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United States Government — Department of Energy

memorandum

Office of River Protection

DATE: SEP - 3 2015

REPLY TO ATTN OF: WSC:GBO 15-WTP-0137

SUBJECT: TRANSMITTAL OF THE OFFICIAL USE ONLY WASTE TREATMENT AND IMMOBILIZATION PLANT LOW-ACTIVITY WASTE FACILITY DESIGN AND OPERABILITY REVIEW AND RECOMMENDATIONS REPORT

TO: Mr. William F. Hamel
Assistant Manager, Federal Project Director
Waste Treatment and Immobilization Plant

This memorandum transmits the Final Official Use Only version of the Waste Treatment and Immobilization Plant Low-Activity Waste Facility Design and Operability Review and Recommendations Report.

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Waste Treatment and Immobilization Plant Low-Activity Waste Facility Design and Operability Review and Recommendations

OFFICE OF RIVER PROTECTION
United States Department of Energy

September 4, 2015

Prepared by U.S. Department of Energy
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Waste Treatment and Immobilization Plant Low-Activity Waste Facility Design and Operability Review and Recommendations

APPROVALS:

9-3-2015

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EXECUTIVE SUMMARY

The U.S. Department of Energy, Office of River Protection completed a review of the Low-Activity Waste (LAW) Facility at the Hanford Waste Treatment and Immobilization Plant (WTP). The review was conducted to provide the U.S. Department of Energy with increased confidence in the design and operability of key LAW Facility mechanical and process systems. The review was intended to identify potential vulnerabilities with respect to operability of specified systems and assist in the resolution of any issues identified. Chartered by the Assistant Manager/Federal Project Director for the WTP, the review was led by the subproject Federal Project Director for Special Projects. Washington River Protection Solutions LLC contracted and coordinated the review teams and served as co-lead for the review.

The review was conducted by independent multidisciplinary teams of established engineering experts from 14 companies with extensive experience in nuclear facility design, radiochemical engineering, and radiochemical process operations. Seven review areas with dedicated teams were established according to process or functional area similarity (Table ES-1).

Table ES-1. Low-Activity Waste Facility Design and Operability Review Areas

SYSTEM REVIEWS			
Container Systems	Mechanical Handling Systems	Process Support Systems	Ventilation Systems
• Container Export Handling • Container Finishing Handling • Container Pour Handling • Container Receipt Handling	• Melter Handling • Melter Equipment Handling • Radioactive Solid Waste Handling • Third Melter Capability	• Primary Off-gas Process • Secondary Off-gas/Vessel Vent Process • Concentrate Receipt Process • Melter Feed Process • Ammonia Reagent	• C1V • C2V • C3V • C5V

FUNCTIONAL REVIEWS		
Electrical Distribution	Instrumentation & Controls	Radiological Control and Industrial Safety & Hygiene
• Feed to the Low-Activity Waste Offgas Process (LOP/LVP) Exhauster fan motors • Feed to both melter power supplies • Feed to both LAW melters • Feed to the C2V, C3V, and C5V confinement system (HVAC) exhaust motors	• Integrated Control Network • Programmable Protection System	• Implementation of Radiological Control by each process system, collective signification, and systemic effects • Implementation of Safety & Health (Industrial Safety & Industrial Hygiene) by each process system, collective significance, and systemic effects

The review teams were independent, but relied on the cooperation of the WTP prime contractor, Bechtel National, Inc. for applicable source documentation and to provide confirmation of the factual accuracy of the review. A WTP subject matter expert was assigned for each system to work with the review teams and provide the required documentation, briefings, site tours, presentations, and general review support.

The WTP subject matter experts provided factual accuracy reviews of the results to ensure that the most recent and relevant project documentation was used by the review teams and was not misinterpreted. Further, dedicated roundtable meetings were conducted near the conclusion of the review to provide WTP with the opportunity to offer additional objective evidence to ensure factual accuracy. All objective evidence associated with factual accuracy provided by WTP has been incorporated in this report. However, to maintain independence, the review teams did not seek WTP concurrence with the review results.

Therefore, this report reflects the technical judgment of the Design and Operability review teams based on the teams' review of information provided by WTP, discussions with numerous WTP subject matter experts and observations made during LAW Facility visits.

The review teams identified 362 significant design vulnerabilities that could limit LAW Facility functionality and operability and 504 distinct opportunities for improvement for which implementation is highly recommended to mitigate the vulnerabilities prior to the start of radioactive operations, and in many cases prior to the start of commissioning. Unless resolved in a timely manner, the review teams expect that these vulnerabilities could result in unacceptable risk to the overall project mission.

Concomitant fundamental weaknesses and breakdowns in the programmatic implementation of design processes were also revealed, which may be a contributory cause of many of the identified vulnerabilities. Most of these programmatic issues (items 1–6 below) are similar to those identified in a design and operability review of the High-Level Waste Facility as reported in DOE/ORP-2014-04, *WTP High-Level Waste Facility Design and Operability Review and Recommendations*. Effective resolution of the programmatic deficiencies is required to prevent occurrence of future vulnerabilities similar to those identified. The eight key programmatic deficiencies are as follows:

1. Inadequate Discipline in Design Execution and Control
2. Inadequate and Incomplete Control System Design Requirements
3. Inadequate Analysis or Understanding of Production Capability
4. Inadequate Implementation of As Low As Reasonably Achievable Principles
5. Transfer of Scope and Risk to the Commissioning Phase
6. Inadequate Definition and Implementation of Design Requirements for Waste Management
7. Inadequate Consideration of Industrial Safety and Hygiene Requirements
8. Inadequate Consideration of Success of Operations and Maintenance Activities.

If left unresolved, the design vulnerabilities, coupled with the programmatic design process weaknesses, would likely continue to have a compounding impact on the functionality of individual LAW systems and the LAW Facility as a whole. If the currently identified vulnerabilities and/or any additional vulnerabilities identified as a result of these process weaknesses are not corrected, the facility is unlikely to achieve operational status within the anticipated timescale or achieve an acceptable throughput.

A key element of the review process was the identification of recommended paths forward and opportunities for improvement. In many cases these potential mitigating actions can be implemented in a relatively straightforward manner, others will typically require additional review and analysis and potentially a cost benefit analysis prior to implementation as part of any overall plan to address the vulnerabilities. In the judgment of the review teams, the associated risks (for the reviewed systems) can be more successfully managed if the opportunities for improvement are effectively implemented.

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ABBREVIATIONS AND ACRONYMS

ALARA	as low as reasonably achievable
AMR	Ammonia Reagent (System)
ASD	adjustable speed drive
BNI	Bechtel National, Inc.
BOF	Balance of Facilities
CD	critical decision
CFD	computational fluid dynamics
CO	carbon monoxide
CO_2	carbon dioxide
CO_x	carbon monoxide and carbon dioxide
CSLD	control system logic diagram
D&O	design and operability
DOE	U.S. Department of Energy
DWPF	Defense Waste Processing Facility
HEPA	high-efficiency particulate air
HLW	high-level waste
HMI	Human Machine Interface
HVAC	heating, ventilation, and air conditioning
ICD	interface control document
ICN	Integrated Control Network
ILAW	immobilized low activity waste
ITS	important to safety
kV	kilovolt
LAW	low-activity waste
LCP	LAW Concentrate Receipt Process (System)
LEH	LAW Container Export Handling (System)
LFH	LAW Container Finishing Handling (System)
LFP	LAW Melter Feed Process (System)
LMH	LAW Melter Handling (System)
LOP	LAW Primary Off-Gas Process (System)
LPH	LAW Container Pour Handling (System)
LRH	LAW Container Receipt Handling (System)
LSH	LAW Melter Equipment Handling (System)
LVP	LAW Secondary Off Gas/Vessel Vent Process (System)
MFPV	Melter Feed Preparation Vessel
MT	metric ton
NO_x	nitrogen oxides
OFI	opportunity for improvement
OR	operational research (model)

ABBREVIATIONS AND ACRONYMS (CONT.)

ORP	U.S. Department of Energy, Office of River Protection
PDSA	preliminary documented safety analysis
PPE	personal protective equipment
PPJ	Programmable Protection System
RWH	LAW Radioactive Solid Waste Handling (System)
SBS	submerged bed scrubber
SME	subject matter expert
SSC	structure, system, and component
TOC	Tank Operations Contractor
UK	United Kingdom
UPS	uninterruptible power supply
WTP	Waste Treatment and Immobilization Plant

1.0 INTRODUCTION

This report documents the results of an independent design and operability (D&O) review of the U.S. Department of Energy (DOE) Office of River Protection's (ORP) Waste Treatment and Immobilization Plant (WTP) Low-Activity Waste (LAW) Facility systems. Key LAW systems were selected for review to provide DOE with increased confidence that the LAW Facility could successfully achieve its mission objectives.

The ORP Assistant Manager responsible for the WTP Project chartered the review and assigned a senior federal project director to be the ORP lead. Washington River Protection Solutions LLC contracted and coordinated the review teams and a senior Washington River Protection Solutions LLC manager co-led the review.

The review was conducted by independent multidisciplinary teams of established experts from 14 companies with extensive experience in nuclear facility design, radiochemical process engineering, operations, and maintenance. Abbreviated review team biographies are included in Appendix A.

This report documents the results of the review performed by the D&O review teams and reflects the technical judgment of the teams based on review of information provided by WTP, discussions with numerous WTP subject matter experts (SME), and observations made during LAW Facility visits. The review identified a number of issues and concerns (collectively termed vulnerabilities) as well as opportunities for improvement (OFI) actions to mitigate or resolve the vulnerabilities. The vulnerabilities identified are discussed in summary fashion in this report. Appendix B provides a detailed list of all vulnerabilities corresponding to each LAW system reviewed.

Although the review teams were all independent, the review process was also appropriately collaborative. A WTP Prime Contractor SME was assigned for each system to provide relevant design documentation including drawings and specifications. The SMEs also assisted the teams with WTP site facility tours, and presentations. In addition, WTP personnel contributed to and provided insights that supported the development of the vulnerabilities as well OFIs.

The remainder of this report is organized as follows:

- Section 2.0 defines the review objectives.
- Section 3.0 describes the scope including the review process and identifies the specific systems evaluated.
- Section 4.0 describes underlying programmatic factors associated with the design vulnerabilities identified in Section 5.0.
- Section 5.0 provides summary review results organized in order of greatest to least impact to LAW Facility functionality.
- Section 6.0 provides a suggested path forward on the key issues for ORP.

