level of detail analysis necessary for a quantitative or probabilistic risk assessment.

DOE recently concurred on the response plan to address the findings of the HPAV Independent Review Team, 24590-WTP-RPT-ENG-10-021, *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan.* The response plan is being revised to address the Recommendations of the report and provide the WTP approach to integrate the QRA with the safety basis documents (as appropriate) relative to 10 CFR part 830 and specifically DOE-STD-3009. DOE will request the Technical Authority Board review and concurrence of the revised plan.

Question 10.A.3 *The Hydrogen in Pipes and Ancillary Vessels Independent Review Team (HPAV IRT) recommended that DOE adopt a de minimis screening criteria for eliminating initiating events and event sequences that have a low frequency of occurrence. However, DOE-STD-3009, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis, does not allow the use of cut-off frequencies to exclude operational accidents from further analysis (DOE-STD-3009, Appendix A). If this HPAV IRT recommendation were accepted by DOE, how would the conflict between the WTP's use of QRA and DOE-STD-3009 be resolved?*

Response 10.A.3 The QRA is a design tool being used to determine whether passive accommodation of the applicable postulated HPAV events for each route is possible. When the maximum pressure from credible HPAV events exceeds the practical passive capacity of the route, either a more robust passive barrier or active preventive controls must be specified. The basis for acceptance of this approach is documented in the February 15, 2010 SER (10-NSD-013) and is substantiated by the report of the HPAV IRT (24590-CM-HC4-W000-00182-01-00001, *Hydrogen in Piping and Ancillary Vessels in the Pretreatment Facility of the Hanford Waste Treatment Plant*).

The initial response and approach to addressing the de minimis screening criteria HPAV IRT finding is presented in 24590-WTP-RPT-ENG-10-021, *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan*. As described in this response plan, "our approach is to not screen events, regardless of frequency."

In order to maintain a meaningful and manageable QRA model, route-specific event sequences will require screening. This is also addressed in the response plan as follows: "The QRA team will propose quantitative screening criteria for route-specific event sequences to propose exclusion from the design model results of those sequences whose quantification is evidently outside the capability of the QRA model. Such criteria will be chosen to ensure that a broad range of sequence frequencies is always retained for the route-specific piping design. ... After sequences are identified for possible exclusion, they will be presented for engineering review (as discussed in the response to Finding 2-9) to evaluate and disposition them. The engineering review will examine the validity of the model for those sequences to verify that the excluded sequences are not credible or, if they are judge applicable to the route design, to prevent their exclusion. Applying this process to screen event sequences is judged to comply with the SRD requirement that the QRA 'not be used to exclude limiting events such as PRC-DDT that can occur for credible gas configuration conditions.' In other words, the defined screening process will not eliminate 'credible' conditions."

Question 10.A.4 *Has the use of QRA at the WTP been evaluated to determine if the QRA represents an acceptable method as described in 10 CFR Part 830? What was the outcome of this evaluation?*

Response 10.A.4 A formal evaluation to determine if the QRA represents an acceptable method as described in 10 CFR part 830 has not been performed. The QRA has not been finalized and its application is not fully defined.

DOE recently concurred in the response plan to address the findings of the HPAV Independent Review Team, 24590-WTP-RPT-ENG-10-021, *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan.* The response plan is being revised to address the Recommendations of the report and provide the WTP approach to integrate the QRA with the safety basis documents (as appropriate) relative to 10 CFR part 830 and specifically DOE-STD-3009. DOE will request the Technical Authority Board review and concurrence of the revised plan.

Question 10.A.5 *What role has DOE's HSS had with respect to the adoption of QRA for the WTP project?*

Response 10.A.5 As part its response to DNFSB Recommendation 2009-1, DOE established a Risk Assessment Technical Expert Working Group (RWG) to assist in the review or development of methodologies for risk assessments. Through this group, DOE-HSS sponsored a Peer Review of the QRA to assess the available standards, the model and modeling assumptions, the data and uncertainties, and the QRA development process. Feedback and recommendations from this review were provided to WTP in a final report, *Peer Review of Waste Treatment Plant Quantitative Risk Assessment of Hydrogen Events in Piping and Vessels, dated May 28, 2010.* The process for implementing the recommendations from this review are described in the response plan to address the findings of the HPAV Independent Review Team, 24590-WTP-RPT-ENG-10-021, *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan.*

Question 10.B The WTP is a first/one-of-a-kind facility with which DOE and BNI have no operating experience.

Question 10.B.1 *How was using QRA justified given the unique aspects of the WTP design? Provide this justification.*

Response 10.B.1 Quantitative risk analysis is used throughout the chemical and nuclear industries to assess hazards. The chemical process industry provides standard methodologies, such as *Guidelines for Chemical Process Quantitative Risk Analysis*, by the American Institute of Chemical Engineers (AIChE), Center for Chemical Process Safety (CCPS). There is nothing unique in the WTP design that prevents the use of QRA. The HPAV IRT evaluation of using the QRA for HPAV concluded:

The QRA approach is acceptable for defining loads to be used in design, and there is a low probability of exceeding either their frequency or their magnitude. The combination of QRA load definitions, best estimate piping system response calculations and conservative acceptance criteria developed pursuant to the piping code B31.3 provides a reasonable balance of probabilistic and deterministic elements appropriate for design of HPAV piping and components.

While there is nothing unique about WTP design that prevents the use of the QRA, the QRA is being used for a fundamentally different purpose than the typical PRA or QRA. Risk assessment techniques are typically used to evaluate plant wide accidents such as plant core melt frequency (CMF) or a large early release frequency (LERF). In the case of the WTP QRA, the objective is to provide route specific design input information related to the severity and frequency of hydrogen events for individual routes in order to prevent a plant accident by designing the piping to maintain pressure boundary integrity for the postulated events. The use of the QRA for the HPAV analysis and design is consistent with ASME Pressure Vessel Code Case 2564-1 which states in part the following:

(a) The User, or his Designated Agent, shall conduct a detailed analysis that examines all credible scenarios that could result in an overpressure condition. The Causes of Overpressure described in Section 4 of API Standard 521, Pressure-Relieving and Depressurizing Systems shall be considered. An organized, systematic approach by a multidisciplinary team employing one or more of the following methodologies shall be used:

(1) Hazards and Operability Analysis (HazOp)
(2) Failure Modes, Effects, and Criticality Analysis (FMECA)
(3) Fault Tree Analysis
(4) Event Tree Analysis
(5) What-If Analysis

In all cases, the User or his Designated Agent shall determine the potential for overpressure due to all credible operating and upset conditions, including equipment and instrumentation malfunctions.

Question 10.B.2 *The HPAV IRT has recommended the use of expert elicitation to develop the QRA.*

Question 10.B.2.a) *If this recommendation is accepted by DOE, what DOE standard(s) will be applied to the WTP's use of expert elicitation?*

Response 10.B.2.a) In the absence of DOE standards for expert elicitation, DOE would apply existing Nuclear Regulatory Commission's guidance as the available national consensus standard.

Question 10.B.2.b) *Are these standards equivalent to the Nuclear Regulatory Commission's position on the use of expert elicitation in support of PRA?*

Response 10.B.2.b) Yes. The Nuclear Regulatory Commission's guidance would be used directly.

Question 10.C *The HPAV IRT determined that the QRA was not ready for final design and has made a number of findings for which they believe corrective actions are necessary.*

Question 10.C.1 *Describe the schedule for enabling the QRA to be ready for design.*

Response 10.C.1 Response to the HPAV IRT findings is documented in the response plan, 24590-WTP-RPT-ENG-10-021, *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan*. The HPAV IRT identified nine findings directly related to the QRA and several other findings related to the run-up distance correlations as they relate to the Event Progression Logic. The schedule of major tasks for completing the QRA are discussed in detail in the *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan.*

Question 10.C.1.a) *Who will make the determination that the QRA is ready for design?*

Response 10.C.1.a) Closure of the HPAV IRT Findings, the DOE-HSS PRT Recommendations, and the report of the to be initiated QRA Peer Review Team (discussed below) will be submitted to DOE for concurrence that the QRA is ready for use in design. The QRA has undergone two independent reviews. The first review was by a DOE-HSS sponsored Peer Review Team (PRT) that used Brookhaven National Laboratory (BNL) experts in probability analysis. The most recent review was completed by the HPAV IRT and upon completion of implementing the HPAV IRT findings, the final QRA model will undergo a rigorous qualification program that will validate both the correlations and the software. Closure of the HPAV IRT findings will require a comprehensive review of all aspects of the QRA model. WTP has re-assembled the QRA team to implement the changes to the QRA and additional experts have been retained to ensure that the software requirements of NQA-1-2000 and DOE Order 414.1C are met. A team of three PRA experts will make the determination that the QRA is ready for design. The team of PRA experts will be made up of the HPAV IRT member, a member from the DOE-HSS sponsored PRT and one additional, nationally recognized expert that will be retained under subcontract. This DOE HSS PRT team will review the changes to the QRA and determine it is ready for use in design. The HPAV IRT findings will be closed once the model changes are agreed to by the WTP QRA team and the QPRT. Once the model is finalized it will be verified and validated (V&V'd) as required by DOE Order 414.1C. After successful completion of the V&V process the QRA will be ready for use in design of the WTP. This process is described in the response plan to address the Findings of the HPAV Independent Review Team, 24590-WTP-RPT-ENG-10-021, *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan.*

Question 10.C.1.b) *How will the determination be made?*

Response 10.C.1.b) See response to question 10.C.1.a) above.

Question 10.C.2 *Describe the safety-related risks posed by using the QRA in its current form.*

Response 10.C.2 Safety-related design risk as used in this question response package refers to the WTP project and/or technical risk associated with the implementation of a design that has not yet been confirmed to be capable of providing its intended function. As described in the response to question 10.C.1.a) the QRA model will be revised to address the findings of the HPAV Independent Review Team and the PRA Peer Review Team. The QRA will then be reviewed to determine whether it is ready for use in design. The revised model will be V&V'ed before its use in confirmed design. New HPAV related designs will not be issued until the supporting analytical tools are in place.

Question 10.C.3 *How is DOE managing these risks?*

Response 10.C.3 As stated in 10.C.2 the QRA is not being used for design in its current form.

Question 10.D *How will the assumptions used in the QRA be managed over the life of the WTP?*

Response 10.D A formal evaluation to determine how the QRA will be used in constructing the safety basis has not been performed yet. If it is determined from this evaluation that there are assumptions used in the QRA that are key to the development of the safety analysis, then protection of those assumptions will be necessary. If assumptions from the QRA require protection it will be necessary for the Project to establish the framework, means, and methods for managing these assumptions over the life of the WTP.

Question 10.D.1 *What QRA assumptions have the greatest impact on the WTP piping and component design?*

Response 10.D.1 A sensitivity analysis will be completed based on the revised QRA (24590-WTP-RPT-ENG-10-008) upon implementation of the HPAV IRT findings. The preliminary sensitivity analysis of the current QRA model before implementation of the HPAV IRT findings showed that probability of ignition, HGR, event durations, and physical layout of route (i.e., are there many dead legs?) had the greatest impact. As the multi-disciplinary team reviews are conducted to evaluate the design, the impact of specific assumptions about operations, fault conditions, and recovery plans for each HPAV-affected pipe route will be documented to identify operational aspects that have the potential to affect the outcome of results.

Question 10.D.2 *The hydrogen generation rate used in the QRA is postulated to be conservative. What is the potential impact(s) on plant operations if the hydrogen generation rate is greater than postulated in the design and safety bases (i.e., impact on PTF throughput)? How will the risks of this potential impact be managed?*

Response 10.D.2 The HGR is a well documented variable and the correlation is well established and proven. An assessment of the uncertainty in the HGR correlation used to estimate generation rates at different points in the facilities is contained in a memorandum, G.M. Duncan to R. E. Edwards and R. M. Kacich, "Partial Response to Condition of Acceptance Item 2.3 on Evaluation of Uncertainty in the WTP HGR Correlation", December 28, 2009 (CCN 142843). The assessment shows that there is appreciable margin against the possibility that the correlation may underpredict the generation rate for a given feed batch. An analysis of incoming LAW and HLW feed is provided comparing the predicted generation rate for each feed batch against that rate calculated. A minimum safety factor of 3 is shown for all batches, with the preponderance of the batches having a factor of 10 or better. The memo notes a number of other conservatisms in calculating the generation rate and determining the time to the LFL in vessels. The memorandum also notes that as part of a feed batch pre-qualification (that starts six months before a feed batch is delivered), the actual HGR is measured at different steps in the treatment process to confirm it is within design and safety limits; the correlation prediction is no longer relied on. This approach precludes delivery of a batch that generates more hydrogen than is allowed. Given the remote possibility of a feed batch being out of specification in this respect, there would be no appreciable impact on plant operations.

WTP manages the technical risk of higher HGRs in two ways 1) as described above, conservative HGRs are used in design, and 2) 24590-WTP-ICD-MG-01-019, Revision 4 requires that the waste is sampled and the HGR is calculated prior to transfer to the WTP. Out of specification waste is not accepted and must be blended or otherwise treated before it can be transferred. As stated in Section 2.3.1, *"If the waste does not meet the Safety Authorization Basis (SAB), the criteria for compatibility or pH, the limits in Tables 5 through 8 of this ICD, the WTP Contractor or the TFC, or both, will determine and take actions necessary for the WTP Contractor to be able to receive the feed, such as waste conditioning or adjustment, or negotiation with DOE."*

Question 10.E *How will the QRA be verified and validated (V&V)?*

Response 10.E The QRA will be V&V'd in accordance with the QRA V&V plan that will be issued following the QRA Peer Review. This V&V plan will be consistent with the DOE requirements for safety-related design software. The results of the V&V plan will be documented in a V&V report that will be issued to document completion of the V&V. These are documents required by WTP software quality procedures (SQP) and WTP procedure 24590-WTP-3PS-G000-T0045, *Supplier Design Analysis with Developed Software*. As the QRA is in development and undergoes testing, routine reviews and audits for software quality and compliance with SQPs will be conducted to ensure software quality.

Question 10.F *Will an independent entity perform the V&V?*

Response 10.F No independent entity is expected to perform the V&V, however, a team of three probability experts will make the determination that the QRA is ready for design. The team of probability experts will be made up of the HPAV IRT member, a member from the DOE-HSS sponsored PRT and one additional, nationally recognized expert that will be retained under subcontract. This QRA Peer Review Team (QPRT) team will review the changes to the QRA and determine it is ready for use in design. The V&V will be performed by a team of personnel comprised of engineers, operators, software experts and probability experts of WTP (BNI, WGI and URS Safety Management Solutions) and BNI Subcontractors such Dominion Engineering Incorporated (DEI) and Global Nuclear Network Analysis (GNNA), and personnel (URS SMS) from other DOE complex sites such as Savannah River.

Question 10.G *What standard will be used to perform the V& V?*

Response 10.G Dominion Engineering, Inc (DEI) is responsible for development of the QRA software. The software will be developed in accordance with the requirements of 24590-WTP-3PS-G000-T0045, *Supplier Design Analysis with Developed Software*. The requirements for the V&V are defined in Section 6.9 and specific test cases and will be documented in the V&V Plan and V&V report.

Question 10.H *Will DOE implement a research plan to gather the data upon which to quantify and model a credible QRA. Describe the research plan?*

Response 10.H There are currently no research plans to gather additional data required to support the WTP QRA beyond the plans necessary to address the HPAV IRT Findings. These plans are described in 24590-WTP-RPT-ENG-10-021, *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan.*

DOE, under the leadership of the Office of Nuclear Safety Policy and Assistance within the Office of Health, Safety and Security (HSS) is performing a study and collecting data on the applications of risk assessments (including QRAs) within DOE and at other Federal Agencies and industries to identify how DOE can improve its use of risk assessments in nuclear safety applications.

This study and data collection is scheduled to be completed in September 2010 and the results of it will be utilized to support development of a DOE Standard or Guide (as appropriate and needed) on the use of risk assessments. The study will also identify additional studies or research that might be useful to support the appropriate use of risk assessments (including QRAs) within DOE to support nuclear safety decisions.

Question 11. Hydrogen in Pipes and Ancillary Vessels Independent Review Team

Responses to Question 11 were developed by:

Primary authors:

<u>**U.S. Department of Energy - Office of River Protection**</u>
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

<u>**Hanford Tank Waste Treatment and Immobilization Plant Project**</u>
Greg Ashley, Project Technical Director

Contributing authors:

<u>**Hanford Tank Waste Treatment and Immobilization Plant Project**</u>
Jeff Monahan, Project Engineering Manager, Pretreatment Facility
Tom Patterson, Manager of Engineering
Mike Wentink, Technical Issues Manager, HPAV & 1066

Question 11.A *On February 15,2010, DOE approved the revised HPAV safety design strategy for use in design and procurement of PTF HPAV affected piping (beginning with Planning Area 3) The HPAV IRT concluded that the new design approach for HPAV piping and components would not be acceptable until the models, assumptions and methodology involved in the approach were improved to resolve the HPAV IRT's findings. What are the potential impacts on the WTP?*

Response 11.A There are no physical impacts on the currently constructed WTP SSCs, i.e. there will be no re-work required. HPAV design changes were not issued between the DOE approval of the design strategy and the issuance of the HPAV IRT final report. Further, no HPAV design changes will be issued until the HPAV IRT findings have been closed and the design criteria updated, as required. Closure responses to the findings are detailed in *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan*, 24590-WTP-REP-ENG-10-021. After closure of the findings and subsequent update of the design criteria, the WTP will re-analyze the HPAV-affected piping to determine the effects of the postulated HPAV events and will develop design changes as appropriate. These anticipated design changes will generally be of the following types:

- Increase in pipe schedule (some pipe may have to be re-procured since a significant percentage of the pipe was previously released [prior to 2005]. Pipe that may be changed has been placed on hold.)
- Modification of or the addition of supports
- Removal of control lines, controls (e.g. valves, instruments, etc.), and bulges

Question 11.A.1 *Describe the procurement schedule for HPAV affected piping and components as compared to the schedule of activities necessary to resolve HPAV IRT team findings.*

Response 11.A.1 The procurement schedule has not been developed to indicate all of the HPAV-affected piping and components. Major procurement items such as the HPAV Bulges (QL-MRA-PY33-0007) have been identified in the July month-end procurement schedule and are planned to be released for quote starting in June 2011.

Bulk commodities such as piping are procured by the planning area in which the piping is located. Most of the BC piping was released by engineering with the exception of some of the HPAV control piping. Some BC HPAV control piping that was issued by engineering was then placed on procurement hold. The released piping is either in backlog to fabrication or may be on site if the original release was before 2005.

Bulk instrumentation is scheduled by instrument type and released based on priority.

Use of the QRA in the issued design will follow implementation of the HPAV Closure Plan. This will require release of some BC control piping (approximately 1200 lineal ft to fabrication to support the construction schedule and piping module assembly. If the final design does not require these controls, the piping will be either removed from the module or capped and abandoned in place.

Question 11.A.2 *Have HPAV-affected piping and/or components been procured for any WTP facility?*

Response 11.A.2 Yes, much of the piping was designed and procured before the design of the active controls was initiated in 2008. Design has been issued, but most HPAV affect design that was changed in 2008 has not been released for procurement or modification.

Question 11.A.2.a) *Are any HPAV-affected piping and/or components installed?*

Response 11.A.2.a) No HPAV affected piping or mechanical components (valves or equipment) have been installed in the PTF facility as of August 18th, 2010. There are embeds already placed in the concrete to accommodate HPAV bulges.

Question 11.A.2.b) *If yes, how was the appropriate pipe schedule selected given that elements of the HPAV design strategy are not yet complete (e.g., the QRA)?*

Response 11.A.2.b) As stated in 11.A.2.a, no HPAV affected piping or mechanical components have been installed as of August 18, 2010. The majority of the piping procured to date is Schedule 40 and a majority of the spools were procured before 2005. Calculation 24590-WTP-M6C-M11T-00007 Revision C, *Hydrogen In Piping And Ancillary Vessels Database* (since Cancelled) was used as input to support design determination of what HPAV related vents and flushes would be required, along with the BOD, SRD and PDSA in effect in 2008. Additional HPAV controls were added to the design of previously procured pipe.

Question 11.A.2.c) *Given HIRT findings and recommendations, are there any pipe or components that can no longer be used (must be discarded)?*

Response 11.A.2.c) This is unknown at this time. The analysis will not be complete until the V&V'd QRA tool has been updated to reflect the HPAV IRT comments and the piping has been analyzed for the postulated HPAV loads. WTP is in the process of placing 29 pipe lines on installation hold for potential upgrade to Schedule 80. Based on judgment, these are lines for which there may be an opportunity to remove HPAV controls from the design if a higher schedule pipe is used. In addition, a limited amount of HPAV control piping spools has been released for procurement, which later may not be required, in order to support construction sequencing (251 Lineal feet in planning areas 01B, 01C and 01D).

Question 11.A.3 *If HPAV piping or components have not been procured, is the tentative procurement schedule tied to the resolution of findings from the HIRT?*

Response 11.A.3 Yes, a phased approach has been taken to implement the HPAV changes in the project plan. Implementation of the changes is planned in multiple phases. Only the first phase has been implemented which started the initial data collection, sample runs of a preliminary QRA and sample piping analysis for the postulated HPAV loads. The second phase, which will include the development of design revisions and detailed procurement schedule, will not be implemented until the HPAV IRT Findings have been resolved and the validation and verification (V&V) of the QRA is completed.

Question 11.A.3.a) *Will the project wait until the HPAV safety design strategy is complete before beginning procurement of HPAV-affected piping and components (e.g., QRA and ANSYS finite element model, component testing or analysis)? If not, what are the potential safety-related impacts of this decision?*

Response 11.A.3.a) The project does not intend to release or install piping affected by HPAV. This will ensure that the HPAV criteria, methodology and implementing procedures and tools are complete and will minimize the potential for rework and additional project cost. HPAV affected components that will be qualified by test will be released for procurement, with the final test and acceptance criteria in accordance with the required project schedule.

There are no adverse impacts associated with allowing the procurement to proceed where required to support the overall project schedule. The recommended design changes are being developed in accordance with the approved WTP *Quality Assurance Manual* (QAM) (24590-WTP-QAM-QA-06-001). Paragraph 3.1.2.8.4 of the QAM states, "Design verification shall be performed prior to releasing the design for procurement, manufacture, construction, or use by another design organization except where this timing cannot be met, such as when insufficient data exists." Paragraph 3.1.2.8.4.2 further states "In all cases the design verification shall be completed prior to relying upon SSCs or computer programs to perform its function and before installation becomes irreversible....". Because all HPAV design will be verified before the change is irreversible, there are no expected adverse impacts where we need to support the project schedule.

Question 11.A.3.b) *When is the procurement of HPAV-affected piping and components scheduled to begin?*

Response 11.A.3.b) Design changes to HPAV affected piping will begin after the HPAV IRT team comments are incorporated, the QRA is V&V'd. Procurements will be completed in accordance with the QAM requirements as discussed in 11.A.3.a) above. The current forecast for production use of QRA is February 2011. Refer to 11.A.3 regarding the detail in the current forecast schedule. WTP has been actively replanning the procurement schedule for future items that are HPAV affected so that they do not significantly effect the overall construction completion schedule.

Question 11.B *What are the impacts to the project schedule from delaying procurement of HPAV affected piping and components if procurement is tied to resolution of HPAV IRT findings and completion of the HPAV safety design strategy?*

Response 11.B The impacts to the project critical path will be mitigated as necessary as noted in 11.A.3.a).

WTP will accomplish this by:

- Identifying the HPAV affected piping in the TEAMWORKS database
    - HPAV Control Piping that has been identified from the baseline design which may not be required pending completion of analysis.
    - HPAV affected process piping that may be upgraded to a higher schedule if a HPAV control were removed which include:

    - Pump suction lines
    - Non-Newtonian return lines in the BC
    - FRP HTR lines
- Reviewing the location of the affected lines in the model in relationship to the construction work packages
- Identifying those spools which must be procured to support construction installation. This will be of special concern in the piping modules where the piping needs to be staged long in advance of the piping module insertion into the BC.
- Releasing the procurement holds on the spools in accordance with the Quality Assurance Manual (24590-WTP-QAM-QA-06-001, paragraph 3.1.2.8) on the piping which would otherwise drive the construction schedule, recognizing that removal of the hold may increase Project costs in the future.

Most of the current impacts would be related to piping procurement and staging (installation) in the BCs. Components that are required to support the project schedule will be released in accordance with 24590-WTP-QAM-QA-06-001, paragraph 3.1.2.8.

Question 11.C *The HPAV IRT found that elements of the HPAV safety design strategy were not complete, e.g., critical calculations supporting the safety basis were draft or not yet complete and the QRA was not finished.*

Question 11.C.1 *What was DOE's basis for approving the HPAV safety design strategy when critical parts of the design methodology were not complete?*

Response 11.C.1 DOE approved HPAV functional performance requirements in the Preliminary Documented Safety Analysis Addendum with a SER issued November 2, 2009 (DOE Letter 09-NSD-044), because they were considered necessary to guide the development of appropriate HPAV design criteria. DOE reaffirmed the requirement for no significant piping system deformation in BC and HTR areas and permitted only limited deformation for Hot Cell piping systems, ensuring significant margin to failure. The proposed HPAV design criteria were found to be insufficiently supported and not approved (Condition of Approval (COA #1)) at that time.

In a second SER issued February 15, 2010 (DOE Letter 10-NSD-013), DOE approved substantially revised HPAV design criteria proposed for inclusion in the SRD following their review and acceptance by outside experts in the ASME B31.3 Code and its application in the nuclear industry. Approved criteria were seen as the final safety basis step necessary for BNI to develop and test detailed implementation methods. The developing implementation strategy was subsequently reviewed by the HPAV IRT. DOE viewed interim approvals as necessary feedback to BNI for this complex, first-of-a-kind design approach.

Question 11.C.2 *What is the timeline for completion of modifying the HPAV safety design strategy to address HIRT findings/recommendations?*

Response 11.C.2 The *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan*, 24590-WTP-RPT-ENG-10-021, Rev. 0, provides forecast milestone dates for resolution of HPAV IRT Findings.

Question 11.C.3 *Which HIRT recommendations will DOE accept?*

Response 11.C.3 Initially, DOE will accept only those HPAV IRT Recommendations determined to warrant inclusion in the response closure plan to support completion of the WTP designs. Many of the Recommendations have longer term applicability both to DOE's response to DNFSB 2009-1 and to the support of WTP operations. These Recommendations will be addressed in the context of those efforts, as appropriate.

Question 11.C.4 *What is the basis for rejecting the remaining HIRT recommendations?*

Response 11.C.4 As discussed in 11.C.3, none of the HPAV IRT Recommendations are being rejected at this time. In the longer term, only those few that do not apply to ongoing activities are expected to be rejected. For example, R4-16 pertaining to experimental modal analysis is seen to have little applicability unless the need for a new experimental program emerges.

Question 11.C.5 *How will DOE verify that HIRT findings have been properly addressed consistent with the HIRT's intent?*

Response 11.C.5 DOE has concurred with the closure plan for the HPAV IRT Findings (10-WTP-205). Then, as part of DOE's oversight role, plans are being made for the DOE Engineering Division to monitor and assess closure implementation. [DOE is also planning to assess DOE's oversight of the closure process}. Further, the plan for addressing HPAV IRT Findings requires the IRT to review and concur that the Finding has been adequately addressed.

Question 11.D *Will DOE require a separate independent review of those elements of the HPAV safety design strategy that were not reviewed by the HIRT? If yes, describe this review.*

Response 11.D The two principal elements of the HPAV safety design strategy that were not reviewed by the HPAV IRT are the design of active preventive systems for those piping routes that cannot demonstrate passive accommodation of HPAV loads and the design of ancillary vessels which also utilize active preventive systems. These designs are judged to involve more conventional engineering considerations amenable to traditional oversight methods and thus not warranting an IRT. DOE would require a separate independent review only if additional (unexpected) changes in design methods or unusual complexity arise.

Additionally, the details of the test and acceptance criteria for qualification of HPAV affected components by test were not presented to the HPAV IRT. BNI will be expected to have those details reviewed by the appropriate members of the HPAV IRT (or other expert IRT) when the details are available.

Question 12.

Responses to Question 12 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Ben Harp, Acting Assistant Manager for Waste Treatment Plant Integration

Hanford Tank Waste Treatment and Immobilization Plant Project
Greg Ashley, Project Technical Director

Contributing authors:

California Institute of Technology
Dr. Joseph Sheperd, DOE Consultant

Question 12 *DOE engaged outside experts in addition to the HPAV IRT to evaluate the revised HPAV safety design strategy, i.e., Dr. Joseph Shepherd of the California Institute of Technology, and ASME code experts Mr. George Rawls and Mr. Ronald Haupt. Have the concerns expressed by these experts been satisfactorily resolved?*

Response 12 Agreement was reached with these experts resolving the concerns they identified during their review of the Project's HPAV criteria. The resolution was documented to support the SER (10-NSD-013 dated 2/15/10) approving the criteria. Confirmation of these resolutions and of the criteria was provided by the HPAV IRT review process that addressed these aspects of HPAV implementation.

Question 12A *For example, Dr. Shepherd expressed concerns regarding Dominion Engineering Incorporated calculations in a letter to DOE dated March, 27, 2010. Were the concerns expressed by Dr. Shepherd in this and other correspondence resolved (e.g., strain data from the pressure reflected deflagration-to-detonation transition (PRC-DDT) tests conducted at the SwRI)?*

Response 12A Specifically with respect to Dr. Shepherd's March 27, 2010 letter, BNI/Dominion Engineering have been working to resolve his comments but have yet to close them. These will be addressed and reflected in calculation revisions responding to the HPAV IRT findings.

Question 12B *Describe the process for resolving Dr. Shepherd's technical concerns. If the concerns expressed by Dr. Shepherd have not been resolved, are the concerns tracked by DOE and will the concerns be formally resolved? Will Dr. Shepherd verify that their resolution is technically acceptable? If not, describe how his and other DOE outside expert's concerns will be resolved.*

Response 12B The following process is typical of how DOE external consultants comments are addressed. Dr. Shepherd provides comments to the DOE Technical Point of Contact (TPOC). The TPOC reviews the comments with Dr. Shepherd to ensure proper understanding of the issues. The TPOC then provides comments to BNI to address with their subcontractors as appropriate. If clarifications are needed, a teleconference with Dr. Shepherd, the TPOC, BNI TPOC, and appropriate subcontractor occurs. Proposed dispositions of the comments are prepared and reviewed by the DOE TPOC and Dr. Shepherd for adequacy. An email record is the typical method to indicate preliminary acceptance of the dispositions. Final acceptance by Dr. Shepherd comes by way of email or letter to the DOE TPOC indicating his review of the implemented dispositions and acceptance or rejection. This process continues until Dr. Shepherd accepts closure of the issue.

Question 13. Safety Aspects of Pulse Jet Mixing Design

Responses to Question 13 were developed by:

Primary authors:

<u>**U.S. Department of Energy - Office of River Protection**</u>
Delmar Noyes, Deputy Assistant Manager, Waste Treatment and Immobilization Plant Project

<u>**Hanford Tank Waste Treatment and Immobilization Plant Project**</u>
Russell Daniel, Production Engineering Manager

Contributing authors:

<u>**Hanford Tank Waste Treatment and Immobilization Plant Project**</u>
Todd Allen, Safety Implementation Manager
Steve Barnes, Process Technical Manager
Donna Busche, Environmental & Nuclear Safety Manager
Robert French, M3 Issue Closure
Phil Kuchlen, Commissioning/Facilities Operations Manager
Tom Patterson, Manager of Engineering
Robert Voke, Discipline Production Engineering Manager

Questions 13 through 21 are related to the WTP's Pulse Jet Mixed (PJM) Vessel safety aspects, design and control strategies, external evaluations, waste characteristics and evaluated test performance. The project responses have been primarily derived from the WTP Integrated Pulse Jet Mixed Vessel Design and Control Strategy, M3 Vessel Assessments and bases, safety documentation, control strategies, external expert evaluation feedback and existing waste qualification information.

