ENVIRONMENTAL MANAGEMENT ADVISORY BOARD
U.S. DEPARTMENT OF ENERGY
1000 INDEPENDENCE AVENUE SW
WASHINGTON DC 20585

September 30, 2010

Dr. Inés R. Triay
Assistant Secretary for
Environmental Management
1000 Independence Avenue SW
Washington, DC 20585

Dear Dr. Triay:

As discussed during our September 15th public meeting, enclosed please find the Environmental Management Advisory Board EM Tank Waste Subcommittee Report for Waste Treatment Plant; Report Number EMAB EM-TWS WTP-001, September 30, 2010, in accordance with the Work Plan directive dated May 10, 2010. This report covers the work plan observations and recommendations concerning the Waste Treatment and Immobilization Plant at Hanford (WTP). The charge is summarized below.

> ***Charge 1: Verification of closure of Waste Treatment and Immobilization Plant (WTP) External Flowsheet Review Team (EFRT) issues***
>
> *The Subcommittee should verify that technical resolutions for the 28 issues identified by the EFRT are being or have been successfully implemented to ensure that engineering and design activities can be completed to reduce WTP project risk.*
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> ***Charge 2: WTP Technical Design Review***
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> *The WTP is at approximately 80% design completion. The Subcommittee should perform a systems-based review of the design against the contract functional requirements.*
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> *The Subcommittee should address and provide advice on the following areas related to the design: 1) technical risks have been adequately addressed in the design, and 2) design is sufficiently mature to allow proceeding with needed procurements and construction activities to meet WTP requirements.*
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> ***Charge 3: WTP Potential Improvements***
>
> *The WTP will treat 53 million gallons of highly radioactive waste in 177 underground tanks at Hanford over several decades. Therefore, the Committee*

should consider any technical improvements that could result in a net reduction in the life cycle cost and schedule of the tank waste cleanup provided that the improvements do not have an adverse impact on the WTP Total Project Cost or project completion date.

If you have any questions or comments regarding the reports and/or recommendations, please feel free to contact either myself or the Board's Designated Federal Officer, Ms. Terri Lamb.

Regards,

James Ajello
Chairman, Environmental Management Advisory Board

Environmental Management Advisory Board

EM Tank Waste Subcommittee Report for Waste Treatment Plant

Report Number EMAB EM-TWS WTP-001

September 30, 2010

We, the undersigned members of the Environmental Management Advisory Board's Subcommittee on Tank Wastes, concur with the Findings, Observations and Recommendations contained in the following report

EM Tank Waste Subcommittee Report for Waste Treatment Plant
Report EMAB EM-TWS WTP-01, Sept 30, 2010

Dennis Ferrigno, Co-Chair

Larry Papay, Co-Chair

Alan Leviton, Member

Kevin Brown, Member

Ed Lahoda, Member

David Shuh, Member

James Stevens, Member

Bernie Meyers, Member

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September 30, 2010

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September 30, 2010

1 Introduction

The mission of the Department of Energy's (DOE's) Office of River Protection (ORP) is to retrieve and treat Hanford's tank waste and close the tank farms to protect the Columbia River. As part of that mission, DOE has contracted with Bechtel National, Inc. (BNI) to design, construct, and commission the Hanford Waste Treatment and Immobilization Plant (WTP) to treat the radioactive waste, separate it into high- and low-activity fractions, and produce canisters of high-level waste (HLW) glass and containers of low-activity waste (LAW) glass. Currently, WTP is at approximately 80 percent design and 52 percent construction completion.

1.1 Structure of the Tank Waste Subcommittee

In May 2010, the Department of Energy established the Environmental Management Tank Waste Subcommittee (EM-TWS). The EM-TWS was established under the Environmental Management Advisory Board (EMAB), whose charter is in accordance with the provisions of the Federal Advisory Committee Act (FACA), as amended, Title 5 of the United States Code (U.S.C.), Appendix 2. The membership of the EM-TWS is noted in Appendix A.

The EM-TWS is charged with providing an independent technical review of liquid waste capital and operations projects related to EM's tank waste cleanup program at Hanford, Washington; the Savannah River Site in South Carolina; the Idaho National Laboratory; and the West Valley Demonstration Project (WVDP) in New York. It will focus on facilities being planned, designed, and constructed at those sites.

The EM-TWS has been tasked to advise on a wide range of matters, including, but not limited to, the assessment of open issues related to technical impediments to delay or change the project delivery; a review of the programmatic processes currently being used for project delivery; and identification of potential technical, programmatic, administrative, and operational improvements to the strategy for retrieving waste from storage tanks and subsequently immobilizing the waste for eventual disposal in accordance with waste acceptance mandate criteria. This includes review of the strategies for implementing such projects, the proposed pretreatment and treatment processes, the technical design of specific facilities, and the safety basis and operational readiness of such facilities. The EM-TWS will produce reports and propose recommendations to the EMAB as necessary.

The duties of the EM-TWS are solely advisory in nature. It reports to EMAB, which, in turn, is appointed by the Secretary of Energy and assigned to the Assistant Secretary for EM (EM-1) at the pleasure of the Secretary of DOE and EM-1. In accordance with the requirements of EMAB, the EM-TWS may not work independently of EMAB and must report its recommendations and advice to the full Committee for deliberation and discussion prior to any release of subject matter information.

1.2 Focus of This Report

Since its start, the EM-TWS efforts have been directed at the WTP. The initial charge to the EM-TWS is to complete a report on the following issues related to the WTP by September 15, 2010. (For the full charge, see Appendix B.)

1. Verification of Closure of WTP External Flowsheet Review Team (EFRT) issues.

   To accomplish this, the EM-TWS should verify that technical resolutions for the 28 issues identified by the EFRT have been or are being successfully implemented to ensure that engineering and design activities can be completed to reduce WTP project risk. This should focus particularly on resolution status of the pulse jet mixing (PJM) capability issue. This issue is discussed in Chapter 3.

2. WTP Technical Design Review

   The WTP is at approximately 80 percent design completion. The EM-TWS should perform a systems-based review of the design against the contract functional requirements, providing advice on the following areas related to the design: 1) technical risks have been adequately addressed in the design and 2) the design is sufficiently mature to allow proceeding with needed procurements and construction activities to meet WTP requirements. This issue is discussed in Chapter 4.

3. WTP Potential Improvements

   The WTP will treat 53 million gallons of highly radioactive waste currently located in 177 underground tanks at Hanford that have accumulated over several decades. Therefore, the Committee should consider any technical improvements that could result in a net reduction in the lifecycle cost and schedule of the tank waste cleanup provided that the improvements do not have an adverse impact on the WTP total project cost or project completion date. Chapter 5 discusses this issue.

The EM-TWS may not work independently of the chartered EMAB, and must report its recommendations and advice to the EMAB for full deliberation and discussion. The EM-TWS has no authority to make decisions on behalf of the EMAB, nor can it report directly to DOE.

1.3 Background

This EM-TWS has undertaken the review of WTP, which is a large, complex, first-of-a-kind plant comprising five integrated facilities with more concrete, steel, and piping than a large nuclear power plant. It represents the combination of British and U.S. nuclear waste management technologies, and the integration of nuclear materials and chemical process industry design principles. In addition, this is a project that has a history spanning more than a generation of programmatic and policy evolution. The plant design and construction have progressed under the leadership of five DOE field office managers, four contractor project managers, and three Federal Project Directors.

The first tank leak at Hanford (all original tanks had a single shell) was discovered in 1956, and throughout the 1960s and 1970s, the concern over additional leaks led to the extraction and encapsulation of much of the cesium (Cs) and strontium (Sr) isotopes (primarily Cs-137 and Sr-90) contained in these tanks, because this material represented the largest fraction of tank waste radioactivity and also had a potential for industrial applications. These capsules are in storage at Hanford. During this same timeframe, a number of higher-integrity double-shell tanks were constructed.

The last double-shell tank was constructed in 1986. In the 1987/1988 period, DOE issued an Environmental Impact Statement and Record of Decision (EIS/ROD) for tank waste treatment, which called for the stabilization of single-shell tank waste in place. This EIS/ROD was found to be unacceptable by the public, and in 1989, a Tri-Party Agreement was signed with regulators and stakeholders to extract and treat most of the tank waste.

In 1991, Secretary of Energy Watkins directed the formation of the Tank Waste Remediation System as a single project. In 1993, the Hanford Waste Vitrification Project was terminated due to safety and environmental issues. In 1994, a revised waste treatment strategy was developed, and in 1995, it was decided to implement this strategy under a privatization model. In 1997, a revised EIS/ROD was issued that called for the vitrification of all tank wastes in two phases (in part, because vitrification offered the option of reducing resultant volumes) and also deferred the disposition of the Sr and Cs capsules.

Consistent with this revised ROD, a privatization contract was negotiated in 1998. Under this scheme, the contractor would construct its own facility at Hanford to fulfill the first phase of treating tank wastes in a vitrified form. This facility would draw heavily upon the British Nuclear Fuels plc experience in treating liquid radioactive waste at its Sellafield Facility. DOE would pay the contractor on a per-unit-of-product basis such that it could recover costs and earn a reasonable profit.

In 1999, it was determined that the cost of capital for the facility (an allowable expense under DOE privatization policy) could increase the product cost by as much as a factor of three. Given the new, higher cost profile, Secretary of Energy Richardson cancelled the privatization effort and competitively bid a cost-plus-award-fee contract for the first phase being supplied by the previous contractor. BNI was awarded an Engineering, Procurement, Construction, and Commissioning (EPCC) contract to deliver a completed operating facility.

An early action by BNI was to re-engineer some of the basic concepts of segmenting high-radiation zones into discrete cells to one using a central canyon approach for remote access, which is common to most U.S. radioactive waste treatment facilities. BNI also committed to an accelerated, or fast-track, approach to develop WTP in a design/build model with the objective of accelerating project completion.

In design/build, the construction of project segments begins early by following shortly behind the completion of the corresponding engineering. In this manner, engineering continues throughout most of the construction process. Consistent with this EPCC model, construction was begun in 2002, and, also consistent with this model, engineering is still ongoing ten years after project initiation.

Concerns regarding the escalation of WTP project cost and schedule began in mid-2002. An independent Commission, reporting to Secretary of Energy Abraham, indicated that cost estimates had escalated by about 40 percent just months after construction began. As baseline estimates increased, the project introduced a "minimum essential" approach to review design decisions to determine whether each action was essential to compliance with technical specifications.

In addition to cost containment, an effort was made to provide "value engineering" to produce more performance for the increased cost. Although WTP has always been considered the first phase of a two-phase treatment program, the WTP melters were reconfigured so that they could treat all of the higher-activity radioactive waste, thereby requiring only lower-level waste to undergo a second phase.

In 2005, Secretary of Energy Bodman assembled a distinguished group of the "Best and Brightest" to review the project technology, cost, schedule, and management (all of which having been subject to many other expert reviews before and since). The Best and Brightest issued a report in 2006 that provided a number of important findings. Among these was a recommendation that DOE act more like an owner since it will have to run the facilities for decades. Other findings suggested substantially increasing cost and schedule contingency given the unique and complex nature of the project. More than two dozen technical issues were identified that needed to be resolved.

Consistent with these recommendations, DOE revised its baseline, which has remained fairly constant since then at a final estimated cost of $12.47 billion and startup date in late 2019. The resolution of the technical issues has been in process since that time and is nearing completion.

1.4 Review Lines of Inquiry

The EM-TWS conclusions and recommendations are detailed in Chapters 3-5. Included are the status of remaining project baseline risk, freezing of project design (current suitability and suggested prerequisite actions), and recommendations for improvements. The conclusions and recommendations that the EM-TWS made to EMAB are included in this report as the Executive Summary, Chapter 2.

The EM-TWS met on three occasions and conducted a series of conference calls to gather input, deliberate its findings, and formulate its recommendations, with the focus being on the three issues mentioned above. The EM-TWS recognized that because of the limited time it had available, there are further reviews and analyses that could have been done. These will be covered in future charges to the EM-TWS at the pleasure of EM-1.

2 EMAB EM-TWS WTP Final Report, September 15, 2010 (EMAB Resolution and Approval)[1]

In May 2010, the Department of Energy established the Environmental Management Tank Waste Subcommittee (EM-TWS). The EM-TWS was charged with conducting an independent technical review of liquid waste capital and operations projects related to the Office of Environmental Management (EM) tank waste cleanup programs at Hanford, Washington; the Savannah River Site in South Carolina; the Idaho National Laboratory; and the West Valley Demonstration Project in New York. The EM-TWS's review focused on the facilities being planned, designed, and constructed at those sites, as well as operations/lifecycle costs.

This report covers the work plan observations and recommendations concerning the Waste Treatment and Immobilization Plant at Hanford (WTP). The charge is summarized below.

> ***Charge 1: Verification of closure of Waste Treatment and Immobilization Plant (WTP) External Flowsheet Review Team (EFRT) issues.***
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The WTP is a large, complex, first-of-a-kind plant involving five integrated facilities with more concrete, steel, and piping than a large nuclear power plant. The WTP represents state-of-the-art technology derived from both British and U.S. nuclear waste management best practices. The WTP integrates nuclear materials and chemical process industry design principles. In addition,

[1] This chapter was first issued as a standalone summary report. As such, some introductory material is repeated.

this is a project with a history that spans more than a generation of programmatic and policy evolution. The plant design and construction have progressed under the leadership of five DOE field office managers, four contractor project managers, and three Federal Project Directors.

Concerns regarding the escalation of WTP project cost and schedule began in mid-2002. An independent commission, reporting to the Secretary of Energy, indicated that cost estimates had escalated by about 40 percent just months after construction began. As baseline estimates increased, the project introduced a “minimum essential” approach that reduced design margins and flexibility. An effort was made to use “value engineering” to produce more value for the project. Although WTP has always been considered the first phase of a two-phase treatment program, the WTP was reconfigured so that it could treat all of the high-level radioactive waste; therefore, only the low-activity waste would require a second phase.

In 2005, the Secretary of Energy commissioned a distinguished group of experts known as the “Best and Brightest” to review the project technology, cost, schedule, and management (all of these areas having been subject to many other expert reviews before and since). The Best and Brightest issued a report in 2006 that provided a number of important findings:

> *…DOE should act more like an owner since it will have to run the facilities for decades, and a substantially greater amount of contingency in both cost and schedule should be budgeted given the unique and complex nature of the project…*

The EFRT report provided specific recommendations, including more than two dozen technical issues that needed to be resolved. DOE revised its baseline consistent with those recommendations. The baseline has remained fairly constant since then, at a final estimated cost of $12.263 billion and startup date in late 2019. The resolution of the technical issues has continued since that time and is nearing completion.

The EM-TWS charter calls for the technical review and expert opinion as to how this project must move forward concerning closure of the EFRT issues as well as observations on technical risks, design sufficiency, and potential improvement areas.

Charge 1: Verification of closure of Waste Treatment and Immobilization Plant (WTP) External Flowsheet Review Team (EFRT) issues.

The Subcommittee should verify that technical resolutions for the 28 issues identified by the EFRT are being or have been successfully implemented to ensure that engineering and design activities can be completed to reduce WTP project risk.

Summary of the Findings for Charge 1

The EM-TWS's observation is that the current WTP Contractor, with DOE's concurrence, has met the WTP procedures and protocols that constitute issue closure and is continuing to pursue the resolution of remaining technology issues in parallel with engineering, procurement, and construction (EPC) activities. The only EFRT issue that does not have full concurrence of the DOE/Contractor Technology Steering Group that it satisfies all closure criteria is that part of the M3 issue, *Inadequate Design of Mixing Systems*, involving the design of the pulse-jet mixing (PJM) systems for five WTP non-Newtonian vessels. Closure of the corresponding non-Newtonian vessel assessment was deemed to be a risk-based management decision by the Federal Technology Steering Group membership.

The EM-TWS finds that the professionalism and effectiveness of the current WTP Contractor are adequate to meet the challenge of keeping the project on track to meet the project schedule.

Background for Charge 1

The External Flowsheet Review Team (EFRT) assessed hundreds of possible concerns involving the WTP design. The scope of the EFRT's review involved an assessment of whether the WTP, as designed in 2006, would meet the throughput capacity specified in the contract and required for the long-term mission. Three fundamental capacity aspects were considered by the EFRT:

1) Basic sizing of the plant and equipment,
2) Process capacity based on the process design, and
3) Actual capacity. Actual capacity is the ability to sustain product output at the desired rates after including plant availability. The scope of the review did not consider many issues, including evaluation of alternatives, cost and schedule, hydrogen in piping and ancillary vessels (HPAV), supplemental low-activity waste (LAW), or waste forms and qualification (EFRT 2006a).

After completing the evaluation, the EFRT identified 28 remaining issues. These issues were classified as either *systematic* or *process area-specific*. The items were further categorized as either *major* or *potential* (i.e., that <u>will</u> or <u>could</u> prevent meeting contract rates with commissioning and future feeds, respectively). Major issues must be fixed to ensure that WTP will meet design throughput for all feeds identified at the time of the EFRT review. The EFRT believed that all of the major and potential issues it identified had possible solutions and provided example fixes for selected issues (EFRT 2006a).

Issue Response Plans for the 28 issues were developed that included at least one closure criterion (and often several criteria) for each EFRT issue. All 28 issues were considered closed at the time of the EM-TWS review. Closure was defined as satisfying the requirements of the closure criteria in the appropriate Issue Response Plan (IRP). When necessary, the closure documents identified actions to be tracked in the Office of River Protection (ORP) Action Tracking System (ATS) to address residual risks.

Findings and Observations:

The EM-TWS reviewed the following areas of concern identified by the EFRT and concluded that none would prohibit continuation and completion of the EPC efforts. The following list summarizes the depth of review and the timeline of confirmed closure to adequately establish that EPC activities should continue as scheduled and planned.

Status Summary of Issues Identified by the EFRT

EFRT Issue(s)	Title	Date Closed
M1	Plugging in Process Piping	02Mar09
M2	Mixing Vessel Erosion	10Oct09
M3	Inadequate Design of Mixing Systems	20Aug10
M4	Designed for Commissioning Waste vs. Mission Needs	13Nov07
M5	Must Have Feed Pre-Qualification Capability	18Oct07
M6 / P4	Process Operating Limits Not Completely Defined / Gelation / Precipitation	16Dec08
M7	Inconsistent Long-Term Mission Focus	13Nov07
M7a / M7b	Lack of Spare LAW Melter / Lack of Spare High-Level Waste (HLW) Melter	02Nov06
M8	Limited Remotability Demonstration	15Oct07
M9	Lack of Comprehensive Feed Testing during Commissioning	18Oct07
M10	Critical Equipment Purchases	15Oct07
M11	Loss of WTP Expertise Base	17Mar08
M12	Undemonstrated Leaching Processes / Pretreatment (PT) Facility	29Sep09
M13	Inadequate Ultrafilter Surface Area and Flux (PT)	24Sep09
M14	Instability of Baseline Ion Exchange (IX) Resin (PT)	18Oct07
M15	Availability, Operability, and Maintainability (PT)	15Apr08
M16	Misbatching of Melter Feed (LAW Vitrification Facility)	18Oct07
M17	Plugging of Film Cooler and Transition Line (LAW Vitrification Facility)	15Apr08
P1	Undemonstrated Decontamination Factor (PT-Evaporators)	15Apr08
P2	Effect of Recycle on Capacity Evaporators (PT-Evaporators)	13Nov07
P3	Adequacy of Control Scheme (PT–Evaporators)	12Dec06
P5	Inadequate Process Development (PT-IX)	21Dec07
P6	Questionable Cross-Contamination Control (PT-IX)	18Oct07
P7	Complexity of Valving (PT-Ion Exchange)	17Mar08
P8	Effectiveness of Cs-137 Breakthrough Monitoring System (PT-Ion Exchange)	18Oct07
P9	Undemonstrated Sampling System (Analytical Laboratory (LAB) and Sampling)	05Nov09
P10	Lack of Analysis before Unloading Glass-forming Chemicals in Silos (Balance of Facilities (BOF))	15Oct07
P11	Incomplete Process Control Design (Design of Control Systems)	21Dec07

The EM-TWS has adopted the standard for verifying closure as being demonstrated compliance with all corresponding IRPs. Each IRP is customized to the nature of the corresponding issue being addressed, but in general, an IRP defines the issue of concern, conditions necessary to address the concern, and a path forward for doing this within ongoing EPC activities, based on industry best practices.

The closure of an issue does not mean that all related technology issues are completely resolved. Industry experience shows that resolution of technology issues frequently continues during construction and startup. For example, the procedures and protocols might require a modification to plant components and/or operating conditions and further require that this modification be demonstrated during the startup and commissioning process. A plan for development and implementation of this modification based on acceptable industry practice would constitute IRP compliance and issue closure, but, given the first-of-a-kind nature of WTP, unanticipated further concerns could arise during this demonstration process.

The EM-TWS's observation is that the current WTP Contractor, with DOE's concurrence, has met the IRP procedures and protocols that constitute issue closure and is continuing to pursue these IRPs in parallel with EPC activities.

The only EFRT issue that does not have full concurrence of the Technology Steering Group that it satisfies all closure criteria is that part of the M3 issue, *Inadequate Design of Mixing Systems*, involving the design of the pulse-jet mixing systems for five WTP non-Newtonian vessels. Closure of the corresponding non-Newtonian vessel assessment was deemed a risk-based management decision by the Technology Steering Group's Federal membership.

Charge 1, Recommendations 2010-02 through 11

In further review of the EFRT activities, the EM-TWS felt that there are some areas of concern and improvement that should be investigated and completed; however, these observations should not delay the WTP EPC execution of work. Chapter 3 of the report[2] articulates these items in detail; however, below is a summary of those observations and recommendations:

[2] To be issued on Sept 30, 2010.

Summary for EFRT Issues with Significant Recommendations per the EM-TWS

EFRT Issue	Description	Impact on Commissioning	Additional Concerns	Significant Recommendation(s)
M1	Plugging in Process Piping	The impact of modifying piping specifications on the commissioning cost and schedule depends greatly on the timing and extent of the changes.	Potential for plugging in WTP lines, especially outside normal operations and the risk of plugging in transfer lines being too high.	**2010-02** Analyze to identify high-risk lines for plugging, reanalyze current transfer line design to ensure acceptable risk of plugging, consider physical processes for reducing or removing plugs in long lines and transfer lines, consider redundancy in high-risk lines.
M3	Inadequate Design of Mixing Systems	Additional equipment and instrumentation may be required to ensure adequate mixing in WTP vessels using PJMs; additional simulants may be needed, specific mixing tests may be defined (especially if neither prototypic nor full-scale testing is performed before commissioning), operations may be refined to accommodate mixing results, and contingency plans may be developed for internal changes to vessels.	Bubbler issues including solids entrainment; the PJMs potentially not meeting Technology Readiness Level (TRL) 6; undocumented / formal analysis supporting closure of non-Newtonian vessels.	**2010-03** Document the formal cost-benefit analyses to evaluate potential benefits of additional testing; clearly document the basis for the final vessel assessment closure, and, if high-risk, confirm the technical basis for scaling and ensure access to the vessel if changes are needed; evaluate the safety basis assumptions and methods and test vessel clearing methods.
M5	Must Have Feed Pre-Qualification Capability	The detailed technical basis for waste feed prequalification will need to be completed (e.g., to confirm that sufficient laboratory space will be available and to validate key assumptions, models, and experiments).	Incomplete technical and test specifications (and corresponding uncertainty if LAB is adequate); two-phase sampling difficulties; need to integrate pre-qualification unit operations; and testing for precipitates and gels in pre-qualification protocol	**2010-04** Develop robust and integrated prequalification protocols and “facility;” develop detailed technical basis for waste feed prequalification and use to confirm adequate laboratory capability; ensure representative sampling of two-phase mixtures in the Tank Farm.
M8	Limited Remotability Demonstration	The development of plans to address remotability issues (e.g., remote replacement of piping and remote repair “sprung” pipes) may require testing that would impact commissioning.	Lack of experience with large (> 10”) jumpers; how to empty vessels with only a single outlet pump and valve in event of failure; potential to damage connectors for flexible electrical and pneumatic jumpers during replacement; and how to handle a failed IX column.	**2010-05** Develop plans and possible training mock-up to address remotability concerns (i.e., gain experience with large jumpers, remote replacement of piping, remote repair of “sprung” pipes, removal and decontamination of failed IX column, how to empty vessels with only a single outlet pump and valve in the event of failure).
M10	Critical Equipment Purchases	**N**o impact.	Limited documentation of bases for decisions concerning “best value” approach.	**2010-06** Provide additional documentation regarding the criteria used for best value selection; evaluate single supplier for IX resin seed; and need to keep “best basis” concepts current.
M14	Instability of Baseline Ion Exchange (IX) Resin (Pretreatment Facility or PT)	There may be impacts on commissioning and operations if the resorcinol formaldehyde (RF) resin is not available due to seed supplier viability.	Testing appears to be limited to support operations.	**2010-07** Extended testing to confirm ion exchange capacity and resin physical stability/lifetime at this temperature; conduct hazards and operability (HazOp) review to determine if the Cesium Ion Exchange Process System (CXP) temperature might increase above 65°C during abnormal operating conditions
M15	Availability, Operability, and Maintainability (PT)	**T**his should be converted into an ongoing project evaluation that continues through WTP Contractor-supported commissioning activities. The lessons learned in planning for operations should provide valuable insight, provide continual interchange between the design/builder and operator, and help to define the appropriate timing and method of handoff during commissioning and startup.	Compliance margin based on current Operations Research (OR) model availability may be insufficient.	**2010-08** Update OR model more frequently (evaluate Reliability, Availability, Maintainability, and Quality Control (QC) Inspection information); review current OR model and the state of knowledge from similar crane operations; establish ongoing coordinating function.
P1	Undemonstrated Decontamination Factor (PT-Evaporators)	Simulant review should take place prior to radioactive functional testing.	Technical specification and performance documentation for the procurement specification have not been confirmed based on the most recent G2 model; possibility and impact of foaming uncertain; lack of simulant testing.	**2010-09** Continue to review the impact of foaming; review simulants.
P4	Gelation/Precipitation	Risks, judged to be acceptable at the time of issue closure, will be carried forward to commissioning and operations.	Impacts of changes to prevent gelation have not been assessed throughout affected systems.	**2010-10** Assess impact of changes to prevent recently observed gelation / precipitation throughout affected systems.
P5	Inadequate Process Development (PT-Ion Exchange)	No impact.	Availability of resin seed for WTP Operations has not been confirmed.	**2010-11** Ensure the availability of RF resin seeds for WTP operations.

Charge 2: WTP Technical Design Review

The WTP is at approximately 80% design completion. The Subcommittee should perform a systems-based review of the design against the contract functional requirements.

The Subcommittee should address and provide advice on the following areas related to the design: 1) technical risks have been adequately addressed in the design, and 2) design is sufficiently mature to allow proceeding with needed procurements and construction activities to meet WTP requirements.

Summary of the Finding for Charge 2

Based on its review of the design processes and systems being employed, the EM-TWS has concluded that, independent of the EFRT issues that are discussed above: 1) no substantial risk to compliance with contract functional specifications was identified, and 2) the design appears to be sufficiently mature to proceed with completion of EPC.

Background for Charge 2

As the WTP project advances toward completion, it will approach what has been described as "a pivot point," at which time the principal focus of management attention will begin to shift from EPC to engineering, procurement, construction, and commissioning (EPCC). The two principal questions raised in this charge concern

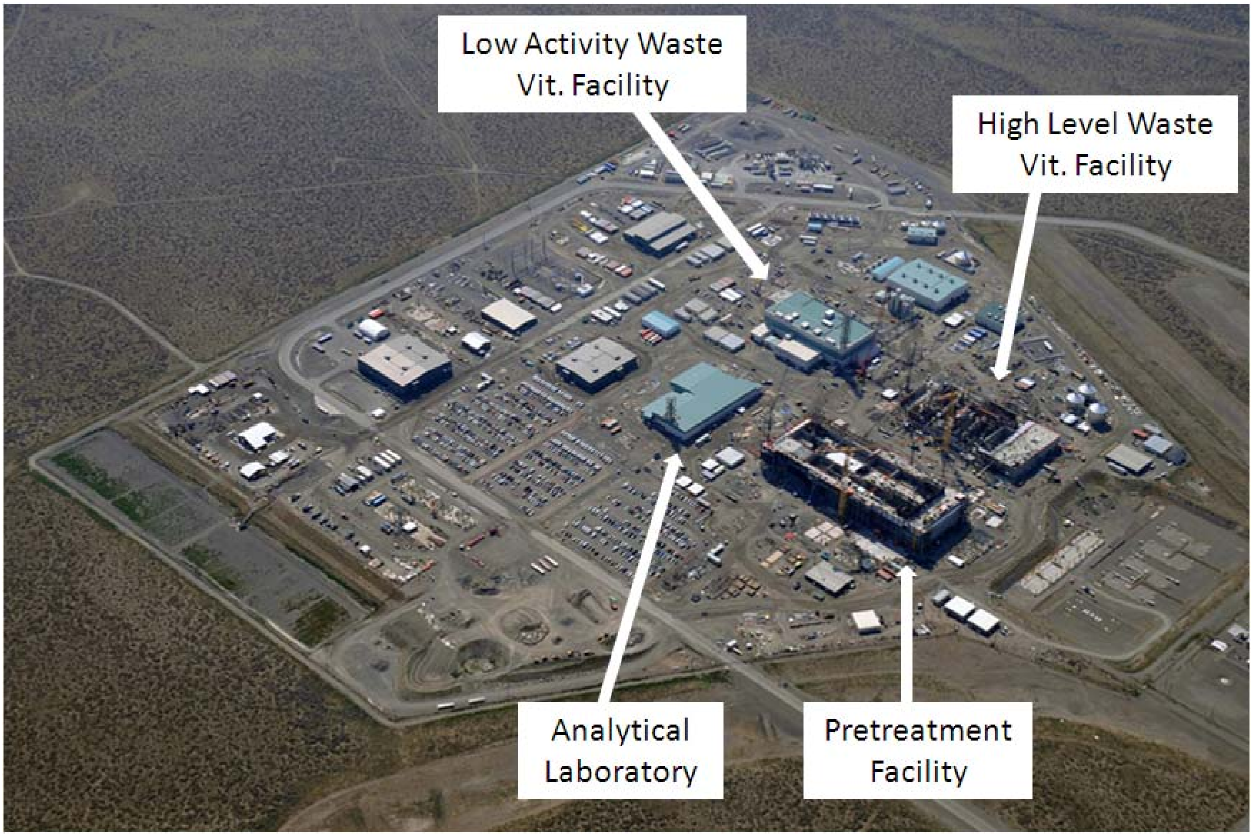
- where the project now stands in relation to this pivot point; namely, whether the technical risks associated with EPC have been sufficiently resolved (i.e., is the remaining risk sufficiently low); and

- whether the design has advanced to a sufficient level of maturity or completeness such that WTP is now at this pivot point.