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2.0 OBJECTIVE

The objective of the review in accordance with the 56962, *Low-Active Waste Facility Systems Design and Operability Review Plan* (Rev. 0) was to evaluate the D&O of selected LAW Facility systems in order to identify potential vulnerabilities with respect to operability and assist in the resolution of any issues identified.

The focused objective of this review was to assess the functional capability of the specified LAW systems and to answer the fundamental question of "will the as-designed systems perform their design and safety function in accordance with the WTP contract and design basis requirements?"

Specifically, the review was to:

- Determine if the system and associated components would meet their functional and design requirements
- Identify design shortcomings and specific issues that would either prevent the specified LAW systems from operating or impact design throughput
- Make recommendations to improve or correct the design based upon the issues found during the reviews.

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3.0 SCOPE

The D&O review targeted the following 13 of 26 LAW Facility systems, which ORP considered having the highest potential risk to impact the LAW mission:

- LAW Container Export Handling (LEH) System
- LAW Container Finishing Handling (LFH) System
- LAW Melter Handling (LMH) System
- LAW Container Pour Handling (LPH) System
- LAW Container Receipt Handling (LRH) System
- LAW Melter Equipment Handling (LSH) System
- LAW Concentrate Receipt Process (LCP) System
- LAW Melter Feed Process (LFP) System
- Confinement Ventilation (C1V, C2V, C3V, and C5V) Systems
- LAW Primary Off-Gas Process (LOP) System
- LAW Secondary Off Gas/Vessel Vent Process (LVP) System
- LAW Radioactive Solid Waste Handling (RWH) System
- Ammonia Reagent (AMR) System.

In addition, the following facility wide operability design aspects were also reviewed:

- Electrical Distribution Systems
- Instrumentation and Controls
- Radiological Control and Industrial Safety and Hygiene
- Third Melter Capability.

The system review was generally broad based, with a deep dive into detail where more significant issues were indicated. Although the review did not represent a full investigation of extent of conditions of system vulnerabilities, it identified a substantial number of vulnerabilities that if not corrected could adversely impact the LAW mission.

3.1 APPROACH

The review teams were comprised of technical experts in a variety of disciplines and the review was organized by common system areas as shown in Table 3-1.

Table 3-1. Low-Activity Waste Facility Design and Operability Review Areas.

SYSTEM REVIEWS			
Container Systems	Mechanical Handling Systems	Process Support Systems	Ventilation Systems
• Container Export Handling • Container Finishing Handling • Container Pour Handling • Container Receipt Handling	• Melter Handling • Melter Equipment Handling • Radioactive Solid Waste Handling • Third Melter Capability	• Primary Offgas Process • Secondary Off-gas/Vessel Vent Process • Concentrate Receipt Process • Melter Feed Process • Ammonia Reagent	• C1V • C2V • C3V • C5V

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The WTP contractor (Bechtel National, Inc. [BNI]) identified and assigned the appropriate SMEs and they provided documentation and briefed the review teams on key aspects of the D&O approach, including technical design basis, control and operating philosophy, and safety basis assumptions. The WTP SMEs also supported several review team visits to the construction site where the teams viewed the physical plant areas and the installed or stored equipment.

The review teams developed and refined their lines of inquiry, identified any additional expertise required to supplement review areas, and ensured an effective and representative evaluation of each system.

The review teams held routine and ad hoc meetings with the WTP SMEs to ask questions, clarify understanding, and informally brief the SMEs on any issues identified. The WTP SMEs reviewed vulnerabilities identified (with associated supporting notes) for factual accuracy.

Throughout the review, the teams provided periodic reports of results to a senior review team, as well as presentations to DOE and BNI.

3.2 REVIEW PROCESS

The review process was systematic and methodical, with the objective of achieving an insightful outcome that suggests remedies that may mitigate the potential adverse impacts associated with design/operational vulnerabilities. The review teams applied a combination of document reviews, meetings/discussions, and in-field assessments to generate review results. Each review team developed summaries of the identified vulnerabilities, which are included in Appendix B. Initial results underwent clarification and factual accuracy review by WTP SMEs to promote understanding, confirm factual accuracy, and gain additional perspective.

This review suggests a cost benefit to addressing vulnerabilities as early as possible since deferral until commissioning or beyond would, in many cases, be more complex and time consuming. In addition, many of the BNI design and construction experts would not be available to lend their expertise to implementing the solutions.

A key element of the review process was to ensure that the results were based on factually accurate design information. Specifically, WTP SMEs provided factual accuracy reviews of the results to ensure that the most recent and relevant project documentation was used by the review team and was not misinterpreted. It is important to note that the factual accuracy review was not intended as a means to reach agreement on issues or to achieve WTP Project approval of the review analysis or results.

WTP personnel contributed to and provided insights that supported the development of the vulnerabilities as well as OFIs. Further, dedicated roundtable meetings were conducted near the conclusion of the review to provide WTP with the opportunity to provide additional objective evidence to ensure factual accuracy. All objective evidence associated with factual accuracy provided by WTP has been incorporated in this report.

The detailed review results were recorded on record of review forms, a summary of the record of reviews are included as Appendix B of this document. Not all issues identified were new issues identified as a result of this review and a number of issues were included that did not appear to have been adequately resolved despite them being previously identified by WTP or other independent reviewers. Where it was known and documented that issues had been previously identified, this information was generally included in the record of review form.

To facilitate future ORP decision making, the review teams ranked the potential impact of identified vulnerabilities, consistent with the review plan approach, relying on experience based judgment regarding the consequences, probability, and overall operational impact using an impact guideline developed for the review (formal risk assessment models were not used). The review impact guideline was adapted from Washington River Protection Solutions LLC's TFC-PLN-39, *Risk and Opportunity Management Plan* and is similar to the impact guideline used to support the High-Level Waste (HLW) Facility D&O review (see DOE/ORP-2014-04, *WTP High-Level Waste Facility Design and Operability Review and Recommendations*).

Tables 3-2 and 3-3 are derived from TFC-PLN-39 for ranking consequence and probability. Table 3-4 was used to determine the vulnerability ranking and associated recommendation. The results and bases for the impact rankings for individual vulnerabilities are provided in the detailed record of review forms.

Table 3-2. Guidelines for Ranking Consequences.

Consequence	Threshold Definition
Very Low	May require post-CD-4 changes to operational/maintenance approaches (e.g., procedures, training tools) to enable full system functionality without redesign/upgrade. Minor throughput (<10%) or operational continuity impacts anticipated. Cost impact: < $1 million Schedule impact: < 1 month
Low	May require post-CD-4 upgrade with attendant change to operational/maintenance approaches to enable full system functionality. Low-risk workaround can be implemented to enable functionality at reduced throughput (10–25% reduction) as bridge to upgrade. Cost impact: $1–$10 million Schedule impact: 1–3 months
Medium	May require redesign/reanalysis of portions of systems to enable adequate system functionality to achieve CD-4. Extensive workaround to achieve desired functionality. Design may not be sufficiently complete such that judgment regarding functionality can be determined. Proceeding with current design may result in significant throughput reductions (25–50%) and intermittent functionality. Cost impact: $10–$50 million Schedule impact: 3–6 months
High	Design likely requires substantial rework to provide acceptable functionality. Workaround not identified or very high risk. Significant throughput reductions (>50%) likely with intermittent functionality. Cost impact: $50–$100 million Schedule impact: 6–12 months
Very High	Design functionality not feasible/operable. New design, operations, or maintenance concepts required. Cost impact: >$100 million Schedule impact: >12 months

CD-4 = Critical Decision 4.

Table 3-3. Guidelines for Ranking Probability.

Probability	Threshold Definition
Very Low	The probability of a specific vulnerability is ≤10%.
Low	The probability of a specific vulnerability is 10% < P ≤ 25%.
Medium	The probability of a specific vulnerability is 25% < P ≤ 75%.
High	The probability of a specific vulnerability is 75% < P ≤ 90%.
Very High	The probability of a specific vulnerability is >90%.

Table 3-4. Guidelines for Ranking Vulnerabilities and the Associated Recommendation.

Action Recommendation (Pre or Post CD-4)

Probability						
	Very High	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	High – Action Pre-CD-4	High – Action Pre-CD-4
	High	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	High – Action Pre-CD-4	High – Action Pre-CD-4
	Medium	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium –Action Pre-CD-4
	Low	Low – Action Post CD-4	Low – Action Post CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4
	Very Low	Low – Action Post CD-4	Low – Action Post CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4
		Very Low	**Low**	**Medium**	**High**	**Very High**
		Consequence				

CD-4 = Critical Decision 4.

During the course of this review, the teams identified recurring fundamental deficiencies in the approach to design that appeared to be key contributors to the evolution of the vulnerabilities affecting design functionality. These design approach deficiencies are reported in Section 4.0.

Summary descriptions of the vulnerabilities identified in the 13 selected LAW Facility systems that were considered to require remediation before Critical Decision (CD) 4 completion or requiring significant actions are presented in Section 5.0 of this report. The system-specific issues identified in Section 5.0 are considered in many cases to be a result of the underlying design process issues identified in Section 4.0.

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4.0 FUNDAMENTAL PROGRAMMATIC DEFICIENCIES CAUSING DESIGN AND OPERABILITY VULNERABILITIES

The D&O review teams observed recurring fundamental programmatic design process deficiencies that appear to be key contributors to or causes of the system-specific D&O vulnerabilities. Most of these programmatic issues (items 1–6 below) are similar to those identified in a D&O review of the HLW Facility as reported in DOE/ORP-2014-04.

However, the impacts of the programmatic deficiencies are revealed differently in LAW since the LAW Facility design is uniquely based on a contact operation and maintenance approach. Furthermore, the LAW Facility is at an advanced state of design and construction, thereby increasing the urgency of corrective actions associated with the programmatic deficiencies.

Therefore, the review teams concluded that a full discussion of the programmatic issues was appropriate rather than deferring to the HLW D&O Report. The teams recognize that ongoing and planned corrective actions to resolve the issues self-identified by WTP through the WTP Reliability Validation Process may ultimately improve the programmatic deficiencies. However, the teams did not review proposed corrective actions associated with the programmatic deficiencies as part of the LAW Facility D&O review process.

In the judgment of the teams, the D&O vulnerabilities in combination with the fundamental programmatic deficiencies are likely to have a compounding impact on the functionality of individual LAW Facility systems and the LAW Facility as a whole. The LAW Facility D&O review was intended to complement and reinforce, not substitute for, project multidiscipline design reviews that typically are performed at a very detailed level.