The strategy supplements the M3 Inadequate PJM Mixing System Design External Flow Sheet Review Team Recommendation Issue Response Plan (IRP) and serves as a roadmap for disposition of all remaining PJM-related technical issues. The primary technical issues are related to three potential safety concerns:

- The potential for criticality due to the accumulation (collection) of fissile materials;
- The generation of hydrogen due to the accumulation of solids; and
- The potential for PJM overblows (discharge of air from the PJM) due the inability to control the PJMs as a result of the accumulation of solids impacting the vessel level detection system.

The strategy consists of three distinct phases.

- Phase 1 is the closure of the M3 EFRT issue and achievement of the targeted technology readiness level based on the IRP. Phase 1 has been completed and consisted of the following key activities:
  - Definition of the mixing requirements including the design basis waste feed properties. [Questions 16, 20 and 21]
  - Assessment of each vessel against its specific mixing requirement. The assessments were completed by design analysis that was underpinned by testing. [Questions 13A, 13B, 13C, 13H, 13I, and 13G]
  - Identification of recommended design, operational and contract changes. [Question 13B]
  - Identification of the methods that will be used for design confirmation. [Question 13G]

During the closure of Phase 1, external reviews by the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) [Question 14] and the Savannah River National Laboratory (SRNL) [Question 17] were conducted. In addition, the Pacific Northwest National Laboratory (PNNL) supported the testing that has been conducted [Questions 13D and 18].

- Phase 2 is the closure of additional issues identified with the PJM control (bubblers), suction line design, and sampling systems. These issues will be closed in part by completion of large-scale prototypical tests of a Newtonian and Non-Newtonian vessel configuration [Question 19]. Additional technical issues identified by the DNFSB, CRESP, SRNL, and PNNL [Questions 13E, 14, 17, and 18] external review groups related to aspects of the criticality control and gas release strategies will be resolved during this Phase.
- Phase 3 is the completion of the design change process to implement any required vessel or supporting system changes and confirm the design for the PJM-mixed vessels/systems. [Questions 13F, 13G, and 15]

With the execution of this three phase strategy, DOE/WTP is committed to resolving the potential safety concerns associated with the accumulation of fissile materials, hydrogen generation, and performance of the vessel level control that could impact PJM operation (overblow events)

Question 13.A *Describe the small-scale test platform.*

Response 13.A Document 24590-WTP-RPT-PET-08-009, Revision 1, *Functional/Design Requirements for the M3 PJM Test Platform* provides a full description of the small-scale test platform. Specifically, Section 4 provides the functional requirements; Section 5 provides the design requirements; and Section 11 identifies the interfacing systems.

In addition, Section 4 of document 24590-PTF-PL-PET-10-0001, Revision 1, *Plan for M3 Test Platform Testing,* provides a description of the key small-scale test platform equipment.

Question 13.A.1 *What scale factors were chosen for each vessel simulated in the WTP?*

Response 13.A.1 The scale factors are as follows:

- UFP-VSL-01A/B (Ultrafiltration Process) has a scale factor of 5.5.
- FEP-VSL-17A/B (Evaporator Feed) has a scale factor of 6.1.
- HLP-VSL-22 (HLW Feed Receipt) has a scale factor of 10.6.
- FRP-VSL-02A/B/C/D (Feed Receipt Process) has a scale factor of 13.0.

Question 13.A.1.a) *What is the technical basis for their selection?*

Response 13.A.1.a) DOE G 413.3-4, *Technology Readiness Assessment Guide*, defines Engineering/Pilot scale testing as that conducted between 1/10th scale and full scale, with provision that the scale may vary based on engineering judgment. Document 24590-WTP-ES-PET-09-001, Revision 0, *M3 Platform Test Data Study*, Section 4.1 Static Scaling - Test Stand Prototypicity summarizes the technical basis for platform design. The original test platform was developed with PJM arrays for the FEP-17 and HLP-22 vessels with scale factors of 6.1 and 10.6, respectively. After fabrication of the test vessel, the FRP PJM array was fabricated which resulted in a scale factor of 13.0. Based on the low weight percent solids in this vessel and the testing of similar arrays for the HLP vessel, the scale factor of 13.0 was considered acceptable based on engineering judgment.

Question 13.A.1.b) *What are the technical strengths and weaknesses in the selection of these scale factors?*

Response 13.A.1.b The technical strength associated with the selected scale factors is that the scale factors for the UFP-01 and FEP-17 vessels (5.5 and 6.1, respectively) are well within the scaling guidance provided in DOE G 413.3-4, *Technology Readiness Assessment Guide* (scale factor of 10.0). These lower scale factors provide added assurance in overall vessel performance at full scale.

The technical weaknesses are associated with the selected scale factors for the HLP-22 and FRP-2 vessels.

- The scale factor for the HLP-22 vessel is slightly outside the recommended scale factor of 10.0 but was determined to be satisfactory based on engineering judgment.

- The scale factor for the FRP-02 vessels was greater than the recommended scale factor from the guide. However, based on the low weight percent solids (3.8 wt% solids with a settling velocity less than 0.3 ft/min) in this vessel and the testing of similar arrays for the HLP vessel, the scale factor of 13.0 was considered acceptable based on engineering judgment.

Question 13.A.1.c) *Were the vessels tested a geometric match to the actual vessel design? If not, please identify and discuss the significance of any differences.*

Response 13.A.1.c) CCN 186341, *M3 Test Platform - Prototypic Comparison*, compares the M3 test stand to the WTP plant design with respect to prototypicity. Attachment 1 of the referenced document provides a summary for 14 attributes. The comparison includes an appraisal of differences, and concludes that none significantly impacts conclusions related to M3 closure.

Question 13.A.1.d) *What are the technical risks associated with performing scaled tests in vessels that lack geometric similarity?*

Response 13.A.1.d) As stated in the *Handbook of Industrial Mixing*, Changing geometry on scale-up is a very complex undertaking that should be avoided whenever possible. As documented in CCN 186341, the Mid-Columbia Engineering platform achieves geometric similarity. There are no technical risks.

Question 13.B *Describe the safety-related test objectives that were closed with the small-scale testing.*

Response 13.B Section 3.0 of 24590-WTP-RPT-ENS-10-002, Revision 2, *M3 Criticality Safety Test Requirements*, summarizes the issues and resolution strategies related to M3 that are associated with the current approach taken in the CSER for ensuring criticality safety. Section 4.0 identifies test requirements to support criticality safety. These test requirements were completed during the M3 testing campaign.

Document 24590-PTF-PL-PET-10-0001, Revision 1, *Plan for M3 Test Platform Testing*, documents the test objectives, success criteria, and primary test data for each specific mixing criteria for the vessels tested. The safety-related test objectives are related to the following mixing criteria/requirements:

- Limit solids accumulation
- Sampling (criticality and hydrogen release)
- Release gas

Question 13.B.1 *What was the testing strategy for resolving solids accumulation issues?*

Response 13.B.1 Document 24590-PTF-PL-PET-10-0001, Revision 1, *Plan for M3 Test Platform Testing*, documents the testing strategies, including test objectives, success criteria and primary test data, for each specific mixing criteria for the vessels tested. Section 5.2 of this document provides a description of the overall testing strategy. Section 5.3 provides a description of the testing for the limit solids accumulation criteria.

Question 13.B.2 *What was the testing strategy for resolving gas retention and release issues?*

Response 13.B.2 Document 24590-PTF-PL-PET-10-0001, Revision 1, *Plan for M3 Test Platform Testing*, documents the test strategies, including test objectives, success criteria and primary test data, for each specific mixing criteria for the vessels tested. Section 5.2 of this document provides a description of the overall testing strategy. Section 5.4 provides a description of the testing for the release gas criteria.

Question 13.B.3 *What are the technical strengths and weaknesses in these testing strategies?*

Response 13.B.3 The technical strengths with these testing strategies are:

- The ability to visually observe the bottom clearing for the limit on solids accumulation criteria.
- The ability to visually observe the bottom mobilization for the release gas criteria.
- The NQA-1 measurements and data analysis of the solids remaining in the heel for direct comparison to the starting concentrations and particle size distribution.
- The ability to utilize the data to benchmark analytical tools (models).

The technical weaknesses with these testing strategies are:

- Due to the small-scale testing, the test velocity was required to be scaled. In order to mitigate the uncertainties with the scaled velocity, testing was conducted at multiple scale factors. In addition, the final prototypic testing was used to underpin the analytical methods that were utilized to assess full scale performance. As such, the uncertainty in the jet velocity due to scaling for the prototypic testing was minimized.

Question 13.B.4 *Discuss how the results of the small-scale testing change the design of the WTP.*

Response 13.B.4 Based on initial testing results, design and operational changes (as discussed in the responses to questions 13.B.4.a), 13.B.4.b) and 13.B.4.c) below) were identified and tested in the small scale test platform. The results of these experimental configurations were reviewed, analyzed and the recommended design configuration was documented in the following Engineering Studies.

- 24590-PTF-ES-ENG-10-001, *HLP-VSL-00022 - Feed Receipt Vessel Engineering Study for M3 (Closure Criterion 3)*;
- 24590-PTF-ES-ENG-10-002, *FEP-VSL-00017A/B - Waste Feed Evaporator Engineering Study for M3 (Closure Criterion 3)*; and
- 24590-PTF-ES-ENG-10-003, *UFP-VSL-00001A/B - Ultrafiltration Preparation Feed Vessel Engineering Study for M3 (Closure Criterion 3)*.

The recommended changes were then assessed against the vessel specific mixing requirements and final recommendations were provided for the specific design changes. The design change recommendations are provided in the following vessel assessments.

- 24590-WTP-RPT-ENG-08-021-06, *EFRT Issue M3 PJM Vessel Mixing Assessment*, Volume 6 - FRP-VSL-00002A/B/C/D, Table 1;

- 24590-WTP-RPT-ENG-08-021-07, *EFRT Issue M3 PJM Vessel Mixing Assessment*, Volume 7 - UFP-01, Table 1;
- 24590-WTP-RPT-ENG-08-021-08, *EFRT Issue M3 PJM Vessel Mixing Assessment*, Volume 8 - HLP-22, Table 1; and
- 24590-WTP-RPT-ENG-08-021-09, *EFRT Issue M3 PJM Vessel Mixing Assessment*, Volume 9 - FEP-VSL-00017A/B, .

Finally, the recommended changes were reviewed by the TSG. The closure packages listed below identify the changes that were approved by the TSG. The recommended changes are then implemented into the design following the WTP Design Change Process.

- CCN 220452, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 6, FRP-VSL-00002A/B/C/D), Inadequate Mixing System Design;*
- CCN 220453, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 7, UFP-VSL-00001 A/B), Inadequate Mixing System Design;*
- CCN 220454, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 8, HLP-VSL-00022), Inadequate Mixing System Design;* and
- CCN 220455, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 9, FEP-VSL-00017A/B), Inadequate Mixing System Design.*

Question 13.B.4.a) *What physical changes to the vessels were made to improve mixing performance?*

Response 13.B.4.a) The recommended physical changes are documented in Attachment 1 to the following closure packages for the EFRT M-3 Issue.

- CCN 220452, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 6, FRP-VSL-00002A/B/C/D), Inadequate Mixing System Design;*
- CCN 220453, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 7, UFP-VSL-00001 A/B), Inadequate Mixing System Design;*
- CCN 220454, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 8, HLP-VSL-00022), Inadequate Mixing System Design;* and
- CCN 220455, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 9, FEP-VSL-00017A/B), Inadequate Mixing System Design.*

The following is a summary of the key design changes that were recommended:

- Adding additional PJMs to 3 vessels (HLP-VSL-00022 and UFP-VSL-00001A/B);
- Increasing PJM jet velocity for 5 vessels (FEP-VSL-00017A/B and FRP-00002B/C/D);
- Changing the PJM nozzle angle for 9 vessels (HLP-VSL-00022, UFP-VSL-00001A/B, FEP-VSL-00017A/B and FRP-00002B/C/D); and
- Lower the suction line to 3" off the vessel bottom for 9 vessels (FEP-VSL-00017A/B, UFP-00001A/B, HLP-VSL-00027A/B, HLP-VSL-00028, and UFP-VSL-00002A/B).

Add vessel inspection and heel removal capability with enhanced transfer capacity for 10 high-solids vessels (HLP-VSL-00022, FEP-VSL-00017A/B, UFP-00001A/B, HLP-VSL-00027A/B, HLP-VSL-00028, and UFP-VSL-00002A/B[heel removal previously planned, inspection ports added).

Question 13.B.4.b) *What operational changes to the process were made to improve mixing performance?*

Response 13.B.4.b) The recommended operational changes (i.e., PJM firing sequences, reduced batch sizes, and reduced feed concentrations) are documented in Attachment 1 to the following closure packages for the EFRT M-3 Issue.

- CCN 220452, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 6, FRP-VSL-00002A/B/C/D), Inadequate Mixing System Design*;
- CCN 220453, *Technology Steering Group -Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 7, UFP-VSL-00001 A/B), Inadequate Mixing System Design*; and
- CCN 220454, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 8, HLP-VSL-00022), Inadequate Mixing System Design*; and
- CCN 220455, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 9, FEP-VSL-00017A/B), Inadequate Mixing System Design*.

Question 13.B.4.c) *What changes to the process flow were made to improve mixing performance?*

Response 13.B.4.c) The recommended process flow changes (e.g., no receipt of evaporator bottoms in FRP-2 vessels and administrative control for feed streams into FEP-17A/B vessels) are documented in Attachment 1 to the following closure packages for the EFRT M-3 Issue.

- CCN 220452, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 6, FRP-VSL-00002A/B/C/D), Inadequate Mixing System Design;*
- CCN 220454, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 8, HLP-VSL-00022), Inadequate Mixing System Design*; and
- CCN 220455, *Technology Steering Group -Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 9, FEP-VSL-00017A/B), Inadequate Mixing System Design.*

Question 13.B.4.d) *What systems are or have been added to detect and mitigate accumulation of solids in the vessel heel?*

Response 13.B.4.d) No active systems are included in the current design to detect and mitigate accumulation of solids in the vessel heel. The current design provides the ability to add caustic or other chemical solutions to mitigate the potential accumulation of solids in the vessel heel.

A heel management system is currently being implemented into the design via the formal WTP design change process. The heel management system provides the ability to pump down the vessel contents to a lower level (reduced heel) and provides for heel dilution. In addition, two access ports are being put added into the design for specific vessels via the formal design change process. These will allow access to the vessel internals to observe conditions if required during operations.

Question 13.B.4.d)(1) *What are the functional requirements of these new systems?*

Response 13.B.4.d)(1) 24590-PTF-RPT-ENG-10-004, Revision. 0, *Pretreatment Vessel Heel Dilution/Cleanout Functional Requirements*, documents the functional requirements for heel management. A summary is provided in Section 4 of the document. The functional requirements for the credited safety function of this system has not been determined. Those details will be identified during the ISM meeting as required.

Question 13.B.4.d)(2) *What is the current design status of these systems?*

Response 13.B.4.d)(2) The design status of the heel management system and access ports is a conceptual design. The conceptual design is described in 24590-WTP-RPT-PET-10-013, Revision 0, *Pretreatment Vessel Heel Dilution/Cleanout Feasibility Study*, Section 4, paragraphs 4.1 (process), 4.2 (plant), and 4.3 (pump). The design is being developed using the formal design change process.

Question 13.B.4.d)(3) *Has testing of these new systems been performed to see if these functional requirements have been met?*

Response 13.B.4.d)(3) Prototypic testing of the heel management system has not been conducted. Prototypic testing will be completed as part of the large-scale testing. However, as depicted in document 24590-WTP-RPT-ENG-08-021-08, Revision1, *EFRT Issue M3 Vessel Mixing Assessment, Volume 8 - HLP-22*, Appendix D, Figures 18 and 19, small-scale testing has been completed to investigate the impacts of heel dilution. As depicted in the figures, heel dilution provides a reduction in the concentration of material remaining in the heel after pump-out.

Question 13.C *Are there any vessels that were not tested in the small-scale platform? If so, explain the technical basis for not performing tests for a particular vessel.*

Response 13.C Vessels containing no-solids or low solids were not tested in the small-scale platform at MCE and are identified below:

- CXP-VSL-00026A/B/C
- CNP-VSL-00003
- CNP-VSL-00004
- CXP-VSL-00004
- UFP-VSL-00062A/B/C
- RDP-VSL-00002A/B/C
- HOP-VSL-00903
- HOP-VSL-00904
- PWD-VSL-00015
- PWD-VSL-00016
- TCP-VSL-00001
- TLP-VSL-00009A/B
- RLD-VSL-00008
- PWD-VSL-00033
- PWD-VSL-00043
- PWD-VSL-00044

- RLD-VSL-00007

Appendix A, Vessel Mixing Performance Assessments in the following vessel assessments document the technical basis for closing the M-3 issue without vessel specific testing in the small-scale platform.

- 24590-WTP-RPT-ENG-08-021-01, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 1 - CXP-VSL-00026A/B/C*;
- 24590-WTP-RPT-ENG-08-021-02, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 2 - CNP-VSL-00003/4, CXP-VSL-00004, UFP-VSL-00062A/B/C, RDP-VSL-00002A/B/C* ;
- 24590-WTP-RPT-ENG-08-021-04, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 4 - HOP-VSL-00903/904, PWD-VSL-00015/16, TCP-VSL-00001, TLP-VLS-00009A/B, RLD-VSL-00008;*
- 24590-WTP-RPT-ENG-08-021-05, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 5 - PWD-VSL-00033/43/44*; and
- 24590-WTP-RPT-ENG-08-021-10, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 10 - RLD-VSL-00007.*

The vessel assessments were approved by the TSG and the Basis for Closure section of the following M-3 Issue Partial Closure packages documents the TSGs positions relative to the technical basis provided in the vessel assessments.

- CCN 208996, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package CXP-VSL-00026A/B/C), Inadequate Mixing System Design*;
- CCN 214951, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 2, Solids Free And Resin Storage Vessels), Inadequate Mixing System Design*;
- CCN 221575, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 4, Low Solids Containing Vessels), Inadequate Mixing System Design*
- CCN 204767, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue* M-3 (CLOSURE PACKAGE VOLUME-5, PWD-VSL-00033/43/44), *Inadequate Mixing System Design*; and
- CCN 211816, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue* M-3 (*Closure Packaging Volume 10,* RLD-VSL-00007), *Inadequate Mixing System Design.*

In addition, the five non-Newtonian vessels (HLP-VSL-00027A/B, HLP-VSL-00028, UFP-VSL-00002A/B) have not been tested in the small-scale platform. Appendix A in document, 24590-WTP-RPT-ENG-08-021003, *EFRT ISSUE M3 PJM VESSEL MIXING ASSESSMENT, VOLUME 3, HLP-VSL-00027 A/B, HLP-00028, UFP-00002A/B,* provides the technical basis for closing the M-3 issue without vessel specific testing in the small-scale platform. In addition, Appendix D in the Volume 3 vessel assessment provides a description of the benchmarking that was completed for the Low Order Accumulation Model (LOAM). In order to provide increased confidence in the use of the Low Order Accumulation Model with the non-Newtonian vessel geometry, small-scale testing with the non-

Newtonian vessel geometry will be conducted. The small-scale test objectives are currently being defined.

Question 13.D *How do the results from Mid-Columbia Engineering (MCE) testing compare with results of similar testing performed by Pacific Northwest National Laboratory (PNNL)?*

Response 13.D Section 5, Paragraph 5.8 of document 24590-WTP-ES-PET-09-001, *M3 Platform Test Data Study*, provides an evaluation of test results relative to predictions of solids suspension velocity using the PNNL Phase I correlations. As noted in the specific section, the testing conducted by PNNL was semi-prototypic and was conducted as parametric testing as compared to the prototypic testing conducted on the small-scale platform at Mid-Columbia Engineering (MCE). In general, the correlations developed in the PNNL testing predicted a lower velocity would be required to achieve solids suspension than was observed in the MCE tests.

Question 13.D.1 *What is the magnitude of the differences?*

Response 13.D.1 The magnitude of the differences ranged from 15% up to 69% in the range of predicted solids suspension velocity before any differences between the test platforms were considered. The suspension velocity predicted using PNNL correlations was lower than that measured in the MCE platform. The analysis that reconciled the differences is discussed in 24590-WTP-ES-PET-09-001, *M3 Platform Test Data Study*, Section 5, Paragraph 5.8. An independent assessment of the differences is in preparation by PNNL.

Question 13.D.2 *Describe the safety significance of the differences. If the differences do not have safety significance, provide the technical justification for this determination.*

Response 13.D.2 The correlations that were developed based on the PNNL testing were not used to predict full scale performance in the vessel assessments. The vessel assessments were based on physical models that were benchmarked against the MCE platform data and full scale testing at Washington State University (WSU). Specifically, document 24590-WTP-RPT-ENG-08-021-08, Revision1, *EFRT Issue M3 Vessel Mixing Assessment, Volume 8 - HLP-22*, Appendix D summarizes the benchmarking of the Low Order Accumulation Model (LOAM) against testing completed in the small-scale platform and full scale at WSU. The benchmarking results indicate that LOAM is conservative (under-predicts solids removal) for a stratified vessel (HLP-22 benchmarking results). As the vessel approaches a well mixed state (FEP-17 and UFP-1 benchmarking results), LOAM over-predicts the solids removed from the vessel. This is consistent with the nature of the model. Since this benchmarking was conducted against the actual small-scale and full-scale test results and did not rely on the PNNL correlations to predict full-scale performance, there is no safety significance related to the differences between the PNNL correlations and the small-scale test results.

Question 13.D.3 *How do the differences translate to full-scale performance?*

Response 13.D.3 The PNNL correlations were not used to predict full scale performance in the vessel assessments. The vessel assessments were based on benchmarking physical models against the MCE platform results. The MCE platform results also indicated a higher solids suspension velocity than the PNNL correlations.

Question 13.D.4 *Describe how the differences were resolved.*

Response 13.D.4 The apparent magnitude of the differences, as well as the analysis that reconciled them is discussed in 24590-WTP-ES-PET-09-001, *M3 Platform Test Data Study*, Section 5.8. An independent assessment of the differences is in preparation by PNNL.

Question 13.D.5 *How are differences being managed to prevent safety issues from arising during WTP operations?*

Response 13.D.5 Because the differences were reconciled and the PNNL data was not used to predict full scale performance, no further actions are being conducted.

Question 13.E *What are the open safety issues associated with pulse jet mixer performance?*

Response 13.E It is recognized that some uncertainty will remain on PJM performance related to the safety issues associated with solids accumulation (potential for criticality, hydrogen generation and PJM control (overblows) until extensive experience has been gained through testing of full-scale or near full-scale prototypic PJM vessels and actual operations of WTP.

To reduce this uncertainty, vessel inspection and heel (solid/liquid slurry in a vessel below the normal operating level) removal is an important part of the defense in depth strategy to assure that solids will not accumulate over the life of the facility. External reviews have documented that this capability is a prudent engineering design feature for vessels that are expected to be in service for many years even though current assessment do not predict conditions of solids accumulation.

In addition, the open actions resulting from the M-3 testing program have been identified in CCN 223285. A review by the WTP ISM process of the results of the mixing test program has been initiated to identify the potential safety issues and to develop the necessary controls.

Question 13.E.1 *Describe each open safety-related issue.*

Response 13.E.1 The primary safety-related issue is associated with performance of an integrated system that includes: a prototypic PJM mixing system including PJM controls, a prototypic suction line, and a prototypic sampling system. Each part of the total system has been tested and assessed independently. However, the integrated (combined) system performance has not been tested with respect to solids accumulation (potential for criticality, hydrogen generation and PJM control (overblows). The original planning was to conduct this integrated testing and confirm the overall system performance during cold commissioning. However, a series of large-scale tests are currently being planned to complete this testing prior to cold commissioning.

Question 13.E.2 *Describe the schedule for resolving each open safety-related issue.*

Response 13.E.2 The schedule for large-scale testing and the closure of all open PJM mixing related issues is being developed. The test objectives and schedule for the large-scale testing are projected to be established at the end of calendar year 2010. Further, the schedule for completing the design changes associated with implementation of the vessel inspection and heel removal capability is currently being developed as part of the project planning process. The work activities being included in this baseline update include the detailed application of the WTP ISM process to assess the results of the mixing test program.

Question 13.F *Has BNI finalized the design of the pulse jet mixed vessels?*

Response 13.F No. As discussed in the response to question 13.B.4.a), recommended changes have been identified and are being implemented using the WTP design change process.

Question 13.F.1 *If not, are there limits on BNI's ability to procure pulse jet mixed vessels or related components? Describe these limits.*

Response 13.F.1 No formal limits (HOLDS) have been placed on BNI's ability to procure the PJM vessels or related components. BNI has suspended work that was being performed by the vessel fabricators until the design changes are incorporated per the WTP design change process.

CCN 146071, Contract No. DE-AC27-01RV14136 - Bechtel National, Inc., Purchase Order 24590-QL-POC-MVA0-00001, Revision 26, Pressure Vessels, High Alloy, Shop Fabricated, Large, QL-1 (VXLA (N110) provided the following direction to Harris Thermal Transfer Products Corporation:

- HLP-VSL-00022: Suspend all engineering, procurement of material and fabrication activities.

CCN 214072, Contract No. DE-AC27-01RV14136 - Hanford Tank Waste Treatment and Immobilization Plant, Bechtel National, Inc. (BNI) - Notice of Suspension to Northwest Copper Works, Inc., for 24590-QL-POD-MVA0-00001 provided the following direction:

- UFP-VSL-00001A: Suspend all work.
- UFP-VSL-00001B: Suspend all fabrication work with respect to the vessel internals. Work may only continue with respect to the fabrication of the external cooling jacket.

CCN 146071 also originally suspended work on the HLP-27A/B and HLP-28 vessels. This suspension in work has been removed for the HLP-27A/B and HLP-28 vessels. The design changes for the non-Newtonian vessels (UFP-2 A/B, HLP-27A/B, and HLP-28) will be integrated into the ongoing vessel fabrication schedule since the recommended changes do not directly impact the PJM arrays.

Question 13.F.2 *If the vessel designs are not finalized and BNI has been authorized to procure pulse jet mixed vessels or related components, describe the safety-related risks associated with allowing procurement in the absence of large-scale testing?*

Response 13.F.2 The recommended design changes are being developed in accordance with the approved WTP *Quality Assurance Manual* (QAM) (24590-WTP-QAM-QA-06-001). Paragraph 3.1.2.8.4 of the QAM states, "Design verification shall be performed prior to releasing the design for procurement, manufacture, construction, or use by another design organization except where this timing cannot be met, such as when insufficient data exists." Paragraph 3.1.2.8.4.2 further states "In all cases the design verification shall be completed prior to relying upon SSCs or computer programs to perform its function and before installation becomes irreversible ...." As such, while there may be project risk associated with the procurement of the vessels in the absence of large-scale testing, there is no technical risk that the final design will not perform its function.

Question 13.F.3 *Describe the justification for accepting these risks.*

Response 13.F.3 As noted in the response to question 13.F.2 above, there may be project risks are associated with allowing the procurement to proceed. However, the application of the design change process in accordance with the WTP *Quality Assurance Manual* will ensure any potential technical risks are resolved prior to introduction of a waste feed to the facility.

Question 13.G *Discuss the past and future uses of computational models (i.e., Low Order Accumulation Model (LOAM) and FLUENT™) to resolve safety-related issues.*

Response 13.G The Low Order Accumulation Model (LOAM) and the FLUENT based CFD. models have been utilized in the assessment of the pulse jet mixed (PJM) vessels. This assessment is documented in the M3 Vessel Assessments. The vessel assessments are provided in document number 24590-WTP-RPT-ENG-08-021. This document consists of 10 volumes that represent all 38 PJM mixed vessels.

Once the FLUENT based CFD has completed the verification and validation process, CFD will be utilized in the formal design process to develop calculations that support the design confirmation of the PJM mixed vessels.

Question 13.G.1 *Describe why the computational model is needed and why it was or will be used instead of experimental test results.*

Response 13.G.1 A predictive calculation tool is required because no practical experimental program could test each vessel configuration in WTP at full scale and with all bounding conditions. In order to be able to assess the mixing designs of all WTP vessels it is essential that a predictive method be developed and used.

The computational methods used were not used instead of experimental results. LOAM and CFD were used in conjunction with experimental test results to close the EFRT M3 mixing issue. The LOAM method used in the vessel assessments was benchmarked against the experimental results. In addition, CFD will utilize experimental test results to complete the verification and validation process. Benchmarking of CFD has also been performed against the existing experimental test results.

Question 13.G.2 *How was the model v & v to ensure accurate predictions?*

Response 13.G.2 LOAM does not require a formal V&V. The LOAM method was prepared in Microsoft excel software and checked on project during the development of the specific vessel assessments. The results from LOAM were also benchmarked using experimental data from WTP mixing vessel tests.

For CFD, the model is actually a predictive simulation methodology based on applying the CFD software program Fluent. Fluent has been proven to be robust and incorporates the most thoroughly validated and benchmarked mathematical models of any commercial CFD program and has previously been V&V'd for several applications on WTP. The use of CFD for prediction of solids deposition and resuspension from the bottom of a vessel is a new use of CFD on WTP. Hence, a comprehensive validation testing program is planned for this use. The experiments will be conducted as a fully NQA-1 certified test program. The set of tests to be conducted will be finalized and documented in the next revision of document 24590-WTP-PL-ENG-03-010, *Fluent Computational Fluid Dynamics V&V Plan*. An independent review of the test program in the CFD V&V Plan is being conducted by an academic expert who is a senior member of the ASME V&V 20-2009 *Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer* committee.

Question 13.G.2.a) *What technical standard(s) was (were) used for verification and validation?*

Response 13.G.2.a) Until recently, there were no generally accepted technical standards for validating CFD within the mixing industry or nuclear industry. In particular, there are no official published Technical Standards applicable to CFD for pulse jet mixing. The verification and validation (V&V) plan being employed for Fluent at WTP is described in document 24590-WTP-PL-ENG-03-010, *Fluent Computational Fluid Dynamics V&V Plan*. This document complies with WTP and DOE procedures for software qualification. It is based on an extensive amount of research reported by the leading experts in the field including those from U.S. National Laboratories and leading CFD research universities and applies their methods for V&V to the greatest feasible extent. An independent peer review by industry experts has already been conducted. In addition, the CFD V&V test plan is currently being reviewed for compliance with the recently published ASME V&V 20-2009 *Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer*.

Question 13.G.2.b) *How do test results compare with the computational model predictions? Have these comparisons been done at multiple scales?*

Response 13.G.2.b) Benchmarking of LOAM's bottom clearing model at small and full scale and benchmarking of LOAM for accumulation in WTP mixing vessels at small scale is described in Appendix D of the M3 Vessel Assessments listed below.

- 24590-WTP-RPT-ENG-08-021-06, EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 6, FRP-VSL-00002A/B/C/D
- 24590-WTP-RPT-ENG-08-021-07, EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 7, UFP-01
- 24590-WTP-RPT-ENG-08-021-08, EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 8, HLP-22
- 24590-WTP-RPT-ENG-08-021-09, EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 9, FEP-VSL-00017A/B

For CFD the following reports provide comparison of the CFD to test results.

- 24590-PTF-RPT-PR-06-002, Benchmarking of Computational Fluid Dynamic Simulation of Pulsed Jet Mixers Using Experimental Data
- CCN 205205: CFD Comparisons to 4 FT Platform Tests - M3 Closure Status

These comparisons of CFD and experimental results have been completed at multiple scales. The non V&V comparisons with experimental PJM mixing test data has shown very good agreement. These comparisons have included data for velocity measurements, solids 'cloud height', and vessel bottom solids clearing.

Question 13.G.2.c) *What is the relative error in the computational model predictions?*

Response 13.G.2.c) The benchmarking data provided in Appendix D of the M3 vessel assessments listed above in the response to question 13.G.2.b) provides a comparison of the LOAM predictions and the measured experimental data. This data demonstrates the relative error in LOAM as compared to the experimental results.