WTP consists of five standalone facilities, the first four of which are shown in the aerial photograph below.

- High-Level Waste;
- Low-Activity Waste;
- Pretreatment;
- Analytical Laboratory; and
- Balance of Facilities, a collection of smaller support facilities, e.g., process water.

In order to assess the relative progress of WTP, it is necessary to first understand the EPC process that is currently being deployed. The contract between DOE and the prime contractor for this project calls for all of the EPC elements to be performed as an overlapping, sequential process in order to "fast-track" completion of the WTP project and achieve the lowest feasible cost. Each WTP facility is being developed in this overlapping manner by defining individual work areas, typically starting at the lowest physical level in a given facility and working upwards.



Aerial View of the WTP Construction Site, July 2010

Contract-Derived Plant Specifications

The fundamental project reference document consists of the technical sections of the DOE contract that define the feed that WTP will receive from the Hanford Tank Farms, in addition to the plant productivity and the product quality of the vitrified waste product. The contract also defines safety and quality requirements, contractor engineering work product deliverables, and verification of performance through the post-construction startup and commissioning phase.

For the EM-TWS review, completion of the contractor's work product was determined by whether it complied with contract-derived specifications in a comprehensive and professional manner. To the extent that the work product was not complete due to nonconformance with these specifications, there is an associated future risk.

WTP Conformance with Project Specifications

One common method to determine if a capital project is in conformance with project specifications is to perform a system-by-system review of the physical plant and compare the work products for each system with the documented specifications for a given system and for each of the components within that system. The size and complexity of the WTP project together with the two-month timeframe for the review presented practical challenges in performing a comprehensive system-by-system review.

Consequently, the EM-TWS realized that it needed to take a more holistic approach. The EM-TWS reviewed the methods and procedures used to develop, maintain, and utilize project specifications and to maintain consistency in its system-by-system application among work areas within the plant. The EM-TWS also reviewed the application of these methods to two of the many systems chosen from the WTP Work Breakdown Structure: Pretreatment In-cell Handling (principally, the overhead crane that handles most materials within the hot cell) and the Cesium Ion Exchange process. The EM-TWS also reviewed an extensive WTP system-by-system configuration management review commissioned by the current WTP contractor in 2008 and 2009.

Methods and Procedures for Compliance with Contract Functional Requirements

The current WTP contractor initially developed a set of planning documents that defined the safety envelope, basic process flowsheets that define the strategy for achieving the contract-specified throughput capacity, the glassified product production strategy to meet the contract-specified quality, the operations and maintenance strategy, the environmental compliance strategy, and plant external interfaces. These planning documents formed the platform for developing a comprehensive Basis of Design document, which provides instruction as to the general plant layout, purpose, and requirements; the applicable codes and standards to be utilized by all EPC disciplines and the safety and quality requirements; and the technology issues that require further development. The Basis of Design document also provides high-level guidance for initiating a research and technology program to address these issues.

The most fundamental question regarding technical risk is whether the plant has been built to these specifications and will likely continue to be built to them until completed. The basic answer to this question entails a confirmation that the systems and work processes in place are adequate to ensure compliance and that sufficient oversight exists to confirm that these systems and process are being properly employed.

Management of Change within the EPC Process

The nature of the EPC process being used at WTP, and the duration of this project, has resulted in a large number of changes. The project has employed an array of change management processes to ensure that these changes are properly implemented.

At any given time, a large number of changes within WTP activities are in process. The notation of these changes on design drawings and other work products (e.g., procurement specifications) is managed in part by the project automated database management system. However, it also depends on expert judgment by supervisors and subject matter experts.

Independent Review and Oversight

The WTP project has instituted redundant control systems:

- All work products, and changes thereto, are subject to supervisory and disciplinary review and signoff.
- Work processes are subject to a project-independent QC function, whose purpose is to ensure that established procedures are being properly implemented.
- Work products are subject to a project-independent Quality Assurance organization, whose responsibility is to randomly audit work products to ensure they are in compliance with applicable procedures and specifications.
- Work products and processes are subject to an additional independent review by the current WTP contractor's disciplinary chief and a review by the contractor's chief engineer.
- DOE, through ORP, conducts regular independent audits of WTP work processes and work products.

System-Specific Review of Compliance with Contract Functional Requirements

The EM-TWS asked the contractor for a demonstration of the configuration management system described above for two separate WTP systems: the Pretreatment In-cell Handling (principally, the overhead crane that handles most materials within the hot cell) and the Cesium Ion Exchange process systems. The EM-TWS reviewed the overall design approach documentation, a preliminary documented safety analysis for the PT Facility, and engineering specifications. The EM-TWS also reviewed the applicable procedures for design change requests, design change notices, facility change requests, and facility change notices that were applied to the engineering of these systems. It appeared that the current development of both systems were in compliance with this documentation and with the configuration management system in place.

2008 Broad-Based Review of WTP Configuration Management

The current WTP contractor initiated this review using a team of professional experts independent of the WTP staff in response to ongoing issues of nonconformance identified within the project. The review, which took place in 2008, entailed 10 teams with a total of 60 personnel. The teams conducted both vertical and horizontal "slice" reviews. In total, 1,370 specific requirements were identified, and, when these requirements were compared with the components in the systems chosen, about 8,000 specific component/requirement pairs were identified. The teams reviewed a total of about 14,000 documents.

The audit teams identified 938 potential issues. Aside from documentation concerns, there were just two concerns related to hardware and inspection, neither of which would impede the plant from safely performing its mission.

Maturity of the WTP Design

The WTP design and associated procurement and construction have now been progressing for almost 10 years. Early in the project, when both cost and schedule were beginning to escalate, cost containment measures were employed to reduce the footprint of several facilities within WTP and eliminate spare capacity in many areas under a "minimum essential" philosophy. Subsequently, a number of issues regarding more conservative compliance with codes and standards—most notably, seismic design bases—further reduced engineering reserve margins.

Addressing these and subsequent issues raised by the EFRT has, over time, caused a shift in emphasis in the resources being applied to different facilities within WTP. Therefore, the state of maturity varies from one facility to another.

WTP Completion Status

The following is a summary of the current completion status for WTP as of July 2010.

Current Completion Status of WTP Facilities

High-Level Waste	
Engineering (%)	85
Procurement (%)	58
Construction (%)	29
Low-Activity Waste	
Engineering (%)	92
Procurement (%)	79
Construction (%)	62
Pretreatment	
Engineering (%)	81
Procurement (%)	44
Construction (%)	32
Laboratory	
Engineering (%)	82
Procurement (%)	71
Construction (%)	66
Balance of Facility	
Engineering (%)	82
Procurement (%)	44
Construction (%)	59

In general, it appears that procurement and installation of basic components are somewhat lagging the progression, which might be expected. It has been indicated that this is primarily due to cash flow management. The most schedule-sensitive area is the PT Facility.

Flexibility for Future Changes

One measure for a parallel-design construction project is to consider the constraint on future engineered changes being placed by procurement and construction already completed. Another consideration is the remaining margin at this later stage of the project. The EM-TWS discussed these potential constraints to future changes in a meeting with senior project staff, and the general status can be summarized as follows:

HLW The facility is physically constrained, with minimal floor space to implement future changes. For example, a relatively small air-handling unit on the facility roof could not be relocated inside at the highest level because no space could be identified in which to place it. Although the upper-level structure is not completed, it is essentially fixed because it must conform to the levels below it.

LAB The facility is essentially constructed, with all exterior and interior walls now fixed. The remaining work consists of the procurement and installation of laboratory furniture and some detection equipment.

LAW The LAW is at the most advanced state of the major WTP process facilities. The structure is essentially complete, as well as embeds to set components. The major components are all procured, and most are being installed.

PT This is the least complete of the major process facilities, but it is still highly constrained. Similar to HLW, there is little opportunity to change the still-uncompleted higher elevations of the structure. The efforts to expand capacity and to resolve EFRT issues have congested the available floor space such that, similar to HLW, there is little room for modifications. This is particularly true in the hot cell area.

BOF Most spare capacity for the major utilities; i.e., air, water, steam, and electrical, has been utilized as the design has progressed. The sizing and procurement of emergency diesel generators has been held back and is currently not constrained.

Observations and Findings, Charge 2

The EM-TWS offers the following observations and findings:

- The WTP project has reached the "pivot point," where the principal focus of management attention is shifting from EPC to EPCC. The technical risks associated with EPC have been sufficiently resolved (i.e., the remaining risk is sufficiently low), and the design has advanced to a sufficient level of maturity.

- The WTP is being built to contractual functional specifications and will continue to be built to them until completed. The systems and work processes in place are adequate to ensure compliance, and sufficient oversight exists to confirm that these systems and process are being properly employed.

- At the present stage of construction, the WTP project is physically constrained, with minimal ability to implement future changes.

- On the basis of its review, the EM-TWS has concluded that, independent of the EFRT issues:

  - No substantial risk to compliance with contract functional specifications was identified,

  - The design appears to be sufficiently mature to proceed with completion of EPC activities.

Charge 2, Recommendations 2010-12 through 16

The EM-TWS makes the following recommendations related to Charge 2:

2012-12 The EPC process should proceed to completion.

2012-13 Given the size and complexity of WTP and the irrefutable necessity that these processes rely on sound project management and expert judgment, some future level of nonconformance could evolve; therefore, diligence should be maintained in conducting regular and redundant audits to identify and mitigate potential impacts.

2012-14 With the project at its current advanced state of maturation and given the closure of the outstanding EFRT issues, the focus of attention should shift from EPC to EPCC. This focus requires a coordinated effort by a single owner/operator representative in marrying the WTP and Tank Farm activities.

2012-15 DOE, as the project owner/operator, should take near-term action to create a resource base that is concerned with operability and the proper integration of operability concerns and commissioning activities with Tank Farm and WTP processes and activities.

2012-16 In support of this new resource base, DOE should take action to obtain an integrated Tank Farm / WTP plant operator as soon as practicable.

Charge 3: WTP Potential Improvements

The WTP will treat 53 million gallons of highly radioactive waste in 177 underground tanks at Hanford over several decades. Therefore, the Committee should consider any technical improvements that could result in a net reduction in the life cycle cost and schedule of the tank waste cleanup provided that the improvements do not have an adverse impact on the WTP Total Project Cost or project completion date.

Summary of the Finding for Charge 3

The EM-TWS has a number of recommendations that focus on enhancing system safety, providing improved accountability, and strengthening project management oversight and execution, which will promote early startup and testing, provide added design efficiency, reduce lifecycle cost, enhance plant reliability, reduce operating risk, and improve chemical and nuclear conduct of operations.

Introduction

Current DOE monthly progress reports show that the WTP design is greater than 81 percent complete and construction is at 52 percent completion. At this point, the possibility of making changes to the WTP design that do not adversely affect the total project cost or project completion date is limited. The EM-TWS believes that the project should complete the final design and proceed with construction, considering some areas of recommended focus.

Observations and Findings, Charge 3:

The EM-TWS makes the following observations:

- The WTP and Tank Farm parts of the mission are not well integrated. Two different contractors, who use a variety of planning tools that contain different assumptions and scenarios for mission completion, hold WTP and Tank Farm contracts.

- DOE has been heavily focused on the design and construction of the WTP. It appears that the earliest execution of a contract for a WTP operator is at least two years away. Successful chemical and nuclear industry projects have generally incorporated a strong owner/operator presence from the very beginning to ensure that plant design, construction, startup, and operation proceeds smoothly and results in a facility that successfully completes its intended mission at the lowest feasible lifecycle cost.

- The EM-TWS observation concerns modifying the current contractual startup plans to conform with standard chemical industry practice. Plant performance testing and acceptance (contractual) should not take priority over the early demonstration of plant systems based on easier-to-process feed streams. Current plans focus on early, full-capacity plant performance and acceptance testing with challenging wastes. The WTP, when operating, will be a chemical plant that processes radioactive materials. Standard specialized chemical industry practice starts with low-throughput runs using easy-to-process wastes; however, it often takes a year or more for chemical plants to attain smooth operations and reach full capacity.

- Because WTP will be a complex facility to operate, operator training should be extensive.
- Plant availability is critical for achieving the ORP mission.

Charge 3, Recommendations 2010-17 though 21

The EM-TWS makes the following recommendations related to Charge 3:

2010-17 ***Unify the mission with single-point authority and oversight.*** The EM-TWS recommends that the ORP mission be run as a single program that incorporates the WTP and Tank Farms and functions under a unified baseline with a consistent set of assumptions and models. As outlined in the EM Acquisition and Project Management Subcommittee (i.e., the Office of Science model), the program should be led by a single Federal Project Director. The ORP Federal Project Director would have the field-directed authority and responsibility for integrating the entire mission.

ORP should develop cost/benefit models that integrate the WTP project and mission and provide a uniform basis for evaluating potential improvements against the existing WTP project/mission baseline. The models should include factors that balance cost against reduction in project/mission risk and duration. The models should also conservatively consider the cost and schedule implications of maturing technologies to levels where they can be incorporated into the baseline with a minimum of risk.

2010-18 ***Create a Strong Owner/Operator Group.*** The EM-TWS recommends the immediate creation of a strong Owner/Operator Group comprising specialized plant operations expertise to plan and oversee commissioning and startup, and, most importantly, to conduct an operator review of final design and construction approvals. Under the direction of a Deputy Federal Project Director, the Group would function as the owner/operator until all or part of that function is assumed by the new WTP/Tank Farm operator. Because the WTP will be a chemical plant that treats nuclear waste, the Group should include substantial specialty chemical industry startup and operations experience and expertise as well as dedicated Tank Farm and WTP personnel. The initial tasks of the Group should consist of the following:

- Evaluate operability uncertainties at the Tank Farm and WTP;
- Evaluate the Tank Farm inventory and its effect on operations;
- Augment the standard DOE nuclear safety basis review by conducting a comprehensive Hazards and Operability Study that conforms with chemical industry standards (see Appendix D);
- Confirm regulatory compliance (e.g., Federal Facility Agreement/Tri-Party Agreement, Washington Administrative Code, Environmental Protection Agency, and state and local regulations)

- Define commissioning and operations objectives;
- Assess the risk of delaying certain design decisions based on forward commissioning activities and specifications (e.g., the project has deferred substantial risk in PJM into commissioning, where modifications may be difficult, costly, and time-consuming). The Owner/Operator Group should complete a commissioning readiness analysis that evaluates the magnitude of the risk that has been deferred, determines the potential impacts of the deferrals, and investigates ways to lessen the impacts;
- Establish an integrated commissioning plan that includes simulant definition and development and a feed sequence suitable for hot startup;
- Review the prequalification sampling capability criteria and plan and review the adequacy of sampling to comply with current and future needs;
- Develop the integrated WTP/Tank Farm cost/benefit models described in Recommendation 12010-17, above; and
- Consider a chemistry-oriented model to aid in operational control and confirmation of instrument and control logic, and develop inputs to that model.

The EM-TWS believes that the establishment of such a Group will lead to commissioning, hot startup, and operation improvements that will shorten mission duration, reduce lifecycle costs, and reduce mission risk.

2010-19 ***Alter current contractual startup plans to conform with chemical industry best practices.*** The EM-TWS recommends that the WTP start with easier-to-process waste batches and not attempt to confirm full capacity until the plant operator has confidence that plant operations have been optimized.

2012-20 ***Begin development of operator training plans and tools.*** The EM-TWS recommends that WTP develop training plans and tools with required certifications and operator minimum requirements for service.

2010-21 ***Evaluate options for improving availability.*** The EM-TWS recommends that the WTP begin to evaluate options for improving availability, including workarounds and scheduled outages.

3 Summary of the Closure of EFRT Issues

As illustrated in Appendix B, the initial charge of the EM-TWS was to complete a report concerning three issues. The first issue (denoted as Charge 1) is:

1. ***Verification of closure of Waste Treatment and Immobilization Plant (WTP) External Flowsheet Review Team (EFRT) issues.***

   The Subcommittee should verify that technical resolutions for the 28 issues identified by the EFRT are being or have been successfully implemented to ensure that engineering and design activities can be completed to reduce WTP project risk.

Charge 1 asks for verification that all of these EFRT issues have been closed. The EM-TWS has adopted the standard for verifying closure as being demonstrated compliance with all corresponding Issue Resolution Plans. As such, closure of an issue does not indicate that all related technology issues are completely resolved. Each IRP is customized to the nature of the corresponding issue being addressed, but in general IRPs define the issue of concern, conditions necessary to address the concern, and a path forward for doing this within ongoing EPC activities, based on industry practices.

The EM-TWS has observed that the current WTP Contractor, with DOE's concurrence, has satisfied the IRP procedures and protocols that constitute closure and is continuing to pursue these IRPs in parallel with EPC activities. **The EM-TWS finds that the professionalism and effectiveness of the current WTP Contractor are adequate to meet the challenge of keeping the project on track to meet the project schedule.**

The closure history for all 28 EFRT issues is provided in Table C-1 in Appendix C. Related to those issues, ten specific EM-TWS recommendations (numbered 2010-02 to 2010-11) are provided in the table on p. 10.

As indicated in Appendix C, the resolutions of many issues have some impact on commissioning, primarily in the need to test assumptions made to close issues as well as carrying forward of risks that were deemed acceptable by the Technology Steering Group (TSG). A number of additional concerns were noted by the EM-TWS during its review; the most significant of these concerns the five non-Newtonian vessels using pulse-jet mixers (M3): whether a Technology Readiness Level 6 was achieved and formal analysis to support closing the vessel assessment for the five non-Newtonian vessels was documented.

The EM-TWS has made a series of recommendations to help reduce the risks to the project in accordance with those made in closing the EFRT issues. The recommendations noted in Chapter 2 should be used to construct a corresponding set of actionable items. The remaining recommendations in Appendix C should be reviewed to decide whether they are actionable and, if so, add these to the actionable items for Charge 1.

3.1 Background

The External Flowsheet Review Team (EFRT) assessed hundreds of possible concerns involving the design of the Waste Treatment and Immobilization Plant (WTP). The scope of the review involved an assessment of whether the WTP, as designed in 2006, would meet the throughput capacity specified in the contract and required for the long-term mission. Three fundamental capacity aspects were considered: 1) the basic sizing of the Plant and equipment, 2) the process capacity based on the process design, and 3) the actual Plant capacity. Actual capacity is the ability to sustain product output at the desired rates after including Plant availability. The scope of the review did not consider many issues including evaluation of alternatives, cost and schedule, hydrogen in piping and ancillary vessels (HPAV), supplemental LAW, or waste forms and qualification (EFRT 2006a).

After completing the evaluation, the EFRT identified 28 remaining issues. These issues were classified as either systematic or process area specific. The items were further categorized as either major or potential (i.e., that will or could prevent meeting contract rates with commissioning and future feeds, respectively). Major issues must be fixed to ensure the Plant will meet design throughput for all feeds identified at the time of the EFRT review. The EFRT believed that all of the major and potential issues they identified had possible solutions and provided example fixes for selected issues (EFRT 2006a).

Issue Response Plans were developed for the 28 issues that included at least one closure criterion for each EFRT issue (and often several). Each IRP is customized to the nature of the corresponding issue being addressed, but in general they define the issue of concern, conditions necessary to address the concern, and a path forward for doing this within ongoing EPC activities, based on industry practices.

The WTP Project set up the WTP Technology Steering Group, composed of ORP and Contractor high-level technology personnel to monitor progress on the resolving the issues and close the issues as Issue Resolution Plan closure criteria were met. When necessary, closure documents identified those actions to be tracked in the ORP Action Tracking System (ATS) to address residual risks.

All 28 issues were considered closed at the time of the EM-TWS review. Some issues had paths forward in the IRP and/or closure record(s) that had residual risks for which action plans were defined.

Please refer to Appendix C for detailed analyses for all 28 EFRT issues, including M3.

3.2 The M3 Issue

In Issue M3, the EFRT identified two concerns related to the design of the WTP pulse-jet mixed vessels (EFRT 2006a):[3]

1. Resuspension of solids in Newtonian fluids
2. Mixing times and resuspension of solids in non-Newtonian fluids

An Issue Response Plan was developed for the M3 issue to provide the technical basis to support the PJM and vessel operating mode, mixing requirements, feed limits, and physical design for the WTP PJM-mixed vessels (24590-WTP-PL-ENG-06-0013, Rev. 003). Five closure criteria were defined in the M3 IRP. These closure criteria are summarized below. A complete presentation of the closure criteria is presented in Section M3, Appendix C.

1. Update Vessel Mixing Requirements
2. Demonstrate Vessels Meet Mixing Requirements
3. Evaluate Design Changes, System Impacts, and Cost/Schedule Impacts
4. Identify WTP Contract Changes
5. Design Confirmation Methods, Activities, and Cost/Schedule Impacts

The closure process also required demonstrating the adequacy of the final design and operating limits to a Technology Readiness Level 6 (i.e., demonstration using a prototypic pilot-scale test platform in a relevant environment) (DOD 2009; DOE G 413.3-4).

Closure packages were initially completed for M3 Closure Criteria 1, 4, and 5. Closure for Criteria 2 and 3 was divided into ten separate volumes as identified in Table C-2 (see Appendix C). All of the vessel assessment volumes were approved by the full Technology Steering Group and current WTP Contractor Design Authority except for Volume 3 (addressing five vessels that contain non-Newtonian fluids) where the Federal (DOE/ORP) membership on the TSG did not concur that Volume 3 was *technically* closed, but instead was a management risk-based decision (CCN# 220456).

[3] One additional concern (i.e., the design of baffles in mechanically agitated tanks) was identified by the EFRT that was closed as part of the EFRT P9 issue, *Undemonstrated Sampling System*, as indicated in Appendix C, although the potential issues with the mechanically-mixed vessels were not specifically addressed in the P9 Issue Response Plan (24590-WTP-PL-ENG-06-0038, Rev. 1).

The impasse between the Federal and current WTP Contractor TSG members on non-Newtonian fluid vessels was stated as (CCN# 220456):

> *DOE ORP and WTP have been unable to reach agreement that the Non Newtonian Vessel Assessment adequately demonstrates the vessels will meet their mixing requirements.*

To resolve the issue and close M3, the WTP Federal Project Director and WTP Project Director provided direction including conducting additional small-scale testing, assembling a team to plan additional benchmark tests, and authorizing the non-Newtonian vessel design to continue while a schedule off-ramp is developed to place the design and schedule on hold if additional tests do not support the non-Newtonian vessel assessment (CCN# 220456; CCN# 220510).

The Federal TSG membership expressed a number of remaining concerns (CCN# 218928; CCN# 220510; CCN# 223281). Despite the concerns posed by the Federal membership of the TSG and the nonconcurrence of one of the Federal TSG members, the non-Newtonian Vessel Assessment was closed (CCN# 220456):

> *The WTP Federal Project Director and WTP Project Director have judged the risk associated with delaying non-Newtonian vessel design and fabrication, with its associated potential impact to the WTP Project critical path, is greater than the risk associated with potential rework of the Non-Newtonian vessels, if determined necessary, based on follow-on testing and analysis.*

At the time the Volume 3 non-Newtonian vessel assessment was closed, *design confirmation* was not completed. There were unverified assumptions associated with design calculations involving, for example, Low Order Accumulation Model (LOAM) and bottom-clearing estimates (CCN# 220456).

Ten recommendations were made by the TSG as part of the Volume 3 vessel closure package concurrence, including updating the vessel assessment using small-scale testing, reassessing the lower rheology control limit and requirement, updating requirements documents, and developing contingency plans if the updated vessel assessment indicates that vessels cannot meet mixing requirements (CCN# 220456). A new Technical Issues Evaluation Form and Cut Sheet were developed in September 2010.

In support of the M3 Inadequate Mixing issue, an independent review was conducted for WTP by the Savannah River National Laboratory (SRNL) (Wilmarth *et al.* 2010). DOE-ORP also requested that the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) (Kosson *et al.* 2010) conduct a review. The results of these evaluations were considered by the TSG in its closure of the M3 issue.

The Pacific Northwest National Laboratory (PNNL) responded separately to a series of questions posed by the Defense Nuclear Facilities Safety Board (DNFSB) as part of its review of technical and safety issues concerning the pulse jet-mixed vessels (PNNL 2010).

SRNL evaluated the ability to control the waste feed rheological conditions required to support solids suspension in the non-Newtonian vessels that use PJMs and air spargers for mixing (Wilmarth *et al.* 2010). In general, SRNL concluded that the information available supported that PJM and air sparging mixing was adequate to keep waste suspended throughout treatment as long as the non-Newtonian vessels were operated only in the non-Newtonian regime (Wilmarth *et al.* 2010). The SRNL team raised the issue of the technical basis for scaling from smaller-scale to full-scale results and recommended additional data analysis, modeling, and possibly additional small-scale testing to further reduce risks over the entire range of operation.

The CRESP review evaluated responses to the M3 issue, PJM-related issues concerning closure, residual uncertainties and risks, and made recommendations for future actions to reduce uncertainties and risks (Kosson *et al.* 2010). The CRESP team believed that most significant concerns remained in (i) the performance and flexibility in PJM and vessel operations; (ii) up-scaling PJM performance from smaller-scale tests to full-scale vessels; (iii) criticality assessment; and (iv) design confirmation. CRESP then made recommendations in each of these areas. For example, to address the uncertainties related to scaling, the CRESP team recommended that near full-scale (at least 1/8th-scale or larger by volume) testing facilities and simulation capabilities be available for design confirmation as well as during the full lifecycle of WTP operations[4]. Another important focus of the CRESP review concerned how criticality is assessed. CRESP indicated that while none of the uncertainties noted fundamentally indicate that WTP will not function (provided that there is sufficient flexibility in PJM operation), resolution of the issues may result in the PT process operating at lower waste throughput rates than currently projected.

PNNL personnel responded to a DNFSB question concerning the design and testing of the WTP PJM vessels (PNNL 2010) as part of a scheduled public review planned for October 7-8, 2010. Their responses indicate that although improvements have been made in both designs and operating conditions that "there are still deficiencies with the technical basis for both the Newtonian and non-Newtonian vessels" (PNNL 2010). PNNL raised concerns about the simulants used, the technical basis used to scale from small-scale tests to full-scale plant performance, and inadequate design margin. PNNL recommended "full-scale testing of prototypic systems, utilizing a range of well-designed, bounding simulants" to qualify current designs (PNNL 2010). Issues with scaling, simulants, and requirements could result in small-scale test results that do not represent the magnitude of dead zones and gas retention during operation and provide a misleading representation of the ability to remobilize settled layers after a design basis event and to reestablish a safe, normal operating state (PNNL 2010). It was also noted that there were differences of technical and engineering opinions between PNNL and the current WTP Contractor. Two potential safety-related implications of the weaknesses were identified: risk of criticality and risk of hydrogen flammability.

[4] The feed qualification program will also be needed to verify conformance with the significant waste properties assumptions included in the design and operating basis to ensure successful WTP operations.

3.3 Observations

The EM-TWS observes that the current WTP Contractor, with DOE's concurrence, has met the Issue Resolution Plan procedures and protocols that constitute issue closure and is continuing to pursue remaining risks in parallel with EPC activities.

Closure of the EFRT issues does not mean that all related technology issues are completely resolved. Industry experience shows that resolution of technology issues frequently continues during construction and startup. For example, the procedures and protocols might require a modification to plant components and/or operating conditions and further require that this modification be demonstrated during the startup and commissioning process. A plan for development and implementation of this modification based on acceptable industry practice would constitute IRP compliance and issue closure but, given the first-of-a-kind nature of WTP, unanticipated further concerns could possibly arise during this demonstration process.