It was not the primary goal of the system-specific reviews to focus on recurring process wide vulnerabilities, rather the teams' recorded evidence of these as the review progressed. Because of the nature of the differing lines of inquiry used, these processwide vulnerabilities may not appear as prevalent in some systems as in others. This should not be considered an indication that an extent of condition evaluation should not be performed in relation to these issues. Rather, it is an indication that, for a specific system, the review teams considered the available time to be more effectively used in the identification of new issues specifically related to that system. Therefore, the review teams recommend extent of condition assessments for all programmatic issues identified in this report.

The eight key programmatic deficiencies identified for discussion in this section were repeatedly identified during the course of the review. Effective resolution of these deficiencies is required to prevent occurrence of future vulnerabilities similar to those identified in Section 5.0. No account was taken of ongoing actions in progress at the time of the review as a result of programmatic deficiencies identified from the HLW D&O review and the Reliability Validation Process and the effect these actions would have on mitigating these programmatic deficiencies (e.g., through the 24590-WTP-PL-MGT-14-0006, *Managed Improvement Plan* [MIP]).

A synopsis of the key programmatic deficiencies identified as causing the system-specific vulnerabilities are as follows:

1. **Inadequate Discipline in Design Execution and Control**: It was evident for the systems reviewed that requirements for design execution and control were not being met at an acceptable level.

   Failure to effectively establish disciplined design processes results in procurement and installation of equipment that does not meet the desired functional requirements and technical specifications. If left unmitigated, there is a potential that the final design cannot be validated and verified. This may result in an inability to effectively declare readiness to operate, pass an operational readiness review, and achieve operational status.

2. **Inadequate and Incomplete Control System Design Requirements**: The requirements for the equipment and process control systems lack sufficient clarity of definition and documentation to ensure the functionality of the LAW Facility systems.

   The quality classification for the control system software does not appear to be consistent with the hazards and functions that the system is intended to control.

   Further, the current approach used to document the identified instrument and control system functions results in a very large number of documents, thereby making configuration control of the systems nearly unmanageable. Prior reviews have identified similar concerns.

3. **Inadequate Analysis or Understanding of Production Capability**: The basis for the LAW Facility production capability is incomplete and/or not technically defensible. Therefore, reasonable projections of future plant performance and production are not reliable.

4. **Inadequate Implementation of As Low As Reasonably Achievable (ALARA) Principles**: There are specific regulatory and contractual requirements associated with meeting goals and objectives intended to reduce worker exposures and the potential for spread of radioactive contamination within a nuclear facility to be ALARA.

   Due to a lack of task analyses to reasonably estimate worker exposure and models to predict contamination migration patterns, there is insufficient evidence that ALARA goals and objectives will be achieved. Given the nature of complex chemicals that will enter the LAW Facility, this deficiency exists for chemical as well as radiological hazards.

5. **Transfer of Scope and Risk to the Commissioning Phase**: A number of activities were identified in which integrated testing or functional demonstrations of critical system components are deferred to the commissioning phase of the project.

   Therefore, additional cost and schedule risks are likely as a result of postponing functional design validation of some systems to commissioning.

6. **Inadequate Definition and Implementation of Design Requirements for Waste Management**: The design process has not adequately considered or implemented sufficient features necessary to ensure the capability and reliability of secondary waste management systems to support the LAW mission.

7. **Inadequate Consideration of Industrial Safety and Hygiene Requirements**: There are specific safety and health regulatory and contractual requirements that must be met as part of the design and operational process. In addition, hazard identification and control are key core functions of an effective Integrated Safety Management System (ISMS) Program. Fundamental weaknesses were identified in the hazard identification and mitigation process used to address chemical and physical hazards.
8. **Inadequate Consideration of Success of Operations and Maintenance Activities**: There was limited evidence that a thorough and systematic assessment of the facility design has been undertaken to ensure that operational and maintenance tasks required for the effective operation of the facility are safely executable, as the current design depends on hands-on operation and maintenance activities. There are questions about the safe and efficient performance of operators and maintenance technicians in environments with elevated temperature, chemical and radiological hazards, and challenging ergonomics that are currently incompletely defined and have not been modeled or considered in sufficient detail.

Figure 4-1 illustrates the cause and effect relationships associated with these eight deficiencies. As indicated by Figure 4-1, it is imperative that these programmatic deficiencies be fully addressed, including a detailed extent of condition review. Resolution is essential to remediate current issues and prevent recurrence of D&O vulnerabilities as the design progresses. Appendix C summarizes these programmatic deficiencies and recommended path forward actions.

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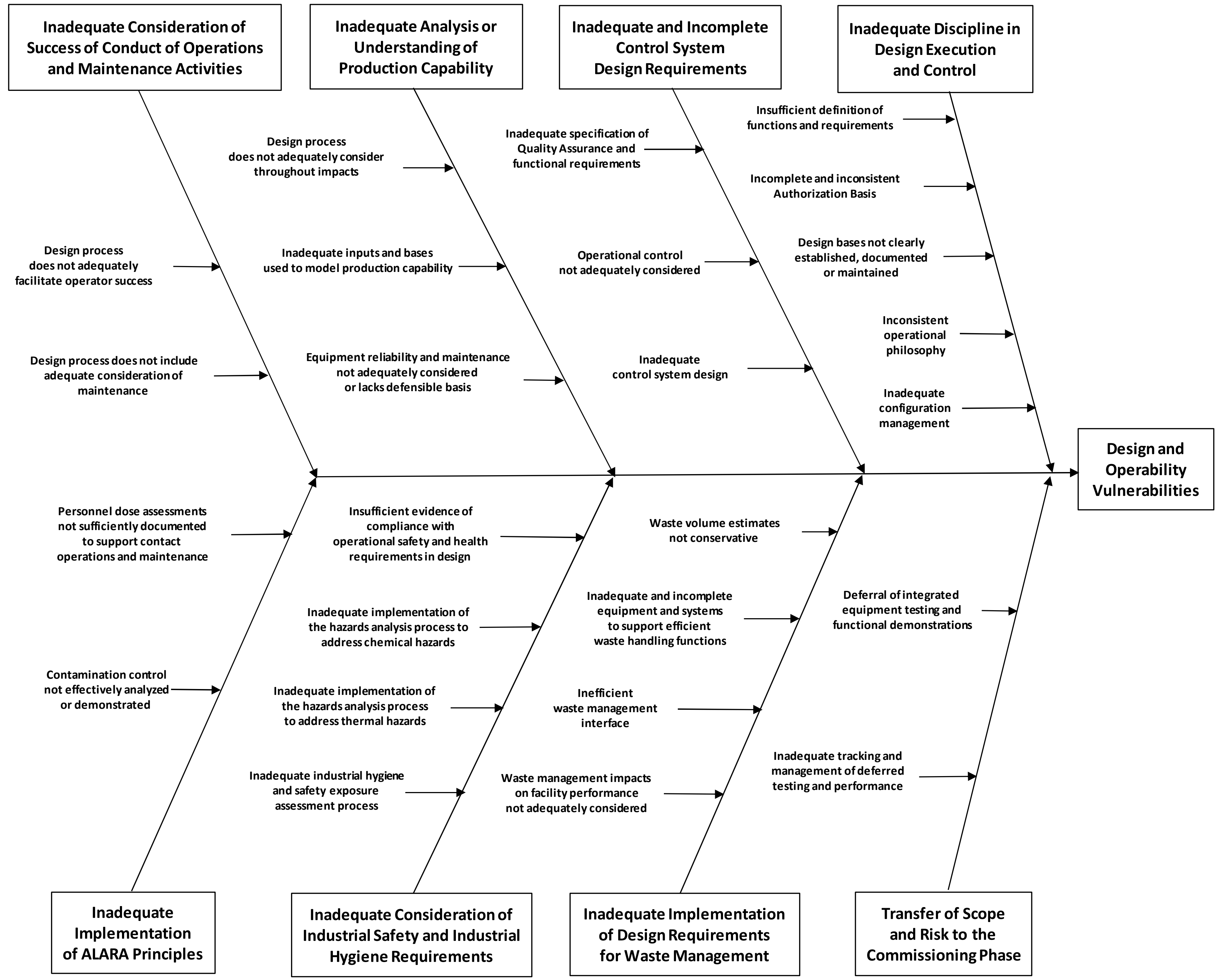

Figure 4-1. Cause and Effects of Fundamental Programmatic Deficiencies.

The following discussion provides representative examples, potential and/or realized consequences, conclusion(s), and recommended path forward for each of the eight deficiencies.

4.1 INADEQUATE DISCIPLINE IN DESIGN AND EXECUTION CONTROL

A comprehensive and rigorous design process should clearly establish the design criteria (design functions and requirements), define a documented basis of design, and apply a configuration management process that manages and maintains the data and information to successfully complete the design development and enable subsequent nuclear operations.

4.1.1 Summary

Throughout the review, it was apparent that a rigorous approach to design execution and control was not evident in the documents reviewed. Design-process issues are the largest cause of all vulnerabilities found during the review and are characterized by the following:

- **Insufficient definition of functions and requirements**: The functions and requirements (design criteria) of each structure, system, and component (SSC) have not been consistently defined or integrated. As a result it cannot be determined if the overall plant design will meet the integrated plant system requirements.
- **Incomplete and inconsistent Authorization Basis**: Key authorization basis documents such as the 24590-WTP-PSAR-ESH-01-002-03, *Preliminary Documented Safety Analysis to Support Construction Authorization; LAW Facility Specific Information* (PDSA) and environmental permits are either incomplete, undergoing revision and/or contain inconsistencies such that the design requirements for some equipment and systems are subject to individual interpretation of design intent. This situation results in system designs that may not be in alignment with the fundamental safety and environmental requirements and are likely to require modification in order to achieve a fully functional system.
- **Inconsistent operational philosophy**: The lack of clear consistent documentation contributed to the lack of common understanding across disciplines within the WTP Project design team of general operational intent. This coupled with a lack of regular multidiscipline reviews led to differences in opinion between project functional groups regarding how some systems should operate. Further, it is unclear that the scope and impact of operations assumptions (e.g., administrative controls and actions) embedded in the design (as a result of calculations, studies, tests, etc.) have been communicated, agreed, and accepted.
- **Design bases are not clearly established, documented or maintained**: The justification for selection of specific design features or the adequacy of how and why the design satisfies the design intent is not clear. As a result, uncertainties are introduced regarding the adequacy of equipment selection, sizing and performance requirements. As a result the information necessary to ensure future modifications can be safely implemented and are consistent with the design basis requirements may not be available. Additionally, design bases information relied upon to establish readiness to operate and support operations activities and troubleshooting may not be available or difficult to identify.