For CFD modeling of the PJM mixing vessels, the relative error (i.e., the discrepancy between experimental measurements and comparable CFD models) will be determined in the forthcoming NQA-1 V&V Test program and will be reported in the next revision of the Fluent Verification and Validation Report.

Question 13.G.2.d) *How are the predictive errors managed to prevent safety issues from arising during WTP operations?*

Response 13.G.2.d) CFD and/or LOAM are used to calculate the performance of the full scale vessel. The predictive errors are either managed by completion of sensitivity analyses for the model based on the key design parameter (jet velocity) or by application of margins to ensure that the safety issues are prevented or mitigated. Additional benchmarking of vessel performance compared to CFD and LOAM predictions will be obtained through planned future large scale testing.

Question 13.G.2.e) *Were the applicable models updated with actual test results to provide improved predictive capabilities?*

Response 13.G.2.e) The LOAM model has no parameters that are adjusted to improve comparisons to individual data sets.

CFD code packages, like FLUENT, include multiple models that the practioner must choose between to configure the simulation. Previous test results are used to make this selection.The predictive capabilities of the final selection of the models will be assessed (validated) in the upcoming V&V testing program. Final calculations will be performed with the V&V'd CFD software.

Question 13.G.3 *Describe the technical basis supporting the development of each computational model.*

Response 13.G.3 The technical basis supporting development of LOAM is documented in Appendix D of the M3 Vessel Assessments listed below.

- 24590-WTP-RPT-ENG-08-021-06, EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 6, FRP-VSL-00002A/B/C/D
- 24590-WTP-RPT-ENG-08-021-07, EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 7, UFP-01
- 24590-WTP-RPT-ENG-08-021-08, EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 8, HLP-22
- 24590-WTP-RPT-ENG-08-021-09, EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 9, FEP-VSL-00017A/B

The technical basis for the CFD modeling methodology is currently described in the document 24590-WTP-PL-ENG-03-010, *Fluent Computational Fluid Dynamics V&V Plan*. This document is currently undergoing a revision to incorporate technical bases that reflect the guidelines specified in the ASME V&V 20-2009 *Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer*.

Question 13.G.4 *What are the relative strengths and weaknesses of each computational model?*

Response 13.G.4 LOAM is a low-order mass conservation model with submodels that parameterize the dominant observed solids transport conduits in WTP mixing vessels. The strengths and weaknesses of LOAM are discussed in conjunction with model development in Appendix D of the M3 Vessel Assessments identified above in the response to comment 13.G.3.

One of the critical strengths with CFD is that it can be used to simulate accurate vessel internal geometry at full-scale using WTP plant operating conditions. The relative strengths and weaknesses (i.e., the relative accuracy and errors) for CFD will be quantified during the forthcoming CFD V&V testing program and reported in the V&V Report.

Question 13.G.5 *How are the technical weaknesses managed to prevent safety issues from arising during WTP operations?*

Response 13.G.5 The technical weaknesses are managed by evaluation of the margin associated with each mixing requirement/criteria in the M3 vessel assessments (Appendix A) listed above in response to question 13.G.3. In addition, the risks associated with the full scale performance of the PJM mixed vessels were documented in the Technical Steering Group Closure Records. The Closure Records listed below specifically identified the risk (technical weakness) associated with the use of LOAM and recommended the conduct of a large scale test prior to commissioning.

- CCN 220452, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 6, FRP-VSL-00002A/B/C/D), Inadequate Mixing System Design*;
- CCN 220453, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 7, UFP-VSL-00001 A/B), Inadequate Mixing System Design*;
- CCN 220454, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 8, HLP-VSL-00022), Inadequate Mixing System Design*; and
- CCN 220455, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 9, FEP-VSL-00017A/B), Inadequate Mixing System Design.*

Question 13.H *Discuss the simulant physical properties used in small-scale testing.*

Response 13.H Answer provided below.

Question 13.H.1 *What are the physical properties of solids used to develop the design basis for the WTP? Discuss the following properties:*

Response 13.H.1 Answer provided below.

Question 13.H.1.a) *Particle size;*

Response 13.H.1.a) The general simulant basis is presented in sections 1 through 4.2.3 of report 24590-WTP-RPT-PET-10-008, the PUO_2 basis in CCN 211814 and the specific simulant qualification data are recorded in individual memos. The post-DBE simulant properties are presented in CCN 211535, the sand only mixing simulant is described in CCN 214950, the HLW sludge simulant properties are the subject of CCN 214953, the FRP simulant is described in CCN 216086, and the simulant for HLP-22 sampling is provided in CCN 216094.

Question 13.H.1.b) *Particle density;*

Response 13.H.1.b) The simulant particle size basis is presented in section 3.2 of 24590-WTP-RPT-PET-10-008. As outlined above, the simulant particle size information is contained in CCNs: 211535,, 214950, 214953, 216086, and 216094.

Question 13.H.1.c) *Solids content;*

Response 13.H.1.c) The solids loading used for the FEP-17 test was 2 wt% solids, the FRP-2 test used 3.8 wt% solids, the HLP-22 test was conducted with 10 wt% solids, and the UFP-01 test was conducted at 10 wt% solids.

Question 13.H.1.d) *Rheological properties including viscosity, shear strength, Bingham yield stress, and Bingham plastic viscosity.*

Response 13.H.1.d) The HLW simulant viscosity is discussed in section 3.4 of 24590-WTP-RPT-PET-10-008. The HLW sludge simulant qualification report (CCN 214953) estimated that the slurry viscosity would be less than 1.1 cP. A shear strength requirement of ~200 Pa was imposed on the post DBE simulant based on Table 2.1 of 24590-QL-HC9-WA49-00001-03-00025. There were no Bingham yield stress nor plastic viscosity requirements imposed on any of the mixing simulants as these were intended to be Newtonian slurries.

Question 13.H.2 *What is the technical basis supporting selection of the design basis properties delineated in 1 above?*

Response 13.H.2 The general simulant technical basis is presented in 24590-WTP-RPT-PET-10-008 and the PUO2 simulation basis is presented in CCN: 211814.

Question 13.H.3 *What are the technical strengths and weaknesses associated with the design basis properties?*

Response 13.H.3 The principal strength is that the simulant particle size is based on the 'upper confidence limit' distribution provided in report RPP-9805, Table 3-2. This distribution indicates the waste is comprised of much larger particles than the WTP-RPT-153 (24590-101-TSA-W000-0004-114-00021) Table 5.0.1 report which summarizes a wider distribution of tanks. The average test particle density is also based on RPP-9805 primary particle density which does not include the reduced, agglomerated particle density observed in the tank wastes. The simulants also were mixed with water and does not credit the observed reduction in particle settling rates associated with viscous supernatants. There was no attempt to scale the simulant particles, and given the reduced PJM nozzle velocities tested, the jet turbulence is much less than the full-scale system will encounter. The post-DBE simulant was based on the 200Pa maximum shear strength after 24 hours value listed in table 2.1 of report 24590-QL-HC9-WA49-00001-03-00025.

The principal weakness of the HLW solids simulant was its representation of the smallest and largest particles as outlined below:

In order to be able to measure the particle size distribution of only the PuO_2 simulant particle (tungsten carbide), no other small particle with a density greater than ~2.6g/mL could be used. This density limitation was required as the test program used a lithium metatungstate solution to separate the tungsten particles from the lighter particles. This density limitation meant that the high density, very small particles in the waste (Ag, Bi, Fe, etc.) were represented only with the tungsten carbonate particles. Therefore, due to detection limit concerns and average simulant density reasons, the volume of tungsten carbide in the simulant is nearly 700 times the average PuO2 concentration.

Also to achieve the desired average simulant particle density, the 700μm, 2.9g/mL particles are present at a much higher concentration than the RPP-9805 95%UL distribution requires. There are 4 times the volume percent of particles greater than 300μm in the simulant than the RPP-9805 95%UL contains.

Question 13.H.4 *What are the uncertainties associated with the selection of these design basis properties?*

Response 13.H.4 The design basis properties used to develop the simulant are based on the best available data as discussed in the response to questions 16.A.4. The current data is based on core samples which have not been conducted in all tanks. However, the data collected represents approximately 80% of the Hanford waste mass.

Question 13.H.4.a) *Are additional waste characterization data needed to reduce this uncertainty?*

Response 13.H.4.a) The 'waste qualification' samples to be received at the WTP six months in advance of receiving the waste will enable complete waste characterization and finalization of the Pretreatment operating strategies for that waste to reduce these uncertainties.

Question 13.H.4.b) *Discuss what additional data are required to reduce this uncertainty.*

Response 13.H.4.b) The 'waste qualification' samples to be received at the WTP six months in advance of receiving the waste will enable complete waste characterization and finalization of the Pretreatment operating strategies for that waste to reduce these uncertainties.

Question 13.H.4.c) *If no additional data are required, what are the potential impacts on the operation of the PTF due to the current level of uncertainty?*

Response 13.H.4.c) Please see the response to 13.H.4.a & b.

Question 13.H.5 *How are these uncertainties being managed to prevent safety issues from arising during WTP operation?*

Response 13.H.5 The uncertainties (risks) are being managed as discussed in the response to question 13.G.5. Specifically, the vessel assessments evaluate the margin associated with each mixing requirement. The TSG closure records then document any potential risks and identify specific recommendations to mitigate the risks. The risks (uncertainties) associated with the simulant utilized in the small-scale testing will be mitigated by the conduct of a large-scale test (with realistic simulants) and the completion of calculations using V&V'd computational fluid dynamics models.

Question 13.I *Describe the pulse jet mixer test velocities used for the small-scale testing.*

Response 13.I For the small scale testing at MCE, the PJM test velocities were determined specifically for each test and vessel geometry. The test velocity selected was dependent on the mixing mechanism being evaluated (solids suspension /mixing /accumulation or bottom clearing/post design basis event (PDBE) solid mobilization). For solids suspension / mixing / accumulation testing, a velocity scaling coefficient of 0.33 was used to determine the test velocities. For the bottom clearing / PDBE solid mobilization testing, a velocity scaling coefficient of 0.18 was used. These velocity scaling coefficients were used to adjust (scale-down) the actual full scale jet velocities calculated for the Jet Pump Pair / Pulse Jet Mixing system.

Question 13.I.1 *What is the technical basis supporting the selection of these velocities?*

Response 13.I.1 CCN 210455, *Scaling of PJM Vessels Containing Settling Solids in Newtonian Slurries* provides the technical basis for the scaling coefficients (scale factors) for each mixing mechanism being evaluated. The scale factors were applied to the full scale PJM jet velocity (based on PJM performance with the bounding design basis properties) to define the small-scale test velocities. The following references document the specific technical basis for the key scale factors.

- Section 7.2.2, Equivalent Solids Suspension, page 23 provides the basis for the scale-down factor of n=0.33 which was used to determine the test velocities for testing associated with solids suspension, mixing or accumulation.
- Section 7.2.3, Mobilization of Cohesive Solids, page 26-27 provides the basis for equal velocity scaling for testing non-Newtonian solids with a yield strength (PDBE solids mobilization).
- Section 7.2.3, Mobilization of Cohesive Solids, page 28 provides the basis for a scale-down factor of n=1/5 for local shear stress of a settled bed by a flowing material (bottom clearing). Note that the n=1/5 was rounded up in the report from the value calculated (n=0.176) in equation 15, page 28.
- Based on this range of scale factors (n=0 to n=0.18) for bottom clearing / PDBE mobilization, the larger exponent (n=0.18) was selected for scale-down to testing velocities.

As noted below in the response to question 13.I.3, uncertainties and non-prototypic effects were accounted for after the full scale jet velocity was scaled-down to the test velocity.

Question 13.I.2 *What are the technical strengths and weaknesses from selecting these test velocities?*

Response 13.I.2 For the solids suspension, mixing or accumulation, the technical strengths of using a scale factor of n=0.33 as documented in CCN 210455 are:

- The application of the n=1/3 exponent provides a sufficiently conservative scale-up for PJM velocities as full scale. (page 2, Executive Summary)
- From stirred tank mixing, the only practical scale-up rules lie between equal velocity and equal power per volume (mass) [Nienow (1992), Dickey (2005)]. This range of conditions also applies to scale-up of PJMs from a practical perspective. (page 21, Section 7.1)

- A summary of the solids suspension correlations from previous test data was completed. This analysis resulted in a scale-up coefficient of around n=0.26 or n=0.27. As such, the use of n=0.33 is conservative. (page 33, Section 7.3.1)
- Analysis of previous PNNL testing data resulted in a scaling factor of n=0.33 for low concentrations of rapidly settling particles and a scale factor of approximately n=0.20 for concentrations (0.5 vol % and 1.5 vol %). As such, the use of n=0.33 as a scale factor is conservative. (Section 7.3.1, page 33)

For the bottom clearing / PDBE solids mobilization, the technical strengths of using a scale factor of n=0.18 are:

- A range of scale factors (n=0 to n=0.18) for bottom clearing / PDBE mobilization was presented. The larger exponent (n=0.18) was selected for scale-down to testing velocities. (Section 7.2.3)
- As noted in bullet 4 above, a scale factor (for solids suspension / mixing) of approximately n=0.2 was determined for high concentrations of solids. As such, using a scale factor of n=0.18 for solids mobilization and bottom clearing is conservative.

The primary weaknesses are:

- The testing was conducted at reduced velocities based on the scale factors; however, the particle size was not scaled and the testing was conducted with larger size particles than a properly scaled physical modeling test. Also, the viscosity of the liquid phase was not reduced to maintain the Reynolds number in the small-scale tests. The jet turbulence is less than would be expected at full scale.
- The uncertainty associated with the scale factors (as discussed in the response to question 13.I.3 below) were also considered weaknesses that have been evaluated.

Question 13.I.3 *What uncertainties are associated with scaling-up the test results from small-scale to full-scale?*

Response 13.I.3 These scaling factors were not used to scale-up the test results. As such, no uncertainty is associated with scaling-up the test results. As discussed in the response to question 13.I.1 above, the scaling factors (coefficients) were used to establish a representative test velocity at the small-scale based on the actual full-scale jet velocities. The following section describes the uncertainties that are associated with the scale-down of the jet velocities from full-scale to small-scale.

CCN 210455, page 41, Section 7.9, Adjustments for Non-Prototypic Effects and Uncertainty provides a discussion of the potential uncertainties and recommended correction factors. As noted, these adjustments for non-prototypic effects should be made after scale-up (scale-down). The coefficients defined for non-prototypic effects include geometry, carrier fluid properties, and solids properties. In addition, overall uncertainty is addressed by the coefficients for confidence and design margin.

- Geometry coefficient: CCN 210455, Section 7.9.1 recommends a coefficient of C_{Geom} = 1.07 for flanged and dished bottom vessels and 1.16 for 2:1 elliptical bottom vessels. For small-scale testing, a geometry coefficient of 1.0 was used for determining scaled jet velocities. The basis for this was the previous selection of a conservative scale factor (n=0.33 or n=0.18) and as noted in

CCN 210455 (page 42), a discontinuity in curvature exists where the test vessel bottom joins the test vessel wall. In this area, clearing of the vessel bottom in this area requires more power than would be required to mobilize solids in the real (full scale) geometry.

- Carrier fluid coefficient: CCN 210455, Section 7.9.2 recommends a coefficient off $C_{fluid} = 1.0$. However, a coefficient of $C_{fluid} < 1.0$ (results in higher test velocities) was also recommended for hydraulic conveying, sludge bank yielding, and erosion by shear. The recommended coefficient of $C_{fluid} = 1.0$ was used.
- Solids coefficient; CCN 210455, Section 7.9.3 recommends a coefficient of $C_{solids} = 1.0$ based on use of a simulant that bounds the WTP design basis. The coefficient of $C_{solids} = 1.0$ was used as a conservative coefficient since the particle size of the simulant was not scaled.
- Design margin coefficient: CCN 210455, Section 7.9 recommends a $C_{DM} = 1.0$. The design margin is evaluated based on the vessel performance in order to ensure the actual design margin is known and understood. As such, the design margin coefficient C_{DM} was set equal to 1.0 to determine the scaled velocities.
- Degree of confidence: CCN 210455, Section 7.9.4 recommends a $C_{Conf} = 1.11$. This recommended coefficient was used to define the small-scale test velocities for solids suspension / mixing / accumulation. However, a $C_{Conf}=1.0$ was used for bottom clearing / PDBE solid mobilization testing. The use of $C_{Conf}=1.0$ was based on the selection of n=0.18 for the scale factor and the technical strengths described above in the response to question 13.I.2.

Question 13.I.4 *How are these uncertainties managed to prevent safety issues from arising during WTP operations?*

Response 13.I.4 The application of the coefficients discussed above in question 13.I.3, were used to provide confidence in the development of the scaled testing velocities. These test results were then used to benchmark specific low order models. The vessel's performance against the mixing requirements were then based on low order models that represent the physics of the mixing system. The models do not rely on scaling to predict the full scale vessel performance.

In addition, the uncertainties are being managed as discussed in the response to question 13.G.5. Specifically, the vessel assessments evaluate the margin associated with each mixing requirement. The TSG then identifies any potential risks and provides specific recommendations to mitigate the risks. The risk associated with scaling was identified and will be mitigated by the conduct of a large-scale test and completion of formal calculations using V&V'd computational fluid dynamics models.

Question 14. Consortium for Risk Evaluation and Stakeholder Participation (CRESP) Findings (CRESP Review Team Letter Report 7 - PJM Vessels)

Responses to Question 14 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Delmar Noyes, Deputy Assistant Manager, Waste Treatment and Immobilization Plant Project

Contributing authors:

U.S. Department of Energy - Office of River Protection
Gary Brunson, Director, WTP Engineering Division
Rob Gilbert, Chemical Process Safety System Oversight Engineer

Question 14.A *Will DOE accept the recommendations from the CRESP report?*

Response 14.A See response provided to question 14.B.

Question 14.A.1 *If yes, describe the action(s) taken by DOE to address the technical content of each recommendation.*

Response 14.A.1 See response provided to question 14.B.

Question 14.A.2 *If not, which recommendations will not be accepted and what is the basis supporting DOE's action.*

Response 14.A.2 See response provided to question 14.B.

Question 14.B *If DOE is still evaluating the CRESP findings, when will DOE decide how to address the CRESP recommendations?*

Response 14.B There were 13 primary recommendations in the CRESP Review Team Letter Report 7. DOE and its contractors will address the recommendations from the CRESP report. Each CRESP recommendation is presented in italics below followed by the current status of the planned action.

Recommendation 1: *Near full-scale vessel testing facilities and simulation capabilities should be available for design confirmation and during the full life cycle of WTP operations.*

DOE, the WTP Contractor, and the Tank Farm Contractor are evaluating options to develop and maintain large scale vessel mixing and integrated system testing capability. The approach to perform this testing and plans for long term retention of this capability are currently being developed.

Projection of the schedule to perform large scale testing will be established around the end of calendar year 2010.

The initial scope envisioned for the large scale testing includes testing of selected pulse jet mixed (PJM) tanks to resolve any remaining PJM risks prior to commissioning. At a high level, these risks include, but are not limited to, demonstration of:

- PJM operation over the range of fill conditions, including operation of fully prototypic control systems
- Sampler operation and data interpretation for process control and nuclear safety
- Non-Newtonian slurry rheology control
- Particle settling effects in non-Newtonian slurries
- Large-scale, post-DBE remobilization
- Vessel inspection and heel removal systems

These tests would enable early completion of the PJM mixing, process control and operating procedure demonstrations, and sampling system performance objectives which would normally be critical path activities during the Pretreatment Facility (PTF) commissioning period.

Recommendation 2: *PJM vessel designs should retain as much flexibility as possible to process the expected range of feed compositions and to mitigate off-design and upset conditions.*

DOE and the WTP Contractor agree with the objective to retain as much flexibility as possible in the PJM vessel design. These capabilities include feed characterization and prequalification, vessel inspection capability, heel dilution and pump-out, and PJM firing flexibility. This flexibility is planned to be maintained through the design process. The WTP Contractor will create a critical items action report (CIAR) item to address this recommendation by August 28, 2010. The responsible WTP Contractor manager will then establish the date to complete the action.

Recommendation 3: *The cumulative design margin as a result of design assumptions should be quantitatively assessed against the individual batches of the planned feed vector (e.g., with respect to zone of influence (ZOI), mixing energy/power, actual anticipated settling velocities).*

The ability to project mixing performance for specific batches in tank waste feed vectors is limited. The approach to evaluate cumulative design margin is still being evaluated with the Contractor. The WTP Contractor will create a CIAR item to address this recommendation by August 28, 2010. The responsible WTP Contractor manager will then establish the date to complete the action.

Recommendation 4: *A tracking system should be instituted for design assumptions that impose requirements on the feed qualification program.*

The approach to track design assumptions that impose requirements on feed qualification is being evaluated. The WTP Contractor will create a CIAR item to address this recommendation by August 28, 2010. The responsible WTP Contractor manager will then establish the date to complete the action.

Recommendation 5: *Functional performance specifications need to be developed for inspecting and accessing vessel bottoms.*

DOE and the WTP Contractor agree that a functional specification for vessel inspection is needed. The WTP Contractor will create a CIAR item to address this recommendation by August 28, 2010. The responsible WTP Contractor manager will then establish the date to complete the action.

Recommendation 6: *Sensitivity analysis should be carried out for WTP throughput as a function of heel removal needs and operating strategies.*

Analysis of the impact of heel removal operations on WTP treatment capacity has been completed using the dynamic Tank Utilization model (G2) and the results are documented in 24590-WTP-MRR-PET-10-001, *WTP Mission Assessment of the Design and Operating Changes Expected to Resolve PJM Mixing in PTF Vessels.* The analysis concluded there is minimal impact to treatment capacity as a result of heel removal operations. Special case operations such as batches with higher fissile material content of larger or denser particles are not expected to be routine and will be assessed on a specific basis when identified. The Tank Utilization model will continue to implement heel removal as a routine operation in future assessments of treatment capacity.

Recommendation 7: *Systems level assessments of tank waste processing should consider alternative processing strategies for the most challenging tank wastes as part of the defense in depth strategy.*

The ability to project which feed batches are challenging from a mixing perspective is limited based on current information provided in the tank waste feed vectors. Batches that are challenging from a mixing perspective will be identified in characterization performed as part of tank waste retrieval and feed staging work and will be further assessed as part of the tank waste feed prequalification work performed prior to transfer of waste to the WTP. Feed prequalification work is described in 24590-WTP-PL-OP-07-0001, Revision. 1, *Plan for WTP Feed Prequalification.* The Tank Farm Contractor will assess all available tank waste treatment paths throughout mission performance to identify and use the appropriate processing strategy.

Recommendation 8: *Integrated vessel performance under design basis event (DBE) condition should be verified using actual vessels or a near full-scale cold test platform. Individual PJM ZOI scale up and restart after a DBE should be verified at or near full scale for a range of simulants that reflect the range of properties expected to be encountered during waste processing.*

Testing for DBE conditions is planned to be performed as part of the large scale testing described in the response to Recommendation 1.

Recommendation 9: *Assessments of potential particle segregation during sedimentation should consider estimates based on considerations beyond the equivalent volume sphere.*

Further evaluation of this recommendation will be performed. The WTP Contractor will create a CIAR item to address this recommendation by August 28, 2010. The responsible WTP Contractor manager will then establish the date to complete the action.

Recommendation 10: *The Preliminary Criticality Safety Evaluation Report for the WTP (CSER),* WTP-CSER-ENS-08-0001, Revision 0b*) needs to be revised and include workable and validated methods for criticality controls.*

The M3 vessel assessment closure packages for the high solids PJM mixed tanks include a requirement to take the following action: The Preliminary Criticality Safety Evaluation Report (CSER) must be updated based on the results and evaluations provided in the M3 analyses. This update should also include an evaluation of impacts that could be associated with the removal rate of poisons as compared to the removal rate of PuO_2 and evaluation of differential solids settling rates. The next revision of the CSER is planned to be completed by December 30, 2010.

Recommendation 11: *Sampling strategies for PJM vessels need to be demonstrated with characterization of sampling uncertainty.*

Sampling strategies for PJM mixed vessels are planned to be demonstrated as part of the large scale testing described in the response to Recommendation 1.

Recommendation 12: *Design confirmation for PJM vessels should not be based only on CFD simulation but also should include full-scale or near full-scale experimental demonstration of critical performance aspects of PJM vessels containing Newtonian and non-Newtonian slurries.*

Further evaluation of this recommendation will be performed. The WTP Contractor will create a CIAR item to address this recommendation by August 28, 2010. The responsible WTP Contractor manager will then establish the date to complete the action.

Recommendation 13: *A separate, focused CFD V&V plan should be developed for PJM vessel performance and should include validation using the results of near full-scale or full-scale experiments.*

Further evaluation of this recommendation will be performed. The WTP Contractor will create a CIAR item to address this recommendation by August 28, 2010. The responsible WTP Contractor manager will then establish the date to complete the action.

Question 14.C *What role will the CRESP have in the review of DOE responses to CRESP recommendations?*

Response 14.C DOE has taken the input from CRESP and will continue to work with the WTP and Tank Farm Contractors to address the recommendations. At this time, DOE does not have further plans to use the CRESP team for assessment of WTP vessel mixing systems.

Question 15.

Responses to Question 15 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Delmar Noyes, Deputy Assistant Manager, Waste Treatment and Immobilization Plant Project

Hanford Tank Waste Treatment and Immobilization Plant Project
Russell Daniel, Production Engineering Manager

Contributing authors:

Hanford Tank Waste Treatment and Immobilization Plant Project
Robert French, M3 Issue Closure
Phil Kuehlen, Commissioning/Facilities Operations Manager

Question 15 *In the event that testing and modeling does not resolve remaining issues related to pulse jet mixing, what alternatives are being studied?*

Response 15 Currently, no additional alternatives are being studied. As documented in the response to question 13.B.4.a), 13.B.4.b) and 13.B.4.c), design, operational and process changes have been identified and are being implemented which provide reasonable assurance that the vessels will meet their established mixing requirements. These recommended changes include the incorporation of a heel management system which provides added assurance that the WTP will be able to address potential accumulation of solids in vessels during the life of the facility, and ports which provide limited access to identify potential solids accumulation in key process vessels. In order to provide additional confidence in the performance of the Non-Newtonian vessels, a series of small-scale tests are also being developed. The small-scale testing will provide additional data to underpin the use of the Low Order Accumulation Model (LOAM) for non-Newtonian vessel geometries in a Newtonian regime. Potential hold points related to the fabrication of the non-Newtonian PJM vessels have also been identified to ensure the benchmarking of the LOAM continues to support the non-Newtonian vessel design.

In addition, large scale testing is being planned (as discussed in the responses to question 19.A) to further evaluate operation of the integrated pulse jet mixing system (including PJM controls), transfer system and sampling system. In the event the large-scale testing identifies additional risks, additional alternatives will be defined and evaluated. Based on the current technical understanding and past testing, the potential alternatives that would be focused on are:

- batch sizes,
- waste concentrations,
- process control of the waste rheology, and
- blending of feed streams

Question 16. Feed Qualification

Responses to Question 16 were developed by:

Primary authors:

__**U.S. Department of Energy - Office of River Protection**__
Delmar Noyes, Deputy Assistant Manager, Waste Treatment and Immobilization Plant Project

__**Hanford Tank Waste Treatment and Immobilization Plant Project**__
Russell Daniel, Production Engineering Manager

Contributing authors:

__**Hanford Tank Waste Treatment and Immobilization Plant Project**__
Todd Allen, Safety Implementation Manager
Donna Busche, Environmental & Nuclear Safety Manager
Garth Duncan, Manager of Process Engineering and Technology
Robert French, M3 Issue Closure
Dennis Hayes, Plant Operations Manager
Phil Kuchlen, Commissioning/Facilities Operations Manager
George Matis, Commissioning Operations Manager

Question 16.A *Describe the development of feed qualification requirements for WTP.*

> **Response 16.A** Feed qualification requirements are identified as inputs or assumptions to the WTP design activities. The WTP waste acceptance criteria (WAC) (and therefore feed qualification requirements) are contained in 24590-WTP-ICD-MG-01-019, *ICD-19 - Interface Control Document for Waste Feed.* References to the origin of the various WAC are provided within the ICD. The allowable uncertainty around a given waste acceptance parameter is to be developed through a data quality objectives process involving WTP, Tank Farms, and DOE that will be performed in the future.

Question 16.A.1 *Given the assumed MAR, physical properties of the waste, and limitations of the WTP design, describe the expected range of feed compositions.*

> **Response 16.A.1** The range of expected feed compositions is as described in the WAC contained in ICD-19, along with the proposed modifications for MAR and HLW feed delivery temperature (documented in meeting minutes ICD-19 Team Meeting - Finalize Issues to be Included in Revision 5, December 17, 2009, (CCN 209161)), and with the changes described in Ashley T. Morris (DOE) to N. F. Grover (BNI), Proposed Changes to Contract Tank Waste Feed Specifications Resulting from External Flowsheet Review Team (EFRT) Vessel Mixing Response, June 24, 2010

(CCN 220806). Note that ICD-19 is a dynamic "living" document and is expected to be updated periodically, and further adjustments that relate to feed compositions may be made.

Question 16.A.1.a) *Did the simulants used in the small-scale testing and computational fluid dynamics (CFD) modeling include the expected range of properties?*

Response 16.A.1.a) A discussion of the simulants is provided in the response to question 13.H.1. The simulant was developed based on the best available data for the design basis waste properties are based on the best available data. The waste simulant bounds the design basis and while it may not bound all the waste, it is believed it bounds the large majority of the waste. Pre-qualification of the waste will be required and any waste outside the design basis will be evaluated prior to receipt. Features are included in the design, such as cleanout and inspection ports in vessels, to mitigate the receipt of waste that has properties outside the design basis. CFD modeling has been performed in the past but has not been used in the vessel assessments used to close M3.

Question 16.A.1.b) *Did the simulants selected for small-scale testing represent all of the physical and rheological properties of WTP feed important for determining mixing performance?*

Response 16.A.1.b) Yes. See the response to 16.A.1.a) above. Also, see the response to question 13.H.1.

Question 16.A.1.c) *What physical and rheological properties not represented in the simulant selected pose the greatest uncertainty? Describe these uncertainties. Describe the safety related risks that are associated with these uncertainties.*

Response 16.A.1.c) See the response to question 13.H.4.

Question 16.A.1.d) *What are the safety-related risks associated with establishing feed qualification requirements using simulants?*

Response 16.A.1.d) Because establishing feed qualification requirements using actual wastes tested at engineering scale is not remotely practical, the use of simulants is necessary. The selection of simulants is based upon the review of actual waste sample characteristics. By carefully selecting the simulants to represent the most challenging mixing conditions reasonably expected (e.g., particle size and density distribution, lowest possible viscosity, settled layer rheology, etc.) and occurring simultaneously makes it highly improbable that actual feed would be more challenging to mix. Along with a thorough feed pre-qualification program to detect any feed outliers, it is considered that there are minimal or no safety-related design risks associated with establishing feed qualifications requirements using simulants.

Question 16.A.1.e) *Will these risks be addressed during large-scale testing and cold commissioning? Describe how these risks will be addressed.*

Response 16.A.1.e) As noted above, no significant safety-related design risks are expected to be realized with the simulants that have been used. Larger scale testing, *per se*, would not change the uncertainty associated with selected simulants. The integrated, large-scale testing will provide more information about operations and operational flexibility and for that reason may involve several, more realistic, simulants. Uncertainty associated with the simulants used will be mitigated by the feed pre-qualification process which ensures the waste meets the design basis or has been evaluated to ensure processing capability prior to its receipt at WTP.