The EM-TWS concurs with the Federal TSG member that there appear to be unresolved technical issues with the PJM design for the WTP non-Newtonian vessels; however, the EM-TWS believes engineering and construction should proceed in accordance with current schedule and funding criteria pending the information that will be obtained from the direction provided by the Project Directors (CCN# 220456).

The EM-TWS recommends that closure of the final vessel assessment be based on a formal cost-benefit analysis instead of an unsupported declaration by the Project Directors.

As illustrated in Appendix C, several other EFRT issues were closed with residual risks that were treated by entering actions on the ATS or developing cut sheets. The EM-TWS observes that the WTP defense-in-depth strategy for Safety Basis issues such as criticality and flammability is typical for DOE. The EM-TWS recommends, however, that the assumptions underlying criticality be tested and assessed in light of the potential impacts of compounding conservatism on operations as well as what is known about the nature of the wastes that will be processed in WTP. This evaluation may also entail taking a new look at the safety basis for criticality and how it is defined. The EM-TWS review found that the criticality controls in the Tank Farm and WTP were not necessarily consistent, and any impact from this lack of consistency on Safety Basis confirmation and operations should also be evaluated as part of the path forward.

4 WTP Technical Design Basis Review

The second issue (denoted as Charge 2) is:

> *The WTP is at approximately 80% design completion. The Subcommittee should perform a systems-based review of the design against contract functional requirements.*
>
> *The Subcommittee should address and provide advice on the following areas related to the design: 1) technical risks have been adequately addressed in the design, and 2) design is sufficiently mature to allow proceeding with the needed procurements and construction activities to meet WTP requirements.*

As the WTP project advances toward completion, it will approach what has been described as "a pivot point," at which time the principal focus of management attention will begin to shift from the interactions between EPC (sometimes referred to as design/build) to the interactions happening between the completion of construction and startup and commissioning (sometimes referred to as "build/commission"). The two principal questions raised in this charge concern where the project now stands in relation to this pivot point; namely, have the technical risks associated with design/build been sufficiently resolved (i.e., is the remaining risk sufficiently low), and has the design advanced to a sufficient level of maturity or completeness such that WTP is now at this pivot point.

4.1 The WTP EPCC

To assess the relative progress of WTP, it is necessary to first understand the EPCC process that is being employed. The contract between DOE and the current WTP Contractor for this project calls for all of the EPCC elements to be performed as an overlapping, sequential process entailing EPC activities. In this manner, procurement, followed by construction, is initiated for some specific areas of the plant after the engineering for those areas has advanced to about 80 percent of design and while engineering for other areas is still underway or even may not yet have begun. This process of overlapping activities was chosen to "fast-track" completion of the WTP project to achieve the lowest feasible cost. A more classical method for engineering and construction of a project like this would have been to first complete engineering for the entire plant to a point at which remaining engineering details could be finalized in the field. This level of engineering design is typically in the range of 80 percent complete. Subsequent to achieving this level for a given work area, procurement and construction would commence (in some cases, long-lead procurement items may be purchased earlier).

WTP consists of five standalone facilities: HLW, LAW, PT, LAB, and BOF, a collection of smaller support facilities, e.g., process water. Each WTP facility is being developed in this overlapping manner by defining individual work areas, typically starting at the lowest physical level in a given facility and working upwards.

4.2 Contract-Derived Plant Specifications

When assessing the remaining technical risk or maturity of completeness, the basis of reference is the set of detailed specifications that define the plant that the current WTP Contractor was contracted to build and commission. The fundamental reference document is the technical sections of the current contract with DOE that define the feed that WTP will receive from the Hanford Tank Farms, in addition to the plant productivity and the product quality of the vitrified waste product. The contract also defines safety and quality requirements, contractor engineering work product deliverables, and verification of performance through the post-construction startup and commissioning phase.

These fundamental specifications have been used to develop higher-level project documents, such as a listing of applicable codes and standards, the plan for executing work, and safety and quality compliance plans. DOE has concurred on each of these plan documents. These higher-level project documents provide specific technical guidance to each EPC discipline through a series of detailed procedures and guidelines. Taken together, this set of information forms the contract-derived specifications.

For the EM-TWS's purposes, completion of the current WTP Contractor work product is determined by whether it complies with contract-derived specifications in a comprehensive and professional manner. To the extent that the work product is not complete due to nonconformance with these specifications, there is an associated future risk. From a different perspective, to the extent that the project has now matured because a substantial fraction of the work is complete, the flexibility to modify remaining activities without unscheduled rework diminishes, either to achieve compliance with specifications or to make further enhancements beyond these specifications. These are the issues that are discussed in this chapter. The additional question of the remaining risk associated with identified EFRT technical issues that have not yet been resolved is addressed in Chapter 5.

Once detailed procedures and guidelines are in place and workers have been trained on their use, the EPCC activities can commence, which consist of engineering calculations and drawings, procurement purchasing details, and as-built construction descriptions. As the project progresses, these work products create a growing body of details that guide later phases of the work. Subsequent phases of the EPC work must therefore conform with this growing database of information. The issue of how continuing work products conform with this growing database of relevant EPC information is one important measure of whether the project is proceeding in a comprehensive and professional manner.

4.3 WTP Conformance with Project Specifications

One common method to determine if a capital project is in conformance with project specifications is to perform a system-by-system review of the physical plant and compare the work products for each system with the documented specifications for a given system and for each of the components within that system. WTP, as one of the largest capital projects now ongoing within the U.S. and as one of the largest, most complex nuclear chemical processing facilities ever constructed, presents particular challenges in applying this approach.

When comparing these challenges with the schedule and resources committed to the EM-TWS's review, it became apparent that EM-TWS needed to take a more practical approach. The EM-TWS has instead reviewed the methods and procedures used to develop, maintain, and utilize project specifications and to maintain consistency in their system-by-system application among work areas within the plant. This is sometimes termed "configuration management." The EM-TWS also reviewed the application of these methods to two systems chosen from the WTP Work Breakdown Structure (WBS). The two systems chosen were Pretreatment In-cell Handling (PIH) (principally the overhead crane that handles most materials within the hot cell) and the Cesium Ion Exchange (CIX) process. The EM-TWS also reviewed the final report from an extensive WTP system-by-system configuration management review commissioned by the current WTP Contractor in 2008 and 2009, termed the "Broad-Based Review."

4.3.1 Methods and Procedures for Compliance with Contract Functional Requirements

The current WTP Contractor initially developed a set of planning documents that defined: the safety envelope, basic process flowsheets that define the strategy to achieve the contract-specified throughput capacity, the glassified product production strategy to meet the contract-specified quality, operations and maintenance strategy, the environmental compliance strategy, and plant external interfaces. These planning documents, which received DOE concurrence, formed the platform for developing a comprehensive Basis of Design document (on which DOE also concurred), which provides instruction as to the general plant layout, purpose, and requirements. It also defines the applicable codes and standards to be utilized by all EPC disciplines and the safety and quality requirements. It defines the technology issues that require further development and provides high-level guidance for initiating a research and technology program to address these issues.

The Basis of Design is used to develop specific procedures for each associated EPC discipline. These procedures are incorporated into work instructions for staff engineers, which they use to initiate the engineering process by developing process and material flow diagrams and general arrangement drawings for each WTP facility. The engineering staff then advances the design by progressing through work areas and producing piping and instrument diagrams, ventilation and instrument diagrams, systems descriptions, equipment lists, and equipment location drawings. The engineering work then progresses further in each work area to detailed specifications, data sheets, and drawings.

This level of engineering detail provides feedback to the procurement organization, which has been determining qualified lists of vendors. The procurement process is initiated with these vendors, based on area-specific equipment and general bulk commodities required.

The construction process begins for each of the five WTP facilities. The initial stage consists of preparing the site and laying the facility basemats (at this point, the footprint for space available with WTP's principal facilities has been essentially established). Work then begins at the lowest elevation within each facility and generally works upwards to the top elevation. Although this progression has been steady within each facility, the construction progress between facilities (and their corresponding maturity) has not been uniform.

It is the EM-TWS's opinion that the fundamental question regarding programmatic and technical risk is whether the plant has so far been built to these specifications and will likely continue to be built to them until completed. The basic answer to this question entails a confirmation that the systems and work processes in place are adequate to ensure compliance and that sufficient oversight exists to confirm that these systems and process are being properly employed.

4.3.2 Management of Change within the EPCC Process

The nature of the design/build process being used at WTP and the commensurate length of this project have resulted in a large number of changes. The project has employed an array of change management processes to ensure that these changes are properly implemented.

The engineering change process is initiated when the cognizant engineer issues a design change request, which is subject to management and independent reviews. Upon approval, a design change notice is issued and transmitted to all relevant engineering work products, engineering procurement, and construction resources.

Procurement can also generate changes when vendors cannot, for valid reasons, produce the engineered component or when vendors provide value-based feedback that a change is desirable. These change requests are processed through the management and discipline system, similar to that for engineering changes. Finally, the construction staff can generate changes when the constructability or installation of an engineered or procured component is not feasible in accordance with the design.

It is apparent to the EM-TWS that at any given time, many changes within WTP activities are in process. The notation of these changes on design drawings and other work products (e.g., procurement specifications) is managed in part by the project automated database management system (InfoWorks). However, it also depends on expert judgment by supervisors and subject matter experts.

4.3.3 Independent Review and Oversight

A number of redundant systems of control have been established:

a. All work products and changes thereto are subject to supervisory and disciplinary review and signoff.

b. Work processes are subject to a project-independent Quality Control function, whose purpose is to ensure that established procedures are being properly implemented.

c. Work products are subject to a project-independent Quality Assurance organization whose responsibility is to randomly audit work products to ensure they are in compliance with applicable procedures and specifications.

d. Work products and processes are subject to an additional independent review by the manager of engineering and a review by the Bechtel Chief Engineer.

e. DOE, through ORP, conducts regular independent audits of WTP work processes and work products.

4.3.4 System-Specific Review of Compliance with Contract Functional Requirements

The EM-TWS asked the current WTP Contractor for a demonstration of the configuration management system described above for two separate WTP systems and was given a package of material relating to the PIH and the CIX systems. This package contained overall design approach documentation, a Preliminary Documented Safety Analysis for the PT Facility, and engineering specifications. Items in these documents that relate to the systems in question were highlighted. In addition, the EM-TWS was given copies of the applicable procedures for design change requests, design change notices, facility change requests, and facility change notices that were applied to the engineering of these systems. It appeared that the current development of both systems were in compliance with this documentation and with the configuration management system in place.

4.3.5 Broad-Based Review of WTP Configuration Management

The current WTP Contractor initiated this review using a team of professional experts independent of the WTP staff in response to ongoing issues of nonconformance identified within the WTP project. The review entailed ten teams with a total of 60 personnel involved and took place in 2008. The teams conducted both vertical and horizontal "slice" reviews. The horizontal slice evaluated common components across many systems, and the vertical slice examined several plant systems, including: low- and high-activity waste offgas, plant services air, medium-voltage electric, feed receipt, and preparation.

The requirements for components in these systems (similar to the above description) were derived from the Basis of Design, safety requirements and envelope, product compliance plans, interface control documents, notices of construction, and various permits. In total, 1,370 specific requirements were identified and when these requirements were compared with the components in the systems chosen, about 8,000 specific component/requirement pairs were identified.

In addition, a large number of configuration management control-related documents were reviewed, including: action tracking system reports, nonconformance reports, corrective action reports, and construction deficiency reports. A total of about 14,000 documents were reviewed.

The audit teams identified a total of 938 potential issues. Of these, 312 issues were related to configuration management and were not resolvable by direct discussion with the project staff. Of those not immediately resolvable, the great majority related to incomplete, incorrect, or inconsistent documentation. Aside from documentation concerns, there were just two concerns related to hardware and inspection, and neither of these was related to defects that would impede the plant from safely performing its mission.

4.4 Maturity of the WTP Design

The WTP design and associated procurement and construction have now been progressing for almost ten years. Early on in the project, when both cost and schedule were beginning to escalate, cost containment measures reduced the footprint of several facilities within WTP and eliminated spare capacity in many areas under a "minimum essential" philosophy. Subsequently, a number of issues regarding more conservative compliance with codes and standards—most notably, seismic design bases—further reduced engineering reserve margins. In addition, DOE and the current WTP Contractor have concurred with a number of important changes (e.g., rearranging the waste melter configuration) that have increased the processing capacity of WTP, resulting in a potential to reduce the time to treat and immobilize the Hanford tank wastes; in addition, there may be a corresponding reduction in mission life. In some cases, these improvements have further eroded the engineering margin.

Addressing these WTP seismic issues and the resolution of subsequent issues raised by the EFRT has, over time, caused a shift in emphasis in the engineering resources being applied to different facilities within WTP. In addition, WTP has an annual funding limitation that only allows work to proceed at a certain pace. Thus, the Pretreatment and HLW Vitrification facilities have a construction complete percentage lower than other WTP facilities. Therefore, the state of maturity varies from one facility to another.

4.4.1 WTP Completion Status

Considering all of these circumstances, the following is a summary of the completion status for WTP as of July 2010:

Facility	Engineering (%)	Procurement (%)	Construction (%)
High-Level Waste	85	58	29
Low-Activity Waste	92	79	62
Pretreatment	81	44	32
Laboratory	82	71	66
Balance of Facility	82	44	59

Commodity materials (i.e. steel, concrete, piping) are not tracked by individual facilities but by bulk quantity for the entire project. Based on this measure, the engineering release for concrete is about 92 percent and installation is about 78 percent; for steel, the corresponding numbers are 89 percent engineering, 67 percent procured, and 40 percent installed; and for piping, 73 percent engineered, 55 percent procured, and 10 percent installed.

In general, it appears that procurement and installation of basic components are somewhat lagging the progression, which might be expected. This appears to be primarily due to cash flow management. The lowest float between scheduled engineering and construction was for Area 3 piping installation in Pretreatment, which is the area above where many EFRT remedial measures are being implemented.

4.4.2 Flexibility for Future Changes

One important measure when considering the question of change in focus from design/build to build/commission is the remaining flexibility to make changes (either for compliance or performance improvement) to WTP (i.e., without rework to completed construction) as construction proceeds. One part of that story is the percent-complete figures given above. By that measure, the design appears to be at the average 80 percent state, although procurement and construction appear to be lagging somewhat where they would expect to be at this stage of design maturity.

However, another measure for a parallel-design construction project is to consider the constraint on future engineered changes being placed by procurement and construction already completed. Another consideration is the remaining margin at this later stage of the project. (Note all projects, and especially larger, more complex ones, provide some measure of margin in their initial stages that typically decreases over time as it is utilized to overcome issues that arise.) The EM-TWS discussed these potential constraints to future changes in a meeting with senior project staff, and the general status described therein can be summarized as follows:

a. HLW – The facility is physically highly constrained, with minimal floor space to implement future changes. For example, a relatively small air handling unit on the facility roof could not be relocated inside at the highest level because no space could be identified in which to place it. Although the upper-level structure is not completed, it is essentially fixed because it must conform to the levels below it.

b. LAB – The facility is essentially constructed, with all exterior and interior walls now fixed. The remaining work is procurement and installation of laboratory furniture and some detection equipment.

c. LAW – The LAW is at the most advanced state of the major WTP process facilities. The structure is essentially complete, as well as embeds to set components. The major components are all procured, and most are being installed.

d. PT – This is the least complete of the major process facilities, but it is still very highly constrained. Similar to HLW, there is little opportunity to change the still-uncompleted higher levels of the structure. The efforts to expand capacity (described above) and to resolve EFRT issues have congested the available floor space such that, similar to HLW, there is little room for modifications. This is particularly true in the hot cell canyon. Most major components have been procured, and more than half of the process vessels are emplaced, with embeds set for the rest.

e. BOF – Most spare capacity for the major utilities; i.e., air, water, steam, and electrical, has been utilized as the design has progressed. The sizing and procurement of emergency diesel generators has been held back and is currently not constrained.

4.5 Observations Regarding Charge 2 to the Subcommittee

Based on the discussion given above, the EM-TWS has the following observations regarding this charge.

4.5.1 Technical Risks

Independent of the EFRT issues being addressed under Charge 1, and considering the nature of the EM-TWS's approach to review the design processes and systems being employed, no substantial risk to compliance with contract functional specifications was identified.

4.5.2 Design Maturity

Again, independent of the EFRT issues being addressed under Charge 1, the design appears to be sufficiently mature to proceed with EPC completion. In addition, the design appears to be sufficiently mature to support a shift in project focus from design/build to build/commission. All of the WTP facilities are at this stage of maturity; however, they have limited flexibility to address either open issues or future beneficial improvements

4.6 Conclusions

The EM-TWS has reached the following conclusions regarding Charge 2.

a. There are comprehensive EPC processes in place that are consistent with industry best practice and are sufficient to manage the WTP work process.

b. These processes are being effectively implemented to maintain configuration management.

c. The project is effectively managing change and risk, but it is continually being challenged by other important programmatic issues outside of conformance with contract functional requirements.

d. There appears to be limited input from the operator's perspective within the engineering process. The ability to incorporate that perspective has diminished as the design matures and will continue to diminish as the project approaches commissioning.

e. It would therefore be desirable to obtain an operator's perspective of project activities as soon as possible.

f. At present, there appears to be sufficient schedule float between engineering and construction within the project critical path to resolve remaining EFRT issues, but that schedule float is narrowing, and a commensurate level of diligence should be applied to resolving these issues if the WTP baseline schedule is to be maintained.

g. It would appear that the major project risk is maintaining the desired product throughput. The flexibility to executing a continuous improvement program post-commissioning has diminished due to prior utilization of margin in capacity, physical space, and supporting utilities.

h. The evaluation of risks going forward should consequently be graded, prioritized, and managed accordingly.

4.7 Charge 2 Recommendations

Based on the discussion above, the EM-TWS has the following recommendations regarding Charge 2:

Recommendation 2010-12: The EPC process should proceed to completion.

Based on the investigation under this Charge, the EPC process should proceed to completion.

Recommendation 2010-13: Conduct regular, redundant audits.

Given the size and complexity of WTP and the inevitable reality that the EPC processes rely to some extent on responsible human action and expert judgment, some future level of nonconformance can be expected, and diligence should be maintained in conducting regular and redundant audits.

Recommendation 2010-14: Attention should shift from design/build to build/commission.

With the state of the project at its current advanced state of maturation, and given the closure of outstanding EFRT issues, the focus of attention should shift from design/build to build/commission.

Recommendation 2010-15: DOE should create a resource base for operability issues.

Consistent with this change in focus, DOE, as the project owner, should take near-term action to create a resource base that is concerned with operability and the proper integration of operability concerns with the remaining WTP project activities.

Recommendation 2010-16: DOE should obtain a plant operator for WTP as soon as practical.

In support of this new resource base, DOE should take action to obtain a WTP plant operator as soon as practicable.

5 WTP Potential Improvements

The third issue (denoted as Charge 3) is:

> *The WTP will treat 53 million gallons of highly radioactive waste in 177 underground tanks at Hanford over several decades. Therefore, the Committee should consider any technical improvements that could result in a net reduction in the life cycle cost and schedule of the tank waste cleanup provided that the improvements do not have an adverse impact on the WTP Total Project Cost or project completion date.*

The WTP design is greater than 81 percent complete. Construction is at 52 percent completion. At this point, the possibility of making changes to the design that do not adversely affect the total project cost or project completion date is limited. Contingent on the closure of EFRT issue M3, the EM-TWS believes the Project should be able to complete the final WTP design.

The EM-TWS has developed a series of recommendations for potential improvements that are discussed below.

Recommendation 2010-17: Unify the mission with single-point authority.

At the present time, the WTP and Tank Farm parts of the ORP mission have been focusing on their respective missions. Planning to support eventual commissioning of the WTP and operating of the Tank Farm to support feed delivery is beginning. The WTP and Tank Farm contracts are held by two different contractors, both of which use a variety of planning tools—such as the System Plan, the Hanford Tank Waste Operating System (HTWOS) model, WTP flowsheet model, and the WTP Tank Utilization G2 model—that contain different assumptions and scenarios for mission completion.

The EM-TWS recommends that the ORP mission be run as a single program that incorporates the WTP and Tank Farms and functions under a unified baseline with a consistent set of assumptions and models. In the Office of Science Project Management Model, the program is led by a single Federal Project Director who is responsible for the entire mission with Deputies at the field level. The Federal Project Director is responsible for integrating the entire mission.

ORP should develop cost and benefit models that integrate the WTP Project with Tank Farm and provide a uniform basis for evaluating potential improvements against the existing WTP Project/mission baseline. The models should include factors that balance cost against reduction in Project/mission risk and improved schedule for mission completion. The models should also conservatively consider the cost and schedule implications of maturing technologies to a point at which they can be incorporated into the baseline with a minimum of risk. The models should integrate all aspects of the mission.

Recommendation 2010-18: Create a Strong Owner/Operator Group.

The WTP Project has been heavily focused on design and construction. It appears that a contract for a WTP operator is at least two years away. Successful chemical and nuclear industry projects have generally incorporated a strong owner/operator presence from the very beginning to ensure that plant design, construction, startup, and operation proceeds smoothly and results in a facility that successfully completes its intended mission. The need for such a presence at WTP becomes more critical every day.

The EM-TWS recommends that DOE immediately create a strong Owner/Operator Group by bringing in specialized plant operations expertise to plan and oversee commissioning, startup, and, most importantly, conduct an operator review of final design and construction approvals. Under the direction of a DOE Operations Manager, the Group would function as the owner/operator until all or part of that function is assumed by a single WTP/Tank Farm operator. The WTP is essentially a chemical plant that treats nuclear waste, so the Group should include substantial specialty chemical industry startup and operations experience and expertise as well as dedicated Tank Farm and WTP personnel.

The initial tasks of the Group should include:

- Evaluate uncertainties in Tank Farm/WTP operability.
- Evaluate the Tank Farm inventory and its potential effect on operations.
- Augment the standard DOE nuclear safety basis review by conducting a comprehensive Hazard and Operability Review that conforms with chemical industry standards (see Appendix D).
- Confirm regulatory compliance (e.g., the Federal Facility Agreement, Tri-Party Agreement, Washington Administrative Code, the U.S. Environmental Protection Agency, and state and local regulations).
- Define commissioning and operations objectives.
- Establish an integrated commissioning plan that includes simulant definition and development and a feed sequence suitable for hot startup.
- Develop an integrated WTP/Tank Farm cost and benefit models described in charge 3 recommendation 1, above.
- Form an Operations Oversight Review Group for accountability. The EM-TWS believes that the establishment of such a Group will lead to improvements in commissioning, hot startup, and operation that will shorten mission duration, reduce lifecycle costs, and reduce mission risk.

Recommendation 2010-19: Alter current contractual startup plans to conform with standard chemical industry practice.

Contractual plant performance testing and acceptance should not take priority over early demonstration of plant systems based on easier-to-process feed streams. Current plans focus on early, full-capacity plant performance and acceptance testing with challenging wastes. The WTP is a chemical plant that processes radioactive materials. Standard specialized chemical industry practice would start with low throughput runs on easy-to-process wastes. Chemical plants often take a year or more to attain effective operations and reach full capacity.

The EM-TWS recommends that the WTP start by processing easier-to-process waste batches and not attempt to confirm full capacity until the plant operator has confidence that plant operations have been optimized.

Recommendation 2010-20: Begin development of operator training plans and tools.

The WTP will be a complex facility to operate, and operator training must be extensive. The EM-TWS recommends that the WTP develop plans for operator training that includes both simulator and pilot plant training.

Recommendation 2010-21: Evaluate options for improving availability.

Plant availability is critical for achieving the ORP mission. WTP may encounter unexpected events and equipment failures.

The EM-TWS recommends that the WTP begin to evaluate options for improving availability including workarounds and scheduled outages.

In addition to the above, the Project may wish to consider the following actions and improvements:

Minimize plugging risks.

Given the variable nature of Hanford tank wastes, plugging of processing and transfer lines is expected. The EM-TWS recommends that WTP identify lines that are at high risk for plugging and consider methods for cleaning; e.g., installing stubs and flanges where appropriate. WTP should also consider installing spare lines, particularly transfer lines, e.g., three additional buried lines or aboveground lines (from the Tank Farm to PT and LAW) before hot operations begin.

Develop additional planning models.

As noted in Recommendation 2010-01 above, it appears that the Tank Farm and WTP do not use unified planning models with a single set of assumptions. Some of the models, e.g., the HTWOS model, are very detailed and require extended computer runs to evaluate alternative scenarios.

The EM-TWS recommends that ORP develop a set of unified planning models that integrate the entire ORP mission. The models should include a standardized lifecycle cost analysis model. ORP should also develop a user-friendly planning model that facilitates the evaluation of processing alternatives, allows for rapid analysis of scenarios and their feasibility, and provides a technical basis for robust blending and optimization.

Determine engineering requirements and secure sufficient laboratory space for individual batch qualification.

The current LAB Facility has been designed for what is, by the EM-TWS's understanding, minimal capacity to prequalify and requalify individual batches based on operational feedback. Chemical industry practice typically includes robust laboratory-scale process support to facilitate troubleshooting and process optimization. This is expected to be a full-time job, a critical-path process, and of a still undetermined capacity. It is unlikely that samples can be transported offsite for this purpose.

The EM-TWS recommends that the demand for onsite laboratory space, away from the WTP location (perhaps Facility 222S), should be identified and engineered now, as it must be integrated with whatever space will be utilized within the LAB. The LAB may require some re-engineering of already designed space. This is better done before furniture and detection equipment is procured for the LAB.

The Project should also explore the use of on-line or at-line test and evaluation instruments to ease the load on the number of samples that are sent to the LAB. This would also ease the load on the often-forgotten, but still substantial, generation of radioactive laboratory waste that is usually orphaned and hard to dispose of.

Advance instrument and control logic and design.

The PT Facility will require extensive process control. The design of the process control logic and the control strategy has not yet been fully completed.

The EM-TWS recommends that process control logic within the PT Facility be accelerated so that the control strategy can be investigated across the entire operability range of anticipated performance. The first step would be to prepare a full complement of process functional control logic diagrams and then use the logic diagrams to verify existing wiring diagrams and the orientation of process control in relation to motor control centers within PT. This effort would create a basis for evaluating the potential for inadvertent control actuations and for unscheduled shutdowns or control initiated by transients, which might cause systems or components to exceed their design basis. Redesign or rewiring of process control may be warranted to reduce the risk to plant availability or facility damage. This effort would also support a chemical process Hazards and Operability Review.

The cost to schedule and rework, if warranted, would likely be recovered through resultant reduction of risk to complete scheduled startup and commissioning activities. Performance shortcomings identified during commissioning and operations would likely be identified at a time when remedial action would be considerably more difficult.

Develop dynamic chemistry modeling in order to evaluate performance during transient operation across the anticipated operability range.

The current WTP processing models such as G2 are models designed for steady-state analysis. No models exist to evaluate transient performance across the operability range. The WTP G2 model is a model that calculates inventory at each point every six minutes for the duration of the modeled timeframe. It applies some solubility correlations and split factors at unit operations where partitioning or chemical reactions occur. The enhancement of a model to include chemistry modeling and transient operational dynamics could aid in operability reviews, commissioning and campaign planning for waste treatment.

The EM-TWS recommends that the project select and adapt a proven simulation tool that is designed to employ a dynamic chemistry model. Once adapted, the tool should be used to investigate transient performance across the operability range and across the anticipated range of uncertainty in feed chemical composition.

While limited analysis of limits such as criticality, hydrogen generation rates, and source term have been assessed at key points in the process using the G2 model, it may be appropriate to utilize this tool to optimize the performance of WTP post-commissioning activity. The issue of whether there may be any transient performance that could impact the safety case should be investigated before the design activities are completed and prior to commissioning planning.

Appendix A

Curricula Vitae of EMAB Tank Waste Subcommittee Members

Dennis P. Ferrigno, PE; BSME, MSME, DEME

Senior Executive Management Consultant / Subject Matter Expert –Ferrigno has been an industry leader for 40 years in the Energy, Power and Natural Resources business sectors as well as graduate faculty at the University of Colorado. He has held senior executive roles with Fortune 500 companies with Profit & Loss / Operations responsibility for over $300M per year (self perform managing over $2Billion / year in contract work). He has extensive international energy and natural resource experience for technology demonstration / development, engineering, procurement, construction, nuclear and non nuclear operations within these heavy industry sectors. Some pertinent highlights to large nuclear facility program review:

- Ferrigno is an industry recognized subject matter expert in Energy and Natural Resources, Project Management, Program Trouble shooting, Strategic Planning, Performance Metrics and Operational Readiness.

- Ferrigno has been involved in the design, construction and operational readiness for over 20 nuclear power plants under NRC regulatory licensing requirements

- Ferrigno led the CD-0, CD-1 review for the DOE NNSA Chemical Metallurgical Research Replacement Facility Cost, Schedule and Life Cycle independent review prior to congressional funding submittals

- Recently Dennis has supported large project turn-around such as the Paducah GDP Remediation and Operations Support. He led a team to correct safety, administrative, and employee morale to exceed previous project performance by a factor of 4 and double staff within months to support ARRA goals and objectives.