- **Inadequate configuration management**: Design documentation is not adequately maintained or is inconsistent, making design management and configuration control extremely difficult. In addition, use of obsolete and superseded documents along with inconsistent naming conventions was observed. The WTP documentation system appears to be cumbersome and contains historical, redundant, and restricted information, which makes it difficult to be sure of the document's relevance without recourse to personnel with expert knowledge of the project and the rationale for decisions made. This deficiency can adversely impact the declaration of "readiness" to operate. There are several examples in the DOE Complex where this deficiency has had significant adverse impacts.

4.1.2 Examples

Following are some representative examples of vulnerabilities that appear to be caused by inadequate discipline in design and execution control:

- The ventilation system failure modes and impacts for normal and off-normal conditions have not been identified. These conditions should include startup sequencing, reduced production modes, and defined maintenance modes as well as other conditions that are not considered "normal" operations.
- Exhaust fan sizing does not take into account design changes associated with higher incoming air temperatures. Fan performance is reduced with higher air temperatures and the flowrate will be reduced, resulting in potentially inadequate contamination confinement in some rooms.
- Uninterruptible power supplies (UPS) for critical components are undersized and do not meet capacity requirements during a loss of power event. Equipment rooms that house the UPS batteries are too small to accept the additional number of batteries needed to meet the requirements.
- Cooling times used in design analysis of the LAW container do not have a technically defensible basis. The cooling values provided to the review teams used nonprototypic tests as a basis for input to stress calculations to ensure the container integrity under thermal operating conditions. When a container full of molten glass is lifted, there is a chance that the container lifting flange will fail because it has not cooled enough to regain its strength.
- The submerged bed scrubber (SBS) is a main component in the melter offgas system and is relied on to reduce the temperature of melter offgas stream and remove contaminants from the air stream. The design temperature requirement for offgas stream coming directly off the melter was specified to be 1250°F. Therefore, the design of some SBS components, including an O-ring gasket used to seal the vessel, must be compatible with this temperature. However, the O-ring provided by the vendor will likely fail at temperatures above 250°F. This O-ring design was accepted by the WTP Project without evidence of documented analysis or basis.
- Electrical equipment in high temperature areas are not properly designed for the ambient conditions as required. Projected temperatures in several areas of the pour handling system exceed the specified design values of electrical components. This may lead to

reduced electrical capacity, overheating of components, signal failure, electrical shorts, and interruption of operation.

- According to the PDSA for the LAW Facility, one of the most significant postulated chemical events involves the release of nitrogen oxides (NO_x). Current safety analysis indicates that the NO_x hazard is eliminated 2 hours after feed to the melter is terminated. At this point, safety-significant controls intended to prevent the NO_x hazard can be relaxed. However, the impacts of process scale-up and waste feed uncertainties on the safety analysis that supports the 2-hour based approach to eliminating the NO_x hazard are unclear. Furthermore, only an indirect approach (i.e., temperature in the melter plenum) is currently available to confirm that the NO_x hazard has been eliminated after 2 hours. Confirmation of current estimates that the NO_x hazard is eliminated after 2 hours will be necessary during the commissioning phase. There appears to be no analysis on the rate of cold cap burn off following a loss of power event when the melter is cooling. If the 2-hour period, which is currently based on trials carried out on the Vitreous State Laboratory melter (which may not be representative or conservative), is determined to be inadequate, the design of systems required by the Authorization Basis to function for the burn off period will need to be readdressed. The impact to the design and in particular the credited safety-significant-SSCs could cause significant delays and cost increases, which could be more significant if not realized until commissioning or even active commissioning when a potential inadequacy in the safety analysis could exist.

4.1.3 Conclusions

Failure to effectively establish disciplined design processes, which are relied on to systematically establish and maintain the design bases, results in procurement and installation of items that do not meet the desired functional requirements and technical specifications. There is a risk the final design cannot be validated and verified, resulting in an inability to effectively achieve and demonstrate readiness to operate. Additionally, future design changes may be difficult to implement if these cannot be confirmed to meet the design basis requirements.

4.1.4 Recommended Path Forward

BNI is currently assigned responsibility as both the Design Authority (responsible for specification and confirmation of compliance with design criteria) and the Design Agent (responsible for preparing a design compliant with the specified criteria). Typically the Design Authority is an owner function to ensure that the design policies programs and requirements remain in alignment with the primary goals of the owner. Because in this case the Design Authority and Design Agent are an integral part of the same organization, DOE should ensure adequate oversight at a detailed level to independently ensure that the owner's requirements and intent continues to be the primary focus of the project.

The WTP Project is currently updating the design process as a result of internal reviews. The project should reintroduce and institutionalize multidisciplinary design reviews and monitor their effectiveness. In conjunction, the following suggested complementary actions should further improve design execution and control and mitigate the identified deficiencies:

- Conduct reviews to ensure that the primary documents relied upon to establish design functions and requirements are accurate and complete. A key objective is to ensure that specific/quantifiable requirements are established.
- Review of the overall WTP documentation system should be undertaken with a view to providing relevant and appropriate documentation to support operations and commissioning and removing all superfluous, obsolete, and restricted information to separate archives. This will include the generation of an essential/required documentation list.
- Conduct multidiscipline reviews of the individual system designs and associated documentation for compliance with the functions and requirements established in the primary documents. Confirm that any procured items, those in procurement, or presently installed meet the functions and requirements.
- Implement sizing standards/guides for equipment to provide a standardized documented basis for design. These should include typical design margins to ensure a conservative design is achieved.

4.2 INADEQUATE AND INCOMPLETE CONTROL SYSTEM DESIGN SPECIFICATION AND EXECUTION

The control system hardware and software relied upon to safely and reliably control the LAW Facility equipment must meet functional requirements, design and quality standards commensurate with the defined control function. To ensure the required process control functionally, operability, safety, and efficiency required to meet the LAW Facility production mission these requirements and standards must be clearly defined and demonstrably achieved.

4.2.1 Summary

The WTP Project established two independent control systems to meet the LAW Facility control requirements:

- The **Integrated Control Network (ICN)** is the distributed control system used for nonsafety related routine process control functions. The combination of hardware (instruments and controllers) and software programs for this system must enable the LAW Facility equipment and systems to operate reliably and efficiently to achieve the LAW Facility glass production requirements.
- The **Programmable Protection System (PPJ)** is dedicated to ensuring that the LAW Facility processes and equipment reliably revert to a safe state during postulated events that otherwise could lead to an unsafe condition. The combination of hardware and software for this system must achieve higher levels of reliability than for the ICN and is required to be developed under more rigorous life-cycle requirements commensurate with the safety-related nature of the application.

In order to ensure that the ICN and PPJ are able to perform their required control functions, the functional requirements of both control systems must be specifically defined to provide a clear description of requirements to support design, testing, and review. The review identified significant deficiencies regarding the definition and documentation of the ICN and PPJ control system functions and requirements as follows:

- **Control systems lack adequate specification of quality assurance and functional requirements**: During the course of this review, it was observed that the functional requirements of the control systems were not clearly specified and did not include sufficient supporting bases such that the intended control intent could be validated. Further, the D&O team questions whether the quality level of the software is in full compliance with DOE O 414.1C, *Quality Assurance*, which may therefore lead to conditions where personnel and the environment are not adequately protected.
- **Design process does not adequately consider operational control**: Review of the design and operational parameters of the LAW Facility found that there was not a clear understanding of how certain components of the ICN will support safe operation of the facility. Consequently, systems may not function as expected under normal and off-normal conditions.
- **Inadequate control system design**: The monitoring and control system design for the LAW Facility does not appear to have adequately considered available design input, requirements, or industry standards. This may result in systems not functioning as expected under normal and off-normal conditions.

4.2.2 Examples

Following are some representative examples of vulnerabilities that appear to be caused by inadequate and incomplete control system requirements:

- The ICN appears to perform defense-in-depth functions and to support regulatory reporting criteria for environmental permits. However, the quality level of the software to ensure that the operations and associated data is suitably robust and meets all regulatory and consensus standard requirements is below the level dictated by DOE O 414.1C.
- The current method for documenting control system requirements is through the use of control system logic diagrams (CSLD). The review team concluded that the logic diagrams are inadequate for the function because:
  - There is no clear link back to higher level functions and requirements.
  - There is no clear method to document test criteria.
  - Requirements (from upper tier documents) and design features (functionality to make the system operate) are comingled and mutually indistinguishable within the CSLDs.
  - Permit affecting or defense-in-depth features, providing control system layers of protection within the CSLDs, are indistinguishable from functions with negligible consequence to safe operation of the facility.

  - The methodology is not consistent with the 24590-WTP-QAM-QA-06-001, *Quality Assurance Manual*; NQA-1, *Quality Assurance Requirements for Nuclear Facility Applications*; or ISA 84, *The Standard for Safety Instrumented Systems*.

- Instrument uncertainties are not properly calculated and evaluated, resulting in a control system methodology for the LAW Facility confinement ventilation systems that may not be tenable.
- The control strategy for parallel operation of pumps and fans throughout WTP is not technically defensible and is likely to result in unstable operation.
- No WTP Project process was presented to allow software elements requiring modification during commissioning, startup, and operations to be isolated, modified, and regression tested and reintegrated, while maintaining overall configuration control and minimizing the potential for unintended consequences. If the software structure does not support a process to do this, the consequences are potentially very significant.
- The current level of automation maximizes manual operation, including many functions that are typically automated, such as subsystem startup sequences, valve lineups, ventilation lineups, shutdown sequences, and repeated mechanical handling steps. This approach is likely to lead to an increased incidence of operator error and decrease the overall performance of the facility.
- The Human Machine Interface (HMI) strategy for the LAW Facility is not compatible with current industry best practice.