Question 16.A.2 *What are the implications of processing feed that diverges from the feed requirements?*

Response 16.A.2 Waste that does not meet the feed requirements can not be processed in the WTP. WAC have been established to assure that waste is in alignment with the AB for the facility. The WAC is described in Section 2.3.1 of 24590-WTP-ICD-MG-01-019, *ICD 19 – Interface Control Document for Waste Feed.*

Feed staged in the Hanford Tank Farms will be pre-qualified in accordance with 24590-WTP-PL-OP-07-0001, *Plan for Waste Feed Pre-qualification* prior to transfer to WTP. Should a batch of feed prepared in the Tank Farms be out of specification or not meet the WAC, the waste could be remediated in the Tank Farm by blending or processed at WTP under a modified flowsheet or a combination of the two. A modified flowsheet may require an AB change, design changes and /or processing changes such as diluting feed, reducing batch sizes, or reducing the concentration factor for the waste in the PTF. There may also be downstream effects in the vitrification facilities which result in an increased quantity of LAW or HLW canisters produced for that batch.

It is expected that these requirements will continue to be refined as the methods for waste blending, sampling, and delivery are finalized. The requirements will protect the WTP safety basis.

Question 16.A.3 How does diverging from feed requirements affect the safety-related aspects of pulse jet mixing performance?

Response 16.A.3 Waste that does not meet the approved WAC can not be processed in the WTP. The WAC has been established to assure that waste is in alignment with the AB for the facility. The WAC is described in Section 2.3.1 of 24590-WTP-ICD-MG-01-019, *ICD 19 - Interface Control Document for Waste Feed.*

Feed staged in the Hanford Tank Farms will be pre-qualified in accordance with 24590-WTP-PL-OP-07-0001, *Plan for Waste Feed Pre-qualification* prior to transfer to WTP. Should a batch of feed prepared in the Tank Farms be out of specification or not meet the WAC, the waste could be remediated in the Tank Farm by blending or processed at WTP under a modified flowsheet or a combination of the two. A modified flowsheet may require an AB change, design changes and /or processing changes such as diluting feed, reducing batch sizes, or reducing the concentration factor for the waste in the PTF. An evaluation of the impacts on safety-related aspects of pulse jet mixing performance would be performed at that time.

It is expected that these requirements will continue to be refined as the methods for waste blending, sampling, and delivery are finalized. The requirements will protect the WTP safety basis.

Question 16.A.4 *Given batch-to-batch variability and complexity, how was the worst-case (bounding) feed selected for evaluating mixing power requirements and zone of influence (ZOI)?*

Response 16.A.4 The design basis particle size and density for the WTP feed is based on the currently available data. An initial analysis was conducted based on samples from seven waste tanks (AW-103, AY-101, AY-102, AZ-102, C-104, C-107, and SY-102) and reported in RPP-9805, *Values of Particle Size, Particle Density, and Slurry Viscosity to Use in Waste Feed Delivery Transfer System Analysis* (CCN 160904). The approach for the study was to select a conservative (upper bound) solid density value and realistic values (best estimates) of particle sizes and slurry viscosities. As noted in the report, The selection approach for these three waste properties is expected to support a reasonably conservative assessment for the waste feed delivery transport system.

Section 3 of the report (RPP-9805) describes the approach to developing the particle size analysis which is summarized in Table 3-2 for the Mean, 95% UL and 95/95 TL particle size distributions. Section 6 of the report recommends the use of the Mean particle distribution and states that the 95/95 TL distribution was not recommended. The WTP has selected the 95% UL distribution as the design basis which provides additional conservatism when compared to the recommended Mean particle size distribution.

Section 4 of RPP-9805 describes the approach to developing a solids density based on the data from the seven tanks listed above as well as tank AZ-101. Section 6 then recommends For particle density, in the absence of direct measurements of the agglomerated solid density, the value 2.9 g/ml is recommended. The WTP has selected the particle density of 2.9 g/ml which is conservative when agglomeration of the particles is considered.

In addition to RPP-9805, the report WTP-RPT-153 (PNWD-3824), *Estimate of Hanford Waste Insoluble Solid Particle Size and Density Distribution* has been reviewed. WTP-RPT-153 includes composite particle size distributions representing the waste in up to 19 Hanford waste tanks. The report (Section 5) also developed and evaluated four particle size and density distributions. Figure 1 in document 24590-WTP-ES-ENG-09-001, Revision 2, Determination of Mixing Requirements for Pulse-Jet-Mixed Vessels in the Waste Treatment Plant, compares these results for particle size to the particle size distribution (95% UL) from RPP 9805. In both cases (particle size and solids density), the RPP-9805 report bounded the WTP-RPT-153. As such, the design basis has remained based on the RPP-9805 report. However, the maximum particle size listed in RPP 9805 was a d99 particle of 310 microns for the 95%UL particle size distribution. Consistent with the data evaluation for the sonicated case (Table 5.0.1) in WTP-RPT-153, the d100 particle size was selected as 700 microns.

16.B Sampling

Question 16.B.1 *The ability to sample from WTP vessels is required for a number of purposes (e.g., safety and operations).*

Question 16.B.1.a) *What are the precision and accuracy requirements for safety-related samples taken from WTP vessels?*

Response 16.B.1.a) Operations-related requirements for sampling are contained in the *Integrated Sampling and Analysis Requirements Document*, 24590-WTP-PL-PR-04-0001. Criticality-related sampling at the WTP is no longer expected to be necessary. Please see the response to Question 16.B.1.b).

Question 16.B.1.b) *What implications does this have for criticality control?*

Response 16.B.1.b) The CSLs from Section 8 of the CSER (24590-WTP-CSER-ENS-08-0001) require establishing safety compliance Before waste is released from the WTP receipt vessels for subsequent processing. Based on the results of mixing testing completed in late 2009, it was concluded that the current CSLs for sampling accuracy could not be met. WTP established test criteria for the balance of the mixing test. Current planning is that compliance will be established by using samples drawn from Hanford tank farm staging tanks, so that compliance is established before waste enters WTP. Therefore, the precision and accuracy for samples taken from WTP vessels will not factor into establishing CSL compliance, but rather the precision and accuracy for samples taken from the staging tanks (i.e., tank farm feed vessel) will need to be developed once the staging tanks are designed. This control will be protected with a TSR.

Question 16.B.2 *Have the sampling strategies required for the operation of the pulse jet mixed vessel been demonstrated to meet safety-related requirements? Describe the testing conducted to verify performance of the sampling system.*

Response 16.B.2 No. Section 3.1 of 24590-WTP-RPT-ENS-10-002, *M3 Criticality Safety Test Requirements*, summarizes the issues and resolution strategies related to sampling. Section 4.0 (4th bullet) identifies the specific test requirements to provide the data needed to evaluate the mixing performance for use in evaluating the criticality safety hazards and updating the CSER. This requirement is as follows:

M3 testing will also provide data from the test sample loop to evaluate the representativeness of the recirculation line contents with respect to the vessel contents. The data is not intended to provide information related to the adequacy of the ASX sampling system nor validate alignment with the current CSLs.

These test requirements were satisfied by the collection of samples at each 1/4 batch level and in the heel during the M3 test program. The sample analysis included particle size distribution and concentration for each 1/4 batch level and also in the heel. E&NS is now analyzing test results to determine if revisions are required to the CSER. Testing of the sampling system was outside the scope of M3.

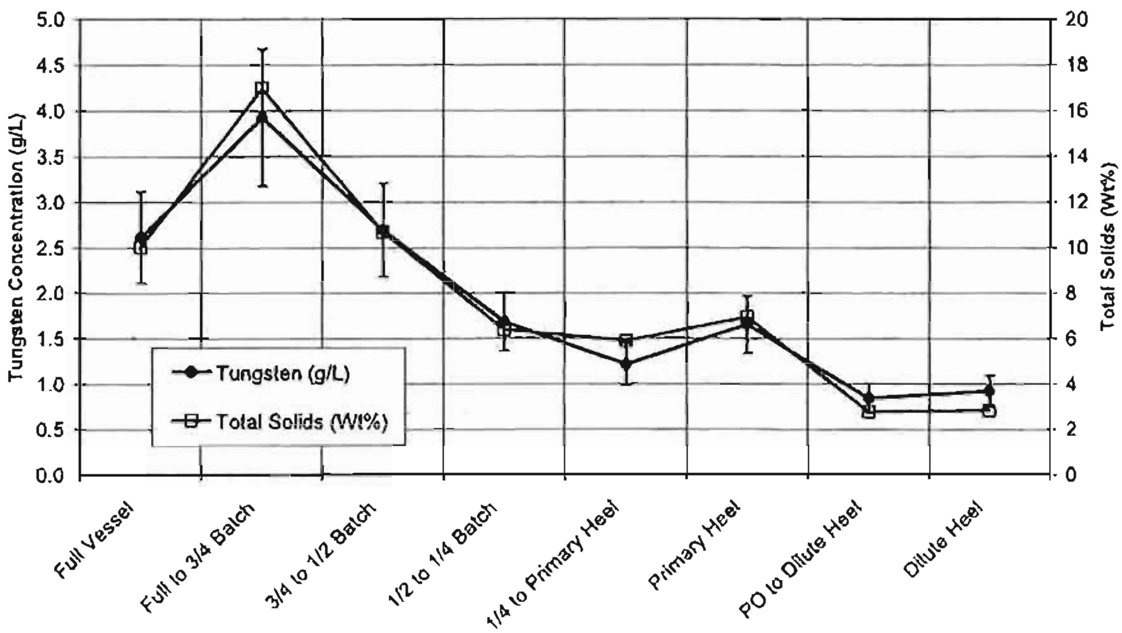
Note that the planned large scale test will be used to verify performance of the sampling systems (based on the updated CSER) with an integrated sampling and mixing performance test.

Question 16.B.2.a) *What were the results of the testing?*

Response 16.B.2.a) The results of the small scale testing indicated that segregation of the particles with high settling rates (primarily larger particles) did occur as expected. In addition, the test results and analysis indicate that the smaller particles follow the fluid movement of the slurry. The results also indicate that the samples collected at the full level contained a larger concentration of the particles with a high settling rate. As such, these samples provided a conservative estimate of the vessel concentrations.

More specifically, the tests completed at the MCE test stand for the HLW Feed Receipt vessel (HLP-22), which is the primary location for the criticality sampling, indicated that large, high settling rate particles were removed from the test vessel relatively early as the test vessel was emptied, and the smaller, low settling rate particles were dispersed more uniformly in the slurry and were pumped out at a more consistent rate. Examples of the large particles would be the sand and ~700μm, 2.9 g/mL simulant particles. The aluminum and iron particles are examples of the smaller, well distributed particles. Based on the maximum observed particle size data presented in Table 3.2.18 of WTP-RPT-153, the waste Fe, U, Bi, Ni, and Mn compounds would be expected to be in the well distributed particle set.

A related question is the behavior of the PuO_2 simulant particles in these tests. Although most of the Hanford plutonium is expected to have formed co-precipitated particles with the iron and other waste elements, a very limited number of tanks are suspected to contain PuO_2 particles, bounded by a 10μm spherical equivalent particle, that are not co-precipitated (CCN: 211814, p. 4, 1st paragraph). These plutonium oxide particles were simulated with a tungsten carbide (WC) alloy. The WC alloy particles ranged from ~1μm to 30μm diameter (CCN: 214953, p. 8). The tungsten concentration as a function of the tank level results from the HLP-22-NQA-007 test shown below clearly shows that the tungsten concentration during the first pump-out was higher than the original full vessel level (which would result in a conservative sample) In addition, the tungsten concentration in the heel slurry remaining after the initial pump down is lower than the initial, full vessel concentration.



HLP-22-NQA-007 Test Results

Note that this testing did not include a prototypic sample system. As such, the results can not be used to draw conclusions on the overall sampling capabilities but were provided to satisfy the test requirement specified in the response to question 16.B.2 above.

Question 16.B.2.b) *Was the testing conducted with a bounding simulant? Describe the physical and chemical properties of the bounding simulant.*

Response 16.B.2.b) The HLW simulant for the final phase of M-3 testing was developed to bound the design basis waste properties. See the response to question 16.A.4 for a discussion on the selection of the design basis waste properties. This simulant employed a particle size distribution larger than the 95%UL particle size distribution (design basis particle size distribution) listed as Table 3-2 in report RPP-9805. The average particle density was much greater than the 2.2g/mL agglomerated particle density reported in RPP-9805, and was designed to represent the larger particle fraction of a waste with an average particle density of 2.9g/mL reported in RPP-9805.

In addition, the simulant liquid phase was water. Using water assured both a low slurry viscosity and density to maximize particle settling rates in the tests. Additionally, the tests were performed at reduced velocities and the simulant was not adjusted to maintain the appropriate turbulence (e.g. Reynolds number) in the test vessels.

The PuO_2 waste particles were simulated using 11.2 g/mL tungsten carbide alloy particles. This tungsten carbide simulant was composed of particles ranging from ~1μm to ~30μm particles and approximately 40% of these particles were larger than the design basis 10μm PuO_2 particle.

The range of the measured simulant shear strength for the post design basis event tests met the ~200 Pa requirement.

Question 16.B.2.c) *How was the wide variation in WTP feed accounted for in these tests?*

Response 16.B.2.c) See the response to question 16.A.4 [*Given the batch-to-batch variability and complexity, how was the worst-case (bounding) feed selected for evaluating mixing power requirements and zone of influence (ZOI)?*]

Question 17. Savannah River National Laboratory Review of Non-Newtonian Mixing

Responses to Question 17 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Delmar Noyes, Deputy Assistant Manager, Waste Treatment and Immobilization Plant Project

Hanford Tank Waste Treatment and Immobilization Plant Project
Russell Daniel, Production Engineering Manager

Contributing authors:

Hanford Tank Waste Treatment and Immobilization Plant Project
Garth Duncan, Manager of Process Engineering and Technology
Robert French, M3 Issue Closure
Phil Kuchlen, Commissioning/Facilities Operations Manager
Mark Medsker, Pretreatment and High Level Waste Facilities Nuclear Safety Supervisor
John Olson, Manager, Process Engineering Design
Robert Voke, Discipline Production Engineering Manager

Question 17.A *The non-Newtonian Independent Review Team in their report (SRNL-RP-2010-00898, Independent Technical Review of the Assessment of Pulse-Jet Mixing Performance in Vessels Containing Non-Newtonian Sludge at the WTP) indicated that given additional time, a more detailed review of the waste characteristics could provide a higher level of confidence. Will the non-Newtonian Independent Review Team be given the opportunity to complete its review?*

Response 17.A The non-Newtonian Independent Review Team did complete its review, terming the report a final report in the report's transmittal letter (Dr. William R. Wilmarth (SRNL) to Richard E. Edwards, Jr. (WTP), SRNL-L3600-2010-00010, dated June 25, 2010 (CCN 281916)). The report said in the Executive Summary of their report, in part, the following:

The team believes that the existing physical waste characteristic data are adequate for use in the design for the non-Newtonian mixing system. Given adequate time, a more detailed independent review of the document and supporting documentation could provide a higher level of confidence in its utilization.

There are no plans at this time for the non-Newtonian Independent Review Team to conduct further review.

Question 17.B *The non-Newtonian Independent Review Team concluded that the minimum static yield stress for the non-Newtonian vessels (UFP-2 A/B, HLP-27 A/B, and HLP-28) be maintained above 6 Pascal and below 30 Pascal.*

Question 17.B.1 *Has BNI adopted this processing strategy? If not, what is the technical basis for not accepting this recommendation-describe the adopted processing strategy and the technical basis for its selection?*

Response 17.B.1 WTP intends to adopt the recommended processing strategy for three non-Newtonian vessels, HLP-27 A/B and HLP-28. See report 24590-WTP-RPT-PET-10-014, *Slurry Property Ranges in Non-Newtonian Pretreatment Vessels at WTP*, Revision 2, June 23, 2010. As noted in that report, UFP-2 A/B will, at times, see Newtonian conditions that are below 6 Pascals (this was noted in Section 4.1.2.2 of the SRNL report, SRNL-RP-2010-00898, Independent Technical Review of the Assessment of Pulse-Jet Mixing Performance in Vessels Containing Non-Newtonian Sludge at the WTP, CCN 218916).

In addition, as documented in the non-Newtonian vessel TSG closure package (CCN 220456), the project will conduct a reassessment of the minimum static yield stress aspect of the processing strategy.

Question 17.B.2 The non-Newtonian Independent Review Team believed that only one of the three methods discussed for controlling rheology will be successful (i.e., measuring permeate production).

Response 17.B.2 The non-Newtonian Independent Review Team report (SRNL-RP-2010-00898, *Independent Technical Review of the Assessment of Pulse-Jet Mixing Performance in Vessels Containing Non-Newtonian Sludges at the WTP* (CCN 218916)) states in Section 4.2.3, Monitoring Rheology, that Due to turbulent flow through the crossflow filters, using either the pressure drop or pump amperage does not appear to the team to provide a successful method to indirectly monitor rheology.

Question 17.B.2.a) Describe the technical basis supporting control of the rheological operating window.

Response 17.B.2.a) A preliminary technical basis for controlling the rheological operating window is provided in Appendix F, Process Controls for Mixing in report 24590-WTP-RPT-PET-10-014, *Slurry Property Ranges in Non-Newtonian Pretreatment Vessels at WTP*, Revision. 2, June 23, 2010. The initial control step will be part of the waste feed pre-qualification testing for percent solids and rheology as indicated in Section 7 of 24590-WTP-PL-OP-07-0001, *Plan for WTP Feed Pre-qualification*, Revision 1, dated December 22, 2008. The specific detailed controls after the feed is received have not yet been specifically defined.

Question 17.B.2.b) Is the design of the controls supporting the rheological operating window complete? If not, what activities remain to be completed (e.g., development activities to validate the selected control strategy)? Discuss the technical scope of these activities and when they would be performed.

Response 17.B.2.b) The control design is not complete. Development activities, if any, and an associated schedule have not been determined.

Question 17.C *The non-Newtonian Independent Review Team concluded that the logic processes in the WTP mixing vessel assessments supporting a determination of confirmation ready were inadequately described in the draft report provided to the review team. Will the non-Newtonian Independent Review Team perform a follow-up review on the final mixing vessel assessments to assess the logic processes used to determine the confirmation ready status of non-Newtonian vessels? If not, will there be a follow-up review, who will do it, and why is this acceptable?*

Response 17.C Any follow-on activity by the non-Newtonian Independent Review Team will be determined later. It should be noted that the team concluded that with the adoption of the lower limit of 6 Pa, in the recommendations on page 43 of SRNL-RP-2010-00898, *Independent Technical Review of the Assessment of Pulse-Jet Mixing Performance in Vessels Containing Non-Newtonian Sludges at the Waste Treatment and Immobilization Plant* (CCN 218916) that Mixing has been shown to be effective in this range of rheology.

Question 17.D *The non-Newtonian Independent Review Team concluded that too little data exists for yield stresses between 0 and 6 Pa to assure accurate scaling or confirm suspension of the expected waste slurry with a high degree of confidence.*

Question 17.D.1 *What vessels will contain slurries with Bingham Plastic yield stresses at the vessel bottoms between 0 to 6 Pa?*

Response 17.D.1 For the five non-Newtonian vessels, only UFP-2 A/B will contain slurries with Bingham Plastic yield stresses between 0 and 6 Pa. UFP-2A/B will initially receive Newtonian feed streams (0 Pa) from UFP-1A/B. For UFP-2A/B, the waste in this regime will be evaluated as Newtonian and will be based on the previous Newtonian scaling and suspension data.

The waste feed stream for HLP-27 A/B and HLP-28 will be controlled to ensure a non-Newtonian behavior with a Bingham Plastic yield stress greater than or equal to 6Pa, as discussed in Section 5 and Appendix F of 24590-WTP-RPT-PET-10-014, *Slurry Property Ranges in Non-Newtonian Pretreatment Vessels at WTP*, Revision. 2, June 23, 2010.

Question 17.D.2 *What control strategy will be used to avoid operating in this rheological window (0 to 6 Pa)? What are the potential safety-related mixing concerns associated with Bingham Plastic fluids with yield stresses between 0 Pa and 6 Pa?*

Response 17.D.2 Control strategies for the five non-Newtonian vessels are not yet developed as discussed in the response to 17.B.2 a). HLP-27A/B and HLP-28 are evaluated in the non-Newtonian vessel assessment at 6 and 30 centipoise, and also by further analyzing the limiting case of 0 Pa, to assure adequate mixing in those conditions with respect to particle settling. In addition, large scale testing is being planned to further evaluate the vessel mixing performance. On the basis of the conclusions from current analysis and the control strategies and capabilities to be established during the planned large-scale testing, it is expected there will be no emergent safety-related mixing concerns for these vessels.

Question 17.E *The non-Newtonian Independent Review Team recommended that ZOI data for non Newtonian vessels be assessed to determine if the Pulse Jet Mixer systems mobilize the entire vessel bottom at a yield stress of 30 Pa.*

Question 17.E.1 *Will DOE require these data be analyzed? If yes, when will this analysis occur? Provide a description of the analysis and results.*

Response 17.E.1 The recommendation has been followed. As reported in Appendix A of 24590-WTP-RPT-ENG-08-021-03, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 3 - HLP-VSL-00027A/B, HLP-VSL-00028, UFP-VSL-00002A/B*, Revision. 1, dated August 19, 2010, bottom clearing calculations for 200, 80, and 30 Pa were performed. As shown in Table 23, Bottom Clearing Calculation Summary for all HLP-27 Operation Cases, 100% clearing (indicating ZOIs are overlapping) was demonstrated for both the 80 and 30 Pa cases. Similar results were determined for HLP-28 (Table39). Table 74 shows 100% clearing for all three cases.

Question 17.E.2 *Are any additional research activities needed to increase confidence in vessel performance at full-scale in this range of rheological properties? Describe these activities.*

Response 17.E.2 Planned large-scale testing would increase confidence in vessel performance over the range of rheologies. Specific large-scale activities are not yet identified.

Question 17.F *The non-Newtonian Independent Review Team stated that they found the heel management program to be a prudent engineering design feature for vessels that are expected to be in service for at least 50 years. Describe the heel management features that are going to be installed on the non-Newtonian process vessels.*

Response 17.F A heel management system is currently in process of being implemented into the design. The conceptual heel management system consists of heel dilution and heel cleanout operations. A summary of features is contained in report 24590-WTP-RPT-PET-10-013, Revision. 0, *Pretreatment Vessel Heel Dilution/Cleanout Feasibility Study*, June 4, 2010. In addition, the functional requirements for heel cleanout and dilution are defined in 24590-PTF-RPT-ENG-10-004, Revision 0, *Pretreatment Vessel Heel Dilution/Cleanout Functional Requirements*. The features are as follows:

1. Lowering pump suctions to ~3-inches off-bottom for the vessels identified in 24590-WTP-RPT-PET-10-013, Revision 0.
2. Installing temporary pumps (as needed) for heel dilution and heel cleanout.
3. Providing secondary pump suction connections for the heel removal pump(s).
4. Provide two connections (access ports) to each vessel head to allow means to access and observe conditions within the vessel.

Question 17.G *The non-Newtonian Independent Review Team recommended that additional data analysis be performed to determine if a model that can predict the mixing performance in non-Newtonian tanks over the entire range of experimentation is needed. Will this reassessment occur? If so, when? What alternative exists if it is determined that a model cannot predict mixing performance?*

Response 17.G Based on the recommendation of the non-Newtonian Independent Review Team, additional data analysis was performed and is documented in 24590-PTF-ES-PET-10-001, *Engineering Study For Non-Newtonian Vessel Cavern Height Correlation*, Section 2, paragraph 2.2. The report successfully correlated the data and concluded that generally, as vessel size increases, required jet velocity decreases. The results were consistent with the conclusions of PNNL report WTP-RPT-113, *Technical Basis for Testing Scaled Pulse Jet Mixing Systems for Non-Newtonian Slurries*, Section 6, paragraph 6.4.3. As such, alternatives are not required.

Question 17.H *The non-Newtonian Independent Review Team stated that CFD simulations will be beneficial to the project and recommended that the project continue to pursue CFD without software validation.*

Response 17.H The Project is pursuing verification and validation (V&V) of the CFD software for mixing of Newtonian fluids only. CFD has been utilized as an indicator of performance along with other analysis methods in the M3 Vessel Assessments for Newtonian fluids. CFD will not be used as a design tool (for design confirmation) until the software has been successfully V&V'd.

Question 17.H.1 *Are CFD simulations without verification and validation of the code going to be used in the design of these vessels?*

Response 17.H.1 No. CFD will not be used for design confirmation of any vessels until after it has been V&V'd. Use of CFD for these vessels will be limited to the design confirmation of UFP-2A/B when the vessel contents are Newtonian.

Question 17.H.2 *When will the verification and validation of non-Newtonian process vessels be performed?*

Response 17.H.2 Verification and validation of CFD will be performed as required by the WTP design process. Note that CFD will not be used for the design confirmation of these vessels except for UFP-2A/B when the vessel contents are Newtonian. The verification and validation of the CFD software for modeling pulse jet mixing of Newtonian slurries is expected to be completed by September 2011.

Question 17.H.3 *What experimental data will be used in the verification and validation process?*

Response 17.H.3 The experimental program to support V&V of CFD for Newtonian slurries in non-Newtonian as well as Newtonian vessels will be defined in a revision of document 24590-WTP-PL-ENG-03-010, *Fluent Computational Fluid Dynamics V&V Plan*. The CFD V&V test plan is being revised in order to align it with the recently published ASME V&V 20-2009 Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer.

Question 17.H.4 *Will the experimental data used for verification and validation of non-Newtonian process vessels include features such as spargers and recirculation pumps? If yes, describe the data.*

Response 17.H.4 The experimental program for verification and validation of the CFD software for modeling pulse jet mixing systems in Newtonian slurries will not include spargers and recirculation pumps.

Question 17.I *The non-Newtonian Independent Review Team recommends that integration of the Pulse Jet Mixers, spargers, and recirculation pump should be considered in the respective vessel assessments. Has DOE accepted this recommendation? If yes, describe when and how integration of the Pulse Jet Mixers and spargers/recirculation pump will be considered?*

Response 17.I The vessels assessment for the non-Newtonian vessels, 24590-WTP-RPT-ENG-08-021-03, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 3 - HLP-VSL-00027A/B, HLP-VSL-00028, UFP-VSL-00002A/B,* Revision 1, dated August 19, 2010, addresses integration of the PJMs and spargers; the operation of the recirculation pump is not included. The recirculation pumps are process pumps used for ultrafiltration in conjunction with the UFP-2A/VB vessels (there are no recirculation pumps for the other non-Newtonian vessels). Although the recirculation pumps would enhance mixing in UFP-2A/B, they are not safety-related and would not necessarily be available in accident conditions to help fulfill safety-related mixing criteria for those vessels. The assessment demonstrates that the PJMs and spargers are sufficient to achieve the mixing criteria for the vessels. There are no plans to attempt to include the recirculation pumps in a future assessment.

Question 18. Pacific Northwest National Laboratory (PNNL)

Responses to Question 18 were developed by the following PNNL staff:

Primary authors:
Loni Peurrung, Product Line Manager

Contributing authors:
Perry Meyer, Staff Scientist
Dean Kurath, Staff Engineer
Michael Minette, Project Manager
Gordon Beeman, Project Manager

Question 18.A. *PNNL has had considerable involvement with the design and testing of the pulse jet mixed vessels at the WTP. What is PNNL's technical opinion regarding the existing technical basis for the design of Pulse Jet Mixing System?*

Response 18.A. PNNL's expert opinion, based on the results of PNNL's Phase I scaled testing (PNNL-18098, *Pulse Jet Mixing Tests with Noncohesive Solids* (WTP-RPT-182)), is that the performance of the PJM vessel types (PWD-43, RLD-07, RLD-08 and HOP-903/904) met the provided set of mixing criteria, PJM vessel types FEP-17 A/B and TLP-09 A/B were marginal, and PJM vessel types FRP-02 A/B/C/D, HLP-22, PWD-15/16, PWD-33, PWD-44, TCP-01 and UFP-01 A/B were inadequate. The current designs have subsequently been improved; however, PNNL has not been provided the opportunity to formally review the current design basis.

The technical basis for design fundamentally resides in selection of mixing criteria. While complete mixing resulting in a fully uniform distribution of particles throughout the vessel volume is not achievable or necessary, the ability to move solids through the plant requires an acceptable suspension and vertical distribution of those solids. PNNL has significant history evaluating the performance of PJMs for WTP, and as a result was asked by WTP to perform a series of scaled mixing tests with the goal of establishing appropriate scaling factors to predict full-scale performance. This work culminated in the completion of Phase I scaled tests limited to non-cohesive, monodisperse particles (PNNL-18098 / WTP-RPT-182). At the time of completion of our report on Phase I testing, PNNL and WTP had selected complete off-bottom suspension and solids concentration near the pump inlet (derived from cloud height) as appropriate rating metrics. These metrics were consistent with the WTP mixing requirements at that time (24590-WTP-ES-PET-08-002, *Determination of Mixing Requirements for Pulse-Jet-Mixed Vessels in the Waste Treatment Plant*). PNNL developed both statistics-based and physics-based correlations from the Phase I testing data to evaluate full-scale mixing behavior. Evaluated against these mixing metrics, two vessel types appeared to be marginal and seven vessel types appeared inadequate.

WTP mixing system designs have evolved, including design changes such as increasing jet velocity and, in some cases, increasing the number of pulse tubes and/or nozzle diameters. Operating conditions have also been changed, such as reducing solids concentrations. As a result, of the nine vessel types evaluated as marginal or inadequate, four of the designs or operating conditions for the vessel types have been improved since PNNL completed Phase 1 testing. However, there are still deficiencies with the technical basis for both the Newtonian and non-Newtonian vessels.

While Phase 1 testing predicted inadequate mixing in some vessels as indicated by off-bottom suspension and cloud height, WTP subsequently changed the mixing metrics in their testing as regards complete off-bottom suspension for a normal, full vessel and moved to a bottom-clearing metric. WTP then performed its own series of bottom-clearing tests using waste simulants. This change represents a significant reduction of the mixing criterion. The achievement of complete off-bottom suspension is a standard requirement in industrial mixing system designs.

In addition, there are no longer any mixing requirements relative to solids vertical distribution, such as a requirement limiting maximum solids concentration (typically near the transfer pump inlet). The project assumed that only a small fraction of the solids (the heaviest) stratified near the bottom of the vessel and that the remainder would be fairly well distributed vertically. Observations from recent WTP testing results (24590-WTP-ES-PET-09-001, *M3 Platform Test Data Study*) demonstrate otherwise, with significant stratification of most or all of the solids being present.

The technical basis for establishing the adequacy of the design based on testing using simulants also depends on how well the simulants bound the behavior of actual tank waste. PNNL has several concerns related to the simulants used in WTP's tests that followed PNNL's Phase 1 testing, which were not necessarily physically representative or bounding of actual waste.

- Actual waste at higher solids concentration typically has a yield stress. The simulants WTP used for scaled testing of normal mixing operations were primarily non-cohesive. The jet degradation near the vessel floor where the solids concentration is high is therefore less severe in the WTP tests than it would have been if the simulant exhibited a yield stress. Consequently, the mixing performance observed in the WTP tests may be better than actual plant performance.
- The 200 Pa simulant used for post-DBE testing was inadequate as a cohesive simulant, since some of its shear strength was due to granular compaction. The concern (WTP/RPP-MOA-PNNL-00494, *Subcontract No. 24590-QL-HC49-00001 – Project 55753 (WA#028) Recipes for Simulant Strengths*) is that the granular simulant is more easily mobilized than tank wastes at 200 Pa and test results may be non-conservative.

Finally, the current design lacks an adequate scaling basis to relate small-scale test results to full-scale plant performance. Some WTP testing applied a scaling law with a velocity scale exponent of 0.18 rather than 0.33. The smaller scale-up exponent allowed the scaled PJMs to be operated at higher velocity in the test stand, thus improving the observed clearing behavior. We think the use of the 0.18 scale exponent (derived from wall shear measurements from steady air jets impinging on a flat plate) to unsteady mobilization of solids in the test stands is not supported by existing data.

WTP also tested pumped-out material in an attempt to demonstrate that no net solids would accumulate in the vessel. The scaling of the mixing, transfer system, and pump-down process is complex. Hence, we think the absence of an experimentally validated scaling basis for pump-down represents a significant weakness of the current design basis.