- Ferrigno chairs the American Nuclear Society standard, ANS 40.35, Volume Reduction of Nuclear Waste.

- Ferrigno continues to support private sector nuclear renaissance development, mining and oil and gas project enhancement and corrective actions in support of client directives.

- Ferrigno holds an active Q clearance and is current in DOE facility training for Radiation Worker, HAZWOPER, and Nuclear Criticality Safety and is certified to make high hazard building entry on an as required basis in DOE radiological contaminated facilities

He has held federal appointments as advisor to the Secretary of Commerce, Secretary of Energy and State Government Advisory Boards. He is currently supporting the Department of Energy as an advisor to the Secretary of Energy for the Environmental Management Program with specific responsibility in Project Performance Metrics.

Ferrigno is a minority partner of a woman-owned small business providing senior level management consulting for U.S. and Foreign Businesses, National Laboratories, and International Agency Organizations. He is an adjunct professor at the University of Colorado Graduate School staff as well as adjunct for Denver Seminary. He has been supportive of research and graduate student advising, and teaches graduate classes for Engineering and Management Masters Program.

Lawrence T. Papay, BS Physics, MS Nuclear Eng., Sc.D. Nuclear Eng.

Papay is currently CEO and Principal of PQR, LLC, a management consulting firm specializing in managerial, financial, and technical strategies for a variety of clients in electric power and other energy areas. His previous positions include Sector Vice President for the Integrated Solutions Sector, SAIC, where he was responsible for business dealing with the integration of technology in the energy, environment and information areas for a variety of governmental and commercial clients worldwide.

Papay was the Senior Vice-President and General Manager of Bechtel Technology & Consulting and was responsible for monitoring new technologies and developing new businesses, principally in the energy sector, employing those technologies including technological developments that impacted existing business lines as well as the engineering and construction business in general. Prior to that he was a Senior Vice President at Southern California Edison where he had a variety of responsibilities over his 21-year career including R&D, Engineering, Power Operations (T&D), Power Generation, Nuclear Power, System Planning and General Administrative functions.

Papay received a B.S. in Physics from Fordham University in 1958, a M.S. in Nuclear Engineering from MIT in 1965, and a Sc.D. in Nuclear Engineering from MIT in 1969. He is a nationally recognized authority in engineering, science, and technology. He is a member of the National Academy of Engineering and serves on its Board of Councilors. He also chairs the California Council for Science and Technology. He currently serves or has served on numerous special committees, panels, boards and task forces including the Department of Energy's Energy Research Advisory Board and the Laboratory Operations Board, the Department of Homeland Security's S&T Advisory Committee as well as the President's Council of Advisors on Science and Technology, National Science Foundation, National Research Council, American Nuclear Society, and Electric Power Research Institute. He is registered Professional Engineer (Nuclear) in California.

Bernard L. Meyers, PE, Ph.D. Civil Eng.

Bernard L. Meyers has more than 40 years of experience as an officer and senior manager in the fields of project and organizational management as well as all phases of engineering and construction management.

Meyers has a Ph.D. in civil engineering from Cornell University, and before he began his industry career he was a researcher and professor of engineering. He also has authored more than 100 papers and a textbook. Meyers has served on the advisory boards of several universities and technical societies as well.

After leaving academia, Meyers spent 35 years at Bechtel, where he advanced from engineering specialist to senior vice president. He participated in the design and construction of nuclear and fossil power stations, the management of complex projects as well as large engineering offices, and the management and oversight of Bechtel technical departments, including Engineering, Construction, Project Controls, Information Technology, Safety, Contracting, Procurement, and Project Management. He also managed Bechtel's North American project execution unit and the worldwide nuclear business unit.

Additionally, Meyers has managed a large environmental cleanup site for the U.S. government and was seconded to the UK government to help design and start up an agency to manage the cleanup of nuclear waste.

Meyers is a registered professional engineer in more than 20 states and a fellow in the American Concrete Institute and the American Society of Civil Engineers.

James E. Stevens, BS Chem. Eng., MS Chemistry, PhD Chem. Eng.

Education

Executive Training, Harvard Business School Seminars, 1977/1978
MBA, General Management, SUNY of Buffalo, 1976
PhD, Chemical Engineering, SUNY of Buffalo, 1966
MS, Chemistry, Niagara University, 1962
BS, Chemical Engineering, University of Michigan, 1960

Experience

Stevens has over 40 years of professional experience with both owners and contractors for major chemical processing facilities. Over his career he has been responsible for the process design, research and development and management of technology programs and projects, and the management of departmental operations with staff of up to 90 personnel. He has extensive experience in developing, building and starting up chemical processes worldwide.

Stevens has been responsible for managing the integration and completion of the design portion of a project. He ensures the objectives of the project are fully completed on time and within budget. He establishes communication links and designates responsibilities and directs project activities. He has extensive experience in developing, building and starting up world-scale chemical process plants for inorganic and fine chemicals such as ammonia, chlorine and agricultural chemicals and for environmental remediation projects.

He was responsible for the design and startup of multimillion-dollar processing plants worldwide. He has supervised engineers in starting up facilities, designing plants, operating plants and in technical information generation. He has developed a wide range of processes for new products and cost reductions. He designed several multi-step plants for chemicals, polymer additives, and specialty monomers.

He acted as start-up coordinator on numerous new technology plants gaining first-hand operating knowledge so that his approach is geared to achieving sound operating processes. Processes designed have spanned a wide variety of reactor types and product isolation techniques. The products have varied from fine chemicals to heavy chemicals and commodity products. Areas of special expertise include: multi-phase reactions; reactant recovery and recycling processes; and compliance with environmental regulations.

Industry—Engineering

Washington Group, Inc.

E.I. du Pont de Nemours. Responsible for managing the integration and completion of the design portion of a project; ensuring objectives met, maintaining schedules, and controlling costs; and providing the communications link between design, construction, and the plant.

Designed specialty fluorinated intermediate facility for DuPont's Washington Works that was constructed and operational 13 months after project approval; Designed and estimated a specialty organic intermediate's process for DuPont's Chambers Works Facility.

Responsible for managing the design aspects of a project to upgrade and expand Aristech's two existing phenol production facilities at Haverhill, OH by 10%. The major portion of the modifications were successfully accomplished during a scheduled 10-day shut-down period and the plant was back on stream and meeting design capacity ahead of schedule.

General Manager BDT, Inc. Responsible for directing the profitable and safe operation of a $4M hazardous waste treatment business and ensuring compliance with all government regulations. Direct reports included marketing, operations, technology, finance, and customer service.

- Doubled the operating rate of the plant, within the permit constraints, to achieve $4MM/year revenue while keeping GPM at greater than 40%. Increased net profit from $40K to $600K.
- Completed application and received NYDEC approval. Developed strong relationships with town officials and area interest groups gaining acceptance of proposed facility expansion.
- Reduced old inventory from two years to three months maximum time to process by resolving technical and safety issues.

Hooker Chemical and Plastics Corporation. Responsible for all technical programs worldwide. Directed 92-person R&D effort.

- A key member of management team for division that achieved $25MM record profits.
- Developed technology that resulted in $12MM per year reduction in raw material costs of an organic fine chemical (PCBTF).
- Developed, piloted, and produced unique intermediate for high-priority new synthetic pyrethroid.
- Developed and produced commercial quantities of new organic intermediate for specialty polymers, polymer additives and new pesticides.

Edward J. Lahoda, PE, BA Chem. Eng., MS Chem. Eng., Ph.D. Chem. Eng., MBA

Education

University of Pittsburgh	Chemical Engineering	B.A.	1971
University of Pittsburgh	Chemical Engineering	M.S.	1972
University of Pittsburgh	Chemical Engineering	Ph.D.	1974
University of Pittsburgh		MBA	1978

Professional Activities
Member, American Institute of Chemical Engineers
Registered Professional Engineer, Pennsylvania

Professional Experience

Lahoda has over 35 years of experience in process analysis, development, design, and field support. He provides R&D and technical and operating support to the Westinghouse fuel manufacturing facility in Columbia, SC, as well as the services division at Waltz Mill, PA. He is lead engineer on advanced products and manufacturing techniques for the Westinghouse Fuels Division. Previous projects include improvements in the Hybrid Sulfur Process for making hydrogen using high temperature process heat from the PBMR, evaluation of the use of AVLIS enriched uranium, the manufacture of ThO_2/UO_2 mixed oxide fuel, the use of up to 20% ^{235}U and the manufacture of large annular pellets at the Westinghouse commercial nuclear fuel plant in Columbia, SC. He has extensive background in the manufacture of uranium based fuels and operation of the waste treatment and other ancillary systems. In the environmental area, he was responsible for the technical development and field startup of the Westinghouse soil washing and high-temperature thermal desorption technologies. He has chemical process design experience in processing chemical warfare agents, nuclear fuels, high and low level nuclear wastes and plasma processing of wastes and plasma production of specialty materials. He has provided field support to operating facilities including the Westinghouse incinerators, nuclear fuels production, steam generator maintenance, soil washing and thermal desorption operations. He has served as a reviewer and consultant at Savannah River Site (Defense Waste Processing Facility (DWPF) operations and test data validity for DWPF, chaired the ITP Chemistry Review Panel, ITP Replacement Review Panel) and Hanford (Pulse Jet Mixer engineering, hydrogen mitigation, Cs removal and WTP project engineering review). He has also served as a member of the National Academy of Sciences ad-hoc Committee on Research Needs for HLW (twice) and was a technical advisor to the committee on evaluating disposal options for the INEEL calcine.

Since joining Westinghouse in 1974, his other program development and implementation efforts have included the following:

- Modeling of radioactive plateout and corrosion of graphite fuel pins in HTGRs
- Chemical plant startup and operations improvements.
- Testing of the high level waste zeolite transfer pump for the West Valley site.
- Survey of high-level waste treatment options for the West Valley site.
- Development of laboratory- and pilot-scale testing methods for removal of low levels of NO_3^- and NH_3, F^-, and solids from discharge streams.
- Development of electrolytic and airborne abrasive techniques for use in decontamination of nuclear steam generators.
- Development of water lancing techniques for removal of steam generator sludges.

Kevin G. Brown, BE Chem. Eng., MS Env. / Water Resources, Ph.D. Environmental Engineering

Education

Vanderbilt University, Ph.D. Environmental Engineering
Vanderbilt University, MS Environmental and Water Resources Engineering
Vanderbilt University, BE Chemical Engineering

Experience

Brown is a Senior Research Scientist in the Department of Civil and Environmental Engineering at Vanderbilt University. His research has been supported by the multi-university Consortium for Risk Evaluation with Stakeholder Evaluation (CRESP). Brown's current research focuses on lifecycle risk evaluation, model integration, and waste management issues related to proposed advanced nuclear fuel cycles and cementitious barriers for nuclear applications.

Between 1986 and 2002 at the Savannah River Laboratory, he was recognized as a DOE Complex-wide authority in process and product control for high-level waste vitrification. His activities supporting the DWPF included: 1) optimizing waste loading, 2) modeling critical properties, 3) managing uncertainties, and 4) supporting variability studies and waste form acceptance. He served a similar role across the DOE Complex supporting vitrification projects at Idaho, Hanford, and West Valley.

Brown spent 2002-2003 at the International Institute for Applied Systems Analysis in Laxenburg, Austria, where he estimated potential transboundary radiation doses resulting from hypothetical accidents at Russian Pacific Fleet sites. They were the first such studies known in the West. Brown led the CRESP evaluation of lifecycle risks for the DOE Idaho Site Subsurface Disposal Area, where wastes contaminated with radioactive and hazardous materials were buried in pits, trenches, and soil vaults before 1970. He supported the corresponding risk evaluation for the Idaho Site Calcined Bin Sets containing high-level wastes and the Bear Creek Burial Grounds at Oak Ridge. The Idaho results were presented to the Idaho Site Citizens Advisory Board, which strongly endorsed the clarity of the approach and the results.

Brown recently participated in the External Technical Review of the modeling and simulation tools used to support liquid waste processing for Savannah River and Office of River Protection. He holds a BE in Chemical Engineering, an MS in Environmental and Water Resources Engineering, and a Ph.D. in Environmental Engineering, all from Vanderbilt University.

David K. Shuh, BS Chemistry, MS Physical Chemistry, PhD Physical Chemistry

Education
1990 Ph.D., Physical Chemistry, University of California Los Angeles
1987 M.S., Physical Chemistry, University of California Los Angeles
1983 B.S., Chemistry, University of California Riverside

Experience

2007 – Present	Senior Scientist and Principal Investigator; Associate Director, The Glenn T. Seaborg Center; Project Leader, Advanced Light Source–Molecular Environmental Science Beamline 11.0.2, Actinide Chemistry Group, Chemical Sciences Division, Lawrence Berkeley National Laboratory
2007-2005	Senior Staff Scientist and Principal Investigator; Associate Director, The Glenn T. Seaborg Center; Project Leader, Advanced Light Source–Molecular Environmental Science Beamline 11.0.2 Actinide Chemistry Group, Chemical Sciences Division, Lawrence Berkeley National Laboratory
2004-2000	Senior Staff Scientist and Principal Investigator; Project Leader, Advanced Light Source-Molecular Environmental Science Beamline 11.0.2, Lawrence Berkeley National Laboratory
2000-1999	Staff Scientist and Principal Investigator; Project Leader, ALS-MES BL-11.02, Actinide Chemistry Group, Chemical Sciences Division, Lawrence Berkeley National Laboratory
1999-1997	Staff Scientist and Principal Investigator; Project Leader, ALS-MES BL-11.0.2, Actinide Chemistry Group, Chemical Sciences Division, Lawrence Berkeley National Laboratory
1997-1992	Staff Scientist and Principal Investigator, Lawrence Berkeley National Laboratory, Actinide Chemistry Group, Chemical Sciences Division, Lawrence Berkeley National Laboratory
1992-1990	Postdoctoral Fellow, Department of Physics, University of California Riverside Surface chemistry/physics at the NSLS with IBM Yorktown Heights.
1990-1986	Research Assistant, Department of Chemistry & Biochemistry, University of California Los Angeles
1988	Visiting Scientist, Laboratory for Quantum Materials, RIKEN, Wakoshi, Saitama, Japan
1986-1984	Teaching Assistant, Department of Chemistry & Biochemistry, University of California Los Angeles
1984-1982	Touring Tennis Professional, Association of Touring Professionals, world-ranked 1983-1984
1982-1981	Research Assistant, Department of Chemistry, University of California Riverside
1980	Research Assistant, SmithKline Incorporated, Santa Clara, CA.

Awards and Honors:
2008 Inaugural Richard G. Haire Lecture, Chemistry Dept., Auburn University

Consulting:
1989 TRW Depth profiling of TiN multilayer materials. El Segundo, CA
1988 West Coast Research Platinum deposition for prototype strain gages. Santa Monica, CA
1988 Spectrolab (Hughes Aerospace) Characterization of solid waste materials Malibu, CA and failure analysis of Si-based solar cells.

Professional Affiliations:
American Chemical Society, American Physical Society
American Vacuum Society, Materials Research Society

Alan E. Leviton, BS Chem. Eng., MS Chem. Eng.

Education
BS Chemical Engineering, Purdue University, 1965
MS Chemical Engineering, University of Illinois, 1967

Experience
Rohm and Haas Company, 1967 to 2004 (Retired April 2004)
Chemical Process Consultant, 2005 – 2009

Chemical Process Engineer (1967-1978)
Process design, process troubleshooting, construction and startup of specialty chemical plants in Pennsylvania, England, and North Carolina.

Ion Exchange Resin Process Technology Manager and Research Section Manager (1978-1986) Managed Amberlite Ion Exchange Resin product line manufacturing scaleup group; corporate process technology consultant to Ion Exchange Resin manufacturing plants.

Technical and Manufacturing Manager for Polytribo toner polymer joint venture (1986-1989)
Managed process design, startup, troubleshooting, and manufacturing functions.

Technical and Quality Control/Assurance Manager for Plaskon (Singapore – 1989-1991)
Managed quality control/quality assurance and process engineering departments for semiconductor epoxy molding powder manufacturing plant.

Engineering Division Technical Fellow (1991-2000)
Senior consultant for process design and startup of grassroots plant in Soma, Japan for manufacture of Amberlite Ion Exchange Resins; Corporate Process Development Network Management Team; Corporate New Technology Platform Team; corporate manufacturing process audit team.

Engineering Division Senior Technical Fellow / Shanghai Plant Technical Manager (2000-2004)
Managed engineering technical services, quality control, and wastewater treatment; project manager for design, construction, and startup of plant expansions in Shanghai, China plant to expand manufacturing capacity for Amberlite Ion Exchange Resins and polymeric adsorbents.

Consultant (2005-2009)
Provided consulting and process operability audit services to Bechtel National Inc for process feasibility and operability review at Hanford Washington DOE nuclear waste disposal facility. Provided chemical process consulting services to Dow Chemical Company.

Appendix B

Terms of Reference for the Subcommittee

ENVIRONMENTAL MANAGEMENT ADVISORY BOARD

ENVIRONMENTAL MANAGEMENT TANK WASTE SUBCOMMITTEE

U.S. DEPARTMENT OF ENERGY

WORKPLAN

Subcommittee's Designation. Environmental Management Tank Waste Subcommittee (the Subcommittee).

Authority. The Subcommittee is being established under the Environmental Management Advisory Board (EMAB), whose charter is in accordance with the provisions of the Federal Advisory Committee Act (FACA), as amended, 5 U.S.C. App. 2.

Objectives and Scope of Activities. The Subcommittee provides independent technical review of the Office of Environmental Management's tank waste cleanup program at Hanford, Washington, the Savannah River Site in South Carolina, and the Idaho National Laboratory and will focus on facilities being planned, designed and constructed at those sites. The Subcommittee advises on a wide range of matters, including, but not limited to, technical improvements to the strategy for retrieving waste from storage tanks and subsequently immobilizing the waste for eventual disposal. This includes review of the strategies for implementing such projects, the proposed pretreatment and treatment processes, the technical design of specific facilities, and the safety of such facilities. The Subcommittee will produce reports and propose recommendations to the EMAB as necessary.

Description of Duties. The duties of the Subcommittee are solely advisory in nature.

Official to Whom the Subcommittee Reports. The Subcommittee reports to the Assistant Secretary for Environmental Management through the EMAB.

Deputy Designated Federal Officer (DDFO). A full-time or permanent part-time DOE employee, appointed in accordance with agency procedures, will serve as the DDFO. The DDFO (or designee) will call for or approve all of the subcommittee's meetings, prepare and approve all meeting agendas, and attend all subcommittee meetings

Estimated Number and Frequency of Meetings. The Subcommittee expects to meet as frequently as needed and approved by the EMAB Chairman.

Duration. In view of the goals and purpose of the Board, the Subcommittee is expected to be continuing in nature.

Membership and Designation. The Subcommittee will be comprised of member(s) from the EMAB and supplemented by individuals with specific technical expertise. Members must have demonstrated an expertise in the following areas including, but not limited to: radioactive tank waste remediation strategies and techniques; the conversion of concept design documents to detailed design drawings, specifications and material/equipment requisitions; chemical process flow sheet development; process engineering; construction, operations, and project management; and design.

The initial charge of the subcommittee is to complete a report on the following issues:

1. **Verification of closure of Waste Treatment and Immobilization Plant (WTP) External Flowsheet Review Team (EFRT) issues.**

   The Subcommittee should verify that technical resolutions for the 28 issues identified by the EFRT are being or have been successfully implemented to ensure that engineering and design activities can be completed to reduce WTP project risk.

2. **WTP Technical Design Review**

   The WTP is at approximately 80% design completion. The Subcommittee should perform a systems-based review of the design against the contract functional requirements.

   The Subcommittee should address and provide advice on the following areas related to the design: 1) technical risks have been adequately addressed in the design, and 2) design is sufficiently mature to allow proceeding with needed procurements and construction activities to meet WTP requirements.

3. **WTP Potential Improvements**

   The WTP will treat 53 million gallons of highly radioactive waste in 177 underground tanks at Hanford over several decades. Therefore, the Committee should consider any technical improvements that could result in a net reduction in the life cycle cost and schedule of the tank waste cleanup provided that the improvements do not have an adverse impact on the WTP Total Project Cost or project completion date.

The Subcommittee may not work independently of the chartered Committee and must report their recommendations and advice to the full Committee for full deliberation and discussion. The subcommittee has no authority to make decisions on behalf of the full Committee, nor can it report directly to the DOE.

Recordkeeping. The records of the Subcommittee shall be handled in accordance with those of the EMAB.

Appendix C

Detailed Reviews of External Flowsheet Review Team (EFRT) Issues

Appendix C
Table of Contents

Introduction

The External Flowsheet Review Team (EFRT) assessed hundreds of possible concerns involving the design of the Waste Treatment and Immobilization Plant at Hanford (WTP). The scope of the review involved an assessment of whether the WTP, as designed in 2006, would meet the throughput capacity specified in the contract and required for the long-term mission. Three fundamental capacity aspects were considered: 1) the basic sizing of the Plant and equipment, 2) the process capacity based on the process design, and 3) the actual Plant capacity. Actual capacity is the ability to sustain product output at the desired rates after including Plant availability. The scope of the review did not include the following (EFRT 2006):

- Evaluation of alternatives or optimization;
- Ability to meet a 17-year mission life or Year 2028 objectives;
- Authorization (safety) basis;
- Building designs and shielding;
- Cost and schedule evaluation;
- Hydrogen in piping and ancillary vessels;
- Process alternatives;
- Seismic criteria;
- Supplemental Low-Activity Waste (LAW) treatment capability;
- Support systems not interacting directly with the process, such as electrical and non-process water;
- Tank farm operation;
- Waste disposal; and
- Waste form and qualification.

After completing the evaluation, the EFRT identified 28 remaining issues. These issues were classified as either *systematic* (i.e., applying to multiple areas or across the entire Plant) or *process area-specific*. The items were further categorized as either *major* (i.e., that will prevent meeting contract rates with commissioning and future feeds) or *potential* (i.e., that could prevent meeting contract rates with commissioning and future feeds).

The EFRT believed all of the major and potential issues it identified during the review had possible solutions (i.e., there were no "show-stoppers"), and provided example fixes for selected issues. Major issues must be fixed to ensure the Plant will meet design throughput for all feeds identified at the time of the EFRT review. Potential issues should be fixed to provide additional assurance of meeting design throughput.

The approach to closing the EFRT issues is outlined in Figure C-1 (Edwards and Duncan 2010). Once the issues are identified and evaluated relative to the corresponding Technical Readiness Assessment (TRA), an Issue Response Plan (IRP) is developed and approved. After any necessary trend and budget changes have been approved, the actions in the Plan are executed with ongoing review by WTP and the Office of River Protection (ORP) until the closure criteria have been satisfied. A Closure Record is developed, reviewed, and finalized with approval by the Technology Support Group (TSG) as well as by ORP and WTP management. The EFRT record is officially closed when it is submitted to the Project Document Control. Any recommended actions in the record are entered into the WTP Action Tracking System (ATS).

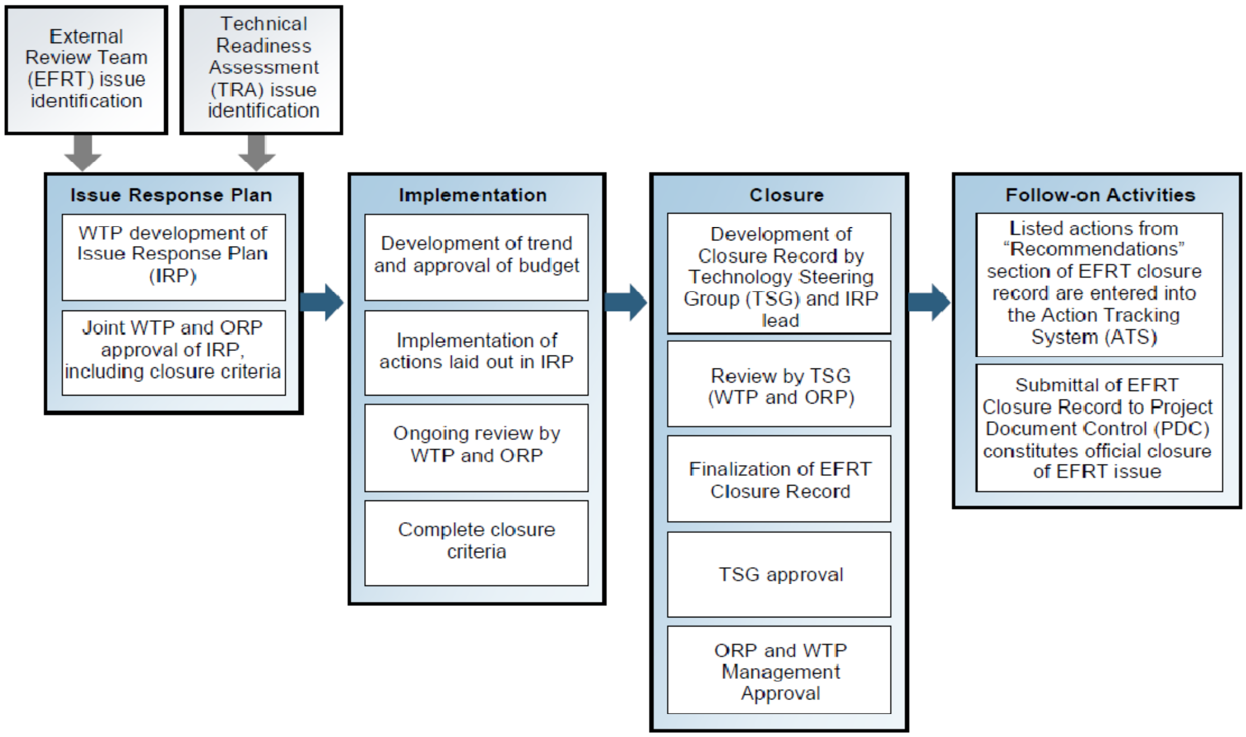


Figure C-1. The Resolution Process to the EFRT Issues (Edwards and Duncan 2010)

IRPs were developed for all 28 issues identified by the EFRT that included closure criteria for each issue. All 28 issues were considered *closed*[5] by the current WTP Contractor at the time of the Environmental Management Tank Waste Subcommittee (EM-TWS) review, as illustrated in Table C-1. *Closure* was defined by the current WTP Contractor as "meeting the requirements of the IRP's Closure Criteria" (CCN# 220456). The plan may identify actions that are tracked in the ORP ATS, as illustrated in Figure C-1. However, in the context of the EM-TWS review, "closure" does not only mean that the closure criteria have been satisfied, but that the plan had been defined to provide a reasonable path to closure with acceptable residual risks.

This appendix represents a detailed, independent review of the closure status for each of the 28 EFRT issues (EFRT 2006a) based on the information provided by August 24, 2010.

[5] As indicated in a DOE Committee Review in 2009 (DOE 2009), "[t]he term 'closure' does not necessarily mean that all risks related to a particular issue have been resolved. Criteria have been developed that are specific for each issue that define application of the term "closure," and in many cases, these involve development of a plan for activities that will continue beyond the point at which the issue is considered to be closed."

Table C-1. Summary of EFRT Issues Status

EFRT Issue(s)	Title	CCN#	DOE CARS#	Date Closed	ATS Items	Potential Related Issues
M1	Plugging in Process Piping	186331	10956	02Mar09	Y	M3, P4, P9
M2	Mixing Vessel Erosion	167395	10957	10Oct09	Y	None
M3	Inadequate Design of Mixing Systems	195208		20Aug10		M1, M4, M5, M6, M9, M12, P9
M4	Designed for Commissioning Waste vs. Mission Needs	163073	10959	13Nov07		M5, M6, M9, M12, M13, P9
M5	Must Have Feed Pre-Qualification Capability	163063	10960	18Oct07		M3, M4, M6, M9, M12, M13, P4
M6/P4	Process Operating Limits Not Completely Defined / Gelation/Precipitation	182202/ 186330	10962	16Dec08		M4, M5, M9, M12, M13, P4, P9
M7	Inconsistent Long Term Mission Focus	163077	10963	13Nov07	Y	
M7a	Lack of Spare LAW Melter	142022	Note 1	02Nov06		
M7b	Lack of Spare High-Level Waste (HLW) Melter	142022	Note 1	02Nov06		
M8	Limited Remotability Demonstration	160531	11583	15Oct07		
M9	Lack of Comprehensive Feed Testing during Commissioning	163064	12858	18Oct07		M3, M4, M5, M6, M12, M13
M10	Critical Equipment Purchases	160530	10967	15Oct07		
M11	Loss of WTP Expertise Base	167388	10969	17Mar08		
M12	Undemonstrated Leaching Processes (Pretreatment Facility)	195043	17247	29Sep09	Y	M4, M5, M6, M9, M13, P4, P5
M13	Inadequate Ultrafilter Surface Area and Flux (PT)	195034	17081	24Sep09	Y	M4, M5, M6, M9, M12
M14	Instability of Baseline Ion Exchange (IX) Resin (PT)	163065	10972	18Oct07		P4, P5
M15	Availability, Operability, and Maintainability (PT)	153215	10973	15Apr08		
M16	Misbatching of Melter Feed (LAW Vitrification Facility)	163066	10974	18Oct07		
M17	Plugging of Film Cooler and Transition Line (LAW Vitrification Facility)	172572	10975	15Apr08		
P1	Undemonstrated Decontamination Factor (PT-Evaporators)	163075	13048	15Apr08	Y	
P2	Effect of Recycle on Capacity Evaporators (PT-Evaporators)	163076	13049	13Nov07	Y	
P3	Adequacy of Control Scheme (PT-Evaporators)	142013	Note 1	12Dec06		
P4	*Combined with M6 as indicated above*					M1, M6, M12, P5
P5	Inadequate Process Development (PT-Ion Exchange)	163081	13282	21Dec07		M4,M12, M14, P4, P6, P7, P8
P6	Questionable Cross-Contamination Control (PT-Ion Exchange)	163067	12859	18Oct07	Y	P5
P7	Complexity of Valving (PT-Ion Exchange)	163082	13283	17Mar08	Y	M15, P5
P8	Effectiveness of Cs-137 Breakthrough Monitoring System (PT-Ion Exchange)	163068	12857	18Oct07	Y	P5
P9	Undemonstrated Sampling System (Analytical Laboratory and Sampling)	184906	17302	05Nov09	Y	M1, M3, M4, M6
P10	Lack of Analysis before Unloading Glass-forming Chemicals in Silos (Balance of Facilities)	160532	12807	15Oct07		
P11	Incomplete Process Control Design (Design of Control Systems)	163080	13284	21Dec07	Y	

Note 1: Issues closed before formation of TSG.
a A new technical issues evaluation form (TIEF) and Cut Sheet will be prepared (CCN# 220456).