4.2.3 Conclusions

The collective evidence indicates that the LAW Facility control systems are lacking in quality assurance, requirements definition, requirements traceability, design processes, design elements, and clear documentation. Further, this lack of requirements definition and traceability to upper-tier requirements prohibited a full assessment of future plant operability, because it is unclear what the control system requirements are and the basis for those requirements. Specifically:

- The LAW Facility functional requirements are not adequately defined and lack a basis traceable to upper-tier requirements.
- WTP has applied a questionable and likely inadequate software quality assurance grading and classification process to the LAW Facility control systems (a unique WTP process). The inadequate software quality assurance grading and classification process has resulted in a quality assurance implementation at a level lower than is required to support the ICN functions.
- WTP has not evaluated the hazards associated with the ICN, which monitors and controls the entire WTP. Lack of hazards evaluation has resulted in inadequate software quality assurance, functional requirements, and hazard controls. The hazards (as defined by 10 CFR 830, "Nuclear Safety Management") must be evaluated in order to successfully complete the design and achieve readiness.

- The LAW Facility control system documentation is inadequate, inconsistent, difficult to use, and is not consistent with industry standards (i.e., Institute of Electrical and Electronics Engineers, Inc.). The current LAW control system documentation issues must be corrected in order to successfully complete design and achieve readiness to operate. The current documentation could be replaced with a much simpler set consistent with industry standards.
- Resolution of identified specific control system issues prior to resolution of the underlying control system design processes would not be productive.
- Without the benefit of sound requirements, quality assurance, and documentation system to inform and frame the design, the LAW Facility control system is at risk of not being able to meet operational expectations or achieve readiness.

4.2.4 Recommended Path Forward

The following suggested actions should be considered to improve the overall control system design:

- Consistently define the ICN boundaries and interfaces commensurate with the functions attributed to the ICN to ensure that functions can be attributed the correct quality level and to allow changes to be safely and effectively executed.
- Evaluate (or reevaluate) the hazards, risk, safety, and permitting compliance controlled or affected by the ICN and its subsystems and ensure the correct quality levels are consistently applied throughout the software development lifecycle.
- Document the evaluation and basis of software quality determinations for future reference.
- Define (or redefine) the WTP-specific functions requirements performed and controlled by the ICN and the PPJ, carefully tracking the flow down of requirements from upper-tier documents. Use these requirements to provide the detailed test criteria when functionality is confirmed during software development or for vendor acceptance criteria.
- Use industry standard documentation sets (e.g., Institute of Electrical and Electronics Engineers, Inc., Software Engineering Standards Series) for the control system and the functional requirements, making it practical for review without recourse to the control system SME.
- Eliminate the use of commingled design and requirements documents and the use of logic diagrams as the sole means of defining functional requirements.
- Develop software modification procedures and processes and ensure changes can be effectively isolated and verified with minimal regression testing required.
- Conservatively evaluate the effect of manual controlled operations and the impacts on facility performance. Identify and implement increased automation for those areas where it is assessed that maximum benefit will be achieved.
- Consider implementing current industry best practice in development of facility HMIs.

4.3 INADEQUATE ANALYSIS OR UNDERSTANDING OF PRODUCTION CAPABILITY

The future performance of the LAW Facility is extremely important as it dictates not only the overall mission length of the facility but also dictates the performance requirements for supporting facilities such as the Low-Active Waste Pretreatment System currently awaiting CD-1 approval of the conceptual design that will provide waste feed from the Hanford tank farms.

4.3.1 Summary

The WTP Project has developed an operational research (OR) model that includes the LAW Facility; however, there was significant evidence to indicate that the inputs to this model were incomplete or lacking conservatism, resulting in an inaccurate and overly optimistic assessment of LAW Facility production capabilities.

Because the performance of the LAW Facility is a key element of the overall mission and the future of Hanford, the WTP Contract requires that WTP undertake OR assessments using OR modeling to ensure compliance with the contract design and required treatment capacities of 30 metric tons (MT) and 21 MT, respectively, of glass per day or an average production rate of 70 percent of the stated design capacity. Compare this 70 percent projection with the West Valley Demonstration Facility, which had a design capacity of 300 MT glass per year actually produced around 250 MT glass in approximately 5 years or a rate of about 17 percent of design capacity. The design capacity of the Defense Waste Processing Facility (DWPF) is 2 MT of glass per day. In 2010 (after 14 years of operation) DWPF had produced 3,000 canisters or approximately 3,700 MT of glass. This equates to an average throughput of approximately 36 percent. This is not to suggest that these figures should be considered low as the West Valley Demonstration Facility was a demonstration facility and DWPF was operated at a higher level than many similar facilities in the United Kingdom (UK).

Operational research models with realistic input data can be an accurate predictor of facility performance and can provide essential early input into the design process to eliminate bottlenecks and maximize the overall production before much more costly physical plant changes are required to achieve the same result.

Figure 4-2 illustrates the potential collective impacts of incomplete or nonconservative inputs on estimates of LAW Facility performance.

The production capability of the LAW Facility is unknown but likely significantly less than specified or anticipated to successfully execute the mission as evidenced by the following:

- **Equipment reliability and maintenance not adequately considered or lacks a defensible basis**: There were recurring instances where the design did not appear to adequately or completely consider the impacts of equipment reliability and maintenance on the production capabilities of the LAW Facility. The review identified that spurious instrumentation trips on the melter offgas system alone will likely result in a decrease in the LAW Facility production capability to below the required 70 percent.

- **Inadequate inputs and bases used to model production capability**: The OR model available at the time of the review, as developed and maintained by WTP, does not provide a realistic prediction of overall plant performance, on which ongoing design decisions and future predictions of mission and operability can be based because:
  - The OR model for the LAW Facility used input assumptions and supporting bases that are not considered to be supportable based on operating experiences from other facilities with analogous equipment and operating constraints.
  - The OR model did not incorporate all the systems necessary to represent integrated facility operations.
  - The OR model was not used to evaluate the full range of operating conditions that might reasonably be anticipated during long-term plant operations.
  - The OR model did not attempt to evaluate losses, other than availability, such as quality and performance losses, which on a minimally automated facility like the LAW Facility could be even more significant than the availability losses.
- **Design process does not adequately consider throughput impacts**: The interactions of systems and associated operations within the LAW Facility have not been adequately considered and may result in unanticipated interruptions in melter glass production operations.

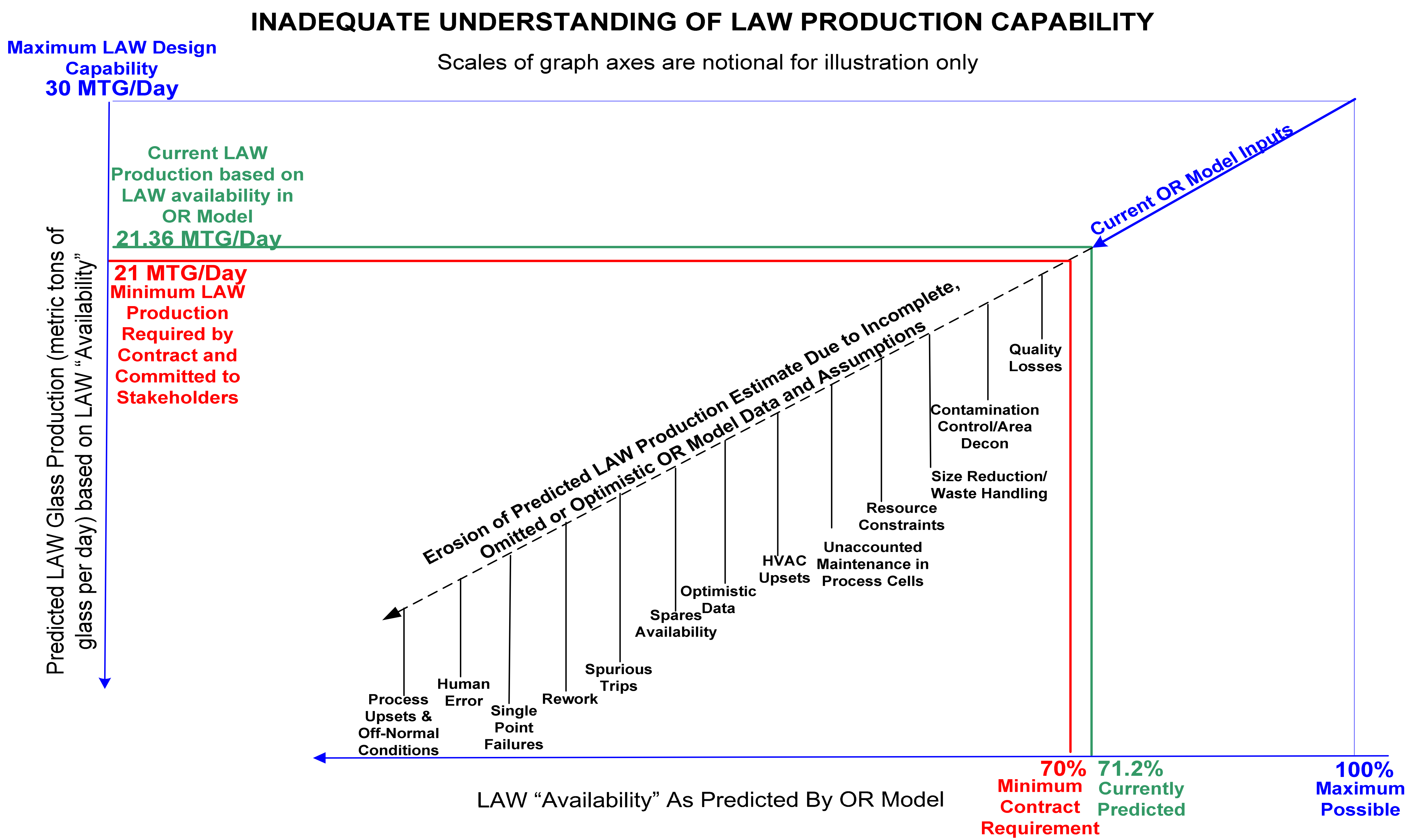

Figure 4-2. Impact of Inadequate Operational Research Model Bases.