As far as we are aware, the only available data for scale-up of PJM systems with non-cohesive solids are the PNNL test data (PNNL-18098 / WTP-RPT-182). Those data were collected explicitly for PJM velocity for complete off-bottom suspension and solids cloud height. Scaling laws were developed at that time based on those two metrics. Current designs are based on applying a scaling exponent of 0.18 for some bottom clearing tests and an exponent of 0.33 for all other mixing modes. To the extent that this is true, the scaling basis for the current testing is not directly supported by PNNL test data.

Question 18.A.1. *What are the technical strengths and weaknesses of the existing design given the information currently available?*

Response 18.A.1. The weakness in the existing design is that it fails to provide adequate design margin. Because the design fails to show that it readily meets conventional mixing criteria, significant investment in scaled testing has been required to determine if it meets lesser requirements under less challenging operating conditions such as reduced solids loading. The significant uncertainty in scaling behavior for these mixing systems makes it difficult to predict with confidence whether those criteria will be met at the full scale, thus suggesting that full-scale testing may yet be required. However, a more robust mixing system with generous design margin would reduce if not eliminate the need for great certainty in scaling factors.

Question 18.A.2. *What are the potential safety-related implications of these technical weaknesses?*

Response 18.A.2 The potential safety-related implications of the weaknesses identified above are the risk of criticality and the risk of hydrogen gas flammability.

A.2.1 Risk of Criticality

The technical understanding and vessel designs must be adequate to control the accumulation of fissile masses (through separation and other causes) in forms, quantities and conditions that might result in a criticality.

The previously mentioned weaknesses associated with scaling, simulants, and mixing requirements all can result in small-scale test results that under-predict how the fissile materials at risk may actually accumulate in the plant. Because of this, a potentially unsafe accumulation of material may occur.

Specifically, if mixing systems are underpowered, the heaviest particles can accumulate in the bottom of the vessels. The fissile materials in Hanford waste are likely among the heaviest particles.

A.2.2 Risk of Hydrogen Flammability

The technical understanding and vessel designs must be adequate to ensure that unsafe accumulation of flammable gasses inside vessels be avoided.

Specifically, the mixing systems must be adequate to ensure safe management of flammable gasses during normal operations and upon restart after a mixing system outage or other DBE. During normal operations, the mixing designs must ensure that dead zones of immobile material are prevented, and that concentrations of flammable gasses in mixed zones are low. For post-DBE operation the mixing systems must be able to overcome the physical waste state that has resulted during the outage.

The previously mentioned weakness associated with scaling, simulants, and mixing requirements all can result in small-scale test results that under-predict the magnitude of dead zones and overall gas retention in the vessels. Also, the test results may give a misleading impression of the ability of the mixing designs to safely overcome the settled layers after a DBE and re-establish a safe, normal operating state.

Question 18.B. *What concerns did PNNL express to DOE regarding the current pulse jet mixer design basis?*

Response 18.B. PNNL has expressed concerns to WTP staff in the areas of vessel mixing, scaling, PJM controls, pipeline plugging, simulants, gas retention, and general concerns. PNNL concerns were provided directly to WTP since PNNL's contractual relationship is to BNI rather than to DOE; however, PNNL received DOE review comments on most draft reports. Specific concerns are detailed below.

Prior to February 2007, Battelle, Pacific Northwest Division provided support to BNI as a true subcontractor, via our 1831 contract "use permit." Subsequent to that date, work has been assigned from DOE to BNI and then to PNNL under the 1830 prime contract via an Inter-entity Work Order (IWO). An IWO is not a contract, and does not make PNNL a subcontractor to BNI. Rather, an IWO is a financial mechanism that shifts DOE funding and tasks among DOE Contractors. Project work scope, budget, schedule, quality and special requirements, deliverables and reporting requirements continued to be directed by BNI; however, PNNL's contractual relationship after February 2007 was with DOE.

Vessel Mixing

- **August 14, 2007** – Letter WTP/RPP-MOA-PNNL-00089 to WTP, *Subcontract No. 24590-QL-HC9-WA49-00001, Project 53019 (WA#2007-008) Transmittal of Preliminary Summary of HLP-22 Testing Results*, HLP-22 (4 nozzle 8m/s) design appears inadequate for Newtonian Wastes.
- **March 19, 2008** – Letter WTP/RPP-MOA-PNNL-00191, *Contract No. 24590-QL-HC9-WA49-00001 – Project 53023 (WA#2007-008) Transmittal of Interim Report, Interim Summary: HLP-22 Mixing Performance Evaluation.* Interim summary - HLP-22 mixing performance evaluation to WTP: HLP-22 design is significantly underpowered.
- **April 17, 2008** – Discussion with WTP PJM Criticality representative: Expressed concern that the PJMs could be a separator. The fissile materials with high density are likely or could possibly separate from the poisons (light metals). While the fissile [materials are] spread on the tank bottom, there is no problem. When pulsed in the liquid moderator, a problematic geometry could occur.
- **December 2008** – Draft Report WTP-RPT-182 Revision A *Pulse Jet Mixing Tests* with non-cohesive solids: During Phase I Newtonian vessel testing, PNNL identified that four vessel types (PWD-43, RLD-07, RLD-08 and HOP-903/904) that satisfied the design criteria for all conditions evaluated, two vessel types were marginal (FEP-17 A/B and TLP-09 A/B) and seven vessel types

(FRP-02 A/B/C/D, HLP-22, PWD-15/16, PWD-33, PWD-44, TCP-01 and UFP-01 A/B) did not satisfy the design criteria for any of the conditions evaluated. Also alternative configurations for HLP-22 (including 6 inch nozzles at 12 m/s) did not satisfy the design criteria for any of the conditions evaluated.

- **January 15, 2009** – Letter WTP/RPP-MOA-PNNL-00349 to WTP, *Subcontract No. 24590-QL-HC9-WA49-00001 – Project 55753 (WA#2008-028) Transmittal of Conceptual Test Requirements,* provided a conceptual plan for phase 2 testing. The concept draft included multi-tank scale testing, parametric simulant testing, bridge test from phase 1 to phase 2 drives, instrumentation for off bottom suspension, in tank shear stress readings and concentration measurements, combined Newtonian and non-Newtonian simulant tests. Cohesive simulant testing was also recommended at two tank scales. (Emails and proposals on how to do phase 2 testing go back to the summer 2008 and include August 1, 2008 Email PNNL to WTP, September 24, 2008 Proposal for SCN-77 Revision 0, and October 14, 2008 Proposal to SCN-77 Revision 1.) The concept draft was concerned that technically defendable testing would need multi-vessel size tests, bridge tests to Phase 1, parametric tests (Newtonian, Cohesive simulants), and an instrumented tank.
- **May 2009** -- Report WTP-RPT-182 Revision 0 *Pulse Jet Mixing Tests with Noncohesive solids*: While the summary statement of the mixing performance evaluation was removed per contract direction, detailed examples, what ifs and summary figures were provided to support the WTP evaluations related to the M3 determination of vessel adequacy. Detailed analysis of the HLP-22 vessel design at the time (4 inch nozzles 8 m/s) and three alternative HLP-22 designs (4/12 m/s, 6/8 m/s and 6/12 m/s) were shown to not be sufficient to lift all the solids from the bottom and would result in pump inlet concentrations that exceeded to 20 wt% criteria. Figures 9.58 through 9.61 show that two vessel types were marginal (FEP-17 A/B and TLP-09 A/B) and seven vessel types (FRP-02 A/B/C/D, HLP-22, PWD-15/16, PWD-33, PWD-44, TCP-01 and UFP-01 A/B) did not satisfy the design criteria for any of the conditions evaluated. The report also raised the concern that actual in-tank waste settling velocities appeared to be faster than those shown in the WTP-RPT-153, *Estimate of Hanford Waste Insoluble Solid Particle Size and Density Distribution,* Case 3.

Scaling

- **December 2008** – Draft Report WTP-RPT-182 Revision A *Pulse Jet Mixing Tests with Non-cohesive solids:* During Phase 1 Newtonian vessel testing, PNNL identified that four vessel types (PWD-43, RLD-07, RLD-08 and HOP-903/904) that satisfied the design criteria for all conditions evaluated, two vessel types were marginal (FEP-17 A/B and TLP-09 A/B) and seven vessel types (FRP-02 A/B/C/D, HLP-22, PWD-15/16, PWD-33, PWD-44, TCP-01 and UFP-01 A/B) did not satisfy the design criteria for any of the conditions evaluated. Also alternative configurations for HLP-22 (including 6 inch nozzles at 12 m/s) did not satisfy the design criteria for any of the conditions evaluated.
- **January 15, 2009** – Letter WTP/RPP-MOA-PNNL-00349 to WTP provided a conceptual plan for phase 2 testing. The concept draft included multi-tank scale testing, parametric simulant testing, bridge test from phase 1 to phase 2 drives, instrumentation for off bottom suspension, in tank shear stress readings and concentration measurements, combined Newtonian and non-Newtonian simulant tests. Cohesive simulant testing was also recommended at two tank scales. (Emails and proposals on how to do phase 2 testing go back to the summer 2008 and include August 1, 2008 Email PNNL to WTP, September 24, 2008 Proposal for SCN-77 Revision 0, and October 14, 2008 Proposal to SCN-77 Revision 1.) The concept draft was concerned that

technically defendable testing would need multi-vessel size tests, bridge tests to Phase 1, parametric tests (Newtonian, Cohesive simulants), and an instrumented tank.

- **May 2009** – Report WTP-RPT-182 Revision 0 *Pulse Jet Mixing Tests with Noncohesive Solids*: While the summary statement of the mixing performance evaluation was removed per contract direction, detailed examples, what ifs and summary figures were provided to support the WTP evaluations related to the M3 determination of vessel adequacy. Detailed analysis of the HLP-22 vessel design at the time (4 inch nozzles 8 m/s) and three alternative HLP-22 designs (4/12mps, 6/8mps and 6/12mps) were shown to not be sufficient to lift all the solids from the bottom and would result in pump inlet concentrations that exceeded to 20 wt% criteria. Figures 9.58 through 9.61 show that two vessel types were marginal (FEP-17 A/B and TLP-09 A/B) and seven vessel types (FRP-02 A/B/C/D, HLP-22, PWD-15/16, PWD-33, PWD-44, TCP-01 and UFP-01 A/B) did not satisfy the design criteria for any of the conditions evaluated. The report also raised the concern that actual in-tank waste settling velocities appeared to be faster than those shown in the WTP-RPT-153 Case 3.
- **January 2010**– Draft Report WTP-RPT-208 Revision A, *Reconciling Differences in Phase 1 and Phase 2 Test Observations for Waste Treatment Plant Pulse Jet Mixer Tests with Non-Cohesive Solids*, identified that a larger scaling factor for U_{CS} (critical suspension velocity, all solids suspended at the end of pulse) is likely to be required for full cycle PJMs used in phase 2. The preliminary U_{CS} scale-up exponents (in the draft report) for phase 2 testing were 0.38 for 8-tube tests and 0.34 for 12-tube tests. (These scaling factors are expected to increase slightly in the final report.)
- **February 16, 2010** – Email to WTP (TDP-WTPSP-443 page 78) (related Emails April 9, 2010 pages 69-70, May 13, 2010 pages 66-68, May 21, 2010 pages 48-51): expressed concern related to the use of the 0.18 ZOI (Journal of Applied Mechanics, *Investigation of a Turbulent Radial Wall Jet*) scaling factor to determine the jet velocity in bottom clearing testing and the related technical basis for the 0.18 scaling factor use in the PJM testing conditions. (Also see WTP/RPT-MOA-PNNL-00507 in TDP-WTPSP-443 Page 327-329.)
- **February 24, 2010** – Email to WTP (TDP-WTPSP-443 page 77) Related Emails February 26, 2010 pages 65-76, and May 17, 2010 page 64): Expressed concern that the suction inlet to the transfer (sampling/ batch pump out inlet) pump was not geometrically or functionally prototypic. (Also see WTP/RPT-MOA-PNNL-00507, *Subcontract No. 24590-QL-HC9-WA49-00001, Project No. 55753 (WA-028) Test Considerations for the Potential Engineering-Scale HLP-27 Test* in TDP-WTPSP-443 Page 329-331.)

PJM Controls

- **February 2007** – Report WTP-RPT-146, Revision 0: The signals from a vent overblow were found to be too small for practical detection and control. The signal for aspiration with drive line length of 50 ft and suction line length of 125 ft also indicated that aspiration could not be detected.
- **August 2009** – Report WTP-RPT-179,Revision 0, *PJM Controller Testing with Prototypic PJM Nozzle Configuration*, expressed concern that the results of the testing presented in Section 6 indicate that the BNI controllers are not capable of detecting drive overblows under all circumstances. Both the ABB and Triconex controllers failed to reliably detect overblows under the scenario where a PJM overblow occurred because the pulse tube was not completely full before the start of the drive phase.

Pipeline Plugging

- **March 2009** – Report WTP-RPT-175, Revision 0, *Deposition Velocities of Newtonian and Non-Newtonian Slurries in Pipelines*: Concern the Thomas (1979) correlation in the design guide is not conservative and a Non-Newtonian deposition velocity design guide should be developed for WTP. Also, calculations should evaluate critical velocities for both the Newtonian and Non-Newtonian fluids and evaluate at least three criteria: first the critical deposition boundary, second the transitional deposition boundary and third the laminar deposition boundary.
- **May 2009** – Report WTP-RPT-178, Revision 0, *Qualitative Investigation of Depositional Velocities On Non-Newtonian Slurry In Complex Pipeline Geometries*: The flush to line volume ratio should be 3 (verses 1.7 in the design guide24590-WTP-GPG-M-0058 Revision 0) and critical deposition velocities on complex fittings are lower than those reported in WPT-RPT-175 for straight pipe sections.
- **July 2009** – Report WTP-RPT-189 Revision 0 *Deposition Velocities of Non-Newtonian Slurries in Pipelines Complex Simulant Testing*: Confirmed concern that a robust pipeline design should consider correlations for both Newtonian and Non-Newtonian transport, identified key line flushing velocities, and determined that Net Positive Suction Head required increased significantly over (1.5 to 2 times) that for water.

Simulants

- **January 13, 2009** – Email to WTP (TDP-WTPSP-443 page 296-298) (related Emails January 13-14, 2009 pages 254-275): WTP Project Manager asked on tour if PNNL could support a 5 micron stainless steel simulant being considered a bounding particle representing Hanford Tank Wastes. This Email string expresses PNNL's concern that 5 micron SS is not bounding, shows much larger Plutonium particle images from the WTP-RPT-153 report and supplies simulant choices that WTP could use to match settling velocities for a potentially bounding 40 to 50 micron Plutonium oxide particle.
- **January 15, 2009** – Letter WTP/RPP-MOA-PNNL-00349 to WTP provided a conceptual plan for phase 2 testing. The concept draft included multi-tank scale testing, parametric simulant testing, bridge test from phase 1 to phase 2 drives, instrumentation for off bottom suspension, in tank shear stress readings and concentration measurements, combined Newtonian and non-Newtonian simulant tests. Cohesive simulant testing was also recommended at two tank scales. (Emails and proposals on how to do phase 2 testing go back to the summer 2008 and include August 1, 2008 Email PNNL to WTP, September 24, 2008 Proposal for SCN-77 Revision 0, and October 14, 2008 Proposal to SCN-77 Revision 1.) The concept draft was concerned that technically defendable testing would need multi-vessel size tests, bridge tests to Phase 1, parametric tests (Newtonian, Cohesive simulants), and an instrumented tank.
- **May 2009** – Report WTP-RPT-182 Revision 0 *Pulse Jet Mixing Tests with Noncohesive Solids*: While the summary statement of the mixing performance evaluation was removed per contract direction, detailed examples, what ifs and summary figures were provided to support the WTP evaluations related to the M3 determination of vessel adequacy. Detailed analysis of the HLP-22 vessel design at the time (4 inch nozzles 8 m/s) and three alternative HLP-22 designs (4/12mps, 6/8mps and 6/12mps) were shown to not be sufficient to lift all the solids from the bottom and would result in pump inlet concentrations that exceeded to 20 wt% criteria. Figures 9.58 through 9.61 show that two vessel types were marginal (FEP-17 A/B and TLP-09 A/B) and seven vessel types (FRP-02 A/B/C/D, HLP-22, PWD-15/16, PWD-33, PWD-44, TCP-01 and UFP-01 A/B) did not satisfy the design criteria for any of the conditions evaluated. The report also raised the

concern that actual in-tank waste settling velocities appeared to be faster than those shown in the WTP-RPT-153 Case 3.

- **February 19, 2010** – Letter WTP/RPP-MOA-PNNL-00489 to WTP (TDP-WTPSP-443 page 206-227): Concerns related to using the RPP-9805 particle size distribution for simulant basis.
- **March 12, 2010** – Letter WTP/RPP-MOA-PNNL-00494 to WTP (TDP-WTPSP-443 page 200-204): Concern that a highly cohesive simulant is expected to behave differently than the 200Pa simulant. (Related Emails January 14, 2009 Pages 237-239, January 15-27, 2009 Pages 277-283, February 23, 2009 pages 248-251 and technical notes to WTP pages 234-235.)
- **June 18, 2009** – Email to Non-Newtonian review group: the use of a static force balance-type criteria for establishing whether a particle will settle in a fluid with a yield stress does not apply in the same way when the fluid is sheared, agitated or in a state of turbulence. … Unsteady jet/sparger hybrid mixing with cohesive settling slurries is complex enough to warrant some experimental verification. [This testing is key for developing a technical basis for shear stress control options in non-Newtonian vessels.]
- **June 25, 2010** – Letter WTP/RPP-MOA-PNNL-00507 to WTP (TDP-WTPSP-443 page 319-332): For potential Non-Newtonian tank testing in the MCE 43-inch test stand, the letter recommended not using a 0.18 bottom clearing scaling factor, parametric testing the transfer suction inlet diameter and velocity, parametric testing using the physical properties of combine cohesive/Newtonian simulants, and scaling of the spargers (also see /RPP-MOA-PNNL-00508).

Gas Retention

- **May 2009**– Report WTP-RPT-177, Revision 0, *An Approach to Understanding Cohesive Slurry Settling, Mobilization, and Hydrogen Gas Retention in Pulsed Jet Mixed Vessels:* The report highlighted technical uncertainties for flammable gas release from cohesive wastes related to both the modeling of their behavior in PJM vessels and uncertainties related to actual waste tank settling and strength behaviors have not been resolved. It also raised concerns that in-tank waste settling velocities appeared to be faster than those shown in the WTP-RPT-153 Case 3. (Follow-on reports include PNNL-18327 and PNNL-19245 see figure 3.1.)

General

- **July 6, 2010** – Email Terry Walton (PNNL) to Frank Russo, *Vulnerabilities*, the list is provided with the following background:
    - The attached list of vulnerabilities does not constitute a complete and comprehensive review by PNNL staff but rather should be considered as some examples of risks that staff are aware of as a result of their involvement with various WTP efforts.
    - BNI staff are aware of and working many of these issues. Designs and operating conditions for several vessels are being reevaluated as a result recent phase 2 testing and PNNL staff may not be aware of the complete suite of actions that BNI is taking to address vulnerabilities.
    - In some cases there are valid differences of technical and engineering opinions between the PNNL and BNI staff.

Question 18.B.1. *Given the concerns identified by PNNL, what additional testing, if any, would be needed to resolve these concerns?*

Response 18.B.1 The type of additional testing needed depends on the ultimate purpose of the test. As indicated in our response to Question A.1, an increase in design margin would provide a clearly robust, easily defensible design requiring relatively little additional testing.

B.1.1. Testing to provide clearly robust, easily defensible designs

Most or all of the significant technical and safety issues can be resolved by tests performed at reduced scale if sufficient air supply and/or type of mixing equipment are provided. This approach requires the use of conservative scale factors, conservative mixing requirements, and conservative simulants. Tests are conducted to determine what mixing equipment operating conditions are required to meet the mixing requirements. With this approach, the degree of conservatism is increased to the point where the significant technical issues are eliminated. This is the testing approach commonly used in process industries. We believe that this testing approach is technically appropriate, especially given the black-cell operating environment. Testing of this type should be planned in conjunction with engineering feasibility and cost benefit studies in order to provide, technically defensible, safe, and robust designs that are least impactful to the WTP baseline.

B.1.2 Testing to establish if existing designs are indeed adequate

If the goal of testing is to confirm the existing designs, we would recommend full-scale testing of prototypic systems, utilizing a range of well-designed, bounding simulants. The prototypic system should include a prototypic air supply system utilizing jet pulse pairs, prototypic bubblers for level and PJM control, a slurry washdown system to prevent slurry creep into the air lines and a prototypic PJM control system. We recommend that if this approach is adopted that the tests be conducted in a conservative manner leading to a sufficient design and operating margin. With this approach, all issues associated with scaling would be bypassed. However, technical issues with simulants would still require resolution.

With this approach, perhaps not all designs would require full-scale testing, as it may be argued that one vessel design bounds another. However no single vessel design should be assumed to be bounding for all vessel designs.

B.1.3 Testing to establish the limits of operation for existing designs

If the goal of testing is to identify the operational limits of current designs, we would also recommend full-scale testing of prototypic systems as described above. However, simulant properties such as concentration, rheology, and particle size and density would require parametric variation in order to determine which combinations of properties the existing design can adequately handle.

Finally, we do not believe that a single test can be conducted that will address the major weaknesses and unresolved technical issues associated with the current mixing system design. The establishment of a carefully considered, technically sound testing strategy is necessary. This strategy would likely involve various combinations of the test types described above.

Question B.2. *Has PNNL been asked to assist in the resolution of these concerns? Describe the extent of PNNL's involvement in the resolution of the remaining pulse jet mixing design issues.*

Response B.2. As part of the current project, PNNL has provided letters related to the scaling on spargers and testing considerations related to non-Newtonian testing. PNNL has been approached by BNI to assist in resolving remaining concerns; however, no specific scope has been identified to date.

PNNL also has two ongoing mixing-related activities that are funded and directed by EM's Office of Technology Innovation and Development. A full description of these activities can be found in section 5.5 of the *EM Tank Waste Research and Development Plan*. In the first activity, PNNL is tasked to develop a more accurate design basis through a review of existing data and additional actual waste tests. The second activity is developing a new computational fluid dynamics approach to more accurately predict solids behavior in slurry handling systems such as tanks and pipelines. This work focuses on overcoming many of the physical oversimplifications in existing codes that limit their accuracy and application.

Question 19. Path Forward

Responses to Question 19 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection

Delmar Noyes, Deputy Assistant Manager, Waste Treatment and Immobilization Plant Project

Hanford Tank Waste Treatment and Immobilization Plant Project

Russell Daniel, Production Engineering Manager

Contributing authors:

Hanford Tank Waste Treatment and Immobilization Plant Project

Robert French, M3 Issue Closure

Phil Kuehlen, Commissioning/Facilities Operations Manager

George Matis, Commissioning Operations Manager

Jeff Monahan, Project Engineering Manager, Pretreatment Facility

Question 19.A *DOE has committed to perform large-scale tests (May 17, 2010, EM-1 letter). Describe additional testing needed to prevent safety issues during WTP operations from inadequate mixing.*

Response 19.A Vessel assessments have been completed that document that there is reasonable assurance that solids will not accumulate in these vessels and that safety-related mixing requirements will be met. Based on document 24590-WTP-RPT-ENG-08-021, EFRT Issue M3 PJM Vessel Mixing Assessment, Volumes 1 thru 10, no additional testing is needed to prevent safety issues during WTP operations from inadequate mixing. However, the TSG identified risk associated with the overall vessel performance (documented in CCNs 220452, 220453, 220454, 220455, and 220456 [Report 24590-WTP-RPT-ENG-08-021, Volumes 3, 6, 7, 8, and 9, respectively]) that will be mitigated with the conduct of additional LOAM benchmarking and large-scale testing. The risks identified by the TSG that will be mitigated with small and large-scale testings are:

- Conditions in the testing that challenge the design condition (e.g. selection of solids in the simulants used in testing that are more difficult to suspend than nominal tank waste).
- Simplifications in the calculation methods (e.g. movement of solids on the vessel bottom and suspension and settling rates as projected by the Low Order Accumulation Model).
- Testing at large scale has not been performed.
- The testing program and design assessment methods have not comprehensively accounted for fluid flow distribution interferences from seismic supports and internal structures.
- Actual waste fluid viscosities, localized concentrations, and temperatures could impact estimated design margins.
- Extrapolation of effective PJM clearing radius results to solids depths that have not been tested are uncertain.
- Operational conditions associated with gravity refill, the suction line transfer system and the PJM control strategy were not completely evaluated.

Question 19.A.1 *Is a series of large-scale tests needed?*

Response 19.A.1 Yes. A series of large scale tests was recommended by the TSG in the M3 Closure Records in order to mitigate risks identified in the mixing vessel assessments (CCNs 220452, 220453, 220454, 220455, and 220456 [Report 24590-WTP-RPT-ENG-08-021, Volumes 3, 6, 7, 8, and 9, respectively]). As documented in these CCNs, this testing should include:

- The capability of the PJMs to operate under the expected range of fill conditions.
- The PJM gravity re-fill mode for the anticipated temperatures during operations.
- The suction line transfer system at full scale.
- Process control sampling strategies
- The PJM control strategies with prototypic operating conditions and controls (e.g., the use of bubblers for vessel monitoring).

Question 19.A.1.a) *If large-scale testing is needed, what are the technical objectives and scope?*

Response 19.A.1.a) A team has recently been chartered to perform conceptual planning for large scale integrated testing (24590-WTP-CH-MGT-10-006, *Charter for the Integrated Waste Delivery and Mixing Team)*. The top level objectives and scope are stated in the TSG Closure Records referenced above and in document 24590-WTP-RPT-ENG-10-001, Revision 0, *Integrated Pulse Jet Mixed Vessel Design and Control Strategy*, Section 3, Paragraph 3.1. The initial planning has generated a consolidated list of recommendations, commitments, and actions from multiple sources that relate to large-scale test planning. These will be considered in planning for large scale tests.

Question 19.A.1.a)(1) *How does this technical scope mitigate the technical uncertainties of small scale testing?*

Response 19.A.1.a)(1) The large scale tests mitigate the technical uncertainties of small scale testing by providing additional confidence in scaling analyses, and by providing an integrated demonstration of related systems for mixing, transport and sampling in advance of cold commissioning.

Question 19.A.1.a)(2) *Will performance of the WTP sampling system be tested?*

Response 19.A.1.a)(2) Yes. Performance of the WTP sampling system is identified to be tested as part of the large scale integrated testing.

Question 19.A.1.a)(3) *Will heel detection/dilution/cleanout abilities be tested?*

Response 19.A.1.a)(3) Yes. Heel inspection and dilution abilities are identified to be tested as part of the large scale integrated testing.

Question 19.A.1.b) *If large-scale testing is not needed, what is the technical justification supporting this decision? How will the remaining technical risk be resolved?*

Response 19.A.1.b) Not applicable, DOE and WTP have committed to large scale testing.

Question 19.A.2 *When would a large-scale test be performed?*

Response 19.A.2 A large-scale test would be performed in advance of cold-commissioning. Conceptually, testing is being targeted to begin in CY 2013 and complete in CY 2014.

Question 19.A.2.a) *Where does this fall in relation to the construction schedule?*

Response 19.A.2.a) All of the WTP PJM mixed vessels are currently planned to be fabricated and installed in the facility before the start of large-scale tests.

Question 19.A.2.b) *Which of the vessels in question will be fabricated and/or installed in the facility before the testing?*

Response 19.A.2.b) All of the WTP PJM mixed vessels are currently planned to be fabricated and installed in the facility before the start of large-scale tests.

Question 19.A.2.c) *Discuss the capability of the project to modify vessel designs based on large-scale test results.*

Response 19.A.2.c) Modifications of low to moderate complexity could be accommodated in the field after fabrication. However, vessel modifications are not anticipated. WTP plans to use robust feed pre-qualification and associated process control options. Examples of identified options include: identification of potential off-specification feed, or feed with unusual processing characteristics through the *Plan for WTP Feed Pre-qualification*, 24590-WTP-PL-OP-07-0001, Revision 1. (See Flowchart, Figure 6-1.) The outcome of this process could be operational options such as sequential PJM operation, feed batch volume limits, rheology control, feed blending, and/or feed concentration management.

Question 19.B *How would additional vessel modifications impact startup milestones for hot operations of WTP?*

Response 19.B The impacts of any vessel modifications would have to be assessed, mitigations developed, and the schedule modified as necessary. As such, impacts of potential vessel modifications that may result from large scale testing on startup milestones cannot be determined at this time.

Question 20.

Responses to Question 20 were developed by:

Primary authors:

<u>U.S. Department of Energy - Office of River Protection</u>
Delmar Noyes, Deputy Assistant Manager, Waste Treatment and Immobilization Plant Project

<u>Hanford Tank Waste Treatment and Immobilization Plant Project</u>
Donna Busche, Environmental & Nuclear Safety Manager

Contributing authors:

<u>Hanford Tank Waste Treatment and Immobilization Plant Project</u>
Dan Herting, WTP Chief Process Chemist
Marshall Perks, Radiological & Fire Safety Manager

Question 20 *WTP criticality program (24590-WTP-CSER-ENS-08-0001, Preliminary Criticality Safety Evaluation Report for the WTP)*

Question 20.A *Describe the current WTP criticality safety limits (CSL).*

Response 20.A The WTP CSLs are described in Chapter 6 of the PDSA(24590-WTP-PSAR-ESH-01-002-01) and Section 8 of the CSER (24590-WTP-CSER-ENS-08-0001, *Preliminary Criticality Safety Evaluation Report for the WTP*).

The four CSLs from the CSER are summarized as:

- CSL 8.1 - Before waste is released from the WTP receipt vessels for subsequent processing, the Pu/metals loading shall be < 6.20 g/kg in the sampled solids. This shall be demonstrated by sample analysis at a 95% confidence level that credits Fe and Ni as the absorber metals and simulates the effects of wash/leach.
- CSL 8.2 - Before waste is released from the WTP receipt vessels for subsequent processing, the FU/U loading shall be less than 8.4 g/kg. This shall be demonstrated by sample analysis at a 95% confidence level for the solids and liquid phases.
- CSL 8.3 - Before waste is released from the WTP receipt vessels for subsequent processing, the Pu concentration in the liquid phase shall be less than 0.013 g/L.
- CSL 8.4 - Before waste is released from the WTP receipt vessels or released as permeate following oxidative leach for subsequent processing, the Pu/metals loading shall be < 6.20 g/kg in the sampled liquids. This shall be demonstrated by sample analysis at a 95% confidence level that credits Fe, Ni, Mn, and Cd as absorber metals and simulates any subsequent processing, including wash/leach, Sr/TRU precipitation, and Cs ion exchange.

Based on the results of mixing testing completed in late calendar year 2009, WTP concluded that CSLs could not be verified prior to release from the receipt vessels. WTP established testing requirements for the balance of the mixing testing to collect data that would facilitate an update to the criticality safety evaluation and establishment of new CSLs.

Question 20.B *What are the technical bases for establishing these CSLs?*

Response 20.B The current basis is provided below, however based on the results of mixing testing completed in late 2009, the established limits and technical basis is not adequate or achievable. WTP will be revising the criticality safety evaluation and developing new CSLs based on the results of mixing tests.

The limits incorporated in the CSLs are derived in Section 4 of the CSER based on referenced, supporting criticality safety calculations. The MCNP computer code is used for the neutron transport calculations and is validated following the guidance of ANSI/ANS-8.24-2007, *Validation of Neutron Transport Methods for Nuclear Criticality Safety.* Additional technical basis demonstrating safety is presented in CSER Section 7, which documents evaluation of contingent or upset conditions. The CSER ensures the subcriticality of the WTP operations by requiring that sufficient absorber masses accompany the fissile masses in the waste and by the implementation of a control on Pu concentration. CSL compliance is to be established by sample analysis that accounts for uncertainties. These limits and supporting analyses will be revised based on the results of mixing tests.