EFRT Major Issues

The issues identified by the EFRT were categorized as either *major* or *potential*. The major issues are those that will prevent meeting contract rates with commissioning and future feeds and must be fixed to ensure the Plant will meet design throughput for all feeds identified at the time of the EFRT review.

M1. Plugging in Process Piping

Piping that transports both solids and liquids (i.e., slurries) can be expected to plug unless it is designed to minimize risk from plugging for both rapidly settling and hindered-settling slurries. Designing process lines to avoid plugging has not been followed consistently, which can lead to frequent shutdowns due to plugging.

M1.a Confirmation of Existing Closure Plans

The Technology Steering Group issued a Closure Record (CCN# 186331 and DOE CARS# 10956) for the M1 issue.

M1.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues were identified.

M1.c Issue Resolution Impact on Commissioning

The modification of Piping Specifications impact on commissioning cost and schedule depends greatly on the timing and extent of the changes. The EFRT recommended a thorough review to ensure the line plugging potential is minimized. This review should consider both mechanical and chemical plugging mechanisms.

M1.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

Some additional studies on the impact of a line plug and the potential for removal have been conducted but are not definitive at this point. Modifications, if required, should be to handle conditions outside normal operations.

M2. Mixing Vessel Erosion

The mixing vessels in the WTP "black cells" have been designed for a 40-year life. Large, dense particles will accelerate erosive wear in mixing vessels. The material allowance for erosive wear for vessels mixed with pulse jets has been determined based on a suite of calculations. The bases for these calculations (e.g., particle size and hardness, fluid velocities, duty cycles) were intended to be conservative; however, none of the estimates were verified by direct measurement. Furthermore, the assumed particle size distribution, hardness, and density were based on measurements of samples taken from the initial tanks to be processed, which did not represent all of the waste types produced at the Hanford Site, the relationship between the properties of the solids-bearing fluids used for design, and those that will be encountered during operations is not known.

M2.a Confirmation of Existing Closure Plans

This issue was resolved by performing tests that verified that the curve used (Figure C-2) was a conservative estimate of erosion. Although run with simulants, these tests should provide a reasonable basis for closure of this issue. However, it was acknowledged that the largest particles cause the wear and the effect is highly non-linear (Page 6 of 24590-WPT-RPT-PET-08-008, Rev. 0), but only the weighted average particle size was used as the parameter to validate the test slurry. It appears that this had no significant effect since the wear curve used for design was still more conservative than that representing the largest particles used in these tests (54 microns).

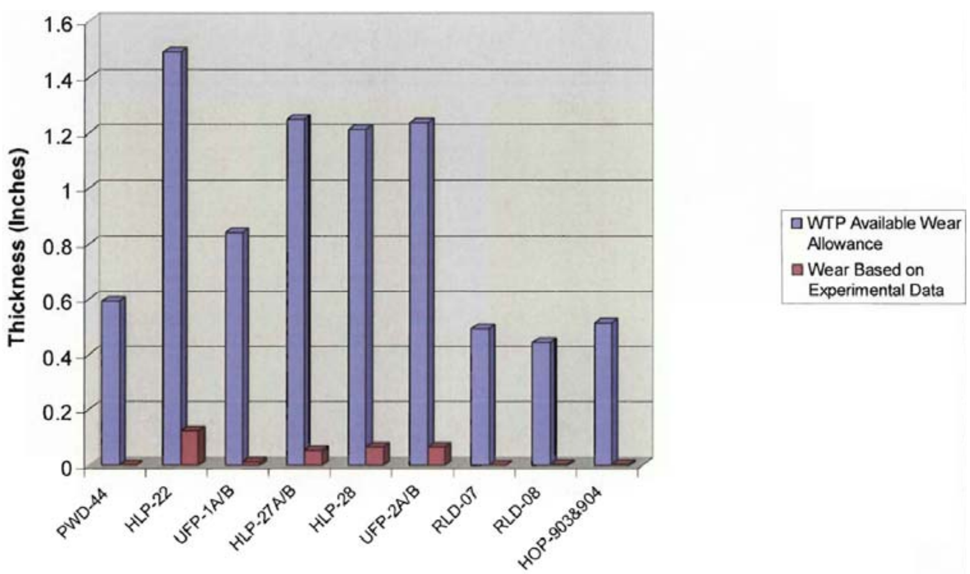


Figure C-2. Comparisons of design wear allowances to the predicted 40-year wear (24590-WPT-RPT-PET-08-008, Rev. 0)

The use of pre-qualification testing to characterize individual batches for erosion is a significant advantage to the program. Tests to determine the average weighed particle size of any incoming batch need to be conducted as part of this characterization program. The results of these tests can be turned into a running tally of expected wear in each tank based on the actual feed percentage and size.

The EM-TWS recommends the following actions for the M2 issues:

1. There was no indicated margin for the design. We would suggest at least 50 percent (60 years).

   Before any chemical cleaning is initiated in any of the tanks containing pulse jet mixers (PJMs), a test program to verify that there are no negative interactions between corrosion and wear must be carried out to qualify the chemical cleaning agents. This testing should be expanded to include all anticipated chemical actions in all tanks (chemicals and materials to be used in each particular tank) that have not already been studied to check for combined chemical/erosion issues.

2. The WTP has an Integrity Assessment Program and schedule for regulated equipment in the WTP facilities (24590-WTP-PER-M-08-001, 24590-WTP-PER-M-08-002). The program describes the regulated equipment; design features, material of construction, quality requirements, and defines baseline measurements to allow future comparisons for vessels, sumps, piping, bulges and miscellaneous equipment. In addition, the EM-TWS recommends that a running tally of the accumulated wear should be kept for each tank/PJM. This will provide a basis for exceeding any assumptions that have been made in the wear calculation if some tanks have larger particles or higher concentrations of particles than expected.

M2.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues were identified.

M2.c Issue Resolution Impact on Commissioning

No impact on Commissioning is expected from resolution of the M2 issue.

M2.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

No additional concerns were identified.

<u>M3. Inadequate Design of Mixing Systems</u>

Uncertainties in particle and fluid characteristics impact mixing. The EFRT identified three mixing issues (EFRT 2006a):

1. Resuspension of solids in Newtonian fluids

2. Design of baffles in mechanically agitated tanks

3. Resuspension of solids and mixing times in non-Newtonian fluids

In general, the design of vessels (Table C-2) with PJMs concentrated on non-Newtonian, hindered-settling slurries; less attention was paid to Newtonian fluids with low solids concentrations that settle rapidly. While the worst-case non-Newtonian fluid that was studied is difficult to blend and may cause unrecognized problems of long blend times or incomplete blending, the fluid properties are not the worst case for solids suspension. Newtonian mixing problems have been evaluated with median-size particles that are not the worst case for solids suspension. Denser, larger particles may be more difficult to suspend than those considered in current designs, resulting in the possible accumulation of settled particles.

The EFRT indicated that the mechanically-agitated LAW and HLW melter feed preparation tanks had questionable baffle designs (EFRT 2006a), which may not be adequate for complete suspension of glass-former solids. The baffle design could result in segregation of larger particle material in process vessels and potentially impact the ability to produce quality glass product. While the impacts to throughput could not be quantified, segregation should be avoided for processes controlled on the basis of composition. The mechanically-mixed vessels were addressed as a result of closing the P9 issue, *Undemonstrated Sampling System*, described below (CCN# 184906).

There was also an issue raised with insufficient testing of the selected mixing system designs or application of the test information to the design. For non-Newtonian slurries that behave as Bingham plastics, required mixing times in the process vessels agitated by PJMs are long enough to potentially reduce throughput. Inadequate mixing times may also result in variable feed delivery to process vessels downstream.

An IRP was developed for the M3 issue to provide the technical basis for supporting the PJM and vessel operating mode, mixing requirements, feed limits, and physical design for the PJM-mixed vessels in the Pretreatment and HLW vitrification facilities (24590-WTP-PL-ENG-06-0013, Rev. 003). There are 38 PJM mixed vessels in the WTP, which are identified in Table C-2 below.

The closure process for the M3 issue required demonstrating the adequacy of the final design and operating limits to a Technology Readiness Level (TRL) 6 (i.e., demonstration using a prototypic pilot-scale test platform in a relevant environment) through testing and analysis. The closure process must also identify any necessary changes to operations, requirements, and/or designs for vessels and confirmation of the effectiveness of the necessary changes. The impacts of these changes relative to those required by resolution of the other EFRT issues should also be evaluated.

Table C-2. Summary of the PJM Vessels

Closure Package	PJM-Mixed Vessels	Description
1A	CNP-03/04, CXP-04, CXP-26A/B/C, UFP-62A/B/C, HLP-27A/B, HLP-28, UFP-02A/B, RDP-02A/B/C	17 vessels that contain high concentrations of solids (non-Newtonian vessels), ion exchange resins (IERs), or do not contain solids under expected operating conditions
1B	HOP-903/904, PWD-15/16, TCP-01, TLP-09A/B, RLD-07/08	9 vessels with less than 5 wt% solids under routine operating conditions
2	PWD-33/43/44, UFP-01A/B, FEP-17A/B	7 vessels with solids contents less than 10 wt%
3	FRP-02A/B/C/D, HLP-22	5 vessels that are used for receipt of waste from the Hanford tank farm and have unique operating functions

CNP – Cesium Nitric Acid Recovery Process System
CXP – Cesium Ion-Exchange Process System
FEP – Waste Feed Evaporation Process System
FRP – Waste Feed Receipt Process System
HLP – HLW Lag Storage and Feed Blending Process System
HOP – Melter Offgas Treatment Process System
PWD – Plant Wash and Disposal System
RDP – Spent Resin Collection and Dewatering Process System
RLD – Radioactive Liquid Waste Disposal System
TCP – Treated LAW Concentrate Storage Process System
TLP – Treated LAW evaporation process system
UFP – Ultrafiltration Process System

Five closure criteria were defined in the issue response plan (24590-WTP-PL-ENG-06-0013, Rev. 003) for the M3, Inadequate Mixing issues:

1. *Update Vessel Mixing Requirements*. Vessel mixing requirements were documented in 24590-WTP-ES-PET-08-002[6]. The PJM vessel mixing requirements are updated following completion of the PJM technology testing and analysis program required to support closure of the EFRT M3 issue.

2. *Demonstrate Vessels Meet Mixing Requirements*. A PJM Vessel Mixing Assessment is completed to demonstrate that all PJM-mixed vessels are *confirmation-ready* when evaluated against their mixing requirements[7]. This criterion is being closed incrementally by TSG approval of closure packages for subgroups of PJM-mixed vessels, as illustrated in Table C-2. A final determination for all PJM-mixed vessels is being documented in an M3 PJM Vessel Mixing Assessment (24590-WTP-RPT-ENG-08-021) that is approved by the WTP Design Authority and Director of the DOE/ORP WTP Engineering Division. Any residual risks are identified and tracked per WTP risk management procedures.

3. *Evaluate Design Changes, System Impacts, and Cost/Schedule Impacts*. PJM-mixed vessel designs and/or operational improvements, where required to ensure a confirmation-ready

[6] This report was superseded by 24590-WTP-ES-ENG-09-001, Rev 2.
[7] According to 24590-WTP-RPT-ENG-08-021-08, Rev. 0, the “term confirmation ready means that sufficient information on the mixing design exists to support the design confirmation process as defined by WTP procedures. The main criteria evaluated were 1) prevent plugging, 2) sampling for criticality, 3) sampling for HGR estimation, 4) sampling for process control, 5) store (solids) - mix to release gas, and 6) limit solids accumulation.”

design, are identified and evaluated in engineering studies. These studies will provide recommendations for design and/or operational improvements and be approved by the WTP Design Authority. If required a trend is approved to implement the recommended design change(s).

4. *Identify WTP Contract Changes*. Required WTP contract changes are identified to support the PJM-mixed vessel assessments and the basis for EFRT Issue M3 closure. The intent to implement these proposed contract changes is formally transmitted by the DOE Contracting Officer and tracked for implementation in the project action tracking system.

5. *Design Confirmation Methods, Activities, and Cost/Schedule Impacts*. The methods (including models, correlations, hand calculations) to be used to confirm the PJM-mixed vessel designs and any additional activities (e.g., benchmarking reports, testing) to support design confirmation are defined by the Design Authority. A trend is approved for work that is not currently identified in the WTP Baseline.

M3.a Confirmation of Existing Closure Plans

Closure packages were initially completed for Criteria 1, 4, and 5 as defined in the M3 IRP for vessels with PJMs (24590-WTP-PL-ENG-06-0013, Rev. 003). Closure for M3 Criteria 2 and 3 was managed separately because of the non-Newtonian nature of the materials that will be mixed in the vessels and the difficulties in proving that the designs were confirmation-ready for these vessels for the full range of expected operations.

As indicated in Table C-3, ten vessel assessment volumes (Volumes 1 to 10) were prepared that addressed each of the 38 PJM mixed vessels in the WTP. The results of all assessment volumes were concurred upon by the full TSG except for Volume 3 (*non-Newtonian vessels*) where the Federal (DOE/ORP) membership on the TSG did not concur that this volume was *technically* closed, but instead was a management risk-based decision (CCN# 220456). The Federal membership of the M3 TSG identified a number of unresolved issues concerning; 1) the assessment strategy for the non-Newtonian vessels, 2) completeness of testing, 3) inadequate mixing power, and 4) incomplete design documentation (CCN# 220456). The resulting impasse between the Federal and current WTP Contractor TSG members was stated as (CCN# 220456):

> *DOE ORP and WTP have been unable to reach agreement that the Non Newtonian Vessel Assessment adequately demonstrates the vessels will meet their mixing requirements.*

The WTP Federal Project Director and WTP Project Director provided the direction including additional small-scale testing, assembling a team to plan additional Low Order Accumulation Model (LOAM) benchmark tests, and authorized the non-Newtonian vessel design to continue while a schedule off-ramp is developed to place the design and schedule on hold if additional tests do not support the non-Newtonian vessel assessment (CCN# 220456; CCN# 220510). The closure packages for criteria 1, 4, and 5 (that included the other nine vessel assessments) were deemed adequate by the full TSG and the EM-TWS.

Table C-3. EFRT Revised Engineering Assessment Document Volumes (24590-WTP-RPT-ENG-08-021-01 through 10)

Volume	PJM-Mixed Vessels	Description
1	CXP-VSL-00026A/B/C	Vessels cleared based on there being no credible upset condition. Worst case is 2% solids. Slurry will behave as Newtonian with no H_2 generation. A Computational Fluid Dynamics (CFD) analysis was applied to mixing criteria (24590-WTP-RPT-ENG-08-021-01, Rev. 1).
2	CNP-VSL-00003/04, CXP-VSL-00004, UFP-VSL-00062A/B/C, RDPVSL-00002A/B/C	CFD analysis was applied. Testing performed (limited to power/volume ratios) to verify CFD. Since these have Newtonian wastes with no H_2 gas retention issues (24590-WTP-RPT-ENG-08-021-02, Rev. 0), we consider this group cleared. Question to be considered: *If there is a leak in the ultrafiltration membranes, will the pumps and PJMs in UFP-62A/B/C be capable of handling any expected solids that could accumulate?*
3	HLP-VSL-00027A/B, HLP-VSL-00028, UFP-VSL-00002A/B	The current WTP Contractor members of the TSG and Design Authority concluded that the design for the non-Newtonian vessels were confirmation-ready based on the Vessel Assessment (24590-WTP-RPT-ENG-08-021-03, Rev. 1); however, the Federal membership of the TSG did not concur and indicated that there were a number of unresolved technical issues with the designs for the non-Newtonian vessels (CCN# 220456).
4	HOP-VSL-00903/904, PWD-VSL-00015/16, TCP-VSL-00001, TLPVSL-00009A/B, RLD-VSL-00008	These vessels will be handling Newtonian or "near-Newtonian" slurries with < 5 wt% solids. This group does not require mixing to release H_2. The analyses presented (24590-WTP-RPT-ENG-08-021-04, Rev. 1; CCN# 195208) indicate that mixing issues are not expected with these tanks. We consider the issues with these vessels closed.
5	PWD-VSL-00033/43/44	These vessels will be handling slurries with low solids and are expected to meet all performance criteria (24950-WTP-RPT-ENG-10-001, Rev. 0; 24590-WTP-RPT-ENG-08-021-05, Rev. 0). These will handle Newtonian or "near-Newtonian" slurries. This group does not require mixing to release H_2. The analyses presented indicate that there are no expected mixing issues with these tanks. We consider the issues with these tanks closed.
6	FRP-VSL-00002A/B/C/D	Materials in these vessels have high-density, high cP, 4-10 M Na. Maximum entrained solids is 3.8 wt%. There are no H_2 buildup and solids buildup requirements (24590-WTP-RPT-ENG-08-021-06, Rev. 0). They are still being assessed for settling solids (24950-WTP-RPT-ENG-10-001, Rev. 0); however, proposed changes (page 8 in 24590-WTP-RPT-ENG-08-021-06, Rev. 0) should mitigate these issues. We consider the issues with these tanks closed per implementation of recommended changes.
7	UFP-VSL-00001A/B	Design changes may be needed (24950-WTP-RPT-ENG-10-001, Rev. 0) since there is an indication that solids cannot be fully suspended with the current design. We note that the issues raised for these tanks are being addressed (pages 9 and 10 in 24590-WTP-RPT-ENG-08-021-07, Rev. 0), and we thus consider this issue closed per implementation of the recommended changes.

Volume	PJM-Mixed Vessels	Description
8	HLP-VSL-00022	Design changes may be needed (24950-WTP-RPT-ENG-10-001, Rev. 0) since there is an indication that the solids cannot be fully suspended with current design. We note that the issues raised for these tanks are being addressed (pages 9 through 11 in 24590-WTP-RPT-ENG-08-021-08, Rev. 0), and we thus consider this issue closed per implementation of the recommended changes.
9	FEP-VSL-00017 A/B	Design changes may be needed (24950-WTP-RPT-ENG-10-001, Rev. 0) since there is an indication that solids cannot be fully suspended with the current design. The issues raised for these tanks are being addressed (page 9 in 24590-WTP-RPT-ENG-08-021-09, Rev. 0), and we thus consider this issue closed per implementation of the recommended changes.
10	RLD-VSL-00007	This vessel will be handling slurries with low solids, low density, and low viscosity and is expected to meet all performance criteria (24590-WTP-RPT-ENG-08-021-10, Rev. 1). Slurries should be Newtonian or very close to Newtonian. This group does not require mixing to release hydrogen. The analyses presented indicate that there are no expected mixing issues with this tank. We consider the issues with this tank closed.

CNP – Cesium Nitric Acid Recovery Process System
CXP – Cesium Ion-Exchange Process System
FEP – Waste Feed Evaporation Process System
FRP – Waste Feed Receipt Process System
HLP – HLW Lag Storage and Feed Blending Process System
HOP – Melter Offgas Treatment Process System
PWD – Plant Wash and Disposal System
RDP – Spent Resin Collection and Dewatering Process System
RLD – Radioactive Liquid Waste Disposal System
TCP – Treated LAW Concentrate Storage Process System
TLP – Treated LAW evaporation process system
UFP – Ultrafiltration Process System

The issues raised by the EFRT concerning the mechanically-mixed vessels were closed as a consequence of closing the P9 issue, *Undemonstrated Sampling System*, even though the potential issues with the mechanically-mixed vessels were not specifically addressed in the P9 Issue Response Plan (24590-WTP-PL-ENG-06-0038, Rev. 1).

M3.b Confirmation of Action Plans for Unresolved Issues

Issue Response Plans were developed to address the five M3 criteria defined to support closing the PJM-related issues for both Newtonian and non-Newtonian vessels. Closure packages were initially completed for Criteria 1, 4, and 5 (24590-WTP-PL-ENG-06-0013, Rev. 003). Closure of Criteria 2 and 3 was managed separately because of the non-Newtonian nature of the materials that will be mixed in the vessels and the difficulties in proving that the designs were confirmation-ready for these vessels for the full range of expected operations. The draft documentation on Volume 3 for the five non-Newtonian vessels was evaluated by the Savannah River National Laboratory (SRNL) (Wilmarth *et al.* 2010) and the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) (Kosson *et al.* 2010). The Pacific Northwest National Laboratory (PNNL) also responded to a series of questions posed by the Defense Nuclear Facilities Safety Board (DNFSB) concerning the pulse jet mixers.

SRNL Review of the Adequacy of Pulse-Jet Mixer Technology

A review was conducted by SRNL over a period of ten days to evaluate the ability to adequately mix high-level wastes in WTP non-Newtonian vessels using PJMs and air spargers under various conditions, including those with rapidly settling particles under conditions of low Bingham plastic yield stress and plastic viscosity (Wilmarth *et al.* 2010). In general, the review concluded that the information available supported that PJM and air sparging mixing performance was adequate to keep waste suspended throughout treatment *as long as the non-Newtonian vessels were operated in the non-Newtonian regime*.

The SRNL team raised an issue of the technical basis for scaling from smaller-scale to full-scale results (because scaling tests were not conducted under exact geometric scaling) and recommended additional data analysis, modeling, and possibly additional small-scale testing to further reduce risks over the entire range of operation. Because the SRNL team had insufficient time to validate that particles of concern would remain suspended until the next discharge cycle for all Hanford sludge types, they recommended that the "[p]roject should confirm reformation of the static yield stress for each sludge type during the pre-qualification runs" (Wilmarth *et al.* 2010).

CRESP Review of the M3 Issue and Related Pulse-Jet Mixer Concerns

The CRESP team evaluated responses to the M3 issue and related PJM concerns concerning closure, residual uncertainties and risks, and recommendations for future actions to reduce uncertainties and risks (Kosson *et al.* 2010). The CRESP team believed that most significant concerns remain in the areas of (i) the performance and flexibility in PJM and vessel operations, (ii) up-scaling PJM performance from smaller-scale tests to full-scale vessels, (iii) criticality assessment, and (iv) design confirmation. Recommendations were made in each of these areas.

One area concerns reducing risks associated with the uncertainties that will remain about PJM performance until extensive experience has been gained through full-scale or prototypic testing of PJM vessels with appropriate simulants, if pursued, and/or actual operation of the WTP during commissioning. The CRESP team noted that (Kosson *et al.* 2010)

> *While none of these uncertainties fundamentally indicate that WTP will not function provided that there is enough flexibility in PJM operation, resolution of these issues may result in the pretreatment process operating at lower waste throughput rates than currently projected.*

To address these uncertainties, the CRESP team recommended that near full-scale (at least one-eighth-scale or larger by volume) testing facilities and simulation capabilities be available for design confirmation as well as during the full life cycle of WTP operations. Near full-scale testing was also considered justified due to the uncertainty in the technical basis for scaling the performance of PJMs because the WTP PJMs represent a first-of-a-kind use for large-volume vessels processing rheologically complex slurries with high solids concentrations. A feed qualification program will be needed to verify conformance with the significant waste properties assumptions (e.g., those related to the safety basis) included in the design and operating basis to ensure successful WTP operations.

PNNL Responses to DNFSB Questions concerning Vessels with PJMs

PNNL personnel responded to a DNFSB question concerning the design and testing of the PJM-mixed vessels at WTP (PNNL 2010). The responses indicate that the PNNL staff responding to the DNFSB request acknowledged that, although improvements have been made in both designs and operating conditions, "there are still deficiencies with the technical basis for both the Newtonian and non-Newtonian vessels" (PNNL 2010). It was also noted that there were differences of technical and engineering opinion between PNNL and the current WTP Contractor.

PNNL raised concerns that the simulants used in the WTP tests "were not necessarily physically representative of bounding of actual waste" (PNNL 2010). Because the simulants used for scaled testing were primarily non-cohesive, the resulting jet degradation would be less severe and the mixing performance better in the WTP tests than in actual operations.
PNNL personnel also raised a concern common to the three reviews of the technical basis used to scale from small-scale tests to full-scale plant performance. Scaling the mixing, transfer, and draw-down processes is complex; the scaling basis used was considered inadequate and not supported by existing data (PNNL 2010).

Another concern was inadequate design margin, requiring significant investments in scaled testing to determine if requirements are met under less-challenging operating conditions. If existing designs are to be deemed adequate, PNNL personnel recommended "full-scale testing of prototypic systems, utilizing a range of well-designed, bounding simulants" (PNNL 2010).

The concerns with scaling, simulants, and requirements could result in small-scale test results that may underrepresent the ability of the designs to remobilize settled layers after a design basis event (DBE) and to reestablish a safe, normal operating state (PNNL 2010). Two potential safety-related implications of the concerns identified the risks of criticality and hydrogen flammability.

Safety Basis Evaluation related to PJM Concerns

It is understood that the WTP defense-in-depth strategy for safety basis issues such as criticality is typical for DOE; however, it is recommended that the underlying assumptions underlying criticality be tested and assessed in light of the potential impacts of compounding conservatism on operations as well as what is known about the nature of the wastes that will be processed in WTP. For example, plutonium in all but two tanks (SY-102 and TX-118) containing wastes from the Plutonium Finishing Plant was co-precipitated with neutron-absorbing isotopes; thus, these tanks should be primarily focused upon. This evaluation may also entail reviewing the safety basis for criticality and how it is defined. The EM-TWS review found that the criticality controls in the Tank Farm and WTP were not necessarily consistent, and any impact from this lack of consistency on safety basis confirmation and operations should also be evaluated as part of the path forward.

Potential Unresolved Issues from the Vessel Assessment of Non-Newtonian Vessels

Closure packages were completed for each of the five closure criteria for vessels with PJMs. Closure for the remaining two criteria was managed separately because of the difficulties in proving that the designs were confirmation-ready for non-Newtonian vessels for the full range of expected operations. Ten vessel assessment volumes were prepared to support closure of IRP criteria 2 and 3. All ten assessment volumes were approved and concurred with by the full TSG and current WTP Contractor Design Authority except for Volume 3 (*non-Newtonian vessels*) (24590-WTP-RPT-ENG-08-021-03, Rev. 1) where the Federal (DOE/ORP) membership on the TSG did not concur that this final volume was *technically* closed, but instead was a *management risk-based decision* (CCN# 220456).

There was an impasse between the Federal and current WTP Contractor TSG members on whether or not the vessel assessment adequately demonstrated that the vessels would satisfy their mixing requirements (CCN# 220456). As of August 20, 2010, it appeared that the full TSG could not "reach a consensus that the technical basis supporting [that] the Non-Newtonian vessels are confirmation ready" when compared to the final two closure criteria (i.e., Criteria 2 and 3 above from the IRP). The Federal membership of the M3 TSG suggested that there were a number of unresolved issues and risks (CCN# 218928; CCN# 220510; CCN# 223281):

Furthermore, the EM-TWS highlights that the DOE should review potential unverified assumptions associated with important calculations including LOAM and bottom-clearing estimates that were used to show vessel capability.

The non-Newtonian Vessel Assessment was closed (CCN# 220456):

> *The WTP Federal Project Director and WTP Project Director have judged the risk associated with delaying non-Newtonian vessel design and fabrication, with its associated potential impact to the WTP Project critical path, is greater than the risk associated with potential rework of the Non-Newtonian vessels, if determined necessary, based on follow-on testing and analysis.*

Ten recommendations were made as part of the Volume 3 vessel closure, including updating the vessel assessment using small-scale testing, reassessing the lower rheology control limit and requirement, updating requirements documents, and developing contingency plans if the updated vessel assessment indicates that vessels cannot meet mixing requirements (CCN# 220456). A new Technical Issues Evaluation Form (TIEF) and Cut Sheet were developed in September 2010.