4.3.2 Examples

Following are some representative examples of vulnerabilities that provide substantial evidence that the LAW Facility production capability is not adequately analyzed or understood:

- The melter offgas treatment system equipment is required to meet environmental requirements prior to discharge to the environment. The offgas treatment system equipment is complex. This complexity coupled with a lack of component redundancy and numerous safety and permit affecting controls is likely to impact the ability to sustain melter operations and meet production requirements because equipment failures are likely to be more frequent and take longer to repair than assumed.
- Maintenance of some melter primary offgas system equipment requires that a confinement barrier for radioactive material control be disconnected and opened. This will require that both melters temporarily cease production operations so that the system can be placed in a safe condition for maintenance. Further, the review team considers it possible that personnel entry to the melter offgas process cells for any reason could require that glass production from both melters be temporarily ceased and the cell vessels be de-inventoried in order to establish safe conditions for cell entry.
- For electrical safety reasons it is anticipated that the melter power will be disconnected and locked-out during some routine operations (e.g., replacement of air bubbler tubes used for agitation in the melters, maintenance of redundant power supplies, etc.). There is no evidence that the melter safe condition lockout and subsequent time periods required for melter cool down and reheat have been factored into the facility production capability. These activities could represent a significant production impact for this routine consumable item replacement.
- Hot molten LAW glass produced in the melter is poured into steel containers. These containers must be allowed to cool for a minimum period of time so that the container can be lifted to the next handling station without risk of distorting the container flange. If this container flange were to distort, the container could fall when lifted. The review team concluded that the current time specified for cooling the containers was insufficient and should be extended. If the cooling time for a container is extended consistent with existing WTP data, container production could be significantly reduced.
- Automation of complex facilities is relied upon to ensure consistent control of the facility processes and to minimize time for response to changes and off-normal conditions, thereby increasing efficiency and production capability. However, the current level of automation in the LAW Facility intentionally emphasizes manual operations. As a result, many functions that are typically fully automated, such as startup sequences, valve lineups, and shutdown sequences rely upon operator interaction for control.
- The impact of the extent of these operator control and response actions on the production capabilities of the LAW Facility do not appear to have been adequately considered. In addition, the WTP Contract requires that the operational research model assess activities such as the time required to perform mechanical handling operations, which are generally assumed within the model to be performed instantaneously without consideration of operator response times. These operator response times could significantly impact LAW Facility glass production rates.

4.3.3 Conclusions

The evidence observed indicates that the basis for the expected LAW Facility production capability is insupportable. Without the benefit of accurate predictive models to inform the design and the design process that emphasizes production capability as a key consideration, the LAW Facility glass production capacity presents a significant challenge to the Hanford tank farms mission.

4.3.4 Recommended Path Forward

The following suggested actions should be considered to improve the basis and understanding of the LAW Facility production:

- Reconsider the bases and requirements for each system associated with facility performance. Confirm that inter-system interfaces and transitions are considered and integrated.
- Develop detailed work plans for a representative set of critical maintenance and operations activities based upon fully-validated design input data that has been analyzed and accepted through a multi-discipline review process. Use this information to develop and validate an OR model that incorporates a consistent process methodology across all plant systems.
- Model all plant operations and maintenance activities in detail using the updated OR model, scale simulations and mockups to validate throughput, space availability, remotability, accessibility, and availability of interfacing systems and organizations such that the production rate and margin can be accurately estimated at the facility and systems level.
- Establish a formal and systematic design approach to identify and disposition issues that may adversely affect plant operations, maintenance, and throughput. Address any redesign effort that may be required to minimize operational work-arounds and unanalyzed production impacts.
- Include reasonable and justifiable assumptions to predict performance and quality losses in the model basis and assumptions.
- Maintain and utilize models, simulations, and mockups as primary operator training tools.
- Consider incorporating lessons learned and operational feedback from the nuclear industry best practices that includes a specific structured approach to examine system operability and maintainability, using data based on supportable documented operational experience.

4.4 INADEQUATE IMPLEMENTATION OF AS LOW AS REASONABLY ACHIEVABLE PRINCIPLES

The WTP is required to meet specific worker radiological dose exposure and contamination limits imposed by federal regulations (e.g., 10 CFR 835.202, "Occupational Radiation Protection," "Occupational Dose Limits for General Employees") and to implement design features so that workers are protected and radiological dose is ALARA.

The LAW Facility design is based upon hands-on operations and maintenance. Consequently, potential radiological conditions must be thoroughly evaluated to ensure radiation exposures and contamination levels are ALARA. Radiological contamination migration, as well as the contamination and dose levels, must be thoroughly modeled and understood. Invalid assumptions can substantially impact the operability and maintainability of the facility.

4.4.1 Summary

Throughout the review it was apparent that ALARA principles, incorporated as part of the design process, had not been effectively implemented. Key observations that the LAW Facility design may not effectively achieve ALARA requirements include:

- **Contamination control not effectively analyzed and demonstrated**: There were recurring instances where contamination control methods, defined in the design bases, such as airflow through doorways and hatches, were not sufficiently considered and demonstrated to be effective, challenging the ability of the project to successfully meet ALARA requirements. This is of particular importance for the LAW Facility because the contamination levels expected to be encountered as part of the hands-on maintenance approach are currently unknown and unanalyzed. Additionally, it was not apparent that the design of SSCs has adequately considered the need for periodic decontamination or provided features to facilitate decontamination efforts (e.g., use of high gloss/nonstick surfaces, or minimization of joints/crevices that can accumulate contamination).
- **Personnel dose assessments are not sufficiently documented to support contact operations and maintenance**: Radiation doses to personnel are undetermined for operations, maintenance, and waste management activities. Total cumulative radiation dose for a representative or bounding set of operations and maintenance evolution have not yet been determined; therefore, it is not known whether contract ALARA dose requirements can be met with currently planned staffing levels.

4.4.2 Examples

Some representative examples of vulnerabilities associated with inadequate implementation of ALARA principles include:

- The LAW Facility confinement ventilation system is a complex low airflow system. Some rooms require multiple ventilation manipulations to maintain correct air flow direction. Entry and exit from potentially contaminated rooms requires that airflow be manually controlled to prevent reversal of air flows and disruption or shutdown of ventilation systems.
- The storage tanks for incoming waste and the associated rooms are expected to become highly contaminated and the potential exists for personnel to receive significant radiation exposure in the process cells. The anticipated dose levels in the cells have not been assessed and no assumptions identified for the time required for removal of inventory from the cells and flush to attain levels acceptable for personnel entry.
- The transfer of bogies (rail based carts used to transport containers) between rooms may be a problem due to contamination potentially being transferred from rooms with higher contamination to rooms with lower contamination. This issue is exacerbated by the

inclusion of design features such as recessed rails and unfinished walls above 7 feet, 6 inches that will trap contamination and make decontamination more difficult.

- The current carbon dioxide (CO_2) system uses high velocity CO_2 pellets to decontaminate the glass waste container. The CO_2 system uses pressurized air in the decontamination process and ablated contaminants are contained and removed by the vacuum effluent removal system. Because the CO_2 system has not been tested as an integrated system, it is unknown as to how well the vacuum effluent system will capture the ablated contaminants, or whether the contamination will be spread in the general finishing line area.
- Maintenance in the process cells, upstream of the melter, and within the pour caves and finishing line may require personnel to be in contact with equipment that exhibits high radiation exposure rates because of the hands-on maintenance design.
- Packaged waste containers that exceed a facility-specified radioactive dose limit, which is often set relatively low to limit cumulative uptake, require special handling and/or shielding so that the waste container can be safely handled and disposed.

4.4.3 Conclusions

There are specific regulatory and contractual requirements associated with meeting ALARA goals and objectives. The review team found that these requirements may not be met, primarily because of uncertainties related to how work will be conducted, a lack of systematic analysis, and modeling to confirm how contamination will migrate.

The effectiveness of a low flow ventilation philosophy has never been demonstrated in this type of facility using a hands-on maintenance approach. The low airflow design may cause contamination to accumulate in some areas or progressively spread in other areas of the facility. There is no model available to evaluate contamination migration paths throughout the facility.

Radiological conditions in the LAW Facility are considered likely to deteriorate over the life of the facility thereby exacerbating difficulties associated with performing contact operations and maintenance. Consideration of design controls to address the radiological dose and contamination hazards over the life of the LAW Facility appears incomplete.

4.4.4 Recommended Path Forward

The following suggested actions should be considered to reduce operational risk in meeting regulatory requirements associated with ALARA implementation:

- Model and evaluate work tasks for each process system, identify potential areas where contamination may migrate, and document any additional engineered (e.g., remotely operated tooling) or administrative controls (e.g., procedures) that will be needed to ensure personnel are appropriately protected.
- Evaluate and document predicted possible airborne radioactivity work locations, given maintenance and operations tasks to be performed, and determine whether existing engineering controls will be effective in mitigating the airborne hazard.

- Apply suitable, easy to decontaminate surface coatings to the unprotected walls in the facility where radiological contamination could be present and operations or maintenance activities will be performed.
- Accelerate the identification and definition of operation, maintenance, and waste management tasks and revise/update the dose assessment reports to accurately reflect anticipated dose.
- Establish a mockup facility/area to evaluate and practice implementation of approaches to control worker dose and work area contamination prior to in-field execution of tasks expected to be high risk or have high radiological consequences.

4.5 TRANSFER OF SCOPE AND RISK TO THE COMMISSIONING PHASE

Inherent in the commissioning phase of any facility is the resolution of previously unidentified issues. These issues occur despite best efforts to identify and resolve them during the design and construction phases, which can significantly increase the planned duration of the commissioning phase. Therefore, the importance of controlling and minimizing the transfer of known equipment testing and design confirmation activities from the design, procurement, and construction phases to the commissioning phase cannot be overstated.

4.5.1 Summary

A number of equipment testing and functional demonstration activities have been identified on the LAW project that would be best performed prior to installation and commissioning. Delaying the completion of these activities transfers the risk of additional engineering, procurement, and construction activities to the commissioning phase of the project and will likely extend the commissioning period significantly.

Key observations include:

- **Deferral of integrated equipment testing and functional demonstrations**: A number of cases were identified where integrated testing or functional demonstration of critical components was deferred to the commissioning phase of the project. Many of the deferred activities lack integrated factory acceptance testing, models, simulations, or mockups that would help provide assurance that the equipment or system can meet its functional requirements. This would mitigate additional cost and schedule risks associated with postponing functional validation to commissioning.
- **Inadequate tracking and management of deferred testing and performance demonstrations**: There is little evidence to indicate the equipment testing and functional demonstration activities being transferred to the commissioning phase are being sufficiently tracked to support planning and risk management. The commissioning schedule has little or no room (i.e., float) to accommodate scope growth as a result of deferral of activities from the design phase. As the commissioning scope grows, it is vital that the scope is controlled and managed to minimize overall cost and schedule impacts to the commissioning phase.