Question 20.C *What set of documents and standards are required by DOE to establish these CSLs?*

Response 20.C The documents and standards required by DOE that apply in establishing CSLs and performing a criticality safety evaluation are identified in the WTP criticality safety program document (24590-WTP-PL-ENS-03-013). The primary DOE requirements for criticality safety are in:

- - DOE order on facility safety (DOE O 420.1B) that provides requirements for criticality safety programs.
- - DOE-STD-3007-2007, Guidelines for Preparing Criticality Safety Evaluations at DOE Nonreactor Nuclear Facilities, provides the primary requirements on how to prepare CSERs.
- - DOE-STD-1135-99, Guidance for Nuclear Criticality Safety Engineer Training and Qualification

In addition to these DOE documents, some nuclear industry standards from the American National Standards Institute / American Nuclear Society are specific to criticality safety. These apply to WTP and include:

- ANSI/ANS-8.1-R2007, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors has guidance for various criticality safety practices including methods of ensuring subcriticality,
- ANSI/ANS-8.19-2005, Administrative Practices for Nuclear Criticality Safety, and
- ANSI/ANS-8.24-2007, Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations

The requirements and guidance specified above will be used to update the CSER and CSLs based on the results of mixing tests.

Question 20.D *What are the process chemistry assumptions underlying these CSLs? Does the current flow sheet support their use?*

Response 20.D Most of the high-level radioactive waste solutions from Hanford chemical operations were acidic and contained metals dissolved by nitric acid. These acid wastes ware neutralized with sodium hydroxide to prevent corrosion of the carbon steel waste tanks. During neutralization, metals, including Pu, which were insoluble in basic solutions, precipitated. Because the neutralized wastes contain thousands of times more Fe and Al than Pu, the Pu coprecipitated by sorption on the Fe and Al hydroxides that precipitate first in much larger quantities. Much of the Pu that coprecipitated with the absorbers became fixed into the interior of the coprecipitated particles. This fixing of the Pu in the interior of particles such as Fe makes the Pu resistant to dissolution processes such as carbonate addition, wash/leach, and the presence of organic complexants.

The fixing process implies that the Pu cannot be released into solution from the solids without the dissolution of the absorber. Thus, the chemistry of the WTP waste with the presence of absorber atoms in proper abundance ensures subcriticality of the waste. There is an exception to this general chemistry description with waste generated at the Plutonium Finishing Plant because some of the Pu that entered the waste stream was resistant to acid dissolution and is found in SY-102 and TX-118 tanks as discrete PuO_2 particles. Additional discussions of the general chemistry phenomena are provided along with references in Section 7 of the Preliminary CSER (24590-WTP-CSER-ENS-08-0001) on various contingencies or upsets.

In evaluating the expected compliance with the CSL for the various feed batches, Section 6 of the CSER makes use of the current flowsheet. This flowsheet will be evaluated against the results of mixing tests and may require modification. The potential impact of a change to the process flowsheet is not know at this time.

Question 20.E *What WTP performance metrics are required to meet CSLs?*

Response 20.E None are required at this time. The planning basis assumes that compliance with the CSLs will be established by analysis of samples drawn from the Hanford Tank Farm (HTF) staging tanks. Performance metrics to demonstrate meeting the CSLs include the uncertainties associated with sample analysis that are summarized in CSER (24590-WTP-CSER-ENS-08-0001) Table 4-1 and include process concentration changes, sample analysis, Sr/TRU precipitation, wash/leach, Cs ion exchange, and sample non-representativeness, which includes two components, radial blending and gravity segregation/differential settling. These will be updated (as needed) based on the update of the CSER and CSLs.

Question 20.F *How will these metrics be monitored?*

Response 20.F The various sampling metrics associated with the HTF sample analysis will be monitored by following laboratory procedures that will apply when determining compliance of the WTP feed batches with the CSLs.

Question 20.G *What technical weaknesses have been identified in establishing the criticality control strategy?*

Response 20.G The technical weakness of the current CSER is the inputs and assumptions based on assumptions related to mixing and sampling adequacy. The results of mixing in late 2009 concluded that the current control strategy was not adequate or achievable.

The current CSER identifies know uncertainties. They are included in this response for completeness. Each uncertainty will be re-evaluated in the update to the CSER and revised or eliminate (as needed).

Appendix A of the WTP CSER (24590-WTP-CSER-ENS-08-0001) identifies Open Items in development of the safety evaluation. Some of these Open Items relate directly to the criticality safety control strategy.

Item A.1.2 from the CSER identifies the need to develop methods for determining sample non-representativeness uncertainties. Concern with these non-representativeness uncertainties for the CSLs was subsequently reinforced in recommendations from the CSSG (Letter CCN 193555, *DOE Criticality Safety Support Group - Review of the Washington River Protection Solutions Tank Farm Operating Contractor Criticality Safety Technical Basis, December 7-11, 2009*) and the CRESP (Letter CCN 218915, *CRESP Review Team Letter Report 7 - PJM Vessels*). Current operational planning is that CSL compliance will be established by samples drawn at the staging tanks of the Hanford Tank Farms, rather than in WTP vessels. It is expected that sample non-representativeness uncertainties for establishing CSL compliance will be developed once the staging tanks are designed by the TOC.

Item A.1.3 from the CSER identifies concern that some batches of waste feed may not hold sufficient U-238 absorber to established compliance with CSL 8.2 ensuring safety of fissile U-235 and U-233. U-bearing wastes released to the Tank Farms years ago were considered safe with appropriate margins, but additional conservatism in margins is now required. If waste feed batches failed to comply with CSL 8.2, then they could not be processed beyond the WTP feed receipt vessels. The CSER, in Item A.1.3, discusses options for addressing this concern with CSL 8.2 compliance, and because of many conservatisms in CSL 8.2, various other options are available. A primary option being considered for providing more reactivity margin with CSL 8.2 is to credit sodium (Na) as an absorber in addition to U-238, because the U in the waste is commonly in forms such as sodium diuranate ($Na_2U_2O_7$).

Item A.1.4 identifies a need to verify that neutron absorbing metals will accumulate together with Pu on the resins of the ion exchange columns, so that compliance with CSL 8.4 is maintained during the LAW stream processing. This concern with the criticality control strategy for the ion exchange columns was subsequently reinforced in guidance with Condition of Approval 2 from the DOE Safety Evaluation Report for the CSER (Letter 09-NSD-034, *Inadequate Mixing, Waste Treatment and Immobilization Plan*).

Item A.1.6 identifies concern that gravity segregation effects might allow separation of large Pu-rich particles, such as PuO2 crystals, from neutron absorbing metals credited for establishing safety in CSL 8.1. This concern with the criticality control strategy was subsequently reinforced in a DNFSB letter (CCN 212039) and a recommendation of the CSSG (Letter CCN 193555).

Question 20.H *What development activities are associated with resolving these technical weaknesses?*

Response 20.H For Item A.1.2 that is discussed above, current planning is that CSL compliance will be established by samples drawn at the staging tanks of the Hanford Tank Farms, rather than in WTP vessels. Development of these sample non-representativeness uncertainties is awaiting information on staging tank design by the TOC.

Concerning potential insufficient 238U in feed batches to WTP, discussion with Item A.1.3 outlines options that may be used in further criticality safety evaluation to address this issue. As described above, a primary option for addressing this concern is to credit Na as an absorber along with U-238 in CSL 8.2. Criticality safety limits have been calculated for the sodium diuranate form (24590-WTP-Z0C-W11T-00006) and demonstrate sufficient reactivity margin to allow processing the few feed batches of concern.

For Item A.1.4 on verification of neutron absorbing metals presence with Pu in ion exchange, current criticality safety evaluation activities are considering the potential to sample ion exchange eluate streams to verify compliance with CSL 8.4. Additional criticality evaluations are being considered to document that because of low Pu concentrations significant upsets would have to occur over a long operating duration before criticality risks would arise.

For Item A.1.6 on potential for gravity segregation effects that might allow separation of Pu-rich particles, such as PuO2, from neutron absorbing metals, development activities have been on-going with M3 mixing tests to address criticality concerns (24590-WTP-RPT-ENS-10-002). Testing results are becoming available, such as documented in CCN 211822 by D Herting, on Tungsten Analyses to Support M3 Mixing Tests. Other development activities to collect Hanford historical information on Pu particle sizes, densities, and inventories are briefly described (24590-WTP-RPT-ENS-10-007) with one of those activities nearing completion (24590-CM-HC4-W000-00176-T02-01-00002, Historical Overview of Solids in PFP Aqueous Waste Transferred to Tank Farms: Quantity of Plutonium, Particle Size Distribution, and Particle Density). With completion of the M3 testing that included support for criticality safety and completion of additional activities collecting Hanford historical information, discussions have been initiated on the options for improved criticality safety control strategies to address issues of fissile material gravity segregation.

Question 20.I *When will these activities be performed?*

Response 20.I For Item A.1.2, the schedule for quantifying the non-representativeness uncertainties associated sample measurements for CSL compliance awaits information on staging tank design by the TOC and evaluation of the mixing test results. The schedule for resolution (i.e., update of the CSER and CSLs) is unknown at this time.

20.J *What is the technical scope of these activities?*

Response 20.J The technical scope will be determined after the mixing test results have been reviewed and the plan to the CSER has been developed. Those activities are in process and are anticipated to continue until mid calendar year 2011.

Question 20.K *The Criticality Safety Support Group (CSSG) Report (Attachment to 10-WTP-049, Review of the Washington River Protection Solutions Tank Farm Operating Contractor Criticality Safety Technical Basis) found that the pulse jet mixer operation may break up the agglomerated solids and solids with weak chemical bonds, and has the potential to separate the lighter material from the heavier particles.*

Question 20.K.1 *Was preferential separation of heavy and light materials observed in the small-scale testing?*

Response 20.K.1 In general, the final series of mixing tests completed at the MCE test stand in the HLW slurry vessels (UFP-1, FEP-17, and HLP-22) indicated that the large, high settling rate particles were removed from the test vessel relatively early as the test vessel was emptied, and the smaller, low settling rate particles were dispersed more uniformly in the slurry and were pumped out at a more consistent rate. Examples of the large particles would be the sand and ~700 µm, 2.9 g/mL simulant particles. The aluminum and iron particles are examples of the smaller, well distributed particles. The tungsten carbide particles did not accumulate and behave like the other very small particles.

Question 20.K.2 *How will separation of heavy and light materials impact the development of the criticality safety evaluation report (CSER)?*

Response 20.K.2 A specific phenomenon involving PJM break up of agglomerated Pu and metal-bearing solids was briefly discussed with the CSSG in December 2009. The phenomenon was evaluated by a chemistry expert (Letter CCN 211814, *Evaluation of Plutonium Settling in Pretreatment Vessels*) with a conclusion that Pu particulates will not be separated from neutron absorbers (e.g., Fe, Ni) by PJM action / mechanical turbulence in the WTP Pretreatment vessels. Section 2.1 of 24590-WTP-RPT-ENS-10-007, *Plan of Action to Address Recommendations of the Criticality Safety Support Group (CSSG)* provides further detail on criticality evaluation for this specific CSSG concern. The CSSG concern will be further addressed and resolved by expanded discussion of contingent or upset conditions in Section 7 of the CSER (24590-WTP-CSER-ENS-08-0001), following DOE guidance (DOE-STD-3007-2007, *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities*) on criticality evaluations.

A broader concern, included in other CSSG discussion, is with the potential for separation of large, dense Pu-rich discrete particles, such as PuO2 crystals, from absorbing metals and will also require further evaluation in the CSER to demonstrate safety. However, as described in the response to 20.H, the approach to improved criticality safety control strategies to address this broader concern has not yet been selected.

Question 20.K.3 *The CSSG found that the December 2009 vessel design does not assure heel removal from the mixing tank and observed heavier particles. What is the criticality risk if the heavier particles are predominately plutonium?*

Response 20.K.3 The criticality safety risk of a vessel heel containing heavier particles that are predominately plutonium has not been evaluated. The control strategy for criticality safety in the Pretreatment facility is to prevent an inadvertent criticality.

Based on mixing test results that concluded in late calendar year 2009, WTP concluded that the CSER required a complete revision. WTP summarized the current criticality safety approach and concerns associated with the current criticality safety evaluation report in 24590-WTP-RPT-ENS-10-002, Revision 2, *M3 Criticality Safety Test Requirements*, Sections 2, Current Criticality Safety Approach. The issues associated with criticality safety and the strategies for resolution are also provided in Section 3.1.2, Strategy for Resolution in the documented identified above.

Question 20.K.4 *Will the proposed heel dilution/cleanout systems be used to mitigate or prevent criticality events in the WTP?*

Response 20.K.4 The vessel assessments provide reasonable assurance that the vessels will meet their mixing requirements and solids will not accumulate. The proposed heel dilution/cleanout system is one of several options for providing additional confidence that an accumulation of Pu does not create the quantity or distribution of material that would result in criticality being a credible scenario. As described in Item 20.H above, the approach to improved criticality safety control strategies to address this issue has not yet been selected.

Question 20.K.5 *The CSSG observed that the WTP preliminary assumes sampling of input batches would have an uncertainty of five percent, and the CSSG found that this is no longer a reasonable assumption (further data is needed to determine the sampling uncertainty).*

Question 20.K.5.a) *Will criticality sampling testing be performed with a large-scale vessel under fully prototypic conditions and bounding simulants?*

> **Response 20.K.5.a)** See response to question 19.A.1.a)(2): Yes. Performance of the WTP sampling system is identified to be tested as part of the large scale integrated testing.

Question 20.K.5.b) *If so, has the testing decision been made and when is this testing scheduled? If the decision has been made not to test, how was this decision technically justified? Describe the technical basis for design?*

> **Response 20.K.5.b)** See response to question 19.A.2: A large-scale test would be performed in advance of cold commissioning. Conceptually, testing is being targeted to begin in CY 2013 and complete in CY 2014.

Question 21 Waste Feed Delivery

Responses to Question 21 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Delmar Noyes, Deputy Assistant Manager, Waste Treatment and Immobilization Plant Project

Hanford Tank Waste Treatment and Immobilization Plant Project
Russell Daniel, Production Engineering Manager

Contributing authors:

Hanford Tank Waste Treatment and Immobilization Plant Project
Garth Duncan, Manager of Process Engineering and Technology
Robert French, M3 Issue Closure
Jeff Monahan, Project Engineering Manager, Pretreatment Facility

Washington River Protection Solutions
Paul Rutland, Mission Analysis & Strategic Planning Manager

Question 21.A. *WTP Waste Acceptance Criteria (WAC)*

Question 21.A.1 *Describe the impact on the WTP WAC from the resolution of pulse jet mixing issues.*,

Response 21.A.1 At this time, the impact on the WTP WAC are changes that align with the WTP contract changes described in the letter CCN 220806, Ashley T. Morris (DOE) to N. F. Grover (BNI), *Proposed Changes to Contract Tank Waste Feed Specifications Resulting from External Flowsheet Review Team (EFRT) Vessel Mixing Response*, dated June 24, 2010 . These changes relate to the volume of HLW feed that can be transferred and to the retrieval method for LAW feed. Additional changes (if needed) will be identified during the systematic evaluation of hazards in the mixing vessel assessment documents and closure records discussed in response to Question 13 above.

Question 21.A.1.a) *What are the physical and rheological properties that must be controlled to assure that the validity of the small-scale testing applies to the full scale tanks?*

ICD-19 - Interface Control Document for Waste Feed. The tables below itemize the current transfer properties. Additional changes (if needed) will be identified during the systematic evaluation of hazards in the mixing vessel assessment documents and closure records discussed in response to Question 13 above.

Table 5 Nominal Waste Feed Transfer Properties

Transfer Property	Delivery Limit
Transfer flowrate	90 to 140 gal/min (CH2 2002a)
System design limits	400 lb/in^2 (Section 2.1.1) * 200 °F (Section 2.1.1)
Pump discharge head	550 ft (90 gal/min) to 500 ft (140 gal/min) of slurry at 1.5 SpG (CH2 2002a)

* Assumes jumper connections are leak test qualified to this limit

Table 6 LAW Transfer Properties

Physical Property *	Delivery Limit (reference)
Maximum solids C_{wt} (wt%)	≤ 3.8 (BNI 2000, Specification 7)
Slurry pH	≥ 12 (BNI 2004b)
Slurry bulk density ρ_{bulk} (kg/L)	< 1.46 (BNI 2005a)
Critical velocity V_{cr} (ft/s) [in a nominal 3 inch diameter pipe]	≤ 4.0 (BNI 2008a)

* See Appendix C for definitions of terms

Table 7 HLW Transfer Properties

Physical Property *	Delivery Limit (reference)
Maximum solids (unwashed) C_s (g/L)	≤ 200 (BNI 2000, Specification 8)
Slurry viscosity (at 25 °C)	
Non-Newtonian (Bingham plastic)	
– Consistency μ_c (cP) #	< 10 (BNI 2002b)
– Yield stress τ_o (Pa) #	< 1.0 (BNI 2002b)
Slurry pH	≥ 12 (BNI 2004b)
Bulk density of slurry ρ_{sib} (kg/L)	< 1.5 (BNI 2005b)
Critical velocity V_{cr} (ft/s) [in a nominal 3 inch diameter pipe]	≤ 4.0 (BNI 2008a)

* See Appendix C for definitions of terms

Consistency, and yield stress are values used in WTP design but still under investigation as needed or applicable for waste feed acceptance.

Question 21.A.1.b) *What gaps exist between the current WTP WAC and the required physical and rheological properties supporting scaled testing?*

Response 21.A.1.b) The gaps that are currently identified are described in CCN 220806, Ashley T. Morris (DOE) to N. F. Grover (BNI), *Proposed Changes to Contract Tank Waste Feed Specifications Resulting from External Flowsheet Review Team (EFRT) Vessel Mixing Response*, dated June 24, 2010.Additional changes (if needed) will be identified during the systematic evaluation of hazards in the mixing vessel assessment documents and closure records discussed in response to Question 13 above.

Question 21.A.2 *What activities are needed to resolve gaps between the scaled testing feed acceptance requirements and the current WTP WAC?*

Response 21.A.2 A contract change for known gaps described in the letter cited in the response to question 21.A.1 above is necessary before the current WTP WAC (24590-WTP-ICD-MG-01-019, *ICD19 Interface Control Document for Waste Feed*), can be revised. Tables 6, 7, and 8 of the ICD will be revised. Revision of the ICD requires approval by WTP, TOC, and DOE. The ICD revision process is governed by 24590-WTP-PL-MG-01-001, *Interface Management Plan*.

Question 21.A.2.a) *When will these activities be performed?*

Response 21.A.2.a) WTP is still planning this activity. The completion date is unknown at this time. Planning will be completed after the additional changes (if needed) are identified during the systematic evaluation of hazards in the mixing vessel assessment documents and closure records discussed in response to Question 13 above.

Question 21.A.2.b) *How much of waste will not meet existing feed acceptance requirements?*

Response 21.A.2.b) Report 24590-WTP-ES-PET-08-001, *Technical and Risk Evaluation of Proposed ICD-19*, in the executive summary, states, that the approximately 5% of the feed that may not meet some given waste acceptance limits can likely be adjusted to meet the limits by dilution, blending, chemical adjustment, or other means with baseline Tank Farms and WTP equipment capabilities. DOE agreed as documented in letter, John R. Eschenberg, DOE, to L. J. Simmons, BNI, *U.S. Department of Energy, Office of River Protection (ORP) Comments on ICD-19 proposed Technical and Risk Evaluation and Waste Feed [sic].*

Question 21.A.2.c) *How will off-specification waste be treated*?

Response 21.A.2.c) Waste that does not meet the feed requirements can not be processed in the WTP. Waste acceptance criteria (WAC) have been established to assure that waste is in alignment with the AB for the facility. The WAC is described in Section 2.3.1 of ICD-19 (24590-WTP-ICD-MG-01-019). Additional discussion is provided in response to question 16.A.2 above.

In the very unlikely case that an out-of-specification condition is determined after receipt at WTP, the WTP Contract (Contract No. DE-AC27-01RV14136, *Design, Construction, and Commissioning of the Hanford Waste Treatment & Immobilization Plant*) specifies in Section C.7(a) (6) requires that The PTF shall have the capability to return to the Hanford DST Farm process streams in accordance with Specification 9, *Liquids or Slurries*, transferred to DOE tanks by pipeline. As a practical matter, the first option for non-compliant feed within WTP would be to adjust the feed (such as by dilution) or the process (such as operating at reduced temperatures) to enable the feed to be processed through the facility within the operating and safety basis; return of feed to the Tank Farms would be a last resort.

Question 21.B Feed Delivery Schedule

Question 21.B.1 *How is the WTP lifecycle affected by the pulse jet mixer design changes?*

Response 21.B.1 The estimated effects of PJM design changes that potentially affect the WTP lifecycle (i.e., the estimated Pretreatment facility waste treatment duration) are summarized in 24590-WTP-MRR-PET-10-001, *WTP Mission Assessment of the Design and Operating Changes Expected to Resolve PJM Mixing in PTF Vessels*. The results indicate little impact.

Question 21.B.2 *Describe the impacts on the baseline WTP processing schedule from the reduction of solids loading in WTP vessels due to pulse jet mixer design requirements?*

Response 21.B.2 The combined impact of reducing the wt% solids loading, sodium molarity, and the reduced batch volumes for HLW feed receipt vessel HLP-VSL-22, reduced batch in volume in UFP-1A/B, and the reduced fast-settling solids loading in evaporator feed vessels FEP-17 A/B, in conjunction with other design changes not associated with PJM mixing, is evaluated in 24590-WTP-MRR-PET-10-001. The results indicate little impact.

This is to be expected since the HLW feed is typically blended in the UFP-1 A/B ultrafiltration feed preparation vessels to a solids loading and sodium molarity that is equal to or less than the new HLP-22 solids and sodium molarity limits as part of the first step in the pretreatment process. Also, FEP-17 A/B are typically not operated at above 1 wt% solids of any type, so the new limit of 2 wt% on fast-settling solids is not significant.

Question 21.B.3 *Provide a description of the results from process models used to assess PTF operations.*

Response 21.B.3 A description of the results of the process models used to assess Pretreatment facility operations relative to changes arising from M3 is provided in 24590-WTP-MRR-PET-10-001.

Question 21.B.3.a) *What are the processing assumptions used to determine the baseline and revised schedule?*

Response 21.B.3.a) The processing assumptions used to estimate PTF treatment through-put rates (which do not always drive the overall schedule) related to the baseline (WTP Contract, Section C.7, Table C.7-1.1, *WTP Facility Design Capacity*) are provided in 24590-WTP-RPT-PTF-02-005, *Flowsheet Bases, Assumptions, and Requirements Document* and in Section 6 of 24590-WTP-DB-ENG-01-001, *Basis of Design*. Changes from those processing assumptions due to changes arising from M3 resolutions, and other changes that have been adopted not related to PJM mixing, are documented in 24590-WTP-MRR-PET-10-001. The principal differences between the baseline model and the model with the mixing-related changes are the inclusion of the design and operating changes made to prevent precipitation after leaching, including conducting the caustic leaching process step in the UFP-2A/B vessels rather than the UFP-1A/B vessels, and the changes associate with PJM mixing outline in 21.B.2 above.

Question 21.B.3.b) *Describe major assumptions used in the analysis to predict the impact on PTF operations due to changes in pulse jet mixer design? How are these assumptions being protected?*

Response 21.B.3.b) Major assumptions used to predict the impact on PTF operations due to changes in PJM design are documented in 24590-WTP-MRR-PET-10-001. They include the new limits on feed delivery conditions and reduced batch sizes in HLP-22 and UFP-1 A/B as discussed in the response to 21.B.2 above. All unverified assumptions will be verified during the design confirmation process and any controls required to protect the assumptions will be developed and implemented.

Question 21.B.3.c) *Describe the results of DOE's review of the impacts on PTF operation from changes in pulse jet mixer design.*

Response 21.B.3.c) DOE has accepted the predicted impacts as indicated in letter CCN 220806 from Ashley T. Morris (DOE) to N.F. Grover (WTP), *Proposed Changes to Contract Tank Waste Feed Specifications Resulting from External Flowsheet Review Team (EFRT) Vessel Mixing Response.*

Question 22. Waste Characterization in Support of Waste Feed Delivery

Responses to Question 22 were developed by:

Primary authors:

U.S. Department of Energy - Office of River Protection
Stacy Charboneau, Assistant Manager, Tank Farms Project

Washington River Protection Solutions
Paul Rutland, Mission Analysis & Strategic Planning Manager

Contributing authors:

Hanford Tank Waste Treatment and Immobilization Plant Project
Garth Duncan, Manager of Process Engineering and Technology

Washington River Protection Solutions
Chris Burrows, Manager, WTP Support

Question 22.A *Data Quality Objectives (DQOs)*

Question 22.A.1 *What DQOs are established for the Waste Feed Delivery system?*

Response 22.A.1 RPP-44057, *Data Quality Objective to Support Strategic Planning* provides the characterization data needed and requirements for planning feed batches. Additionally, a DQO for WTP feed acceptance is currently being developed. DQOs are developed as needed and it is anticipated that additional DQOs will need to be developed as plans progress. These additional DQOs have not been specifically identified at this time.

Question 22.A.2 *How have these DQOs been revised to incorporate changes resulting from small-scale mixing tests (including criticality sampling)?*

Response 22.A.2 DQOs identify the data needed and requirements for that data. We have not identified any changes to the characterization data needed for WFD based on small scale mixing tests at this time.

Question 22.A.2.a) *What development activities are needed to develop a defensible set of DQOs?*

Response 22.A.2.a) The Tank Farms develop DQOs by procedure (TFC-ENG-CHEM-C-16, *Data Quality Objectives for Sampling and Analysis*). This procedure, in turn, implements the U.S. Environmental Protection Agency (EPA) DQO methodology (EPA QA/G4 - *Guidance for the Data Quality Objective Process*). This methodology describes any activities needed to write DQOs. Per the EPA guidance, DQOs generally define development activities.

A jointly developed DQO between Tank Farms and WTP will be developed for WTP feed acceptance criteria. These criteria will be assessed as part of the DQO process to ensure processability through unit operations in the PTF, LAW, and HLW facilities. The specific data needs based on those criteria will then be the basis for developing a defensible set of DQOs for delivery of WTP feed batches.

Question 22.A.2.b) *When will these activities be performed?*

Response 22.A.2.b) The DQO assessment of the WTP feed acceptance criteria is planned for FY 2011. Development activities are scheduled as needed as DQOs are developed.

Question 22.B Functional Requirements

Question 22.B.1 *How have DQOs for the Waste Feed Delivery system been mapped to functional requirements for the systems and components?*

Response 22.B.1 The development of DQOs and functional requirements are complementary processes. Functional requirements flow down from analysis of the mission. DQOs are generated to satisfy information requirements from sampling. This information may be used to validate and refine functional requirements. Conversely, a specific functional requirement may drive the need for a particular sample, which could then require development of a DQO. However, in general, functional requirements are not mapped to specific DQOs.

Question 22.B.2 *Do these Waste Feed Delivery system functional requirements consider changes resulting from small-scale mixing tests?*

Response 22.B.2 Yes. The Tank Farm small scale mixing tests will confirm whether or not the current architecture can meet the requirements of ICD-19. If the current baseline architecture cannot meet the current requirements of ICD-19, then either the requirement or the architecture will need to be changed to achieve alignment.

Question 22.B.3 *How does the current Waste Feed Delivery system meet these functional requirements?*

Response 22.B.3 The current assumption is that the current baseline architecture will meet the functional requirements of ICD-19. The Tank Farm small-scale mixing tests are designed to confirm this assumption. DOE has identified this as a risk that may require a change in architecture such as a modification to the B Complex Waste Retrieval Facility (WRF) to include Waste Feed Delivery (WFD) functions and requirements to mitigate the risk.

Question 22.B.4 *What development activities are needed to have a Waste Feed Delivery system that meets these functional requirements?*

Response 22.B.4 ORP-11242, *River Protection Project System Plan*, identifies the logic for waste transfers and blending within the DSTs and the transfers to WTP. RPP-40149,*Integrated Waste Feed Delivery Plan*, identifies the design, procurement, construction, and commissioning activities required for the tank farm infrastructure and individual tank waste feed delivery systems as well as the design, fabrication and acceptance testing of the submersible mixer pumps, transfer pumps, incremental lowering devices, and pump relocation equipment.

Question 22.B.5 *When will these activities be performed?*

Response 22.B.5 The schedules are identified within ORP-11242 and RPP-40149. *Integrated Waste Feed Delivery Plan.*

Question 23. Design Status of Waste Feed Delivery System.

Responses to Question 23 were developed by:

Primary authors:

<u>**U.S. Department of Energy - Office of River Protection**</u>
Stacy Charboneau, Assistant Manager, Tank Farms Project

<u>**Washington River Protection Solutions**</u>
Paul Rutland, Mission Analysis & Strategic Planning Manager

Contributing authors:

<u>**Washington River Protection Solutions**</u>
Chris Burrows, Manager, WTP Support

Question 23.A *Current mission and status of waste feed delivery (including the Waste Retrieval Facility [WRF])*

Question 23.A.1 *What is the mission of the Waste Feed Delivery system?*

Response 23.A.1 The RPP mission, as stated in RPP-RPT-41742, *River Protection Project Mission Analysis Report, (RPP-MAR)*, is to store, retrieve, and treat Hanford's tank waste; store and dispose of treated wastes; and close the tank farm waste management areas (WMA) and treatment facilities in a safe, environmentally compliant, cost-effective, and energy-effective manner. Within the larger encompassing RPP mission, the goal of the WFD system is to deliver waste feed to the treatment facilities.

Question 23.A.1.a) *Describe the functional requirements for delivery of feed to the WTP.*

Response 23.A.1.a) The WFD functional requirements are listed in the RPP-MAR, Appendix A-2.4 (RPP-RPT-41742).

Question 23.A.1.b) *Describe the degree of "pretreatment" planned as a part of feed delivery to the WTP.*

Response 23.A.1.b) There are no pretreatment functions planned as a part of feed delivery. ORP-11242, *River Protection Project System Plan*, , establishes the baseline case that is used as the technical basis for the alignment of program costs, scope, and schedule, from upper tier contracts to individual operating plans. Strategic planning is ongoing; therefore, the System Plan will be revised periodically to reflect recent progress, current plans, responses to emergent issues, changes in the regulatory environment, and budgeting constraints. The System Plan also provides input to RPP-40149, *Integrated Waste Feed Delivery Plan*, which outlines how the retrieved wastes will be staged and transferred to the WTP.

Question 23.A.1.c) *Describe how the sizing requirements for the Waste Feed Delivery system will be determined?*

Response 23.A.1.c) Sizing requirements start with the allocation of the functional requirements as specified in the RPP-MAR taking into account the initial state. Inputs to the RPP-MAR include programmatic requirements from DOE, environmental laws, the System Plan as the technical baseline, the waste feed interface control document (ICD-19), the Tank Operations Contract (TOC), and the TOC Performance Measurement Baseline (PMB). DOE and regulatory requirements are managed via the TOC and WTP contracts. The AB is another key requirements source. Deficiencies or challenges identified in the RPP-MAR are targeted for technology development, trade studies, and/or flowsheet evaluations. The end result of this planning is the scope definition of the projects necessary to complete the mission. The functions and requirements for each project are flowed down from the RPP-MAR and further developed in plans (e.g., RPP-40149, *Integrated Waste Feed Delivery Plan*) and project specifications.

Question 23.A.2 **Qualification of WTP feed.**

Question 23.A.2.a) *What elements of the Waste Feed Delivery system will be needed to qualify WTP feed?*

Response 23.A.2.a) HLW feed qualification requires mixer pump operation, certification sampling, and the necessary DST infrastructure systems (e.g., tank ventilation) functionality to allow safe operation of these two systems. LAW feed qualification requires an operational grab sample system and the necessary DST infrastructure systems allowing safe operation.