M3.c Issue Resolution Impact on Commissioning

Based on the recommendations made to close the non-Newtonian vessel assessment (CCN# 220456), it is conceivable that additional tests and perhaps simulants may be required during commissioning that may extend the period and cost of commissioning. The impacts on cost and schedule may be significant if major changes must be made to PJMs and interiors of vessels because they cannot meet mixing requirements.

M3.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

Some issues have been noted with bubbler operation (24950-WTP-RPT-ENG-10-001, Rev. 0; 24590-WTP-3YD-50-00003, Rev. B). These issues could be addressed relatively easily before commissioning. Some suggestions are as follows:

1. The use of humidified air could help avoid the formation of solids at the tip of the bubblers.
2. Consider the use of another bubbler at a third height to give differential density for tanks with potentially high vertical density differences.
3. Consider surrounding the bubbler with a perforated or solid tube to avoid issues with PJM.

The bubblers may also cause an increase in solids entrainment into the offgas ventilation systems. At this, the exhaust from reverse flow diverters and PJMs throughout the HLW vitrification plant is collected in the pulse ventilation system headers (24590-WTP-3YD-50-00003, Rev. B). Electric preheaters eliminate liquid aerosols and reduce the relative humidity of the gas stream, as necessary, before it encounters the system high-efficiency particulate air (HEPA) filters. A method for cleaning the solids from the heaters would seem prudent. In addition, these heaters should be designed to be easily replaced.

Various paths are available to address the additional issues and potential risks raised and/or recommendations made by the SRNL and CRESP reviews as well as PNNL and DOE comments. Actions that include additional testing (e.g., small-scale and prototypic up to full-scale), data analysis, and modeling appear warranted to reduce the risks associated with inadequate PJM performance. These paths are being evaluated by DOE and the current WTP Contractor as a result of closing the criteria related to the M3 issue (CCN# 220456).

One additional concern that was not raised concerns the assertions in the M3 Issue Response Plan that the PJM technology will achieve TRL 6 (24590-WTP-PL-ENG-06-0013, Rev. 3):

The Department of Defense (DOD) and DOE definitions of TRL 6 are provided in Table C-4 and Table C-5, respectively. The conclusions of the CRESP Review (Kosson *et al.* 2010), the PNNL responses to the DNFSB (PNNL 2010), and the unresolved issues asserted by the Federal TSG membership for the non-Newtonian vessel assessment (CCN# 220456) seem to belie the conclusion that the PJM technology has reached TRL 6. Additional testing, including the use of prototypic test systems and appropriate/bounding simulants, appears needed to satisfy all original closure criteria and demonstrate TRL 6 for the PJM technology for non-Newtonian vessels (24590-WTP-PL-ENG-06-0013, Rev. 003).

Table C-4. DOD *Hardware TRL Definitions, Descriptions, and Supporting Information* (Excerpt of Table C-1 from DOD 2009)

TRL	Definition	Description	Supporting Information
5	Component and/or breadboard validation in a relevant environment.	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include "high-fidelity" laboratory integration of components.	Results from testing a laboratory breadboard system are integrated with other supporting elements in a simulated operational environment. How does the "relevant environment" differ from the expected operational environment? How do the test results compare with expectations? What problems, if any, were encountered? Was the breadboard system refined to more nearly match the expected system goals?
6	System/subsystem model or prototype demonstration in a relevant environment.	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.	Results from laboratory testing of a prototype system that is near the desired configuration in terms of performance, weight, and volume. How did the test environment differ from the operational environment? Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before moving to the next level?

Table C-5. *DOE Technology Readiness Level Scale* (Excerpt of Table 4 from DOE G 413.3-4)

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
Technology Development	5	Laboratory scale, similar system validation in relevant environment	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Examples include testing a high-fidelity system in a simulated environment and/or with a range of real waste and simulants.
Technology Demonstration	6	Engineering/pilot-scale, similar (prototypical) system validation in relevant environment	Representative engineering-scale model or prototype system, which is well beyond the lab scale tested got TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype with real waste and a range of simulants.

To support additional testing, the EM-TWS observes and further recommends that formal cost-benefit analyses be performed to evaluate potential benefits (e.g., reduced risk of inadequate mixing) of additional testing to support the M3 issue versus the costs of performing the tests as well as those risks incurred if prototypic testing is omitted in lieu of other paths forward (e.g., initial full-scale testing during commissioning) and the difficulties of making changes to the PJMs during or after commissioning. Needed actions may impact testing before, during, and after commissioning, the pre-qualification program, operations and Safety Basis confirmation during operations. Additional data analysis (including appropriately validated CFD analysis) and smaller-scale testing may be used in lieu of prototypic testing with confirmation during commissioning. It is recognized that there are limits on the information obtained from even full-scale testing and commissioning depending on the types and numbers of simulants used.

Because of the importance of clearing the material from the vessel to support the defense-in-depth strategy currently underlying the Safety Basis, it is also recommended that the vessel clearing methods be tested during commissioning using appropriate simulants. The EM-TWS observations and further recommendation require adequate methods to inspect the vessels bottoms during commissioning and, perhaps, subsequent operations.

To summarize, the EM-TWS has reviewed the information for the M3 issue and concurs that the EFRT M3 issue has been closed. The EM-TWS believes that engineering and construction should proceed in accordance with current schedule and funding criteria for the five non-Newtonian Vessels identified as HLP-VSL-00027A/B, HLP-VSL-00028, and UFP-VSL-00002A/B. We have the following primary recommendations:

1. The basis for closure should be clearly documented based on cost-benefit analysis or technical review in conformance with the Issue Resolution Plan.
2. If risk is found to be high, the criteria and approach for the technical basis of scaling (e.g. prototypic or full-scale testing) confirming non Newtonian fluid mixing in WTP should be reviewed.

If risk is evaluated as high, assure sufficient access to dark cell interior and the five non Newtonian vessels through cold (non-radioactive) simulant testing and acceptance to allow design and fabrication modifications as needed.

M4. Design for Commissioning Waste vs. Mission Needs

The EFRT identified a major systemic issue that the WTP has not demonstrated that its design is sufficiently flexible to reliably process all of the Hanford tank farm wastes at design throughputs (EFRT 2006a).

M4.a Confirmation of Existing Closure Plans

The WTP M4 Issue Response Plan identified two closure criteria needed to resolve the issue: waste typing and initial feed analysis and ESP model runs to corroborate the selection of waste types (CCN# 163073). Closure of the M4 issue resulted in defining a set of 14 waste types that more fully described Envelope D wastes and also provided support to follow-on development of simulants suitable for process testing to support resolution of other EFRT issues including M12, M6, and M2.

The identification of 14 waste types, based on WTP process chemistry and operating characteristics, is a significant departure from the WTP contract definition of Waste Envelopes A through C that subdivided LAW feeds by their sodium, sulfate, ^{90}Sr, and transuranic content and Waste Envelope D, containing all high-activity waste feeds, no matter their compositions, physical characteristics, or WTP processing/operability characteristics.

M4.b Confirmation of Action Plans for Unresolved Issues

The TSG and ORP evaluated the M4 report and acknowledged that the Hanford tank waste feed batches contain compositions that may impact the WTP processing rate. The WTP Issue Response Plan includes the following recommendations (CCN# 163073) [8]:

- *The Tank Farm Contractor should be requested to formally review the M4 report and recommend tank waste feed staging changes, as determined beneficial, to enhance mission performance.*

- *DOE should continue to evaluate the potential impacts of waste composition to throughput of the WTP. DOE should carry a* [Technical and Programmatic Risk Assessment] *TPRA risk that the complete understanding of tank waste chemistry does not exist and therefore there is uncertainty in WTP processing rates throughout the mission.*

While it is unlikely compositions of waste tanks will be fully understood until tank contents are staged and sampled in preparation for transfer to the WTP, models should continue to be refined and validated (using samples and experiments).

M4.c Issue Resolution Impact on Commissioning

Completing the work represented by the recommendations (Section M4.b) should reduce the impacts, including problems and delays, during radioactive commissioning and WTP operations.

M4.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

It appears that the Tank Farm Contractor and WTP Design/Build Project Contractor are using different assumptions in their respective feed staging models. A unified set of assumptions should be developed and used by all parties to optimize feed vectors.

[8] These recommendations are examples of work that can be performed under the direction of the Strong Owner/Operator Group described in Chapter 5 (Recommendation 2010-02) of the EM-TWS Reports and Recommendations to the EMAB (September 15, 2010).

According to the final M4 report (24590-WTP-RPT-PE-07-001, Rev 1): "... the most challenging batches are the first few batches. In general, the rest of the batches should be less problematic to process." Unless there are compelling reasons to do otherwise, hot commissioning should start with easier-to-process batches to give the WTP operator a chance to gain experience operating the plant with minimum difficulty.

M5. Must have Feed Pre-Qualification Capability

The EFRT identified a major issue that without feed pre-qualification of the waste, each new batch of waste would require additional time for WTP to evaluate unit processes and adjust operating parameters for efficient processing (EFRT 2006a). Bench-scale testing of unit operations with actual wastes could identify unexpected results and help avert potential Plant problems.

M5.a Confirmation of Existing Closure Plans

The WTP Issue Response Plan identified three closure criteria to resolve issue M5: update the Integrated Sampling and Requirements Document (ISARD), issue a detailed waste pre-qualification plan, and identify lab space for waste pre-qualification (CCN#163063).

M5.b Confirmation of Action Plans for Unresolved Issues

The WTP pre-qualification plan indicates that the technical specification for equipment and work performance will be developed after the completion of the EM-TWS review and more information becomes available. Test specifications will also be updated.

M5.c Issue Resolution Impact on Commissioning

Feed pre-qualification is essential to the success of radioactive commissioning and ongoing operations. It will validate key assumptions, models, and experiments that form the basis for the design and operation of the WTP. It will provide fundamental information required by the WTP Operator to set initial operating conditions for each new batch of WTP feedstock. It is also essential to support ongoing troubleshooting and optimization work throughout the life of the WTP.

M5.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

A more robust feed pre-qualification program will provide greater potential for success in meeting WTP mission goals. The technical and test specifications have not been completed. Until a detailed technical basis for waste feed pre-qualification is available, it is not possible to confirm that sufficient and adequate lab space is available for waste pre-qualification testing. Closure of the M5 issue satisfies the three criteria defined in the IRP, but there still may not be sufficient contingency to address all operational and pre-qualification testing needs.

Essentially all of the WTP feed batches will contain liquid and solid phases. Fully representative two-phase samples are very difficult to obtain. Some sampling error risk will exist when samples are taken from the Tank Farm staging tanks. This must be considered in the design of the pre-qualification laboratory/laboratory equipment and interpretation of pre-qualification test results.

The pre-qualification plan is based on bench-scale (laboratory) equipment. It must be demonstrated that test results will scale to the WTP, or at least, relationships must be established between bench-scale results and WTP operations.

The pre-qualification unit operations could be integrated to reduce uncertainties and risks associated with testing the operations independently.

The EFRT also identified an issue related to precipitates and gels in the feed to the Cesium Ion Exchange columns. Testing for precipitates and gels should be explicitly included in the pre-qualification protocol.

M6. Process Operating Limits not Completely Defined

Many WTP operating limits have not yet been determined; instead, much of the research and technology work has been to validate the process equipment design (EFRT 2006a). This work is required but certainly not adequate to completely develop the process. Key process variables must be identified and characterized. Without a more complete understanding of each process, it will be difficult or impossible to define practical operating ranges for WTP (EFRT 2006a).

The EFRT recommended additional testing to better understand WTP process capability and to define practical process operating limits.

Potential Ultrafiltration/Leaching Issue: Gelatin Precipitation (P4). Some feeds to the leaching operation will contain significant amounts of aluminum compounds and other materials that could precipitate under the appropriate conditions. There is the possibility that aluminum gel will form in the leach tank or in other streams from the leaching operation if unfavorable leaching conditions occur.

M6.a Confirmation of Existing Closure Plans

WTP approached this issue by defining ten risks (Table C-6) considered to be related to operating limits.

Table C-6. Ten Risk Groups representing 35 Technology Gaps identified from a WTP Process Limits Gap Analysis (CCN# 186330)

Table# (CCN# 177730)	Risk Topic	Probability*	Risk Level* (Consequence)
1	HLW Melter Feed Rheology at Process Operating Limits	Likely	Low
2	LAW Melter Feed Rheology at Process Operating Limits	Likely	Low
3	Precipitation at Operating Limits for LAW Concentrate from PTF to LAW	Unlikely	Moderate
4	Precipitation in CNP Evaporator and Potential Impacts on CXP Process	Unlikely	TBD
5	CXP Impacts Due to Solids in Ion Exchange Feed	Likely	High
6	Impacts of Radiation, Temperature, and Oxygen on Resin Durability	Likely	Moderate
7	Impacts Due to IX Resin and Resin Fines Entering Processing Streams	Unlikely	Low
8	Potential Impacts to FEP and UFP Performance Due to GFCs in Recycles	Unlikely	Low
9	Process Operating Limits Not Yet Determined for UFP System	Unlikely	Low
10	Process Feed Variability Impacts on Integrated Operating Limits	Unlikely	Low

M6.b Confirmation of Action Plans for Unresolved Issues

The recommendations made by the M6/P4 team to address the risks in Table C-6 have not been finalized. These risks are in review using the risk submittal process (24590-WTP-GPP-PT-003, Rev 4).

M6.c Issue Resolution Impact on Commissioning

No impact is expected from the resolution of the M6 issue on WTP commissioning.

M6.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

No additional concerns were noted.

M7. Inconsistent long-term mission focus (including Lack of Spare HLW and LAW Melters)

The EM-TWS has analyzed the EFRT long-term mission focus issue where the WTP project has made design changes without consistently taking into account lifecycle costs and where decisions have been focused more on capital costs than on long-term operation and throughput (EFRT 2006a).

M7.a Confirmation of Existing Closure Plans

The EM-TWS reviewed this issue and found that the trend issues were corrected and lifecycle costing has been trended and reflected in the programmatic approach of the project execution in compliance with DOE O 413.3A.

M7.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues were identified at this time.

M7.c Issue Resolution Impact on Commissioning

No impact on commissioning was identified as a result of resolving this issue.

M7.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

It was noted during the Construction Project Review that no funding was available to manage risks beyond those presently identified (DOE 2010).

No additional concerns were identified by the EM-TWS; however, as the ongoing Operational Readiness Review / Assessment is being completed and feed stream definition is more refined, an analysis of the potential impact to lifecycle cost and baseline budgeting is recommended.

<u>M8. Limited Remotability Demonstration</u>

The planned remotability demonstration will not provide sufficient confidence that subcomponents in hot cells can be remotely replaced many years after commissioning (EFRT 2006a). The ability to install a subcomponent does not imply that it can be remotely replaced upon startup. Displacements may be induced over time and clearances for pipes and subcomponents may change. The EFRT suggested that subcomponent remotability using the permanently installed crane and viewing system be demonstrated after thermal cycling to increase confidence in its feasibility and to verify procedures and enhance operator proficiency (EFRT 2006a). Those problems that are identified before radioactive operations commence are more easily fixed by hand.

M8.a Confirmation of Existing Closure Plans

Two action items that were identified to close out this issue (CCN# 160531):

1. *Identify remote component types that are unique to WTP or are subject to appreciable heat-up and/or cool-down cycles and any additional testing requirements.*

2. *Revise the WTP remotability plan (24590-WTP-PL-OP-04-0003) to include additional testing requirements identified in Action 1.*

The EM-TWS concurs with closing this issue based on satisfying these two items; however, the following could be considered to reduce potential risks associated with remotability:

1. A backup plan should be considered (before cold commissioning) in the case that it is found after operations that the piping cannot be taken apart and put back together.
2. A plan is needed to define how a new piece of pipe can be made that precisely replaces the piece of "sprung" pipe (within 1/16") if it is found that a major piece of piping is "sprung" and cannot be reassembled remotely.

M8.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues were identified.

M8.c Issue Resolution Impact on Commissioning

The development of plans to address remotability issues (e.g., remote replacement of piping and remote repair "sprung" pipes) may call for testing that would impact commissioning.

M8.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

Other concerns were raised as part of the EFRT review (EFRT 2006b):

- *There is no experience with jumpers larger than 10" (where there are 22 WTP jumpers between 10 and 24") and limited experience with the 10-inch jumpers making the ability to remotely change the large jumpers after several years of operation (and possibly thermal cycling) a concern.*
- *There is a concern with how to empty those vessels with only a single outlet pump and valve is that in the event of the isolation valve failing closed.*
- *There is a concern with the potential to damage the connectors for the flexible electrical and pneumatic jumpers during replacement using the Parr manipulator (with no force feedback or flexibility in the gripper) on the main gantry crane.*
- *There is a concern about how a failed ion exchange (IX) column would be handled because there is no ability to bring a cask into the export bay.*

No plans have been developed for the items listed above.

M9. Lack of comprehensive feed testing during commissioning

The EFRT identified the following major systematic issue that current plans for WTP commissioning are based on contract requirements, do not include large-scale testing of leaching before hot operations commence, and are not adequate to handle expected feed variation and support the long-term mission (EFRT 2006a). The EFRT suggested that all Plant operations be performed in an integrated manner and including recycle streams as they would be during radioactive operations.

M9.a Confirmation of Existing Closure Plans

The WTP Issue Response Plan identified one closure criterion to resolve issue M5: revise the Commissioning Plan B to outline the process by which open technical issues are integrated into the plan and to include integrated operations and additional cold commissioning tests to demonstrate water washing and caustic and oxidative leaching (CCN# 163064).

M9.b Confirmation of Action Plans for Unresolved Issues

The M9 issue closure record (CCN# 163064) identifies a residual risk that the testing strategy in the commissioning plan will not provide sufficient information to completely determine Plant robustness. Additional testing may be required, but has not yet been defined.

M9.c Issue Resolution Impact on Commissioning

The current WTP commissioning draft plan (24590-WTP-PL-OP-05-0002, Rev. B) only includes a high-level summary description of the tests for the Pretreatment Facility. A detailed plan will be needed to proceed with cold commissioning.

The M9 issue recognizes that while testing PT operations with multiple simulants during cold commissioning is needed, it would not be sufficient to adequately understand the complexities of the PT processes. Additional EFRT issues must also be resolved: M4: *Design for Range of Feed*; M5: *Feed Pre-qualification*; M6: *Process Limits Not Defined*; M12: *Undemonstrated Leaching Process*; and M13: *Ultrafiltration Capacity*.

M9.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

No additional concerns have been identified.

M10. Critical Equipment Purchases

Because of the mission-critical nature of the WTP program and the extensive operating period projected for mission completion, it has been proposed by EFRT that certain critical systems and components should be purchased on a “best value” basis that would consider factors in addition to cost (e.g., unique experience in supplying similar equipment) (EFRT 2006a). These additional factors would be included in the purchase decision. For those vendors who offer a potential best-value product but might lack in some experience attributes (e.g., Cs ion exchange column), the current WTP Contractor is considering the introduction of additional expertise within the supplier team to strengthen its experience.

M10.a Confirmation of Existing Closure Plans

The current WTP Contractor has identified six systems that would qualify for this best-value purchasing approach and has implemented this approach for these systems. By doing so, it has closed this EFRT issue with DOE concurrence.

The concept of buying best value for a limited number of critical components and equipment for a project of this magnitude and importance is well justified. The approach to implementing best value seems reasonable, as do the six systems selected for this approach.

M10.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues were identified.

M10.c Issue Resolution Impact on Commissioning

The resolution of the M10 issue appears to have no impact on commissioning.

M10.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The documentation supporting the best-value approach appeared to be insufficient to support its use. Additional documentation should be provided regarding the criteria used for best-value selection, the DOE procurement provisions to justify selection, the basis and approach for supplementing resorcinol formaldehyde (RF) vendor expertise, and the basis for selection of critical systems for best-value purchasing.

M11. Loss of the WTP Expertise Base

The EFRT identified an issue regarding the retention of the institutional memory by the design staff of the current WTP Contractor (EFRT 2006a). The EFRT noted that given the iterative nature of chemical process design, it is common industry practice to retain the same staff over the entire project length to ensure that knowledge obtained in early stages is consistently available as the project progresses. The EFRT noted the extraordinary length of WTP's design effort which, in combination with the breadth and complexity of design information, creates an unusual challenge to maintain this institutional knowledge base (EFRT 2006). The EFRT noted the existence of considerable turnover in key engineering positions (even four years ago when the EFRT report was prepared). The turnover of key personnel has apparently continued since that time and has been observed during the time of period of the EM-TWS review.

M11.a Confirmation of Existing Closure Plans

The current WTP Contractor response to the M11 issue indicated that the two fundamental issues with knowledge retention are staffing and documentation (CCN#167388).

The EM-TWS concurs that these are the two fundamental issues of concern.

M11.b Confirmation of Action Plans for Unresolved Issues

No additional unresolved issues were identified in the closure record (CCN# 167388).

M11.c Issue Resolution Impact on Commissioning

No potential impact was noted on commissioning.

M11.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The response from the current WTP Contractor indicated that remedial action would be embodied in a comprehensive response plan (24590-WTP-PL-ENG-07-0007, Rev. 0). This plan presents many valuable ideas for recruiting and then motivating those additional personnel recruited. However, the EM-TWS does not believe that this plan represents a comprehensive and effective response to the principal issues raised by the EFRT. The following concerns are noted with regard to this plan:

- The principal focus is on recruiting and retention of new employees and not on retention of existing staff (who possess institutional memory) or methods to reacquire staff resources who have previously left the project.

- The principal focus is on knowledge retention to support commissioning and startup and not on knowledge retention to continue with engineering activities, transfer acquired knowledge to DOE (i.e., the owner), or transfer knowledge to the operator.

- One of the recognized two principal issues, that of documentation, has only received one-half of one page's attention in the plan and this includes suggestions to use local colleges and hiring contractors to document the work of others (neither of which appears to address the fundamental issue).

- The plan does not address the identification and cataloguing of critical knowledge for transfer or identifying Contractor proprietary knowledge and the means for its transfer.

- The plan does not recognize the inherent value of understanding and preserving the basis for engineering judgment in choosing between options, initiatives that were not accepted, or value engineering tradeoffs.

For a project of this magnitude, in which DOE will invest more than $12 billion, it is purchasing not only "bricks and mortar," but also the knowledge base that was used to create them.

The current WTP Contractor should recognize that the "design/build" process requires a longer period of engineering activity than the more conventional "design then build," since engineering must lead construction almost until project completion. This unique circumstance should require correspondingly unique actions for retaining project institutional memory. The two key objectives regarding the institutional memory issue, and which require this unique action, are:

- Retention of the ***key people*** who understand the decision making process behind the work, and

- Documenting the ***decision making and the supporting details*** in a clear and understandable manner for those not directly involved in this work and organizing that information in a manner that ***can be conveniently referenced*** by others who did not perform the work (recognizing the challenge that this project retains a very large body of information).

It is not apparent from the above-referenced response plan, or from the observed history of project staffing, that key personnel who are critical to institutional memory have been identified and incentivized to remain with the project rather than accepting normal corporate rotations to other projects or leaving entirely. It is equally not clear that DOE has addressed these same issues of institutional memory from the owner's perspective.

The following recommendations concerning the EFRT M11 issue were made:

- The current WTP Contractor should revise 24590-WTP-PL-ENG-07-0007 to recognize the inherent value to the project and the customer of the institutional knowledge possessed by long-term employees and take unique actions to preserve that knowledge, such as:

  – Identify key project positions for knowledge retention,
  – Create financial incentives for employees in those positions to remain with the project and revise transfer policies for those employees to other projects,
  – For those employees already transferred or retired, organize a formal program for their periodic contribution to project issues, and
  – Consider an advisory committee of former senior project personnel to periodically review and comment on WTP progress.

- The current WTP Contractor should develop an action plan, budget recourses, and implement this plan to cross-reference documented material within DocSearch from a user perspective by:

  – Broadening the perspective of "customers" for this documentation from just commissioning and startup to ongoing design, DOE, and the future plant operator,
  – Developing a basis for definition of proprietary information and a workable method for "customers" to access that information, and

  - Developing a series of templates for information segmentation, based on customer needs, and implement an effort to cross reference database information under each template, for convenient access.
- DOE should consider taking similar actions with their more modest knowledge base, focusing on personnel considerations through the Federal Project Director and documentation through the Federal Facility Project Directors for each major facility.

M12. Undemonstrated Leaching Processes (Pretreatment Facility)

The caustic leaching and oxidative leaching processes have not been demonstrated beyond the bench scale (EFRT 2006a). Small research-scale experiments can characterize the leaching chemistry; however, this will not necessarily be indicative of leaching performance at WTP scale. Furthermore, the process chemistry for the leaching/oxidation of solids has the potential to result in the formation of gels and/or to precipitate salts within the Ultrafilter Process (UFP) and subsequent downstream processes.

M12.a Confirmation of Existing Closure Plans

The scaleup of the leaching process is a very challenging task that involves complications from multiple chemical interactions, foaming, non-Newtonian behavior, possible precipitation/ gelation, and the use of mixing systems that has not been used before in a similar critical application. The M12 IRP (24590-WTP-PL-ENG-06-0024, Rev. 0) defined seven closure criteria that are addressed in the M12 closure documents (CCN# 195043, CCN# 184903). The focal point of the scale up comparison was the leaching/oxidation processes conducted with the Pretreatment Engineering Platform (PEP) at the 1:4.5 scale. There have been detailed leaching/oxidations studies performed and documented to meet the overall closure requirements (CCN# 184903; Rapko *et al.* 2009; WTP-RPT-200, Rev. 0; WTP-RPT-197, Rev. 0).

As part of this effort, processing improvements and modifications were examined, followed by preliminary G2 modeling to determine the impact on the overall WTP project. The laboratory characterization of the radioactive wastes encompassing the eight major tank waste groups and there leaching/oxidation used was completed. This knowledge was used for simulant development to be used in the PEP experiments (WTP-RPT-184, Rev. 0; WTP-RPT-176, Rev. 0). The leaching/oxidation behavior of simulants at the laboratory and PEP scales was correlated to behavior observed in radioactive laboratory radioactive waste samples. The conclusion was that the laboratory results scaled at unity from the bench to the engineering scale as tested. The performance of the ultrafilters was also characterized (WTP-RPT-185, Rev. 1). Whether this process chemistry truly scales linearly to the actual WTP scale, with the all of the complications, still carries some risk but the degree of confidence is much more significant following the PEP testing. There was a great deal of fundamental operational knowledge gained and improvements in processes as a result of the studies conducted to fulfill the M12 EFRT closure. For instance, the observation of precipitation in the permeate has changed operational parameters in several systems. This experience and will be a large benefit for the development of improved G2 models, commissioning, and WTP operations. Flowsheets for the Pretreatment facility and the

WTP will be improved. A set of issues has been identified and carried forward for in a Phase II study to continue to examine the overall process of sludge treatment.

The results from the studies are related to the characteristics of the feed, process limits of the feed, and the uncertainties in the leaching process (e.g., mixing considerations). For the studies, it appears several well-engineered simulants were developed and investigated. Important bounding limitations of the studies are the compositions of the simulants themselves and how they will represent the real feed streams.

The leaching/oxidation process by nature affects nearly all downstream chemical processes and bears closely to the downstream gelation/precipitation concerns. A key issue is the analytical chemistry, characterization, and sampling that must be done prior to the leach/oxidation and throughout the system to provide the information needed about the effectiveness and control aspects of the leach/oxidation processes (in particular for rheology that can limit process flexibility).

The differential leach characteristics (e.g., differences in gibbsite and boehmite concentrations) are aggravated by the lowering of the leaching temperature. As currently devised, the lower temperature may lower throughput and increase the number of high-level waste canisters. Similarly, the potential for precipitation in downstream permeates requires the process to be refined to achieve optimal performance.

The status of M12 was closed with accompanying ATS entries by the WTP (CCN#195043). The remaining uncertainties and risks in the leaching processes are being carried forward to the commissioning and operations phases of the project. Additional work related to M12 is planned in this area, as indicated by recognition of the Phase II topics.

M12.b Confirmation of Action Plans for Unresolved Issues

The ATS items must be closed before commissioning of the UFPs as recognized in the closure documents. Additionally, the challenges highlighted above will have to be addressed at some point before optimal operations can be conducted.

M12.c Issue Resolution Impact on Commissioning

The remaining uncertainties and risks in the leaching/oxidation processes are being carried forward to the commissioning and operations phases.

M12.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The potential impact of less than expected efficiencies in the leaching/oxidation processes will likely be an increase in the amount of high-level waste canisters produced.

<u>M13. Inadequate Ultrafilter Surface Area and Flux (Pretreatment Facility)</u>

The UFP system in the Pretreatment Facility treats both the HLW and LAW feed streams. A blend of HLW and LAW feed streams is pumped through the Ultrafilters. The solid free liquid permeate is treated with the ion exchange resin to remove cesium before transfer to the LAW vitrification process. The solids are washed and leached to reduce soluble salts and then transferred to the HLW vitrification facility. The design capacity of the UFP system and its performance are critical elements of overall WTP plant performance.