4.5.2 Examples

Examples of vulnerabilities associated with the transfer of scope and risk to the commissioning phase include:

- Filled LAW glass containers are decontaminated by being blasted with CO_2 pellets prior to being removed from the LAW Facility. A previous ORP review of the technical maturity of the selected decontamination technology indicated that additional development and testing were necessary to ensure that the system would perform reliably at the LAW Facility. This technology maturation and demonstration testing were never completed and two identical container decontamination systems are now installed in the LAW finishing line. Additional testing of the systems is necessary but has been deferred to the commissioning phase. Based on the results of the ORP review, there is significant risk this system will not work as intended and will result in a significant delay in commissioning and costly modifications to either improve or replace the systems.
- If a LAW container is damaged during or following the pouring of glass into the container (e.g., due to over-pouring the glass or distortion of the container flange), a special lifting frame would be needed to recover and relocate the container. A workable lifting frame that could be used to recover damaged containers has not yet been designed and is not currently planned to be procured until the first time a damaged container is encountered. This could occur during the commissioning phase. Delaying the final design and procurement of the frame could adversely impact the ability to complete system commissioning or impact subsequent production operations.
- UPS and associated battery systems are included in the LAW Facility design to ensure power is maintained to selected safety systems in the event of an interruption to the normal power supply. Currently, the WTP Project plans to use manufacturer's calculations and factory capacity tests to demonstrate that battery capacity is adequate rather than performing testing when the UPS and batteries are installed, which takes in account impacts to the battery cell's performance resulting from shipping and installation damage. If batteries are not installed until the commissioning phase and batteries then fail a service test due to inadequate capacity, the project may be faced with a design that does not meet requirements and a battery location too small to support the needed battery capacity.
- Integrated Control System testing, including remote input/output (I/O), remote operator interfaces, and instruments, is deferred and no integrated simulation process is proposed prior to commissioning.

4.5.3 Conclusions

The deferral of critical integrated equipment tests and functional demonstrations to the commissioning phase has not been adequately anticipated or controlled. The deferral of these activities will increase the duration and cost of LAW Facility commissioning, which will also delay the processing of radioactive waste.

4.5.4 Recommended Path Forward

The following suggested actions should be considered to reduce the risks associated with deferring testing and functional performance demonstrations to commissioning:

- Identify all systems and components that require testing or functional demonstration as part of commissioning. Where feasible, identify off-line testing, modeling, simulations, or mockups that may be used to minimize the risk of deferring these tests and functional demonstrations to commissioning
- Develop a system for tracking all testing and functional demonstration activities being deferred to commissioning. Use the tracking system to support the planning and manage the risk caused by the deferral of these activities.

4.6 INADEQUATE IMPLEMENTATION OF DESIGN REQUIREMENTS FOR WASTE MANAGEMENT

The operation of a nuclear facility necessarily generates radioactive solid waste. The majority of this "secondary" solid waste consists of maintenance waste items contaminated with radioactive material (e.g., pumps, agitators, valves, etc.) and consumable items (e.g., bubbler tubes used to mix the melter contents).

The secondary radioactive waste must be packaged and removed from the facility in an efficient manner to meet waste storage and disposal requirements and to reduce the hazards to workers. The packaging of the secondary radioactive waste may require flushing or other decontamination to reduce hazardous constituents to levels acceptable for disposal and may also require size reduction so that waste items will fit into waste containers.

If the secondary radioactive waste cannot be efficiently handled, packaged, and exported, the waste can accumulate to the point that facility glass production operations are either suspended or slowed so that adequate resources can be applied to manage the waste backlog.

4.6.1 Summary

The review team identified that the design requirements for secondary radioactive waste management were incomplete, and adequate design features were not included to support efficient secondary waste management. The capabilities to perform size reduction, decontamination, storage, and export of secondary radioactive solid waste are considered insufficiently developed to support sustained LAW glass production operations. In addition, the forecasted secondary waste volumes appear to be underestimated based on other analogous facilities and processes.

Retrofitting waste management capabilities into the design during the operating phase may require significant facility modifications or operational compromises that impact LAW glass production objectives.

Observations include:

- **Waste volume estimates not conservative**: The review team observed that estimates of secondary waste volumes are either incomplete or lack appropriate conservatism.

Secondary radioactive waste can become a bottleneck, and LAW glass production may be slowed or halted until the waste backlog is processed.

- **Inadequate and incomplete equipment and systems to support efficient waste handling functions**: The review team observed that the LAW Facility design did not include expected waste handling design features typically applied to efficient waste handling operations in other nuclear facilities.
- **Inefficient waste management interface**: Currently, radioactive solid waste generated at WTP facilities is planned to be packaged at the facility that generates the waste and then exported to the Tank Operations Contractor (TOC) for size reduction and repackaging for disposal. The TOC currently has no facility to repackage waste. Interface Control Document (ICD) 03 for radioactive solid waste management specifies functional requirements and associated responsibilities for contractors involved in the preparations for and disposal of secondary waste. However, the ICD appears to assign requirements and responsibilities or contains requirement gaps that are inconsistent with proven and successful waste management practices on the Hanford Site. Per ICD-03, WTP waste packaging and management responsibilities are restricted to characterizing and packaging the radioactive waste for transport rather than for disposal. Further, ICD-03 does not impose specific requirements on WTP for performing waste treatment, such as ensuring waste packages meet void fraction requirements or providing data needed for waste disposal. As a result, these responsibilities are owned by the TOC and/or Plateau Remediation Contractor without the necessary resources/facilities to implement these responsibilities. This situation could lead to difficulties in establishing readiness to operate and attendant delays in starting glass production operations.
- **Waste Management Impacts on Facility Performance Not Adequately Considered**: Assessments of the throughput capabilities of the radioactive waste handling system do not adequately address the required time and resources for all waste management activities (e.g., size reduction, packaging). Inadequate consideration of all waste management steps will result in a reduction of the overall facility throughput capability.

4.6.2 Examples

Some representative examples of vulnerabilities associated with inadequate implementation of design requirements for secondary radioactive waste management include:

- It is not evident that all necessary lifting and handling equipment (e.g., cranes/hoists, carts, cradles, etc.) has been provided to enable movement of secondary radioactive waste containers from potential packaging locations within the LAW Facility to potential export locations.
- The travel routes for moving waste from the point of generation to packaging areas and export areas are not well defined, except for some known consumable items (e.g., melter bubblers). It is important to understand these waste travel routes to ensure that the wastes can be moved through the facility without a need to implement special administrative controls to minimize hazards to facility workers. Implementation of special administrative controls could result in a need to halt or slow glass production activities.

- Areas for temporary storage of secondary solid waste in compliance with regulatory permit requirements have not been defined or established.
- Size reduction of some large equipment items will be required so that these can be packaged in waste containers. However, a location to perform size reduction activities and the equipment needed to perform the required size reduction is not specified.

4.6.3 Conclusions

The design process has not adequately considered or implemented sufficient features necessary to ensure the effective functionality of waste management systems to support the LAW Facility lifecycle mission needs.

4.6.4 Recommended Path Forward

The following suggested actions should be considered to improve the basis and understanding of facility secondary radioactive waste handling:

- Reassess the adequacy of the functional requirements associated with secondary radioactive waste management to confirm that the full range of wastes anticipated over the life of the LAW Facility is addressed.
- Reassess current secondary waste volumes and waste classifications to derive conservative estimates for design. Provide waste handling process design features to accommodate the forecasted waste volumes and classifications.
- Update the OR model to fully incorporate the waste management processes required to handle the estimated volumes of radioactive wastes generated over the life of the LAW Facility. Develop a range of anticipated scenarios and use the OR model to assess the impacts of waste management activities on overall production. Assess areas that require design changes to ensure that LAW glass production is not impacted to the extent that mission objectives are jeopardized.
- Evaluate the ICD-03 to ensure all roles, responsibilities, and impacts to the involved contractors are understood and agreed to ensure the waste treatment packaging and transportation are available to support earliest effective operations of the LAW Facility.
- The DOE must ensure a facility to satisfy the secondary radioactive solid waste size reduction and repackaging requirements of the LAW Facility is available prior to operation.

4.7 INADEQUATE CONSIDERATION OF INDUSTRIAL SAFETY AND INDUSTRIAL HYGIENE REQUIREMENTS

The DOE is a self-regulating agency responsible for implementation and oversight of a worker safety and health program that reduces or prevents occupational injuries, illnesses, and accidental losses. The DOE Worker Safety and Health Program is regulated under 10 CFR 851, “Worker Safety and Health Program,” and requires contractors to provide a place of employment that is free from recognized hazards that cause or have the potential to cause death or serious physical harm and ensure work is performed in accordance with regulations and the contractor Worker Safety and Health Program.

The DOE requires contractors to establish procedures to identify existing and potential workplace hazards and assess the risk of associated workers injury and illness, using recognized exposure assessment and testing methodologies as part of the design process for new facilities. For hazards identified in the facility design, controls must be incorporated into the design or procedure, and hazard controls must be selected based on the following hierarchy:

- Elimination or substitution of the hazards where feasible and appropriate
- Engineering controls where feasible and appropriate
- Work practices and administrative controls that limit worker exposures
- Personal protective equipment (PPE).

In addition, contractors must address hazards when selecting or purchasing equipment, products, and services.

4.7.1 Summary

Throughout the review process it was apparent that fundamental safety and health principles, incorporated as part of the design process of the LAW Facility, had not been effectively implemented. Key observations indicating inadequate consideration of industrial safety and hygiene requirements include:

- **Insufficient evidence of compliance with operational safety and health requirements in design**: During the course of this review, it was observed that there were recurring instances where safety and health requirements were not effectively incorporated into the design of the LAW Facility.

- **Inadequate implementation of the hazards analysis process for worker safety to address chemical hazards**: The identification of chemicals, other than chemicals associated with the melter offgas system, has not been considered as part of the facility design process. In addition, exposure assessments conducted to date were not accurate and did not adequately reflect hazards associated with the LAW Facility.

- **Inadequate implementation of the hazards analysis process for worker safety to address thermal hazards**: There are two worker safety thermal hazards that are expected to be encountered when the facility is operational: (1) the potential for burns due to hot equipment and (2) the potential for heat stress due to elevated room/work environment temperatures and heat. The review team found that these hazards had not been appropriately evaluated.

4.7.2 Examples

Some examples of vulnerabilities indicating inadequate consideration of Industrial Safety and Industrial Hygiene requirements include:

- The review team was not able to find any documentation that identified expected chemical compounds in the feed to the LAW Facility from the Pretreatment Facility. The WTP Project maintains a list of anions and cations, along with generic volatile organic compound information; however, no documentation was provided to the review team identifying the worst case, or bounding source term, for chemicals present in the waste feed. These compounds and/or list of chemicals need to be compared against worker protection limits to ensure engineering controls are adequate and workers are appropriately protected. In addition, no routine area monitoring for chemicals, other than those associated with the melter offgas system, was found to have been incorporated into the facility design process. This is of particular concern due to the worker protection issues that are associated with the tank farms operations and potential exposures to similar chemical vapors at the LAW Facility should incoming waste migrate from the containment piping (e.g., leaking valve, equipment maintenance).