Question 23.A.2.b) *What operations will be used to limit particle size, particle density, solids content, and the rheological properties for feed sent to WTP?*

Response 23.A.2.b) Specific particle size and density screening and adjustments are currently not planned for HLW feed. Particle size/density related screening will be based on critical velocity measurements. LAW feed will be administratively controlled such that problematic solids will have sufficient time to settle in the feed staging tanks prior to delivery to the WTP. LAW feed delivery systems will be configured such that settled solids are not likely to be entrained in the transfer system. Feed staging will be planned based on staging WTP WAC-compliant feed tanks with solids concentrations below the prescribed acceptance limits. Feed certification sampling will confirm WAC compliance (includes critical velocity and rheological properties) at which time any final blending or diluting adjustments will be identified.

Question 23.A.2.c) *What are the functional requirements applicable to sampling?*

Response 23.A.2.c) Representative samples of the LAW feed and HLW slurry will be collected from the feed staging tank a minimum of 210 days prior to planned feed delivery. The sample will be delivered to the WTP-identified laboratory for certification analysis. Requirements for representative samples are currently undefined and will be defined through development of WTP DQOs for feed certification. The current planning basis includes a minimum sample size of 500 mL and a minimum solids content of 350 g for slurry samples.

Question 23.A.3 *Will the feed delivery design strategy attempt to resolve PTF design concerns? What is the current design status of the each element of the Waste Feed Delivery system?*

Response 23.A.3 The TOC and the WTP design and construction contractor have been working together in an integrated fashion to address more effective means of resolving the PTF mixing and throughput issues. Best value studies have been performed to define potential solutions within the Tank Farms and the WTP. Modifications to the waste feed design strategy may be appropriate in some cases. RPP-40149, Revision 1 (Draft), *Integrated Waste Feed Delivery Plan*, Figures 8-1 and 8-3 show the schedule for the WFD design. More detailed schedules are available as part of the near term baseline.

Question 23.A.4 *What is the WRF design schedule?*

Response 23.A.4 The outyear planning estimate range (OPER) plans for the B-Complex waste retrieval facility (WRF) conceptual design to begin in 2015 with the detailed design completing in 2016. The OPER plans for the T-Complex WRF design to begin in 2015 and complete in 2017. Given that the current system plan draft does not start retrievals in T-Complex until 2030 (initial focus is on S/SX farms), it is likely that this schedule will be adjusted in future planning.

Question 23.A.5 *When will feed be delivered to WRF? Describe the feeds sent to WRF.*

Response 23.A.5 The draft System Plan 5 begins waste transfers to the B-Complex WRF in 2019 and to the T-Complex WRF in 2030. Feeds sent to the WRFs will be waste retrieved from single-shell tanks in B-Complex (B, BX, and BY Tank Farms) and T-Complex (T, TX, and TY Tank Farms). RPP-PLAN-40145, *Single-Shell Tank Waste Retrieval Plan*, describes the use of the WRFs. Single-shell tank (SST) saltcake will be dissolved to form supernatant which will then be used to retrieve sludge wastes from the tanks. Periodically, the retrieved wastes will be transferred to the DST system to be staged for transfer to the WTP.

Question 23.A.6 *What research and development activities are needed to support the design of waste feed delivery?*

Response 23.A.6 The ability to adequately mix and sample the waste in the DST's to meet the WTP acceptance requirements needs to be developed and demonstrated. This is detailed in RPP-PLAN-43988, *WRPS Technology Development Roadmap* document. There may be blending and pretreatment processes that could be performed to optimize the feed to WTP but those are improvements and are not required to feed WTP.

Question 23.B *Impacts to Supplemental Treatment - how have changes in the design's supporting waste feed delivery and WTP affected options under review for supplemental treatment of low activity waste?*

Response 23.B Selections of supplemental LAW treatment has not been made at this time, so changes in designs have not affected selection. Compatibility with interfacing systems will be a criterion in the selection process, but this activity has not been performed.

References

10 CFR 830, *Nuclear Safety Management*, February 9, 2001, U.S. Department of Energy, Washington, DC.

24590-06-04367, Revision 0, *Integrated Change Package (ICP) for PTF Control Strategy Modifications*. J. Monahan, 2010, Bechtel National Inc., Richland, Washington.

24590-101-TSA-W000-0004-114-0021, Revision B, - WTP-RPT-153 (PNWD-3824), *Estimate of Hanford Waste Insoluble Solid Particle Size and Density Distribution*, Particulate Characterization Working Group Battelle - Pacific Northwest Division, February 2007, Richland, Washington.

24590-CM-HC4-W000-00182-01-00001 Revision 0A, *Hydrogen in Piping and Ancillary Vessels in the Pretreatment Facility of the Hanford Waste Treatment Plant*, Independent Review Team Report, July 12, 2010, Bechtel National Inc., Richland, Washington.

24590-PTF-ES-ENG-10-001, HLP-VSL-00022 - *Feed Receipt Vessel Engineering Study for M3 (Closure Criterion 3)*, A. Harshfield , 2010, Bechtel National Inc., Richland, Washington.

24590-PTF-ES-ENG-10-002, FEP-VSL-00017A/B - *Waste Feed Evaporator Engineering Study for M3 (Closure Criterion 3)*, A. Harshfield, 2010, Bechtel National Inc., Richland, Washington.

24590-PTF-ES-ENG-10-003, UFP-VSL-00001A/B - *Ultrafiltration Preparation Feed Vessel Engineering Study for M3 (Closure Criterion 3)*, D.V.Vo, 2010, Bechtel National Inc., Richland, Washington.

24590-PTF-PER-M-04-0010, Revision 2, *Leak Detection Capability in the Pretreatment Facility*, P. Rajagopalan, March 30, 2010, Bechtel National Inc., Richland, Washington.

24590-PTF-PL-PET-10-0001, Revision 1, *Plan for M3 Test Platform Testing*, S. Barnes, 2010, Bechtel National Inc., Richland, Washington.

24590-PTF-RPT-ENG-10-004, Revision 0, *Pretreatment Vessel Heel Dilution/Cleanout Functional Requirements*, P. Omel, 2010, Bechtel National Inc., Richland, Washington.

24590-PTF-RPT-PR-06-002, *Benchmarking of Computational Fluid Dynamic Simulation of Pulsed Jet Mixers Using Experimental Data*, C. Barringer, November 2, 2006, Bechtel National Inc., Richland, Washington.

24590-PTF-Z0C-W14T-00002, Revision F, *Revised Severity Level Calculations for the Pretreatment Facility*. A. Hassan, May 25, 2007, Bechtel National Inc., Richland, Washington.

24590-PTF-Z0C-W14T-00020, Revision 0D, *Design Basis Event, Pretreatment Facility Drop of Radioactive Material*, R. Van Vleet, April 19, 2002, Bechtel National Inc., Richland, Washington.

24590-PTF-Z0C-W14T-00036 Revision 0A, *Severity Level Calculations for the Pretreatment Facility Based on Updated MAR*, J. McAllister, October 26, 2009, Bechtel National Inc., Richland, Washington.

24590-PTF-Z0C-W14T-00036 Revision B, Severity Level Calculations for the Pretreatment Facility Based on Undated MAR. (pending)

24590-QL-HC4-W000-00091-05-00007, Revision 0A, *Phase II HPAV Gaseous Deflagration, Detonation, and Deflagration-To-Detonation Transition (DDT) Test Program*, M.R. Ehnstrom, April 2010, Southwest Research Institute, San Antonio, TX.

24590-QL-HC9-WA49-00001-03-00025, Revision 00A, An Approach to Understanding Cohesive Slurry Settling, Mobilization, and Hydrogen Gas Retention in Pulsed Jet Mixed Vessels, Test Report No. WTP-RPT-177, P. Keuhlen, June 2, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-3DP-G04B-00001 Revision 14B, *Design Criteria*, J. L. Wetzler, June 30, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-3DP-G04B-00016, *Engineering Studies*, D. J. Pisarcik, 2008, Bechtel National, Inc., Richland, Washington.

24590-WTP-3DP-G04T-00905, Revision 10b, *Determination of Quality Levels*, M. A. Ehlinger, April 23, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-3DP-G04T-00913, Revision 9, *Review of Engineering Documents*, M. A. Ehlinger, April 24, 2009, Bechtel National, Inc., Richland, Washington.

24590-WTP-3PS-G000-T0045, Revision 0, *Engineering Specification for Supplier Design Analysis with Developed Software*, M. Ehlinger, June 24, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-05-0011, *Change Source of Process Service Water to Potable Water*, K. Cleveland, February 25, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-06-0007, *Revise Welding Requirements in Black Cells and Hard-to-Reach Areas*, S.W. Vail, October 7, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-07-0008, *Revision of Fire Protection Scope Statement*, K. Law, February 25, 2008. Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-07-0009, *Cold Chemicals Services and Utilities*, T. R. McDonnel, July 15, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-07-0010, *Clarification of emergency Stop Monitoring for Locally Controlled Equipment*, S. Smith, March 8, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-07-0016, *Environmental Basis of Design*, S. Hill, November 17, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0001, *Clarification of Non-ITS 4.16kV Bus Auto-Transfer Operations*, D. Williams, September 23, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0002, *Addition of Pretreatment Facility Chiller Plant and Cooling Tower*. R.G. Obst, July 1, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0003, *Clarify the Difference Between the Two Types of Egress Light Fixtures*, D. Williams, May 19, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0005, *Clarify Multiwire Branch Circuits Wiring Requirements*, D. Williams, August 29, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0007, *Treatment of Codes and Standards in the BOD*, J. Forrest, May 4, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0008, *Revision of Black Cell and Hard-to-Reach Area NDE Requirements*, S.W. Vail, October 2, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0009, *Interim Approval for Implementation and Significant Design Requirements*, J. Ferguson, November 5, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0011, *Allow Selected Vessels and Breakpots to use WSGM*, S.W. Vail, November 17, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0012, *Implementation of Requirements from the Prime Contract Revision*, J. Olson, May 28, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0013, *Allow Selected Components to Use WSGM*, S.W. Vail, March 13, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0014, *Use of WSGM for PTF Hot Cell Equipment and Ancillary Jumpers/Equipment/Components*, J. Weamer, March 13, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0015, Fire Rated Seal Penetration Clarification (pending)

24590-WTP-BODCN-ENG-08-0019, *Align BOD with Current WTP Alarm, Security Access and Waste Tracking Philosophy*, S. Romero, July 8, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-08-0026, Fire Rated Penetration Seal Requirements Clarification (pending)

24590-WTP-BODCN-ENG-08-006, Design Criteria for Ambient Air (Temperature) (pending)

24590-WTP-BODCN-ENG-09-0001, *Correction to Steel Manual Reference*, A. Roussopoulos, January 8, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0006, *Clarification of Description of Melter Cell Embeds in Chapter y, Codes and Standards in Chapter 10*, K. Edwardsen, June 11, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0007, *Additional Hard-to-Reach Piping Details in Chapter 16*, S.W. Vail, May 4, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0008, *Clarify Light Switching Criteria and Common Path of Travel Egress Lighting Fixtures*, D. Williams, May 28, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0010, *Use of WSGM for Mechanical Systems Equipment and Components*, J. Julyk, June 11, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0011, Use of WSGM for Selected Pretreatment Facility (PTF) and High-Level Waste Facility (HLW) Heating, Ventilating, and Air Conditioning (HVAC) Components, S.W. Vail, March 3, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0012, Minimum Conductor Size for Vendor Supplied Equipment, Removal of the SC Switchgear Buildings and Updated Egress Light Battery Size, D. Williams, November 17, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0013, *NQA-1 Reference*, J.S. Ferguson, October 26, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0014, *Mechanical Design Criteria for Diesel Fuel Oil Storage Tanks*, K. Cleveland, January 21, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0015, *Use of WSGM for HLW Power Manipulator Cranes and Cable Reels*, T. Semmens, November 6, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0016, Revision of Table 12-1 to Include PTF Control Building Compressor, Chilled Water Equipment, and HVAC Equipment Room Internal Conditions, N. Dzoan, December 2, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0017, Codes and Standards for Mechanical Design (pending)

24590-WTP-BODCN-ENG-09-0018, *Offgas Capacity Rated for 2 Melters*, V. Chernev, December 8, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0019, *Revise References in Section 15*, S. Cook, January 7, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0020, *Alignment of Piping Design Requirements with PDSA Addendum Revision for Seismic Changes*, J. Monahan, March 16, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0022, *Instrumentation Signal and Power Supply Grounding*, C. Icayan, December 15, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0023, *Continuous Air Monitor (CAM) Locations*, M. Friedrich, February 22, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0024, Eliminate High Pressure Steam and CO2 for Crane Decontamination (pending)

24590-WTP-BODCN-ENG-09-0025, *DOE 1066 Equivalency and BOD Clarification*, L.H. Solis, April 21, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0026, *Steam/Condensate Isolation*, R. Tometczak, April 21, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0027, Heat Tracing Remote Indication and Facility Network Infrastructure System (FNI) Fiber Optic Cable Laterals, L.D. Williams, June 25, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-09-0028, *Bolted and Threaded Connections in the Black Cells for the Evaporators*, S.W. Vail, April 26, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-10-0001, *HPAV Analysis and Design Criteria*, J. Minichiello, March 16, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-10-0002, *Incorporation of DOE O420.1B* (pending)

24590-WTP-BODCN-ENG-10-0003, As Received Waste Feed Particle Size and Density (pending)

24590-WTP-BODCN-ENG-10-0004, *Clarification of Outdoor Design Temperature*, D. Miller, May 24, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-10-0005, C1 drain lines from PTF Control Bldg to C2 drain lines in PTF bldg (pending)

24590-WTP-BODCN-ENG-10-0006, Use of Waste Treatment Project (WTP) Site-Specific Ground Motion (WSGM) for PTF Power Manipulator Cranes and Cable Reels, T. Semmens, May 27, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-10-0006, *Use of WSGM for PTF Power Manipulator Cranes and Cable Reels*, T. Semmens, July 19, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-BODCN-ENG-10-0007, Update: HPAV Analysis and Design Criteria (pending)

24590-WTP-BODCN-ENG-10-0008, Reinforcement Plates for Vessel Modifications (pending)

24590-WTP-BODCN-ENG-10-0009, *Seismic Interaction of Piping* (pending)

24590-WTP-BODCN-ENG-10-0010, Addition of Reinforcing Pads for Black Cell and HTR Vessels (pending)

24590-WTP-BODCN-ENG-10-0011, *Update BARCT Table* (pending)

24590-WTP-CH-MGT-10-006, Revision 0, *Integrated Waste Delivery and Mixing Task Team*, G Ashley, August 3, 2009, Bechtel National, Inc., Richland, Washington.

24590-WTP-CPRO-ADM-0001, Revision 4, *C&T Administrative Procedure: Operations Procedures Administration*, J. Bouton, May 19, 2009, Bechtel National, Inc., Richland, Washington.

24590-WTP-CRPT-QA-08-0629-B, Revision 0, *Safety Class and Seismic Category for PVP [BBR]*, R. Rider, November 13, 2008, Bechtel National, Inc., Richland, Washington.

24590-WTP-CRPT-QA-09-0096-B, Revision 0, *System Descriptions [BBR]*, C. Alderman, February 25, 2009, Bechtel National, Inc., Richland, Washington.

24590-WTP-CSER-ENS-08-0001, Revision 0B, *Preliminary Criticality Safety Evaluation Report for the WTP*, R. E. Miles, August 28, 2009, Bechtel National, Inc., Richland, Washington.

24590-WTP-DB-ENG-01-001 Revision 1P, *Basis of Design*, R. Claghorn, et.al., July 15, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-ES-ENG-09-001, Revision 2, *Determination of Mixing Requirements for Pulse-Jet-Mixed Vessels in the Waste Treatment Plant*, J. Mauss, June 28, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-ES-PET-08-001, Revision 4, *Technical and Risk Evaluation of Proposed ICD-19*, M. N. Hall, February 29, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-ES-PET-08-002, Revision 1. *Determination of Mixing Requirements for Pulse-Jet-Mixed Vessels in the Waste Treatment Plant*. J. Olsen, October 20, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-ES-PET-09-001, Revision 0, *M3 Platform Test Data Study*, A. Edmondson and S. Thomson, March 4, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-ES-PET-10-001, Revision 0, *Engineering Study for Non-Newtonian Vessel Cavern Height Correlation*. A. Edmondson, June 18, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-GPG-ENG-0143, Revision 0, *Design Guide: HPAV Stress Analysis Design Guide*, J. Sasson, March 18, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-GPG-ENG-0143, Revision 0, *HPAV-Stress Analysis Design Guide*, J. Sasson, March 18, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-GPG-M-0065, Revision 0, *Qualitative Risk Analysis Data Collection Process*, S. Lachmann, March 24, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-GPP-PTF-003, Revision 6, *Project Risk Assessment and Management*, R. S. Hajner, November 10, 2009, Bechtel National, Inc., Richland, Washington.

24590-WTP-GPP-SANA-011, Revision 3A, *Safety Input Review Committee*, M. A. Platt, April 29, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-GPP-SREG-002, Revision 23, *E&NS Screening and Authorization basis Maintenance*, M.A. Platt, August 10, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-ICD-MG-01-019, Revision 4, *ICD-19 - Interface Control Document for Waste Feed*, M. N. Hall, April 15, 2008, Richland, Washington.

24590-WTP-M4C-V11T-00011, Revision 0C, *Revised Calculation of Hydrogen Generation Rates and Times to Lower Flammability Limit for WTP*, K. Eager, May 7, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-M6C-M11T-00007, Revision 0C, *Hydrogen in Piping and Ancillary Vessels Database*, A. Coulam, February 4, 2008. Bechtel National Inc., Richland, Washington.

24590-WTP-MRR-PET-10-001, Revision 0, *WTP Mission Assessment of the Design and Operating Changes Expected to Resolve PJM Mixing in PTF Vessels*, Y. Deng, May 25, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-PIER-MGT-09-1213-C, Revision 0, *Resolution of Mis-Alignments Between PDSA and Physical Design*, P. Martinelli, June 30, 2009, Bechtel National, Inc., Richland, Washington.

24590-WTP-PIER-MGT-09-1846-B, Revision 0, *PTF 4-Pack Black Cell Floor Sloping Issue*, G. Hendricks, December 22, 2009, Bechtel National, Inc., Richland, Washington.

24590-WTP-PL-ENG-03-010, Revision 7, *Fluent Computational Fluid Dynamics V&V Plan*, C. A. Kennedy, February 18, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-PL-ENG-06-0021, Revision 1, *Issue Response Plan for Implementation of External Flowsheet Review Team (EFRT) Recommendation - M9, Lack of Comprehensive Testing in Commissioning*, G. Matis, November 22, 2006, Bechtel National Inc., Richland, Washington.

24590-WTP-PL-ENS-03-013, Revision 4A, *Criticality Safety Program for the WTP*, R. E. Miles and D. C. Losey, May 24, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-PL-MG-01-001, Revision 4, *Interface Management Plan*, M. J. Pell, August 11, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-PL-OP-05-0002, Revision B, *WTP Commissioning Plan Part B*, D. M. Burks and G. Matis. April 27, 2007, Bechtel National Inc., Richland, Washington.

24590-WTP-PL-OP-07-0001, Revision 1, *Plan for Waste Feed Pre-qualification*, A. V. Arakali, December 22, 2008. Bechtel National, Inc., Richland, Washington.

24590-WTP-PL-PR-01-003, Revision 5. *Risk Management Plan*, K. C. Baer, November 9, 2009, Bechtel National, Inc., Richland, Washington.

24590-WTP-PL-PR-04-0001, Revision 2, *Integrated Sampling and Analysis Requirements Document*, D. A. Dodd, A. V. Arakali, May 5, 2008, Bechtel National, Inc., Richland, Washington.

24590-WTP-PSARA-ENS-09-0001, Revision 2, *Preliminary Documented Safety Analysis - Control Strategy Changes for the PTF Facility*, B. T. Allen, April 22, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-PSAR-ESH-01-002-02 Revision 4l. *Preliminary Documented Safety Analysis to Support Construction Authorization; PTF Facility Specific Information*, J. Hinckley, June 17, 2010, Bechtel National Inc., Richland Washington.

24590-WTP-PSAR-ESH-01-002-02 Revision 4m, *Preliminary Documented Safety Analysis to Support Construction Authorization; PTF Facility Specific Information*, J. Hinckley, August 12, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-QAM-QA-06-001, Revision 6, *Quality Assurance Manual*, A. M. Neuberger, June 14, 2010. Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-ENG-07-011, Revision 3, *HPAV Engineering Analysis and Design Methods and Criteria*, S. Lachmann and J. Minchiello, April 26, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-ENG-08-021-01 Revision 1, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 1 - CXP-VSL-00026A/B/C*, I. Papp, March 5, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-ENG-08-021-02, Revision 0, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 2 - CNP-VSL-00003/4, CXP-VSL-00004, UFP-VSL-00062A/B/C, RDP-VSL-00002A/B/C*, I. Papp, March 12, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-ENG-08-021-03, Revision 1, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 3, HLP-VSL-00027A/B, HLP-00028, UFP-00002A/B*, I. Papp, August 19, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-ENG-08-021-04, Revision 1, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 4 - HOP-VSL-00903/904, PWD-VSL-00015/16, TCP-VSL-00001, TLP-VSL-00009A/B, RDP-VSL-00008*, I. Papp, March 30, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-RPT-ENG-08-021-05, Revision 0, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 5 - PDW-VSL-00033/34/35*, T. Campbell, March 24, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-RPT-ENG-08-021-06, Revision 1, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 6 - FRP-VSL-00002A/B/C/D*, I. Papp, June 30, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-RPT-ENG-08-021-07, Revision 1, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 7 - UFP-01*, T. Campbell, M. Parker, A. Moon, and B. Fant, June 28, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-ENG-08-021-08, Revision 1, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 8 - HLP-22*, T. Campbell, M. Parker, A. Moon, B. Fant, K. Clossey, and J. Cook, June 28, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-RPT-ENG-08-021-09, Revision 0, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 9 - FEP-VSL-00017A/B*, T. Campbell, M. Parker, A. Moon, B. Fant, K. Clossey, J. Cook, and M. Schaefer, June 21, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-RPT-ENG-08-021-10, Revision 1, *EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 10 - RLD-VSL-00007*, I. Papp and M. Parker, June 3, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-RPT-ENG-09-040, Revision 0, *Seismic Classification and Evaluation for the Pretreatment Facility Piping and Vessels*, J. C. Minichiello, January 27, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-ENG-10-001, Revision 0, *Integrated Pulse Jet Mixed Vessel Design and Control Strategy*. R Voke. R Hanson, P. Keuhlen, February 20, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-RPT-ENG-10-008, Revision 1, *Quantitative Risk Analysis of Hydrogen Events at WTP: Development of Event Frequency-Severity Analysis Mode*, S. Lachmann, April 26, 2010. Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-ENG-10-021, Revision 0, *Hydrogen in Piping and Ancillary Vessels Implementation and Closure Plan*, S. Lachman, August 19, 2010. Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-ENS-10-001, Revision 1, *WTP Methodology for Spray Leak Scenarios*, A. Larson and B. T. Allen, August 11, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-ENS-10-002, Revision 2, *M3 Criticality Safety Test Requirements*, R. E. Miles, June 18, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-ENS-10-007, Revision 1, *Plan of Action to Address Recommendations of the Criticality Safety Support Group (CSSG)*, D. C. Losey and R. E. Miles, May 10, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-RPT-OP-01-001, Revision 2, *Operations Requirements Document*, G. Davis, May 5, 2003, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-PET-08-009, Revision 1, *Functional/Design Requirements for the M3 PJM Test Platform*, P. Omel, July 29, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-PET-10-008, Revision 1, *Revised Simulant Design and Basis for FEP-17, FRP-02, HLP-22, and UFP-01 Vessels for EFRT M3 Mixing Studies*, S. Barnes, R. Gimpel, and D. Dickey, March 4, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-PET-10-013, Revision 0, *Pretreatment Vessel Heel Dilution/Cleanout Feasibility Study*, J. Olson and K. Jenkins, June 4, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-RPT-PET-10-014, Revision 2, *Slurry Property Ranges in Non-Newtonian Pretreatment Vessels at WTP*, R. Gimpel, June 23, 2010, Bechtel National, Inc., Richland, Washington.

24590-WTP-RPT-PTF-02-005, Revision 5, *Flowsheet Bases, Assumptions, and Requirements Document*, V. S. Arakali, et. al., October 17, 2009, Richland, Washington.

24590-WTP-SE-ENS-06-0043, Revision 0, *SRD Appendix H Cleanup*, S.W. Vail, October 11, 2006, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-08-0060, Revision 0, *Incorporation of DOE O 421.1B into the SRD*, K. D. Gibson, September 3, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-08-0066, Revision 0, *Removal of SDC/SDS/RRC from the SRD*, K. D. Gibson, November 20, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-08-0097, Revision 0, *Implementation of the WTP Site Specific Ground Motion Spectra into the Safety Requirements Document for Selective Use*, C. Lindquist, September 10, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-08-0122, Revision 0, *SRD Change to Natural Phenomena Hazards Design Criteria*, M. A. Medsker, November 26, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-08-0152, Revision 0, *Clarification of Use of AISC M016-89, Manual for Steel Construction in the SRD*, K. D. Gibson, January 7, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-08-0154, Revision 1, *New Safety Classification Process for the WTP*, C. Ortiz, February 26, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-08-0159, Revision 0, *Removal of RL/REG-97 from the AB*, K. D. Gibson, November 13, 2008, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-08-0163, Revision 0, *Addition of Specific Administrative Controls into the AB*, K. D. Gibson, January 28, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0013, Revision 0, *Applicability of 10 CFR 50.49 and IEEE-323 on the WTP Project*, K. D. Gibson, February 27, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0019, Revision 0, *Revision of the SRD to Tailor the Requirements to Implement Section 14 of DOE-STD-1066-97*, S. Woolfolk, September 30, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0023, Revision 0, *Clarification of Section VIII Division 1 and Division 2 Requirements*, J. C. Minichiello, September 31, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0039, Revision 0, *Removal of the Project Safety Committee (PSC) from the AB*, K. D. Gibson, May 1, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0063, Revision 0, *AB Changes Regarding Safe State to Support the Elimination of DOE/RL-96-0006 from the WTP Contract*, L. S. Semmens, May 3, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0069, Revision 0, *Removal of DOE/RL-96-0003, DOE/RL-96-0004, DOE/RL-96-0005, and DOE/RL-96-0006 from the Authorization Basis*, K. D. Gibson, August 11, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0074, Revision 0, *Provide Additional Detail in SRD Safety Criterion 4.1-3 Interaction Requirements (two over one protection)*, J. C. Minichiello, March 1, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0084, Revision 0, *Emergency Diesel Generators*, L. S. Semmens, July 29, 2010. Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0089, Revision 0, *Revisions to Hydrogen Control Strategy Requirements*, J. Hinckley, October 20, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0100, Revision 0, *Implementation of Current Terminology of 10 CFR 835 Into the SRD and PDSAS*, K. D. Gibson, November 11, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0120, Revision 0, *Revisions to HPAV Acceptance Criteria*, J. Hinckley, February 10, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-09-0126, Revision 0, *Combustible Loading Program* (pending)

24590-WTP-SE-ENS-10-0001, Revision 0, *Clarification of the SRD Introduction*, K. D. Gibson, January 6, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-10-0016, Revision 0, *Update API Standard 610 to the Latest Revision and add ASME/ANSI B73.1 and B73.2 as Applicable Pump Standards* (pending)

24590-WTP-SE-ENS-10-0017, Revision 0, *Addition of ANSI/ISA 67.04.01-2006 to the Safety Requirements Document Volume II*, C. Ortiz, August 5, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-SE-ENS-10-0023, Revision 0, *Clarification of Seismic Testing Requirements in SRD, Appendix C.2*, K. D. Gibson, May 20, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-SRD-ESH-01-001-02, Revision 5n, *Safety Requirements Document, Volume II*, K. D. Gibson, November 24, 2009, Bechtel National Inc., Richland, Washington.

24590-WTP-SRD-ESH-01-001-02, Revision 5p, *Safety Requirements Document, Volume II*. K. D. Gibson, February 24, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-SRD-ESH-01-001-02, Revision 5t, *Safety Requirements Document Volume II*, K. D. Gibson, June 23, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-SRD-ESH-01-001-02, Revision 5u, *Safety Requirements Document Volume II*, K. D. Gibson, August 19, 2010, Bechtel National Inc., Richland, Washington.

24590-WTP-Z0C-W11T-00006, Revision 0A. *Criticality Calculations for WTP Sodium Diuranate*. A Woodruffe, February 18, 2003, Bechtel National, Inc., Richland, Washington.

24590-WTP-ZOC-W14T -00020 Revision 0C. *Unit Dose Factors for Use in Updated MAR Accident Analyses*, R.I. Smith, 2010, Bechtel National, Inc., Richland, Washington.

40 CFR 280, *Code of Federal Regulations, Title 40, Protection of Environment, Part 280 - Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)*, July 2009, U.S. Environmental Protection Agency, Washington, DC.

6450-01-P, *Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP-EIS), November 12, 1999*, U.S. Department of Energy, Washington, DC.

AIChE, *Guidelines for Chemical Process Quantitative Risk Analysis 2nd Edition*, October 1999, Center for Chemical Process Safety (CCPS)

ANSI/ASME NQA-1, *Quality Assurance Program Requirements for Nuclear Facility Application*, 2000.

ANSI/IEEE Std 323, *An American National Standard IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations*, 1983.

ASME B31.3-96, *B31 Code Case 178*, 1996, American Society of Mechanical Engineers, New York, New York.

ASME Pressure Vessel Code Case 2564-1, *Impulsively Loaded Pressure Vessels*, ASME Boiler and Pressure Vessel Standards Committee, January 29, 2008, American Society of Mechanical Engineers, New York, New York.

ASME V&V 20-2009 *Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer*, American Society of Mechanical Engineers, Fairfield, New Jersey.

Dickey DS, *Don't Get Mixed Up by Scale-up*, Chemical Properties, August 2005.

DOE G 413.3-4, *Technology Readiness Assessment Guide*, October 12, 2009, U.S. Department of Energy, Washington, DC.

DOE G 420.1-1, *Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria Guide for use with DOE O 420.1, Facility Safety*, U.S. Department of Energy, March 28, 2000, Washington, DC.

DOE G 420.1-2, *Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and NonNuclear Facilities*, March 28, 2000, U.S. Department of Energy, Washington, DC.

DOE G 424.1-1B, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements*, April 8, 2010. U.S. Department of Energy, Office of Health, Safety and Security, Office of Nuclear Safety Policy and Assistance, Washington, D.C.

DOE M 413.3-1, *Project Management for the Acquisition of Capital Assets*, March 28, 2003, U.S. Department of Energy, Washington, D.C.

DOE O 413.3A, *Program and Project Management for the Acquisition of Capital Assets*, July 28, 2006, U.S. Department of Energy, Washington, D.C.

DOE O 420.1B, *Facility Safety*, December 22, 2005, U.S. Department of Energy, Washington, DC.

DOE Order 414.1C, Quality Assurance, June 17, 2005, U.S. Department of Energy, Washington, DC.

DOE/EIS-0222-F, *Hanford Comprehensive Land Plan Environmental Impact Statements*, September 1999, U.S. Department of Energy, Washington, DC.

DOE/RL-2010-18, *Hanford Site Active Cleanup Footprint Reduction*, July 2010, U.S. Department of Energy - Richland Operations Office, Richland, Washington.

DOE-001, DOE Risk Assessment Sheet, *Design Authority Hydrogen in Pipe and Ancillary Vessels (HPAV) Case Not Accepted*, M. Wentink, November 26, 2005, Bechtel National Inc., Richland, Washington.

DOE-EH-4.2.1.4-MACCS2-Code Guidance, *DOE MACCS2 Computer Code Application Guidance for Documented Safety Analysis*, June 30, 2004, U.S. Department of Energy, Washington, DC.

DOE-STD-1021-93, *Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components*, April 2002, U.S. Department of Energy, Washington, DC.