An inadequate combination of ultrafilter flux and surface area will likely limit throughput to the HLW or LAW vitrification facilities (EFRT 2006a). The combination of flux and area would appear to be adequate except for two factors:

- *Limited experimental data with both Hanford actual wastes and simulated feeds have shown significantly lower fluxes.*
- *Leaching is included in the current design, but it has an impact equivalent to reducing the ultrafilter area available to support solids concentration by 50 percent.*

Based on these factors, the expected permeate flow is significantly less than the design basis of 15 gpm that would result in a reduction in the production rate of HLW slurry.

M13.a Confirmation of Existing Closure Plans

In the spring of 2005, the current WTP Contractor conducted engineering studies at DOE's request to enhance treatment of tank waste. After the test was completed, a 25 percent increase in filter area was recommended. Improved leaching steps were also identified. The testing program (initiated in the 2006/2007 timeframe) has been completed (including laboratory testing with actual waste, laboratory- and pilot-scale testing with simulants, and modeling work).

The ultrafilter surface area for each of the two UFP process trains was doubled.

Studies were also conducted to determine the optimum conditions to maximize the average filter flux while improving overall throughput.

In addition to the revised design of the UFP system, a series of studies to revise the design of the Pretreatment Facility to improve plant capacity and flexibility were conducted in 2007.

The TSG concurs with the WTP's conclusion that the design for the UFP system is adequate. The TSG issued a Closure Record for the M13 issue (CCN# 195034).

M13.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues were identified in the closure process for the M13 issue.

M13.c Issue Resolution Impact on Commissioning

No impact on commissioning.

M13.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

No additional issues were identified for the M13 issue based on the EM-TWS's review.

M14. Instability of Baseline Ion Exchange Resin (Pretreatment Facility)

Based on test results, the EFRT did not believe that baseline shard resin would achieve the required 10-cycle design life and suggested that the shard-form ion exchange resin be replaced with the bead resin (EFRT 2006a).

M14.a Confirmation of Existing Closure Plans

The WTP IRP identified one closure criterion to resolve issue M14: recommend the use of Spherical Resorcinol Formaldehyde resin as an approved equivalent to SuperLig 644 resin for the CXP process (CCN# 163065).

M14.b Confirmation of Action Plans for Unresolved Issues

An open item in the WTP Risk Register (OPS-044 IER) addresses the issue of single source for seed needed for RF resin production. The WTP project procurement group is concerned that the seed supplier may be having financial problems. At this time, the project has only purchased sufficient seed to produce RF resin for cold and hot commissioning.

M14.c Issue Resolution Impact on Commissioning

If the RF resin is not available due to seed supplier viability, the fallback will be to use Superlig resin. The EFRT concluded that the use of Superlig resin will fall far short of the requirement that resin last for at least ten cycles. This would adversely impact mission duration and cost.

M14.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The CXP operating temperature has been increased to 45°C to minimize the operating risk of aluminum precipitates and gels. Performance testing of the RF resin at 45° C has been limited to a small number of experiments. Extended testing is recommended to confirm ion exchange capacity and resin physical stability/lifetime at this temperature. It will also be of great value to study the effect of operating conditions such as CXP operating temperature and sodium concentration on the overall productivity of the WTP.

Experimental work on hydrogen generation and chemical decomposition of spherical RF ion exchange resin was carried out at temperatures of 25 °C and 65 °C (24590-WTP-RPT-RT-06-001 Rev. 1) based on an anticipated CXP operating temperature of 25 °C. Since then, the CXP design operating temperature has been increased to 45 °C. A Hazards and Operability Review should be performed to determine if the CXP temperature could increase above 65 °C during abnormal operating conditions. If it is concluded that the CXP temperature could exceed 65 °C, additional experiments at such temperatures should be performed.

M15. Availability, Operability, and Maintainability (Pretreatment Facility)

Issue M15 is a significant factor impacting WTP's ability to achieve mission compliance and hence residual design risk. The contract requires WTP to demonstrate target plant availability through an Operations Research (OR) model for average feed conditions and operations limits determined by contract specifications. While it is expected that the plant will be operated differently from batch-to-batch by the operator, the use of average design values is a best practice for process system design. The plant designer cannot be asked to anticipate all operational conditions over the mission life but it could be that one develop an OR model with sufficient detail so that the operator can evaluate the full range of expected operating conditions.

The current WTP Contractor is using the WITNESS software model, which is an industry standard, acceptable tool. They are applying the WITNESS model using a Crystal Ball Monte Carlo simulation framework, which is also an industry standard, acceptable approach. However, using an acceptable model will only be effective if the associated Reliability, Availability, Maintainability, and Inspectability (RAMI) input data are demonstrated to be suitable for the current application and appropriately conservative. The current WTP Contractor has employed expert opinion as a facilitator for RAMI data, which is also a common approach, provided that it effectively references prior experience.

The EFRT raised a concern that average contract feed values may not represent an accurate estimate of actual availability, that RAMI values should be justified for their intended use, and that, in particular, the PT canyon bridge crane appeared to be a choke point that could prevent the facility (and plant) from achieving the then-80 percent availability target (EFRT 2006a).

The current WTP Contractor has responded with a number of actions to add more details to the OR model by including additional systems. It did, in fact, review most all PT systems to identify the ones that should be included. The current WTP Contractor also detailed additional accident event conditions that should be included in the model. These upgrades have significantly improved the OR model; it is now more robust and a reasonable representation of the facility from a reliability analysis point of view.

M15.a Confirmation of Existing Closure Plans

This issue was closed with DOE concurrence more than two years ago (CCN# 153215), although, as would be expected because the design was still in progress, the attendant issues regarding availability are still subject to design evolution. For example, the current WTP Contractor, with DOE concurrence, has since the EFRT report issuance reduced the target availability to approximately 70 percent. DOE has added an integrated facility availability requirement of 70% in the Contract as part of Mod M143. In addition, the availability of systems and their reliability is dependent on the resolution of technical issues such as hydrogen in piping and ancillary vessels (HPAV) and mixing, and the resolution of additional residual risks. In general, it is apparent that greater complexity introduced to provide a more robust response to safety and operational risk considerations can also potentially reduce availability.

M15.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues were identified during closure of the M15 issue.

M15.c Issue Resolution Impact on Commissioning

During the EFRT response, the projected availability was stated to be about 83 percent, and currently the latest OR modeling is reported to be approximately 70 percent. It is not apparent what drivers have caused this reduction in availability and if they are still in play as the design progresses. It is also not apparent if these drivers can impact availability regarding issues identified during commissioning or early startup. A review of the current OR model would consequently be advisable as part of the EM-TWS's evaluation (and future Construction Project Reviews (CPRs)) of this issue. In the current configuration, any further reduction in availability would likely reduce it below contract specified target levels. Therefore, these become important questions.

Based on the above considerations, and the changes which have occurred since issue closure, the EM-TWS concurs that issue M15 should be converted into an ongoing project evaluation that continues through WTP Contractor-supported commissioning activities, including the root cause of changes to availability and the impact of future design revisions on availability. This is the subject on Contract deliverable 2.5, Operations Research Assessment, due to DOE every two years for the duration of the Contract.

Evaluation of plant availability is no doubt an issue of operational analysis being studied by Washington River Protection Solutions (WRPS), since it is key to the strategy of how the plant will be run for each batch. As mentioned above, the responsibility of ensuring operations availability and efficiency for batch-specific conditions should be delegated to the plant operator. However, the lessons learned in planning for operation may provide valuable insight to the WTP project and should be part of a continual interchange that supports the design/builder and operator "seamless interface." This would also help to define the appropriate timing and method of handoff during the commissioning/startup period.

M15.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The EFRT discussion demonstrated the substantial sensitivity of canyon crane operations to the facility availability. Similarly, the further analysis by the current WTP Contractor in response to this concern also demonstrated this sensitivity in that a reanalysis of basic RAMI data was a basic mechanism employed to improve estimated crane availability. The original RAMI data had crane availability of more than 99 percent, and it has apparently been reduced in this EFRT response. It would seem advisable to review the current OR model and the state of knowledge from similar crane operations at the Defense Waste Processing Facility (DWPF), other current DOE facility operations, and prior reprocessing facilities at DOE (all of which employed a central canyon and crane). The WTP crane is unique in that it employs a six-degree-of-freedom manipulator extension to navigate the crowded conditions in the PT canyon. Again, complexity to achieve efficiency could impact availability, and it should be confirmed that this has been investigated for current design conditions.

The WTP Project Manager indicated that the current WTP Contractor was performing as contracted and designing availability to contract-average specification. He further indicated that it was not reasonable to expect the plant to operate exactly in this manner for a specific batch, and that operator expertise and experience would be needed to improve efficiency and availability. These statements are reasonable, and, therefore, care should be taken not to confuse resolution of the M15 issue with future operator responsibilities. However, the WTP contractor is nonetheless bound to deliver a comprehensive OR model with defensible RAMI data that demonstrates target availability within contract specifications. At present, the margin in that compliance seems thin, and the residual risk is that it can be maintained with the remaining work.

Several observations and recommendations were made as a result of the EM-TWS review of the M15 issue:

1. The current WTP Contractor is employing industry-acceptable models for OR analysis and has included sufficient functional details within these models to represent PT operations.

2. RAMI data input to these models was appropriately revised in response to the EFRT, but it has apparently been subsequently revised as predicted availability has changed in the two years since closure. The current WTP Contractor should provide the criteria for determining these data and the basis for their subsequent revision, especially for the canyon crane.

3. The current WTP Contractor should review the current OR model results to determine changes since EFRT resolution and the lessons learned regarding availability.

4. Given that the design and technical risk reduction are still ongoing, OR model compliance should remain a continual issue for review through the CPR.

5. Considering that availability is a central focus of the Tank Farms Management under their operability responsibilities, an ongoing coordinating function should be established between the two contractors and should be part of an integrated seamless management concept to manage issues between design/builder and operator.

6. This coordinating function should also be used as a resource to assist in planning for the timing and method of plant handoff during commissioning.

<u>M16. Misbatching of Melter Feed (LAW Vitrification Facility)</u>

The glass-forming chemicals (GFCs) are added to storage silos. Although the chemical compositions are specified, there is no guarantee the GFCs will be put into the correct silo. Since there is no feedback from analysis of the melter feed, the same misbatching error will be made repeatedly, potentially sending misbatched feed to the melter until glass can no longer be poured. Thus, there is a significant risk of misbatching the LAW melter feed, leading to premature melter failure (EFRT 2006a). This risk can best be eliminated through analysis of the melter feed.

M16.a Confirmation of Existing Closure Plans

This issue was resolved by requiring that a sample of the feed tank be collected and analyzed after it is mixed (CCN# 163066). This takes care of the cases where the wrong dry feed is put into a feed bin and where the feed system (e.g., a valve) does not operate correctly.

M16.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues were identified in closing the M16 issue.

M16.c Issue Resolution Impact on Commissioning

Resolution of this issue should not affect the commissioning schedule.

M16.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The remaining issue that has to be addressed is what to do if a batch is found to be noncompliant to specification. A method for handling such an out-of-specification batch needs to be developed, whether using an administrative approach or through the addition of a recycle or drain to a previous tank.

While the current assumption is that an out-of-specification batch can be fed to the melter feed tank and thus diluted, this may not be an acceptable approach if the batch has to be diluted with large additions of new chemicals. This appears to be a question that can be handled administratively or with a relatively simple piping change. Therefore, the EM-TWS considers this issue to be closed with the caveat that an acceptable approach is generated before the commissioning phase.

M17. Plugging of Film Cooler and Transition Line (HLW Vitrification Facility)

Film cooler and transition-line plugging was observed in the DM 1200 HLW pilot plant tests at the Vitreous State Laboratory (VSL) (Ref., Phase 1 DM1200 Melter Testing of Film Cooler Cleaner Final Report, VSL-07R7800-1, Rev. 0). The plugging occurred as a result of entrainment and subsequent deposition of aerosols that formed in the melter plenum or were entrained in the offgas due to operation of the melter bubblers. The extent of plugging was correlated to the melter bubbler flow rate and the level of solids in the feed. While the current design operates at bubbler rates that are well below the high plugging rate regime, there is still a significant potential for plugging at low bubbler flow rates (EFRT 2006a). In addition, unless high solid levels can be maintained in the feed to the HLW melter, the higher water feed rate and subsequent steam formation will also increase the chance for plugging.

M17.a Confirmation of Existing Closure Plans

WTP considers the issue with plugging of the film coolers closed (CCN# 144619; CCN# 172572):

1. Based on operating conditions, the cooler will not plug and indicate that neither West Valley Demonstration Project (WVDP) nor DWPF require coolers.

2. Operating conditions have been selected that should minimize carryover.

3. A film cooler cleaning device will be installed based on test work at VSL (24590-101-TSA-W000-0009-183-00001, Rev. 00A).

M17.b Confirmation of Action Plans for Unresolved Issues

Plans have been made to verify the ability to readily remove and replace both the film cooler and the film cooler cleaning device.

M17.c Issue Resolution Impact on Commissioning

The resolution of the M17 issue should have no impact on commissioning.

M17.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

While it is true that the WVDP and DWPF projects did not use clog removal devices, there are indications that plugging occurred even without the use of bubblers that increases the carryover of material into the gas vent. Test work at VSL (24590-101-TSA-W000-0009-183-00001, Rev. 00A) showed that plugs could form. Testing indicated that clogs can be removed with a freefalling ram device; however, these tests have resulted in damage to the film cooler. The current plan is to use the cleaning device once per day, which will increase the chance of damage to the film cooler. Finally, during testing at VSL that used simulated WTP glasses (24590-101-TSA-W000-0009-183-00001, Rev. 00A), the cleaning device became stuck. Due to the carryover of solids, this may also occur during operation.

The device that is to be installed should be relatively rugged. However, it is a moving device that will be located in a reasonably hostile atmosphere with entrained solids, materials that will plate out, and high gas temperatures. Therefore, this device has a reasonable likelihood of failing.

The installation of a camera to provide a visual indicator of material buildup could enhance productivity, illustrating when maintenance is required rather than forcing reliance on an aggressive cleaning schedule using secondary indicators (e.g., pressure drop).

While the film cooler has the most immediate buildup of solids, this is only an indication that there is a significant amount of solids carryover. This carryover can also precipitate out at other locations in the piping (e.g., elbows or the film cooler cleaning device). Therefore, the entire offgas section from the melter to the submerged bed scrubber (SBS) should be readily removable for cleaning or replacement. This implies that there must also be a laydown area where cleaning can occur.

Potential Issues

The issues identified by the EFRT were categorized as either *major* or *potential*. The major issues are those that could cause the current WTP Contractor to fail to meet contract rates with commissioning and future feeds, and should be addressed to provide additional assurance of meeting design throughput.

P1. Undemonstrated Decontamination Factor (Pretreatment Facility—Evaporators)

The EFRT raised the issue that the Cs-137 decontamination factor (DF) of 6×10^7 for the Feed Evaporator Process (FEP) and Treated LAW Evaporation Process (TLP) has not been demonstrated in WTP operations (EFRT 2006a; CCN# 163075). The DF requirement is driven by radiological exposure limits from the downstream storage vessel. The EFRT summary analysis identifies Engineering, Procurement, Construction, and Commissioning risks associated with the capability of the FEP and TLP evaporators to meet functional requirements. This issue was determined to be a low risk due to potential rezoning and fencing of storage vessels with regards to limits for radiological exposures.

P1.a Confirmation of Existing Closure Plans

The IRP for the P1 issue identified five closure criteria (CCN# 163075): 1) clearly document cesium-137 concentration requirements for the condensate streams from the TLP and FEP evaporators; 2) understand and clearly document the cesium-137 DF requirements for the FEP and TLP evaporators; 3) if required, identify the specific design changes and/or operation requirements to align FEP and TLP evaporator cesium-137 DFs to the condensate concentration requirements; 4) issue a summary report indicating closure of all reviewer comments; and 5) change the FEP and TLP evaporator cesium-137 DFs. The TSG reviewed the resolution of the EFRT P1 issue and determined that the closure criteria have been satisfied (CCN# 163075).

P1.b Confirmation of Action Plans for Unresolved Issues

The current WTP Contractor decided to remove the integrated evaporator performance testing from the equipment specification, resulting in residual engineering, procurement, construction, and commissioning (EPCC) risk associated with the capability of the FEP and TLP evaporators to meet their functional performance requirements. Various design issues were identified in the Cesium Nitric Acid (CNP) evaporator system (CCN# 163075), but an evaluation of the FEP and TLP evaporators had not been completed at the time of the EM-TWS review that would ensure that the CNP evaporator design issues do not exist in the FEP and TLP evaporators. The TSG recommends that the current WTP Contractor evaluate the designs of the FEP and TLP evaporators to ensure that CNP evaporator design issues identified do not exist in the FEP and TLP evaporators and that any design issues identified are reported to ORP and corrected.

P1.c Issue Resolution Impact on Commissioning

Simulant review is recommended as an ORP activity prior to radioactive function testing.

P1.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The performance of the Evaporator DF is dependent on proper analysis, batch pretreatment, and conformity to operations technical specifications as well as limitations from internal vessel conditions such as foaming. The EM-TWS believes the technical specification and performance documentation for the procurement specification need to be confirmed and reviewed based on the most recent G2 model. The following are concerns:

- Evaporator DF and efficient performance will be impacted by foaming; adequate DF is dependent on the absence of foam in the evaporators.
- Pre-qualification testing includes evaporation/foam testing. The EM-TWS raises the question, does the bench-scale pre-qualification test adequately predict lack of foam at the plant scale?
- Testing should be completed for all potential physiochemical and radiological simulants.

P2. Effect of recycle on capacity (Pretreatment Facility—Evaporators)

The EFRT raised the concern of capacity limitation due to individual purge, washes, and PJM washwater streams (EFRT 2006a). The amount of water and the composition of wash products are still not known.

P2.a Confirmation of Existing Closure Plans

The IRP for the P2 issue identified one closure criterion to resolve the issue (CCN# 163076): completion of the interim G2 modeling run based on the bounding values of flush volumes and frequency established by the HPAV analysis and the M1 line plugging interim evaluation. The TSG reviewed the results of this analysis and determined that the closure criterion was satisfied. Additionally, WTP issued a G2 modeling run that shows the design could accommodate the expected recycles without significant impact to plant production or the effluent treatment facility.

P2.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues were identified.

P2.c Issue Resolution Impact on Commissioning

Analyses should be run on potential Evaporator performance impacts of recycle fluids during both commissioning and operations.

P2.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The EM-TWS reminds the WTP design team of the potential impacts of recycle streams containing small concentrations of materials that may cause foaming that will not show up during pre-qualification testing.

The issuance of the G2 modeling has closed this issue for the moment. Once the Operational Readiness Review (ORR) or Hazards and Operability Review is completed, this question should be again confirmed as not impacting the design basis of the facility and evaporator performance.

P3. Adequacy of Control Scheme (Pretreatment Facility—Evaporators)

The EFRT raised the concern of evaporator discharge limitation of 5M sodium to ion exchange treatment (EFRT 2006a). The question raised was based on density measurement technology and adequacy. The conclusion is that the bubbler technology was adequate with no significant residual risk.

P3.a Confirmation of Existing Closure Plans

Response claims that ± 20 percent accuracy for Na concentration is adequate for operation of the IX columns (24590-WTP-PL-ENG-06-0041, Rev. 1). A best practice is to use an experimental boildown curve to cope with the fact that Na versus density is obscured by the presence of other salts.

P3.b Confirmation of Action Plans for Unresolved Issues

There were no unresolved issues identified for the P3 issue.

P3.c Issue Resolution Impact on Commissioning

The EM-TWS does not believe the resolution of the P3 issue would adversely impact commissioning.

P3.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

No additional concerns resulted from the EM-TWS review.

P4. Potential gelation/precipitation (Pretreatment Facility— Ultrafiltration/Leaching)

The process chemistry for the leaching of solids has potential to form gels and/or to precipitate salts in the leaching tanks and subsequent downstream processes if unfavorable leaching conditions exist (EFRT 2006a). This is based upon knowledge that the feed contains significant amounts of aluminum and other materials that could gel and/or precipitate depending on the process and process chemistry. Furthermore, the P4 issue is closely related to the characteristics of the feed and the process limits of the feed (i.e., EFRT issues M6 and M1, respectively), and uncertainties in the leaching/oxidation process (EFRT issue M12). The possibility of gelation and/or precipitation has potentially large effects on several WTP systems.

P4.a Confirmation of Existing Closure Plans

EFRT issues P4 and M6 are closely related. Therefore the P4 (*Gelation/Precipitation - Due to Unfavorable Leaching*) and M6 (*Process Limits Not Completely Defined*) issues were addressed in a coordinated manner from an EFRT perspective (CCN# 186330). Furthermore, both of these issues are directly related to other EFRT issues examined in the breadth of the M12 studies, *Undemonstrated Leaching Processes* (CCN# 195043; CCN# 184903; WTP-RPT-200, Rev. 0; WTP-RPT-197, Rev. 0). Aspects of the P4 issue relating to system performance and operations are important, along with the role of unfavorable leaching in potential overall line plugging (EFRT issue M1, *Plugging in Process Piping*).

The response to the EFRT P4 issue was divided into two phases (24590-WTP-PL-ENG-06-0016, Rev. 0). The first phase established formally defined process operating limits, the risks associated with the identified gaps, evaluation of process chemistry, and chemical testing for plugs. The second phase was not required for closure and made several important recommendations for future work (where issue M12, *Undemonstrated Leaching Processes,* activities were underway).

Issue P4 could affect a large number of systems within the WTP. The potential for gelation and precipitation was evaluated for all affected systems (touches on additional EFRTs) based on the operational envelope process limits, current knowledge of process operating conditions, feed, and the risks evaluated for each. The gelation/precipitation concerns were addressed in this flowsheet method as well in an experimental study of chemical plugging (WTP-RPT-180, Rev. 0). Plugging studies observed trisodium phosphate plugs using simulants and evaluated the potential of other species to cause plugs. Measures and strategies were identified and documented to reverse line plugging.

The later M12 studies also identified solids in the permeate that were attributed to trisodium phosphate and other compounds. The gelation/precipitation issues may be complicated by the differential leaching characteristics of the Al phases in the waste as determined in M12 studies especially when operating conditions such as temperature are changed. The plugging studies gave credence to the formation of plugs from trisodium phosphate and sodium oxalates, which were found as solids in the M12 permeates. These results indicate that special process conditions may be necessary for processing bismuth phosphate and other wastes high in phosphates.

Recycles that contain glass formers (including offgas contributions) also have the possibility of increasing the potential for gelation and precipitation (as well as elevating the sodium content).

The P4 issue is closed with no ATS entries (CCN# 186330). Importantly, processing limits were further defined. The closure criteria were met but several important forward-going recommendations were made prior to the M12 results. The results of the M12 studies show that a flowsheet or process change affects the possibility of gelation/precipitation in the process (e.g., change in the feed and/or leaching/oxidation process). As a result of the P4 recommendations and M12 results, additional work should be performed and some risks will be carried forward into commissioning and operations. The risks were judged not related to design but rather to waste processing strategies and were within the flexibility of the WTP as designed. This design could be committed based on this information.

P4.b Confirmation of Action Plans for Unresolved Issues

The results from the M12 studies confirm the nature of the P4 recommendations. These issues will continue to have to be managed as the processes and process chemistry are refined to attain optimal efficiencies. Process boundaries, conditions, and simulants will be important issues. As processes are refined, it is important to translate the changes and potential impacts throughout WTP systems.

P4.c Issue Resolution Impact on Commissioning

Risks judged to be acceptable at the time of issue closure will be carried forward to commissioning and operations.

P4.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The impact of changes to prevent the recently observed gelation/precipitation results should be assessed throughout the affected systems.

<u>P5. Inadequate process development (Pretreatment Facility—Ion Exchange)</u>

The effects of process variables (concentrations of chemical species such as hydroxide and aluminum; recycles; flow rates; and temperature) on the performance of the RF resin need to be determined experimentally to predict the performance of the ion exchange process with feeds that vary in composition (EFRT 2006a). The EFRT P5 issue spans a broad set of interconnected issues within the CXP/CNP system.

P5.a Confirmation of Existing Closure Plans

To address the EFRT issue, comprehensive and directed characterization of the RF resin was conducted under the Stage 2-3 testing programs, along with more recent studies to further understand the behavior of the RF resin under the currently envisioned operating conditions. The

EFRT closure has been well-documented (CCN# 163081; 24590-PTF-3YD-CXP-00001, Rev. 1 and references therein). The current WTP Contractor has also updated the EM-TWS on the status of the CXP/CNP system. The effective closure of the scope covered by the EFRT P5 issue recognized the linkage to and dependence on the process modifications introduced as a result of the changes from other EFRT improvements and developments (M6, M10a, M12, and M14, plus P6, P7, and P8). The modifications in these processes have been brought forward into the CNX/CNP as encountered and continue to be addressed as needed.

The P5 issue has been closed (CCN# 163081). There has been continuing activity to further define and refine the overall CXP/CNP system since closure. In particular, there has been focus on the issues brought about by updates and changes in processes affecting CXP/CNP performance and to better define the properties of the RF resin within the range of system operational limits.

The CXP/CNP process is greatly affected by the overall CXP/CNP design and processes (CCN# 163081; 24590-PTF-3YD-CXP-00001, Rev. 1; 24590-PTF-YD-CNP-00001, Rev. 1), resin properties (CCN# 163081; 24590-WTP-RPT-RT-06-001 Rev. 1), equipment-related decisions (24590-CM-HC4-HA00-00002-01-00001; 24590-WTP-RPT-PR-07-005, Rev. 0; 24590-WTP-RPT-PR-06-001, Rev. 0), and feed and recycles (WTP-RPT-185, Rev. 1; WTP-RPT-200, Rev. 0; Rapko *et al.* 2009). The current WTP contractor is bringing all the components together with respect to the CXP/CNP systems leading up to the new system plan description.

P5.b Confirmation of Action Plans for Unresolved Issues

A key accomplishment will be the new, fully updated CXP/CNP system plan description that is targeted for early 2011 to identify any remaining issues. The finalization of the CXP/CNP system plan is currently recognized as a lead element in the critical path (DOE 2010).

P5.c Issue Resolution Impact on Commissioning

No direct impact is expected on commissioning from resolution of the P5 issue. However, the general issue of the representative nature of the stimulants that will be used in commissioning has impact throughout the considerations of feeding the WTP.

P5.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The availability of RF resin seeds for WTP operations needs to be ensured. There is ongoing work further establishing the performance of ion exchange systems at 45° C.

P6. Questionable Cross-Contamination Control (Pretreatment Facility—Ion Exchange)

The EFRT identified a potential Pretreatment Facility issue concerning cross-contamination of piping that could result in LAW melter feed being too high in cesium-137 and thus out of specification (EFRT 2006a). The flowsheet reviewed by the EFRT indicated that loading and eluting of ion exchange columns would be in a downflow mode, thereby sending both the concentrated cesium-137 solution and decontaminated salt solution through the same piping. If a small amount of eluate (containing the concentrated cesium-137) was trapped in a section of pipe and then mixed with the salt solution, the resulting immobilized low-activity waste (ILAW) would be out of specification. Significant cross-contamination would require ion exchange retreatment of a large amount of treated LAW solution.

P6.a Confirmation of Existing Closure Plans

The IRP for the P6 issue identified one closure criterion to resolve the P6 issue: submit a technical report documenting the evaluation results for cross-contamination control. The current WTP Contractor evaluated the potential for cross-contamination of feed, eluant, and product streams within the CXP system. Recommended changes to piping and instrument diagrams (P&IDs) were made to 1) dedicate LAW pumps for separate operations and 2) change and monitor piping to provide for a treated LAW recycle line to ensure that treated LAW meets specifications before switching to the product vessel. The recommendations did not include upflow elution.

P6.b Confirmation of Action Plans for Unresolved Issues

The closure report for the P6 issue indicated that the recommended actions should mitigate any residual risks from cross-contamination within CXP.

P6.c Issue Resolution Impact on Commissioning

Successful resolution of the P6 issue is dependent in large part on the success of a change in operating procedure: loading cycle to be started in a recycle mode (treated LAW recycled to the feed vessel rather than forward to the product receipt vessels). A best practice would be to validate during cold commissioning using tracers or some other suitable method.

P6.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The P6 closure plan suggested the possibility that facility structure, equipment size, and design features would limit piping layout, resulting in unacceptable cross-contamination, including the distinct possibility that subtle piping configuration issues may go unnoticed.

No additional issues were identified as part of the EM-TWS review.

P7. Complexity of Valving (Pretreatment Facility—Ion Exchange)

The EFRT identified a potential Pretreatment Facility issue concerning the complexity of the valving in the ion exchange system and the resulting increased risk of processing outages and decrease in availability (EFRT 2006a). Valving errors could also lead to cross-contamination and retreating of materials before immobilization.

P7.a Confirmation of Existing Closure Plans

The IRP for the P7 issue identified one closure criterion: complete and document an independent evaluation of opportunities to simplify the valving design in the CXP system (CCN# 163082). The resulting options to simplify valving design will be evaluated by the current WTP Contractor and recommendations will be made. .

An independent evaluation was performed of the CXP valving requirements by engineers who were not involved in CXP system design (24590-WTP-RPT-PR-07-005, Rev. 0), which resulted in recommendations. The reviewers concluded that reducing the number of valves further was not warranted without sacrificing process capability. The EM-TWS review concluded that no process valves could be removed due to the proposed operating mode.

P7.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues or residual risks were identified for the EFRT P7 issue.

P7.c Issue Resolution Impact on Commissioning

There should be no impact on commissioning related to resolving the P7 issue.

P7.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

Several of the ATS items require closure. The most critical item within the ATS is the Cesium Monitoring System Specification 24590-WTP-3PS-11-T0001, that, when issued, will tie the entire system together.

Design and specification of the process control system, including features such as dual limit switches on critical valves, and DCS interlocks, have not been completed.

P8. Effectiveness of cesium-137 breakthrough monitoring system (Pretreatment Facility—Ion Exchange)

The WTP Cs-137 breakthrough monitoring system consists of the triad of flow measurement, sampling, and gamma monitoring. The Cs-137 breakthrough detection system provides critical operational information for the IX process, defines several operational aspects of the CXP/CNP process, and is an indication of the Cs-137 that will be fed to the melter. The design basis for the Cs-137 breakthrough monitoring system within the CXP/CNP systems was questioned by the EFRT because one of the legs for breakthrough detection relies on gamma radiation from the Cs-137 daughter Ba-137m with a 2.6-minute half-life rather than radiation directly from Cs-137 (EFRT 2006a). Previous experience at WVDP indicated that calibration for in-line Cs-137 monitoring was difficult and required sampling that could slow the CXP/CNP processing cycle.

P8.a Confirmation of Existing Closure Plans

The IRP identified one closure criterion to resolve the issue as stated below: complete an evaluation of the planned Cs-137/Ba-137m breakthrough monitoring system to determine adequacy to support anticipated WTP operations. The functional requirements and capability of the system will be summarized, uncertainties and potential operational risks will be identified, and design changes will be recommended.

The EFRT P8 issue was closed (CCN# 163068; 24590-WTP-RPT-PR-06-001, Rev. 0; 24590-PTF-3YD-CXP-00001, Rev. 1; 24590-WTP-ATS-QAIS-07-1159; 24590-WTP-ATS-QAIS-07-1160). Based on the EFRT recommendations, the required capabilities, performance, and operating strategy of the Cs-137/Ba-137m component of the breakthrough monitoring system were redefined, re-evaluated, and incorporated into components of an updated design for later specification (CCN# 163068; 24590-WTP-RPT-PR-06-001, Rev. 0; 24590-PTF-3YD-CXP-00001, Rev. 1; 24590-WTP-ATS-QAIS-07-1159; 24590-WTP-ATS-QAIS-07-1160). The redesign process and its objectives satisfied the closure criterion. The gamma monitors are a useful operational system that provides information on Cs-137 column loading and on residual Cs-137 in fluids, even though the gamma monitors have now been relegated to a less critical role within the CXP/CNP system. Five key recommendations were submitted and logged into the ATS. The recommendations enveloped the remaining essential characteristics for the Cs-137/Ba-137m breakthrough monitoring system.

P8.b Confirmation of Action Plans for Unresolved Issues

Three ATS items generated from the five recommendations remain open. Additional work must be performed; however, the tasks are straightforward as described in the ATS records, and there are no perceived technical impediments. The completion of the ATS items within the appropriate timeframe(s) and the completion of a final design and specification are recognized. The timing of the ATS actions is necessarily integrated to the level appropriate with the updating of the CXP/CNP system that will be completed in early 2011. Possible impacts of CXP/CNP process change will be translated into the Cs-137 breakthrough monitoring system.

P8.c Issue Resolution Impact on Commissioning

No impact is expected on commissioning from resolving the P8 issue.

P8.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The reliability of the number of gamma detectors (as the number has been reduced) should be carefully evaluated in light of, and versus, their overall utility. It is clear that feed characterization, flow control, sampling, and operational experience will play the largest role in the actual operation of the CXP/CNP system with respect to Cs-137 control. The results of resolving the P8 issue is a Cs-137/Ba-137m gamma detection system that can be employed as a useful, integral part of the system. Verification of successful integration of the monitoring system with the CXP/CNX system plan design document will be issued in early 2011.

P9. Undemonstrated Sampling System (Analytical Laboratory and Sampling)

The WTP must rely on analyses of sampled slurries to provide information required for effective process and product control, and thus the sampling and analytical systems are critical to the success of WTP. Based on experience at WVDP and DWPF, sampling and analysis of solids-containing fluids is challenging. There is confidence that the *analytical methods* selected will provide sufficiently precise and accurate analyses of samples (assuming that samples from the vessels have been proven to adequately represent vessel contents). However, an early test of the sampling system was compromised (due to a lack of adequate tank mixing) and did not demonstrate the adequacy of the sampling system. Similarly, the DWPF required rework of its slurry sampling system before it met its requirements. Based on this information, the EFRT indicated that the sampling system as designed may not prove adequate for handling slurries (EFRT 2006a).

An IRP was developed to address the P9 issue (24590-WTP-PL-ENG-06-0038, Rev. 1). The plan was to confirm that the Autosampling System (ASX) sampling system design is acceptable using simulants representing low and high bounds of rheology for LAW and HLW feed in a large, prototypic (approximately 70 percent) scale system that includes prototypic vessels, agitators, transfer pumps, and samplers. The results from these tests would support the final design of the selected sample system and the relevant Product Compliance Plans (24590-WTP-PL-RT-03-001, Rev. 4 for ILAW and 24590-WTP-PL-RT-03-002, Rev. 2 for immobilized high-level waste (IHLW)). The completion of the planned testing to support final sampling system design was considered necessary to ensure sampling system adequacy.

One closure criterion was identified in the IRP for the P9 issue:

> *to demonstrate that the sampling system will deliver samples within acceptable bias and uncertainty limits for HLW and LAW melter feed using both high- and low-bound simulants (24590-WTP-PL-ENG-06-0038, Rev. 1). The uncertainties estimated for sampling and level and composition measurements will be used in the algorithms used to define operating windows for subsequent vitrification.*

P9.a Confirmation of Existing Closure Plans

The closure basis for the P9 issue was the results of tests performed using a prototypic-scaled test platform representing WTP pretreated waste and melter feed vessels for HLW and LAW constructed at the VSL (CCN# 184906). A prototype of the ASX sampler was employed during the tests, although none of the automated sample transfer features was included in the test platform. The operating sequence for the final ASX sampler design was optimized and tested using four simulants in a campaign equivalent to four months of WTP operation.

Originally, four simulants (two HLW and two LAW) were defined for testing; however, the low-bound rheology simulant was excluded because of the absence of solids. HLW simulants included pretreated waste and melter feeds representing low-bound and high-bound rheological conditions. *Homogeneity testing was performed at selected tanks levels relative to impellers that demonstrated that simulants in the tank were sufficiently mixed*[9].

ASX sampling tests were performed to verify that the ASX system could collect samples that were representative of vessel contents. The numbers of samples collected were defined based on statistical analyses of previous data. Analyzed pretreated HLW and melter feed compositions were required to be within 4 percent bias and 5 percent relative standard deviation (RSD) at the 90 percent confidence level. If the bias is found to not be statistically different than zero, the allowable RSD is increased to 15 percent. Similarly for the LAW materials, the allowable bias is less than 10 percent and a 5 percent RSD at the 90 percent confidence level; if the bias is not statistically different than zero, then the allowable percent RSD is raised to 15 percent. If a component bias does not meet the criteria, then additional data are taken and analyzed to evaluate the nature of bias and its potential impact on the glass processing envelope.

The overall results for the LAW simulant tested indicated that the melter feed was well-mixed and that the samples collected were representative of vessel contents for the conditions tested (CCN# 184906). It is assumed that the pretreated LAW feed would also be well-mixed and that samples would be representative because of the absence of solids in the proposed simulant. It was not stated if additional testing confirmed this conclusion or if simulants with lower solids loadings would also be well-mixed and that samples would be representative; however, the corresponding risk would likely be small.

The HLW mixing and sampling requirements were largely satisfied for melter feed results (i.e., the waste compliance hold point). The acceptance limit for RSD was satisfied for the conditions tested; however, biases for some elements (e.g., lithium and boron) with analytical uncertainties, perhaps from dissolution problems during analysis, marginally exceeded test requirements. The biases in the data were reevaluated using a more traditional definition of bias and found to satisfy acceptance criteria (CCN# 184906).

An analysis of the potential impacts of the observed uncertainties and biases for pretreated LAW and HLW melter feed indicated that sufficient margin was likely available based on current LAW and HLW glass algorithms. Because the number of samples collected during testing exceeds that of an expected WTP maintenance outage to replace melter components, no impact on plant availability was anticipated.

P9.b Confirmation of Action Plans for Unresolved Issues

The TSG concluded that "there is a risk that the WTP LAW and HLW melter feed mixing, sampling, and analysis system will not support all requirements for waste form production based on the results of the testing program for EFRT issue P9, *Undemonstrated Sampling System*" (CCN# 184906). The risk was based on: (1) analytical uncertainty errors for those minor

[9] The mixing/homogeneity results obtained from resolving the P9 issue can be considered a basis for closing the EFRT issue (originally under the M3 rubric) concerning the lack of mixing for the mechanically-mixed vessels (EFRT 2006a). If additional changes are made to the sampler design or operating sequence, this closure basis will need to be reevaluated. If feeds with important characteristics significantly different than those used to develop the basis for defining simulants are discovered during characterization, the basis will have to be reevaluated.

components (< 0.5 wt%) important to melter operations and (2) higher sampling and analytical uncertainties from the high-bound HLW simulant testing results. The analytical procedures and methods can be improved, which could help resolve the potential performance risks associated with melter feed blending and composition control.

The TSG recommended the following (CCN# 184906):

- Review and assess the analytical methods and techniques identified for LAW and HLW composition control to ensure that they are appropriate.
- Issue the final mixing and sampling reports that address all test objectives and exceptions and incorporate the results from all issues data packages.
- Update LAW and HLW glass algorithms with the uncertainty estimates derived from the LAW and HLW sampling studies. ORP will be able to assess and determine any potential impact of the work completed in support of closure of the P9 issue.
- Confirm the performance and reliability of the Isolok® sampler O-ring.

The EM-TWS concurs with the above recommendations.

P9.c Issue Resolution Impact on Commissioning

The closure of the EFRT P9 issue does not represent an implicit acceptance of the vessel, mixing, or sampling system designs and/or the analytical methods and procedures that will be used in the WTP (CCN# 184906). Qualification testing will be required to qualify these systems for WTP operations. The mixing, sampling, and analytical uncertainties must be verified during WTP cold commissioning and updated in the LAW and HLW glass composition algorithms to ensure that sufficient margin is available for operations.

P9.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The current sampling system seems complex and, after a number of years, may become plugged or not work for some other reason. It may be appropriate to evaluate alternative methods for sampling.

No additional concerns were identified as a result of closing the EFRT P9 issue.

<u>P10. Lack of Analysis before Unloading Glass-Forming Chemicals into Silos (Balance of Facilities)</u>

The GFCs are added to storage silos. Although the chemical compositions are specified, there is no guarantee the GFCs will be put into the correct silo. Since there is no feedback from analysis of the LAW melter feed, the same misbatching error would be made repeatedly, sending misbatched feed to the melter potentially until glass can no longer be poured. Thus, there is a significant risk of misbatching the LAW melter feed, leading to premature melter failure (EFRT 2006a). This risk can best be eliminated through analysis of the melter feed.

P10.a Confirmation of Existing Closure Plans

Two approaches to handling this issue were proposed (CCN# 160532):

1. Include in WTP procedures for unloading glass formers into the silos verification of the proper routing of materials.

2. WTP approved revision to Integrated Sampling and Analysis Requirements Document, as described in the M16 IRP.

With an administrative procedure to make sure that the correct chemicals are in the correct bins, the chance of having the wrong chemical in a bin should be greatly diminished. This will be in addition to the normal signage that will be used to mark the unloading points. Even if a wrong chemical is put into a bin (or if the GFC loading system fails), the issue of making bad glass through using the wrong type or amount of GFC is resolved by taking a sample of the feed tank after it is mixed and before it is transferred to the melter feed tank.

The EM-TWS considers this issue closed because a sample of the melter feed will be taken.

P10.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues were identified during the closure process for the P10 issue.

P10.c Issue Resolution Impact on Commissioning

No impact is likely on commissioning from resolution of the P10 issue.

P10.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

No additional concerns were identified from the EM-TWS review of the P10 issue closure process.

P11. Incomplete Process Control System Design (Design of Control Systems)

The EFRT was concerned that the WTP process control system may not provide adequate control of the WTP process (EFRT 2006a).While design and implementation of the control system was in the early stages, the EFRT found indications that the system might not perform adequately due to differences among documents defining the design basis, lack of evidence of an agreed-upon control strategy, and a loss of experienced personnel needed to review system specifications. Experienced personnel have also been reassigned away from control system design and development to work on important, yet undemonstrated, process steps like caustic and oxidative leaching. There is risk that the control system will be incompatible with operational and control strategies and thus may provide inadequate process control.

P11.a Confirmation of Existing Closure Plans

The P11 IRP identified two closure criteria (CCN# 142014):

1. Issue the C&I Engineering Execution Plan that outlines resource deployment, training, and retention for design and implementation of control software and addresses the potential for loss of experienced personnel to review systems specifications.
2. Issue the Control Systems Design Review Plan that defines activities to review control system strategies relevant to the P11 issue and to demonstrate that these activities will address inconsistencies in upper-tier documents.

The P11 issue was closed when the above plans were issued and approved (CCN# 163080). Trends were also initiated for additional design verification and off-project review activities and to enhance P&IDs such that control functions are more fully shown.

P11.b Confirmation of Action Plans for Unresolved Issues

No unresolved issues were identified.

P11.c Issue Resolution Impact on Commissioning

No impact is likely on commissioning from resolution of the P11 issue.

P11.d Identification of Potential Additional Concerns Regarding EFRT Technical Issues

The WTP process control system may not provide adequate control if methodology and instrumentation specifications are not firm early enough. Resolution of this concern will be delayed until other flowsheet concerns are resolved. No additional concerns were identified from the EM-TWS review of the P11 issue closure process.

Summary

Charge 1 to the EM-TWS asks for verification that all of these EFRT issues have been closed. The EM-TWS adopted the standard as being demonstrated compliance with all corresponding IRPs. Each IRP is customized to the nature of the corresponding issue being addressed, but in general IRPs define the issue of concern, conditions necessary to address the concern, and a path forward for doing this within ongoing EPC activities, based on industry practices.

Closure of an issue does not mean that all related technology issues are completely resolved. Industry experience shows that resolution of technology issues frequently continues during construction and startup. For example, the procedures and protocols might require modification to plant components or operating conditions and further require that this modification be demonstrated during the startup and commissioning process. A plan for development and implementation of this modification based on acceptable industry practice would constitute IRP compliance and issue closure but, given the first-of-a-kind nature of WTP, unanticipated further concerns could possibly arise during this demonstration process.

The EM-TWS has observed that the current WTP Contractor, with DOE's concurrence, has satisfied the IRP procedures and protocols that constitute closure and is continuing to pursue these IRPs in parallel with EPC activities. The EM-TWS finds that the professionalism and effectiveness of the current WTP Contractor are adequate to meet the challenge of keeping the project on track to meet the project schedule.

The EM-TWS reviews for the 17 major and 11 potential issues (as designated by the EFRT) are summarized. The resolutions of many issues have some impact on commissioning, primarily in the need to test assumptions made to close issues as well as carrying forward of risks that were deemed acceptable by the TSG. A number of additional concerns were noted by the EM-TWS during its review; the most significant of these concerns for the five non-Newtonian vessels using PJMs: whether a TRL 6 was achieved and the apparent lack of a formal analysis to support EFTR M3 issue closure. A series of recommendations were made by the EM-TWS to help reduce the risks to the project in accordance with those made in closing the EFRT issues.

Appendix D

Hazards and Operability (HazOp) Review

Alignment with Chemical Plant and Industry Standards

The Environmental Management Tank Waste Subcommittee (EM-TWS) concluded that the plant design discipline is professional and comprehensive with regard to development of a project design in compliance with contract specifications and management of the technical risks associated with these actions in compliance with Department of Energy (DOE) and nuclear facility industry standards. Additionally, the EM-TWS reviewed G2 analysis as well as examples of process flow analysis throughout the system design. The Construction Project Review (CPR) conducted in May 2010 recently recommended a process for increased systems engineering. The EM-TWS believes that recognizing the Waste Treatment and Immobilization Plant (WTP) is a nuclear chemical plant; the systems approach should be in direct alignment to chemical plant operations and industry standards for the chemical industry.

Recognizing that, based on current design specifications, WTP will process a very large number of feed streams (current design calls for more than 500 process circuit campaigns over its mission life) with variable stoichiometric feeds, process set points and operational constraints, the EM-TWS believes that a chemical industry practice for Hazard and Operability analysis (i.e., HazOp) is warranted for each campaign. This analysis should start as soon as feasible and in coordination with the current initiative to prepare detailed system descriptions; but is should not be a precondition of any delay to proceeding with WTP baseline activities.

The review team believes the WTP design at this point is being directed toward a contract-specified set of average conditions that have been developed for consistency with mission performance objectives, but that the plant operator will adapt specific variable treatment schemes for individual feed vectors over the majority of tank waste feeds to achieve compliance with waste acceptance criteria requirements while optimizing operational efficiency. The HazOp analysis is an operational technique borrowed from the chemical industry and leads to a chemical hazards analysis, which should be reviewed for each of the 521 feed stream campaign process strategies to ensure compliance with accepted guidelines over the complete anticipated operating range. The operational team who performs this analysis should be made up of full-time, dedicated personnel from the Tank Farm Management Contractor and the WTP Contractor organizations with expertise in the following disciplines: operations, chemical, mechanical, nuclear materials management, nuclear criticality safety, and instrumentation and control. The team should be chaired by a representative from the DOE Federal Project Director's office. The work deliverable would be a facilitated HazOp review for additional campaigns and documentation of the process flow. This activity would complement a subsequent Operational Readiness Review and commissioning activities by providing insight into potential issues that should be addressed.

The work products from this effort should be integrated with WTP System Descriptions and safety basis documentation as a reference for process systems control strategies and operational strategic decisions over the mission life. Developing this work product is no small venture and since it could entail a one- to two-year effort with a substantial requisite resource base of operations and safety professionals, a scoping effort should be initiated as soon as possible. However, this HazOp analysis could be an effective technique to significantly reducing the resource commitment and residual baseline risk associated with plant commissioning and reduces the lifecycle liabilities associated with the project operations. In these respects, it could be considered to have substantial cost-benefit potential and may have a positive impact on project baseline performance.

Example Solution:

- Begin operational reviews, as soon as possible, using the HazOp methodology, for the best information currently available for feed compositions corresponding to each of the 13 high-level waste (HLW) groups and 2 low-activity waste (LAW) groups defined by the Waste Treatment Plan developed in response to External Flowsheet Review Team (EFRT) Issue M4. Process models (WTP G2, ASE Steady State Flowsheet Simulator, and APPS WTP Calculator) should be completed for each case within the operational review

- Additional WTP feed compositions should be studied based on feedback from Washington River Protection Solutions: operability analysis, advanced system planning, and supplemental waste treatment conceptual and design activities the need to gain further knowledge regarding WTP operability and safety.

- Based on results of the preliminary chemical hazards assessment and operability reviews, establish a standard template approach HazOp procedure to be utilized for subsequent WTP feed batch analysis, as input to the Feed Prequalification Process (EFRT Issue M5).

- Add a requirement to complete a HazOp for each actual WTP feed batch as a prerequisite to the WTP batch-specific feed prequalification process.

Confirmation of HazOp Type Analysis

WTP previously conducted a systems review for a waste stream Modeled "G2".Reference 24590-WTP-MRR-PET-08-002, Rev 1; WTP Contract Run, G2 Dynamic Model Run Results Report

A Dynamic (G2) Flowsheet model run was established by the WTP Contractor and ORP. The purpose of the run was to determine the present WTP Pretreatment baseline capacity for the WTP based on the currently available data. Two model runs were actually performed. The second run was to address issues identified during the first run. The flowsheet assumptions applied during these runs incorporate design changes for the capacity modifications and operational changes made since the last TUA (Tank Utilization Assessment; 24590-WTP-RPT-PO-05-008). Specifically the assumptions incorporated modifications made in response to the EFRT (External Flowsheet Review Team). Detailed descriptions of these modifications can be found in engineering reports 24590-WTP-RPT-ENG-06-011 and 24590-WTP-PL-06-014. A detailed description of the applied assumptions can be found in Appendix T.

A particular goal of these model runs was to estimate the Pretreatment facility mission length, i.e. the time required to process the Tank Farm waste inventory (TFCOUP Rev. 6) and average Pretreatment and HLW canister production rate.

Additionally, there has been steady-state flowsheet modeling for waste feed from approximately five double-shelled tanks at the Tank Farm. This steady-state flowsheet complements the dynamic flowsheet model.

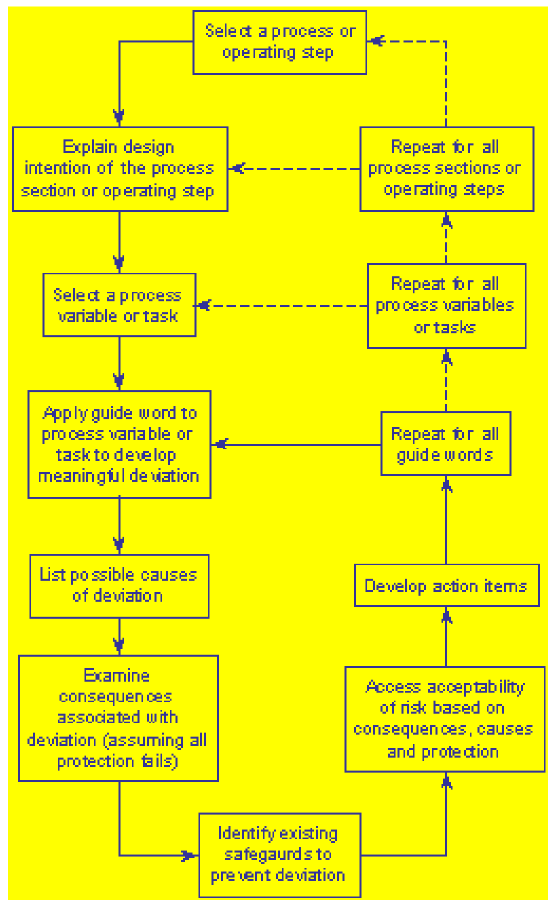
There is also a tool called the WTP Calculator. This tool used the 430 batches generated from the Tank Farm Operations Contractor's Hanford Tank Waste Operations Simulator (HTWOS) system model, not tank feeds, and was also a static flowsheet. This tool did not have a chemistry model, just simplified assumptions. The tool made some use of a thermodynamic ESP code to adjust five of the batches' input, and is the study that produced 13 sludge types and 3 liquid types from the batch feeds (WTP Waste Feed Analysis and Definition)

If the Department chooses to initiate a HazOp Review, the following provides a simplified methodology for a detailed operations feed stream analysis and approach:

A Hazard and Operability (HAZOP) study is a structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation. The HAZOP technique was initially developed to analyze chemical process systems, but has later been extended to other types of systems and also to complex operations and to software systems.

A HAZOP is a qualitative technique based on guide-words and is carried out by a multi-disciplinary team (HAZOP team) during a set of meetings. A HAZOP, or Hazard and Operability analysis, is a structured technique in which a multi-discipline team performs a systematic study of a process using guide words to discover how deviations from the design intent can occur in equipment, actions, or materials, and whether the consequences of these deviations can result in a hazard.

The results of the HAZOP analysis are the team's recommendations, which include identification of hazards and the recommendations for changes in design, procedures, etc. to improve the safety of the system. Deviations during normal, startup, shutdown, and maintenance operations are discussed by the team and are included in the HAZOP. A block flow diagram of the HAZOP process is shown on the right (Ref: http://www.sms-ink.com/services_pha_hazop.html).



- Design Intent - the way a process is intended to function.
- Deviation - a departure from the design intent discovered by systematically applying guide words to process parameters.
- Guide Word - simple words such as "high" pressure, "high" temperature, "leak" etc. that are used to modify the design intent and to guide and stimulate the brainstorming process for identifying process hazards. The library-based approach was used in which the most appropriate guidewords for the process were selected from the total list of possible guidewords.
- Cause - the reason why a deviation might occur.
- Consequence - the results of a deviation.
- Safeguard - engineered systems or administrative controls that prevent the causes or mitigate the consequences of deviations.
- Hazard Category - an assessment of the hazard risk of the operation. In this analysis, we have used the MIL-STD-882D, "Hazard Risk Assessment Matrix."

- Recommendations - recommendations for design changes, procedural changes, or for further study.

Confirmation of Action Plans for Unresolved Issues

The conduct of a HazOp Review should be completed for the basic process runs. The unresolved issues of capacity and alternate treatment requirements should be completed before alternate approaches for pretreatment and additional secondary waste process design are executed.

Issue Resolution Impact on Commissioning

One objective of commissioning should be to verify the necessary protection in place for critical issues identified from the operations review for the HazOp Review.

The final report of the Construction Project Review conducted at WTP in May 2010, states that

> *"…DOE should perform a systems-based review of the design against the contract functional requirements prior to the next CPR, or focus a separate Technical Subcommittee review in this manner…."*

The EM-TWS agrees and would recommend a format to include a HazOp Review and analysis.

Identification of Potential Additional Concerns Regarding EFRT Technical Issues

These will be determined following the detailed HazOp Review.

Appendix E

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Appendix F

Acronyms and Abbreviations

ASX	Autosampling System
ATS	Action Tracking System
BNI	Bechtel National, Inc.
BOF	Balance of Facilities
CARS	Consolidated Action Reporting System
CCN	Correspondence Control Number
CFD	Computational Fluid Dynamics
CIX	Cesium Ion Exchange
CNP	Cesium Nitric Acid Recovery Process
CPR	Construction Project Review
CRESP	Consortium for Risk Evaluation with Stakeholder Participation
Cs	Cesium
CXP	Cesium Ion Exchange Process System
D&D	Decontamination and Decommissioning
DBE	Design Basis Event
DF	Decontamination factor
DOD	Department of Defense
DOE	Department of Energy
DNFSB	Defense Nuclear Facilities Safety Board
DWPF	Defense Waste Processing Facility
EFRT	External Flowsheet Review Team
EIS	Environmental Impact Statement
EM	Office of Environmental Management
EM-1	Assistant Secretary for Environmental Management
EM-TWS	EM Tank Waste Subcommittee
EMAB	Environmental Management Advisory Board
EPC	Engineering, procurement, and construction
EPCC	Engineering, procurement, construction, and commissioning
FACA	Federal Advisory Committee Act
FEP	Feed Evaporation Process System
FRP	Feed Receipt Process System
G2	Process Analytical Model
GFC	Glass-forming chemical
HazOp	Hazards and Operability
HLW	High-level waste
HLP	HLW Lag Storage and Feed Blending Process System
HOP	Melter Offgas Treatment Process System
HPAV	Hydrogen in Piping and Ancillary Vessels
HTWOS	Hanford Tank Waste Operations Simulator
IER	Ion Exchange Resin
IEX	Ion exchange
IHLW	Immobilized high-level waste
ILAW	Immobilized low-activity waste
IRP	Issue Response Plan
ISARD	Integrated Sampling and Analysis Requirements Document
IX	Ion exchange

LAB	Laboratory Facility
LAW	Low-activity waste
LOAM	Low Order Accumulation Model
MTG	Metric tons of glass
MPR	Management Project Report
OR	Operations Research
ORP	Office of River Protection
P&ID	Piping and instrument diagram
PEP	Pretreatment Engineering Platform
PIH	Pretreatment In-Cell Handling
PJM	Pulse Jet Mixer
PNNL	Pacific Northwest National Laboratory
PT	Pretreatment Facility
Pu	Plutonium
PWD	Plant Wash and Disposal System
RAMI	Reliability, Availability, Maintainability, and Inspectability
RDP	Spent Resin Collection and Dewatering Process System
RF	Resorcinol formaldehyde
RLD	Radioactive Liquid Waste Disposal System
ROD	Record of Decision
RSD	Relative Standard Deviation
Sr	Strontium
SRNL	Savannah River National Laboratory
TCP	Treated LAW Concentrate Storage Process System
TFCOUP	Tank Farm Contractor Operations and Utilization Plan
TFM	Tank Farm Management
TIEF	Technical Issues Evaluation Form
TLP	Treated LAW Evaporation Process System
TMP	Technology Maturation Plan
TPRA	Technical and Programmatic Risk Assessment
TRA	Technical Readiness Assessment
TRL	Technology Readiness Level
TSG	Technology Support Group
UFP	Ultrafiltration Process System
U.S.C.	United States Code
VSL	Vitreous State Laboratory
WBS	Work Breakdown Structure
WRPS	Washington River Protection Solutions
WTP	Waste Treatment and Immobilization Plant
WVDP	West Valley Demonstration Project