DOE-STD-1029-92, *DOE Standard - Writer's Guide for Technical Procedures*, December 1998, U.S. Department of Energy, Washington, D.C.

DOE-STD-1189-2008, *Integration of Safety into the Design Process*, March 2008, U.S. Department of Energy, Washington, DC.

DOE-STD-3009-94, Change Notice #3, *DOE Standard Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, March 2006, U.S. Department of Energy, Washington, DC.

E-Mail, CCN 187620, A. Larson to G. Jones, *Impact of New Classification Scheme*, December 2, 2008, Bechtel National Inc., Richland, Washington.

E-mail, CCN 201897, T. B. Ryan to Distribution, *WTP Control of Hazards Associated with HPAV-Alternative Evaluation and Design Approaches (Final HPAV Assessment Team Report) (CCN 201897)*, July 15, 2009, Bechtel National Inc., Richland, Washington.

E-mail, CCN 201910, T. B. Ryan to Distribution, *Transmittal of Operational Review Team Final Report (WTP-09-078) (CCN 201910)* (Attachment is Letter from D. B. Amerine to S. J. Olinger, *Operational Review Team Report on the Impact of Material at Risk (MAR) and Hydrogen in Piping and Ancillary Piping (HPAV) Initiatives*, July 29, 2009), July 30, 2010, Bechtel National Inc., Richland, Washington.

E-mail, CCN 201913, T. B. Ryan to Distribution, *Response to DFNSB Questions on Non-Newtonian Material and Leak Detection*, August 4, 2009, Bechtel National Inc., Richland, Washington.

ENG-048, EPPC Risk Assessment Sheet, *Capital and Schedule Risk for DOE Standard 1066 Compliance*, M. Wentink, February 1, 2008, Bechtel National, Inc., Richland, Washington.

ENG-130, Opportunity Assessment Sheet, *Revised Safety Strategy Based on MAR and HPAV Evaluations*, R. Kacich, September 25, 2009, Bechtel National, Inc., Richland, Washington.

ENG-136, EPPC Risk Assessment Sheet, *Decontamination Issues Associated with Relocating Equipment in R3/C3 Areas*, J. Weamer, December 4, 2009, Bechtel National, Inc., Richland, Washington.

ENG-137, EPPC Risk Assessment Sheet, *Ash Fall Design Impact*, G. Garcia, December 7, 2009, Bechtel National, Inc., Richland, Washington.

ENG-143, EPPC Risk Assessment Sheet, *PTF Control Building ITS Chilled Water and Support Systems*, J. Monahan, December 28, 2009, Bechtel National, Inc., Richland, Washington.

ENG-151, EPPC Risk Assessment Sheet, *PVP-PVV Impacts from M3, Solids Entrainment, etc.*, J. Weamer, May 21, 2010, Bechtel National, Inc., Richland, Washington.

ENG-156, EPPC Risk Assessment Sheet, *Mixing System Design Implementation*, J. Monahan, June 29, 2010, Bechtel National, Inc., Richland, Washington.

ENS-ENG-IP-01, Revision 4, *Waste Treatment and Immobilization Plant (WTP) Authorization Basis Management*, V. Callahan, May 11, 2010, U. S. Department of Energy, Office of River Protection, Richland, Washington.

EPA QA/G-4, Guidance on Systematic Planning Using the Data Quality Objectives Process, February 2006, U.S. Environmental Protection Agency, Washington, D.C.

Letter No. 04-WED-055, R. J. Schepens to J. P. Henschel, *Contract No. DE-AC27-01RV14136 - Approval of Basis of Design Change Notice 24590-WTP-BODCN-ENG-04-0004 for Section 16 Black Cell Basis of Design*, September 14, 2004, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 100140)

Letter No. 05-ED-058, R. J. Schepens to M. A. Wilson, *Leak Detection and Waste Removal Capability in the Pretreatment Facility*, August 19, 2005, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 130853)

Letter No. 08-NSD-052, S. J. Olinger to W. S. Elkins, *Contract No. DE-AC27-01RV14136 - Approval of Bechtel National, Inc. (BNI) Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-08-0097, Revision 0, Implementation of the Waste Treatment and Immobilization Plant(WTP) Site Specific Ground Motion Spectra (WSGM) into the Safety Requirements Document (SRD) for Selective Use*, October 7, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 187637)

Letter No. 08-NSD-057, S. J. Olinger to W. S. Elkins, *Contract No. DE-AC27-01RV14136 - Direction to Implement New Safety Classification Process for the Waste Treatment and Immobilization Plant (WTP),* October 9,2008, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 188218)

Letter No. 08-NSD-070, Letter, S. J. Olinger to W. S. Elkins, *Request for Evaluation of Material at Risk Used for Waste Treatment and Immobilization (WTP) Design and Accident Analysis*, December 2, 2008, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 190857)

Letter No. 08-NSD-077, S. J. Olinger to W. S. Elkins, *Contract No. DE-AC27-01RV14136 - Approval of Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-08-0159, Revision 0, Removal of RL/REG-97-13 From the Authorization Basis*, December 18, 2008, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 191985)

Letter No. 09-NSD-003, S. J.Olinger to W. S. Elkins, *Contract No. DE-AC27-01RV14136 - Approval of Bechtel National, Inc. (BNI) Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-08-0122, Revision 0, Safety Requirements Document (SRD) Changes to Natural Phenomena Hazards Design Criteria*, January 28, 2009, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 193661)

Letter No. 09-NSD-018, S. J. Olinger to W. S.Elkins, *Contract No. DE-AC27-01RV14136 - Approval of Bechtel National, Inc. (BNI) Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-08-0152, Revision 0, Clarification of Use of American Institute of Steel Construction (AISC) MO 16-89, Manual for Steel Construction in the Safety Requirements Document (SRD)*, March 24, 2009, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 196733)

Letter No. 09-NSD-030, S. J. Olinger to W. S. Elkins, *Contract No. DE-AC27-01RV14136 - Approval as Modified of Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-09-0013, Revision 0, 'Applicability of 10 CFR 50.49 and IEEE-323 on the WTP Project*, April 16, 2009, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 198340)

Letter No. 09-NSD-033, S. J. Olinger to T. C. Feigenbaum, *Contract No. DE-AC27-01RV14136 - Partial Approval of Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-08-0060, Revision 0,* August 14, 2009, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 204091)

Letter No. 09-NSD-034, J. E. Mansfield to I. R. Triay, *Inadequate Mixing, Waste Treatment and Immobilization Plant*, January 6, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 204621)

Letter No. 09-NSD-034, S. J. Olinger to T. C. Feigenbaum, *Conditional Approval of Bechtel National, Inc. (BNI) - 24590-WTP-RPT-NS-01-001, Revision 6, Preliminary Criticality Safety Evaluation*

Report (CSER) for the Waste Treatment and Immobilization Plant, August 24, 2009, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 204621)

Letter No. 09-NSD-044, S. J. Olinger to T. C. Feigenbaum, *Contract No. DE-AC27-01RV14136 - Conditional Approval of Pretreatment Authorization Basis Control Strategy Change Package*, November 2, 2009, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 208458)

Letter No. 09-NSD-044, S. J. Olinger to T. C. Feigenbaum, *Contract No. DE-AC27-01RV14136 - Conditional Approval of Pretreatment Authorization Basis Control Strategy Change Package*, November 2, 2009, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 208458)

Letter No. 09-NSD-050, S. J. Olinger to T. C. Feigenbaum, *Contract No. DE-AC27-01RV14136 - Approval of Bechtel National, Inc. (BNI) Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-09-0023, Revision 0, Clarification of Section VIII Division 1 and Division 2 Requirements*, September 14, 2009, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 205736)

Letter No. 10-NSD-008, S. J. Olinger to F. M. Russo, *Contract No. DE-AC27-01RV14136 - Conditional Approval of Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-06-0043, Revision 0, SRD Appendix H Cleanup*, February 23, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 214405)

Letter No. 10-NSD-013, Letter, S. J. Olinger to F. M. Russo, *Contract No. DE-AC27-01RV14136 - Conditional Approval of Safety Requirements Document (SRD) Change Adding Hydrogen in Piping and ancillary vessels (HPAV) Design Criteria for Pretreatment (PTF) Facility*, February 15, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 214109)

Letter No. 10-NSD-019, S. J. Olinger to F. M. Russo, *Contract No. DE-AC27-01RV14136 - Approval of Bechtel National, Inc. (BNI) Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-09-0074, Revision 0, 'Provide Additional Detail in Safety Requirements Document (SRD) Safety Criterion 4.1-3 Interaction Requirements (Two Over One Protection)*, March 26, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 216310)

Letter No. 10-NSD-043, D. A. Brockman to F. M. Russo, *Contract No. DE-AC27-01RV14136 - Approval of Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-09-0084, Revision 0, Emergency Diesel Generators*, August 6, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 223544)

Letter No. 10-NSD-044, S.J. Olinger to F.M. Russo, *Contract No. DE-AC27-01RV14136 - Approval of Bechtel National, Inc. (BNI) Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-10-0023, Revision 0, 'Clarification of Seismic Testing Requirements in SRD, Appendix C.2*, June 15, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington.(CCN 220309)

Letter No. 10-NSD-051, B. J. Harp to R. W. Bradford, *The U.S. Department of Energy, Office of River Protection (ORP) Assessment of Bechtel National, Inc. (BNI) Authorization Basis (AB) Maintenance Program*, June 15, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 220308)

Letter No. 10-NSD-052, D. A. Brockman to F. M. Russo, *Contract No. DE-AC27-01RV14136 - Approval of Bechtel National, Inc. (BNI) Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-09-0063, Revision 0, AB Changes Regarding Safe State to Support Elimination of DOE/RL-96-006 From the Waste Treatment and Immobilization Plant (WTP) Authorization Basis*, July 26, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 222602)

Letter No. 10-NSD-055, S. J. Olinger to F. M. Russo, *Directed Change to Preliminary Documented Safety Analysis (PDSA) Affecting Hydrogen in Piping and Ancillary Vessels (HPAV) Control Strategy for Pretreatment (PTF) and High Level Waste (HLW) Facilities*, July 17, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 222342)

Letter No. 10-WTP-163, A. T. Morris to N. F. Grover, *Proposed Changes to Contract Tank Waste Feed Specifications Resulting from External Flowsheet Review Team (EFRT) Vessel Mixing Response*, June 24, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington. (CCN 220806)

Letter No. CCN 085388, J. P. Henschel to R. J. Schepens, *Contract No. DE-AC27-01RV14136 - Leak Detection and Waste Removal Capability in the Pretreatment Facility*, July 11, 2005, Bechtel National Inc., Richland, Washington.

Letter No. CCN 091022, Letter, J. P. Henschel to R .J. Schepens, *Contract No. DE-AC27-01RV14136 - Black Cell Openings*, June 8, 2004, Bechtel National Inc., Richland, Washington.

Letter No. CCN 117871, Letter, W.F. Hamel to J. R. Eschenberg, *Closure of Black Cell Design Adequacy Oversight Recommendation 4 and Open Item 12: Design Approach to Black Cell Access Openings*, July 6, 2004, U.S. Department of Energy, Office of River Protection, Richland, Washington.

Letter No. CCN 142843, Memorandum, G. M. Duncan to R. E. Edwards and R. M. Kacich, *Partial Response to Condition of Acceptance Item 2.3 on Evaluation of Uncertainty in the WTP Hydrogen Generation Rate Correlation*, December 28, 2009, Bechtel National Inc., Richland, Washington.

Letter No. CCN 146071, Memorandum, L. Walker to E. Groenweghe, *Bechtel National, Inc., Purchase Order 24590-QL-POC-MVA0-00001, Revision 26, Pressure Vessels, High Alloy, Shop Fabricated, Large, QL-1 (VXLA (N110)*, October 9, 2006.

Letter No. CCN 160904, Memorandum, *RPP-9805, Revision 1, Values of Particle Size, Particle Density, and Slurry Viscosity to Use in Waste Feed Delivery Transfer System Analysis, March 2002,* B. S. Austen, August 14, 2007, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 175239, L. J. Simmons to J. R. Eschenberg, *Transmittal of Assessment of Update WTP Design Basis MAR Report*, December 31, 2008, Bechtel National Inc., Richland, Washington.

Letter No. CCN 177718, L. J. Simmons to J. R. Eschenberg, *Comments on Interface Control Document-19 (ICD-19) Proposed Technical and Risk Evaluation and Waste Feed [sic]*, April 18, 2008, Bechtel National Inc., Richland, Washington.

Letter No. CCN 186341, Memorandum, P. Omel to WTP Project Record, *M3 Test Platform - Prototypic Comparison*, May 4, 2009, Bechtel National Inc., Richland, Washington.

Letter No. CCN 192416, Memorandum, M. K. Robinson to Distribution, *Sensitive - WTP Project Technical Issues Review: November 19, 2008*, January 7, 2009, Bechtel National Inc., Richland, Washington.

Letter No. CCN 193555, Memorandum, *DOE Criticality Safety Support Group - Review of the Washington River Protection Solutions Tank Farm Operating Contractor Criticality Safety Technical Basis, December 7-11, 2009*, D. C. Losey, February 8, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 204767, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 5, PWD-VSL-00033/43/44), Inadequate Mixing System Design*, DOE OARS # 18278, March 25, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington.

Letter No. CCN 205205, Memorandum, L. J. Peltier and J. Berkoe to R. Daniel and P. Keuhlen, *CFD Comparisons to 4 FT Platform Tests - M3 Closure Status*, September 23, 2009, Bechtel National Inc., Richland, Washington.

Letter No. CCN 208996, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package CXP-VSL-00026A/B/C), Inadequate Mixing System Design*, DOE OARS # 18156, June 10, 2010, Bechtel National Inc., Richland, Washington.

Letter No. CCN 209161, *ICD 19 Team Meeting - Finalize Issues to be Included in Revision 5*, M. J. Pell, December 17, 2009, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 209933, Memorandum from C. Dunnum to R. Stevens, *HPAV Piping Routes Exempted from Analysis*, March 10, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 210455, Memorandum, W. L. Tamosaitis to R. B. Daniel, *Scaling of PJM Vessels Containing Settling Solids in Newtonian Slurries*, March 4, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 211535, Memorandum, D. L. Herting to S. M. Barnes, *Simulant Qualification Data Package for Post Design Basis Event (DBE) Testing*, March 12, 2010, Bechtel National Inc., Richland, Washington.

Letter No. CCN 211814, Memorandum, D. L. Herting to R. E. Edwards, *Evaluation of Plutonium Settling in Pretreatment Vessels*, February 18, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 211816, Letter, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 10, RLD-VSL-00007), Inadequate Mixing System Design*, DOE OARS # 18337, June 30, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 214072, M. P. Doherty to D. Murphy, *Contract No. DE-AC27-01RV14136 - Hanford Tank Waste Treatment and Immobilization Plant, Bechtel National, Inc. (BNI) - Notice of Suspension to Northwest Copper Works, Inc., for 24590-QL-POD-MVA0-00001*, April 13, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 214950, Memorandum, S. M. Barnes to File, *Sand Simulant for Evaluation of Vessel Bottom Clearing and Flow Visualization Using Various PJM Firing Patterns Qualification Data Package*, March 8, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 214951, *Technology Steering Group -Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 2, Solids Free And Resin Storage Vessels), Inadequate Mixing System Design*, DOE OARS # 18187, June 22, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 214953, Memorandum, *HLW Sludge Simulant Qualification Data Package*, S. M. Barnes, March 23, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 216086, Memorandum, Herting DL to Barnes SM, *Revised Simulant Qualification Data Package for FRP Testing*, April 1, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 216094, Memorandum, Herting DL to Barnes SM, *Simulant Qualification Data Package for HLP-22 Process Sampling Test*, April 16, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 216681, R. W. Bradford to D. E. Knutson, *Contract No. DE-AC27-01RV14136 - Transmittal for Approval Authorization Basis Amendment Request 24590-WTP-SE-ENS-10-0017, Revision 0, Addition of ISA 67.04.01-2006 to the Safety Requirements Document Volume II*, August 9, 2010, Bechtel National Inc., Richland, Washington.

Letter No. CCN 218915, Memorandum, *CRESP Review Team Letter Report 7 - PJM Vessels*, P. Omel, July 29, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 218916, Memorandum, SNRL-RP-2010-00898 Revision 1, *SNRL - Report Revision 1 of Independent Technical Review of WTP's Assessment of Non-Newtonian Vessel Performance*. P. Omel, July 29, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 220425, Letter, D. McDonald to S. J. Olinger and F. Russo, *Re: Submittal of the Leak Detection Capability in the Pretreatment Facility, 24590-PTF-PER-M-04-0010, Revision 2, for Incorporation in the Next Draft Permit for the Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion, Revision 8c, for the Treatment, Storage, and Disposal of Dangerous Waste, Part III, Operating Unit 10, Waste Treatment and Immobilization Plant (WTP), WA7890008967*, June 16, 2010, Washington State Department of Ecology, Richland, Washington.

Letter No. CCN 220452, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 6, FRP-VSL-00002A/B/C/D), Inadequate Mixing System Design*, DOE OARS # 19024, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington.

Letter No. CCN 220453, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 7, UFP-VSL-00001 A/B), Inadequate Mixing System Design*, DOE OARS # 19025, June 30, 2010, Bechtel National Inc., Richland, Washington.

Letter No. CCN 220454, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 8, HLP-VSL-00022), Inadequate Mixing System Design*, DOE OARS # 19026, June 29, 2010, Bechtel National Inc., Richland, Washington.

Letter No. CCN 220455, *Technology Steering Group - Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 9, FEP-VSL-00017A/B), Inadequate Mixing System Design*, DOE OARS # 19027, June 30, 2010, Bechtel National Inc., Richland, Washington.

Letter No. CCN 220456, *Technology Steering Group-Issued Closure Record - Partial Closure EFRT Issue M3 (Closure Package Volume 3, UFP-VSL-00002A/B, HLP-VSL-00027A/B, HLP-VSL-00028), Inadequate Mixing System Design*, DOE OARS # 19028, August 20, 2010, Bechtel National, Inc., Richland, Washington.

Letter No. CCN 221092, Memorandum, G. Matis to D. Hayes. *Draft WTP Commissioning Strategy Available for Project Review - CPR Action CPR3-6(b) Closure*, July 29, 2010, Bechtel National Inc., Richland, Washington.

Letter No. CCN 221575, *Technology Steering Group-Issue Closure Record - Partial Closure EFRT Issue M-3 (Closure Package Volume 4, Low Solids Containing Vessels), Inadequate Mixing System Design*, DOE OARS # 18281, March 25, 2010, U.S. Department of Energy, Office of River Protection, Richland, Washington.

Letter No. CCN 223285, Revision 0, Memorandum, P. J. Keuhlen to G. R. Ashley, S. M. Barnes, R. B. Daniel and R. F. French, *Disposition of M3 Action List Open Issues*, August 19, 2010, Bechtel National Inc., Richland, Washington.

Letter No. WTP/RPP-MOA-PNNL-00089, G. H. Beeman to W. L. Graves, *Subcontract No. 24590-QL-HC9-WA49-00001, Project 53019 (WA#2007-008) Transmittal of Preliminary Summary of HLP-22 Testing Results*, August 14, 2007, Pacific Northwest National Laboratory, Richland Washington.

Letter No. WTP/RPP-MOA-PNNL-00349, G. H. Beeman to P. Keuhlen, *Subcontract No. 24590-QL-HC9-WA49-00001 – Project 55753 (WA#2008-028) Transmittal of Conceptual Test Requirements*, January 15, 2009, Pacific Northwest National Laboratory, Richland Washington.

Letter No. WTP/RPP-MOA-PNNL-00489, G. H. Beeman to W. L. Tamosaitis, *Subcontract No. 24590-QL-HC49-00001 – Project 55753 (WA#028) Simulant Distribution Recommendation for M3 Testing and Responses to February 12, 2010 Meeting Questions on the use of the WTP-RPT-153 Report*, February 19, 2010, Pacific Northwest National Laboratory, Richland Washington.

Letter No. WTP/RPP-MOA-PNNL-00494, G. H. Beeman to H. R. Hazen, *Subcontract No. 24590-QL-HC49-00001 – Project 55753 (WA#028) Recipes for Simulant Strengths*, March 12, 2010, Pacific Northwest National Laboratory, Richland Washington.

Letter No. WTP/RPP-MOA-PNNL-00507, G. H. Beeman to H. R. Hazen, *Subcontract No. 24590-QL-HC9-WA49-00001, Project No. 55753 (WA-028) Test Considerations for the Potential Engineering-Scale HLP-27 Test*, June 25, 2010, Pacific Northwest National Laboratory, Richland Washington.

Letter No. WTP/RPP-MOA-PNNL-00508, G. H. Beeman to H. R. Hazen, *Subcontract No. 24590-QL-HC9-WA49-00001, Project No. 55753 (WA-028) Guidance on the Scaling and Operation of Air Spargers for the Proposed Engineering-Scale HLP-27 Test Vessel*, July 2, 2010, Pacific Northwest National Laboratory, Richland Washington.

Letter No. WTP-RPP-MOA-PNNL-00191, G. H. Beeman to H. R. Hazen, *Contract No. 24590-QL-HC9-WA49-00001 – Project 53023 (WA#2007-008) Transmittal of Interim Report, Interim Summary:*

HLP-22 Mixing Performance Evaluation, March 19, 2008, Pacific Northwest National Laboratory, Richland Washington.

Letter, A. Wallo to Honorable Peter S. Winokur, Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2009-1, Risk Assessment Methodologies at Defense Nuclear Facilities, June 18, 2010, U.S. Department of Energy, Washington, D.C.

Letter Report. R. Haupt to K. Picha. *HPAV B31.3 Piping Review*. February 26, 2010.

09-24(D), Response to DNFSB Request, August 2009, Washington River Protection Solutions LLC, Richland, Washington.

Nienow, A. W., *The Suspension of Solid Particles in Mixing in the Process Industries*, 2nd Ed., A. W. Nienow, N. Harnby, and M. F. Edwards, 1992, Butterworths, London, UK.

NUREG-1140, *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees*, Division of Reactor Accident Analysis, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. 1988.

ORP-11242 Revision 0, *River Protection Project System Plan*, August 2002, G.K. Allen, et.al., U.S. Department of Energy, Office of River Protection, Richland, Washington. National Inc., Richland, Washington.

PNNL-17170 (WTP-RPT-156), Revision 0, *Results of Large-Scale Testing on Effects of Anti-foam Agent on Gas Retention and Release*, C. W. Stewart, L. A. Mahoney, C. E. Guzman-Leong, J. M. Alzheimer, S. T. Arm, J. A. Bailey, M. G. Butcher, S. K. Cooley, E. C. Golovich, D. E. Hurley, L. K. Jagoda, C. D. Johnson, W. R. Park, L. D. Reid, R. W. Slaugh, H. D. Smith, Y. Su, B. E. Wells, C. Wend, S. T. Yokuda, 2007, Pacific Northwest National Laboratory, Richland Washington.

PNNL-17639, (WTP-RPT-175), Revision 0, *Deposition Velocities of Newtonian and Non-Newtonian Slurries in Pipelines*, A. P. Poloski, H. E. Adkins, Jr, M. J. Minette, J. Abrefah, A. M. Casella, R. E. Hohimer, F. Nigl, J. J. Toth, J. M. Tingey, and S.T. Yokuda, 2009, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-17707 (WTP-RPT-177), Revision 0, *An Approach to Understanding Cohesive Slurry Settling, Mobilization, and Hydrogen Gas Retention in Pulsed Jet Mixed Vessels*. P. A. Gauglitz, J. A. Fort, B. E. Wells, P. A. Meyer, 2009, Pacific Northwest National Laboratory, Richland Washington.

PNNL-17973 (WTP-RPT-178), Revision 0, *A Qualitative Investigation of Deposition Velocities of a Non-Newtonian Slurry in Complex Pipeline Geometries*. S. T. Yokuda, N. K. Karri, A. P. Poloski, M. Luna, H. E. Adkins, M. J. Minette, A. M. Casella, J. M. Tingey, R. E. Hohimer, 2009, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-18098 (WTP-RPT-182), Revision 0, *Pulse Jet Mixing Tests With Noncohesive Solids*, P.A. Meyer, J. A. Bamberger, C. W. Enderlin, J. A. Fort, B. E. Wells, S. K. Sundaram, P. A. Scott, M. J. Minette, G. L. Smith, C. A. Burns, M. S. Greenwood, G. P. Morgan, E. B. K. Baer, S. F. Snyder, M. White, G. F. Piepel, B. G. Amidan, A. Heredia-Langner, 2009, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-18267 (WTP-RPT-179), Revision 0, *PJM Controller Testing with Prototypic PJM Nozzle Configuration*, J. R. Bontha, W. A. Wilcox, F. Nigl, D. M. Pfund, D. R. Weier, A. W. Bauman, R. J. Leigh, Y. Wang, E. D. Johnson, 2009, Pacific Northwest National Laboratory, Richland Washington.

PNNL-18316 (WTP-RPT-189), Revision 0, *Deposition Velocities of Non-Newtonian Slurries in Pipelines: Complex Simulant Testing*, A. P. Poloski, H. E. Adkins, Jr, M. L. Bonebrake, J. Chun, A. M. Casella, K. M. Denslow, M. D. Johnson, M. L. Luna, P. J. MacFarlan, J. M. Tingey, and J. J. Toth, 2009, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-18755 (WTP-RPT-191), Revision 0, *PEP Run Report for Integrated Test A; Caustic Leaching in UFP-VSL-T01A, Oxidative Leaching in UFP-VSL-T02A*, C. E. Guzman-Leong, O. P. Bredt, C. A. Burns, R. C. Daniel, Y. F. Su, J. G .H. Geeting, E. C. Golovich, G. B. Josephson, D. E. Kurath, G. J. Sevigny, D. M. Smith, P. L. J. Valdez, S. T. Yokuda, J. K. Young, 2009, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-18894 (WTP-RPT-197) Revision 0, *Pretreatment Engineering Platform Phase I Final Test Report*, D. E. Kurath, B. D. Hanson, M. J. Minette, D. L. Baldwin, B. M. Rapko, L. A. Mahoney, P. P. Sshonewill, R. C. Daniel, P. W. Eslinger, J. L. Huckaby, J. M. Billing, P. S. Sundar, G. J. Josephson, J. J. Toth, S. T. Yokuda, E. B. K. Baer, S. M. Barnes, E. C. Golovich, S. D. Rassat, C. F. Brown, J. G. H. Geeting, G. J. Sevigny, A. J. Casella, J. R. Bontha, R. L. Aaberg, P. M. Aker, C. E. Guzman-Leong, M. L. Kimura, S. K. Sundaram, R. P. Pires, B. E. Wells, O. P. Bredt, 2009, Pacific Northwest National Laboratory, Richland, Washington.

PNWD-3677 (WTP-RPT-127), Revision 0, *Overview of the Pulse Jet Mixer Non-Newtonian Scaled Test Program*, P. A. Meyer, D. E. Kurath, and C. W. Stewart, 2005, Battelle – Pacific Northwest Division, Richland, Washington.

PNWD-3824 (WTP-RPT-153), Revision 0, *Estimate of Hanford Waste Insoluble Solid Particle Size and Density Distribution*, B. E. Wells, M. A. Knight, E. C. Buck, S. K. Cooley, R. C. Daniel, L. A. Mahoney, P. A. Meyer, A. P. Poloski, J. M. Tingey, W. S. Callaway III, G. A. Cooke, M. E. Johnson, M. G. Thien, D. J. Washenfelder, J. J. Davis, M. N. Hall, G. L. Smith, S. L. Thomson, and Y. Onishi, 2007, Battelle – Pacific Northwest Division, Richland, Washington.

Poreh, M., et al., Investigation of a Turbulent Radial Wall Jet. *Journal of Applied Mechanics*, June 1967.

ROD (64 FR 61615), *Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, November 12, 1999, U.S. Department of Energy, Washington, DC.

RPP-8847, Revision 0, *The Best Basis Inventory Template Compositions of Common Tank Waste Layers*, L. M. Sasaki, December, 3, 2001, CH2M HILL Hanford Group Inc., Richland, Washington.

RPP-9805, Revision 0, *Values of Particle Size, Particle Density, and Slurry Viscosity to Use in Waste Feed Delivery Transfer System Analysis*, J. R. Jewett, January 30, 2002. Numatec Hanford Corporation, Richland,

RPP-40149, Revision 0, *Integrated Waste Feed Delivery Plan*, R. D. Greenwood, et. al, July 2009, Washington River Protection Solutions, Richland, Washington.

RPP-44057, Revision 0, *Data Quality Objective to Support Strategic Planning*, D. L. Banning, April 8, 2010, Washington River Protection Solutions LLC, Richland, Washington.

RPP-PLAN-40145, Revision 1, *Single-Shell Tank Waste Plan*, J. S. Schofield, April 2010, Washington River Protection Solutions LLC, Richland, Washington.

RPP-PLAN-43988, Revision 0, *Technology Development Road Map*, T. L. Sams, May 2010, Washington River Protection Solutions LLC, Richland, Washington.

RPP-RPT-41742 (RPP-MAR) Revision 0, *River Protection Project Mission Analysis Report*, D. H. Shuford, et. al., December 2009, Washington River Protection Solutions LLC, Richland, Washington.

TFC-ENG-CHEM-C-16, Revision A-4, *Data Quality Objectives For Sampling and Analysis*, October 12, 2009, Washington River Protection Solutions LLC, Richland, Washington.

TFC-ENG-DESIGNC-35, Revision E, *Process Hazard Analysis Determination and Techniques Screening*, August 13, 2010, Washington River Protection Solutions LLC, Richland, Washington.

TFC-PLN-39, *Risk Management Plan*, D. P. Lund, April 2010, Washington River Protection Solutions LLC, Richland, Washington.

UFP sketches, *UFP Feed Preparation Loop, Post HPAV/MAR Study*.

WAC 173-303-640, *Department of Ecology, Washington State Dangerous Waste Regulations, Tank Systems*, June 30, 2009, Washington State Department of Ecology, Olympia, Washington.

WASH-1400 (NUREG-75/014). *Reactor Safety Study - An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants*. October 1975. U.S. Nuclear Regulatory Commission. Washington, D.C.

White Paper, *Evaluation of Usage of Deposition Velocity within Hanford Waste Treatment Plant Consequence Modeling*, U.S. Department of Energy, Office of River Protection, Richland, Washington.

WTP Contract DE-AC27-01RV14136, *Design, Construction, and Commissioning of the Hanford Waste Treatment & Immobilization Plant*.

WTP-RPT-113 (PNWD-3551) (24590-101-TSA-W000-0004-114-00016, Revision 00A), *Technical Basis for Testing Scaled Pulse Jet Mixing Systems for Non-Newtonian Slurries*, G. H. Beeman, 2005, Pacific Northwest National Laboratory, Richland, Washington.

WTP-RPT-153 (PNWD-3824) (24590-101-TSA-W000-0004-114-00021, Revision 00B), *Estimate of Hanford Waste Insoluble Solid Particle Size and Density Distribution*, B. E. Wells and M. A. Knight, 2007, Pacific Northwest National Laboratory, Richland, Washington.

WTP-RPT-182, Revision 0 (PNNL-18098), *Pulse Jet Mixing Tests With Noncohesive Solids*. P. A. Meyer, PA, J. A. Bamberger, C. W. Enderlin, J. A. Fort, B. E. Wells, S. K. Sundaram, P. A. Scott, M. J. Minette, G. L. Smith, C. A. Burns, M. S. Greenwood, G. P. Morgan, E. B. K. Baer, S. F. Snyder, M. White, G. F. Piepel, B. G. Amidan, A. Heredia-Langner, 2008, Pacific Northwest National Laboratory, Richland, Washington.

WTP-RPT-208 Revision A, *Reconciling Differences in Phase 1 and Phase 2 Test Observations for Waste Treatment Plant Pulse Jet Mixer Tests with Non-Cohesive Solids*, P. A. Meyer, E. B. K. Baer, J. A. Bamberger, J. A. Fort, M. J. Minette, January 2010, Pacific Northwest National Laboratory, Richland Washington.