- Ventilation is the primary means for controlling and mitigating exposure of personnel to chemical vapors. It does not appear that chemical dilution (immediate barrier to release), from a worker protection chemical perspective, was considered as part of the ventilation design.
- Breaker bars are required to provide mechanical advantage to open doors against the building depressions allowing personnel to exit a room during emergencies or other off-normal events. Although breaker bars are available for some areas they are not available for other similar areas, this may preclude egress in the event of an off normal or emergency condition. Operation of these devices under abnormal conditions is likely to cause the ventilation system to shutdown, resulting in a potential loss of effective confinement.
- The potential for carbon fines to ignite in the carbon beds during normal operations or during carbon replacement activities has not been thoroughly analyzed as part of the hazards analysis process. Further, replacement of the carbon in the carbon beds involves workers crouching under the beds in a space approximately 3 feet high. The workers will work in these conditions for an extended period of time since it will require about thirty, 55-gallon drums to collect the spent carbon. This design does not adequately implement suitable worker ergonomic features.
- Container lids used in the finishing line must be manually loaded in the lid holder mechanism. Each lid weighs 45 pounds and there are 35 lid-and-seal assemblies. Back injuries are common when routinely lifting heavy equipment. Given the number of lids needed to be loaded, an engineered means to perform this task is warranted.
- Three high voltage (13.8 kilovolt [kV]) electrical supply power disconnects are all located in the same power supply compartment on the melter power supplies. This configuration makes performing zero energy checks to ensure that the system is safe for worker maintenance impossible unless all incoming power to each LAW Facility melter power supply is disconnected. In addition, there is inadequate space for worker access to the power supply cabinet.
- Existing exposure assessments for the LAW Facility were found to be inadequate and in need of revision to accurately address chemical hazards and controls when performing work. In addition, no administrative process exists that ensures results of the exposure assessments are incorporated into the engineering design process (ensuring engineered solutions to the mitigation of hazards).

4.7.3 Conclusions

There are specific safety and health regulatory and contractual requirements that must be met as part of the design process. The review team found fundamental weaknesses in the hazard identification and mitigation process related to chemical and physical hazards. There is a significant potential that similar worker safety concerns related to chemical vapors in the tank farms may be present in the LAW Facility because the incoming feed to the LAW Facility originates from the tank farms. Thermal hazards need to be thoroughly addressed to ensure workers are appropriately protected from burns and heat stress. Finally, several examples were identified within the LAW Facility that will require retrofitting of installed equipment to meet 10 CFR 851 requirements.

4.7.4 Recommended Path Forward

The following suggested actions should be considered to ensure regulatory requirements associated with safety and health implementation are met:

- Define and document the chemical source term coming into the LAW Facility. The evaluation should consider historical information previously generated for the Hanford tank farms. In addition, identify and incorporate into the design additional area monitoring that may be needed throughout the facility to ensure worker protection (other than areas associated with the offgas system).
- Develop a formal process that ensures safety and health requirements and industrial safety and health personnel are involved in the design process. The process should also list the hierarchy of controls and require a basis to be documented that describes how each control was addressed.
- Verify and validate (i.e., walk down) those systems where design is substantially complete and identify equipment that will need to be retrofitted (engineered solutions) to ensure compliance to 10 CFR 851 requirements during commissioning activities. For those activities whereby an engineered or administrative means cannot be achieved to perform the task, develop a technical basis process to seek a waiver from the requirement (e.g., daily crane inspections in the finishing line).
- Revise exposure assessments to accurately reflect chemical and environmental hazards anticipated during the design phase of the project.

4.8 INADEQUATE CONSIDERATION FOR SUCCESS OF OPERATIONS/MAINTENANCE ACTIVITIES

An important aspect of nuclear facility design is to consider and include conditions that will enable and facilitate the success of operations and maintenance activities. A facility may not be operable or maintainable even though all design requirements have been met. In other words, a compliant facility is not necessarily an operable facility.

The stated intent of the operational philosophy for the LAW Facility, as well as other associated facilities, is to ensure a reliable and operable system that will minimize worker exposure, promote worker safety, successfully complete the ORP tank waste treatment mission, provide cost-effective process operations, maintenance, and minimize life-cycle cost. A primary objective should be to aid the operator to safely and efficiently process radioactive waste.

4.8.1 Summary

The review team observed that the current LAW Facility design was not consistent with the stated operational intent. Inadequate consideration of operations and maintenance conditions needed to successfully operate and maintain the facility will likely impact the ability to meet production targets, challenge safety and hazard exposure goals, and ultimately extend the LAW Facility mission.

Observations indicating a plan leading to successful operations and maintenance of the facility have not been adequately incorporated into the design include:

- **Design process does not adequately facilitate operator success**: Results of the review indicate the design process does not include consideration for hands-on operation, nor does the design process include a feedback mechanism to revise the design when proposed operational activities identify an obstacle to effective operation. The LAW Facility design inadequately considers the provision of information, methods, and tools to the operator, as required, to perform some activities safely, efficiently, and in a cost-effective manner.
- **Design process does not include adequate consideration of maintenance performance**: The LAW Facility relies upon hands-on maintenance for equipment repair, calibration, and replacement. Implementation of hands-on maintenance may require special precautions to protect workers from chemical hazards, high temperature hazards, and to ensure radiological conditions are controlled to maintain worker safety. The impact of these special precautions on maintenance time durations or glass production do not appear to have been adequately considered.

4.8.2 Examples

Some examples of vulnerabilities indicating inadequate consideration of or conduct of operations/maintenance needs are:

- Plant operating environment (e.g., heat, chemical, radiation) within the melter gallery is not defined to date, yet plant design and construction continues to move forward without verification that operators and maintenance personnel can perform anticipated duties within the melter gallery environment during the LAW Facility operations.
- The plant design requires operator action in hazardous environments rather than precluding hands-on operation by implementing engineered controls.
- Maintenance of some equipment requires that a confinement barrier be accessed using hands-on methods. This may require that both melters cease production operations so that the system can be placed in a safe condition for maintenance (e.g., maintenance of some melter offgas equipment).
- Drawings depicting the conduits (conduit schedules) and electrical cables (wire run lists) are used to identify the location of electrical wiring throughout the facility. The accuracy

of these is important to safely troubleshoot or modify plant equipment. However, there are no conduit schedules or wire run lists in the LAW Facility drawing sets; instead WTP Project electrical design uses a proprietary program called SETROUTE to maintain configuration control of conduit runs and wire run data using a database. Currently there are no plans to transfer this proprietary program to the operating contractor. Printouts of the contents of the database are planned to be provided but this database printout will be extremely difficult for maintenance when resolving electrical issues. Additionally, maintaining configuration control/management during future modifications at the facility will prove challenging without having the full capability of SETROUTE software available for use.

- Each LAW melter has two off-gas spray nozzles. Each spray nozzle assembly is a consumable/replaceable item that is removed and replaced annually. The actions to remove and install the spray nozzle are performed in close proximity to the open melter glass pool. Conducting these activities in direct line of sight to the glass pool using the currently proposed methodology is not safe.
- Each LAW melter has 18 bubbler assemblies, which are consumable items and have a service life of 6 months. The current LAW design requires manual actions to remove spent bubblers and replace them with new bubblers. It is anticipated the personnel involved will be required to don PPE including respirators or supplied air masks, as the work includes opening the top of the melter, the hazards do not appear to have been effectively analyzed.

4.8.3 Conclusions

The LAW Facility relies upon hands-on maintenance for equipment repair, calibration, and replacement. There is no precedent for this approach for nuclear waste vitrification facilities with similar hazards. As a result, the complexity of implementing a hands-on contact maintenance approach in the LAW Facility and the associated production impacts appears to be underestimated. This is due, in part, to the unknown magnitude of the hazards that are anticipated in the work spaces. There was insufficient information available regarding the magnitude of the hazards associated with temperature, radiation, contamination, and chemicals affecting proposed operation and maintenance evolutions. Therefore, accurate assessments of future plant operability and maintainability cannot be made using the limited information that was provided. Specifically:

- The anticipated or calculated radiological, thermal, and chemical environment that operators and maintenance technicians will be exposed to has not been fully defined.
- There appears to be an over reliance on the use of PPE in the performance of routine tasks and evolutions. It is not clear that many of the tasks would be possible in standard PPE.

4.8.4 Recommended Path Forward

The following suggested actions should be considered to improve the operability and maintainability at the LAW Facility:

- Complete the hazards analysis for each high-risk anticipated manual operation or maintenance activity, including consumable replacement (e.g., bubbler, film cooler spray nozzle, process agitator, and pumps) and consider mitigating the hazards through engineered methods.
- Accelerate the development of detailed task analyses for a representative set of critical maintenance and operations activities based upon currently available designs using a multi-disciplinary review process.
- Develop training simulations and mockups to include hands-on operations and maintenance activities.

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5.0 SYSTEM REVIEW SUMMARY

This section provides summary results for each of the 13 reviewed LAW Facility systems. These summaries start with a brief overview of the system, followed by the key results and consequences, an overall conclusion regarding the functional capability of the system, and a proposed path forward associated with the system. Full descriptions of all vulnerabilities identified during the course of the review are provided in Appendix B. The results and bases for the impact rankings for individual vulnerabilities are provided in the detailed Record of Review (RoR) forms.

The review team identified many significant issues that—if left unmitigated—may result in unacceptable risk to the LAW Facility startup and commissioning.

5.1 PRIMARY OFFGAS PROCESS (LOP), SECONDARY OFFGAS/VESSEL VENT PROCESS (LVP), AND AMMONIA REAGENT (AMR) SYSTEMS

The combined function of the LOP, LVP, and AMR systems is to safely treat LAW melter and vessel ventilation offgas to protect the public, environment, and operating staff (including co-located workers) from radionuclide and chemical exposure. These systems are also relied upon to confine chemical constituents from treatment of the offgas. Compliance with offgas environmental treatment requirements is achieved prior to release from the LAW Facility stacks for each of the two melters.

There are separate and duplicate LOP trains for each LAW melter. These separate trains are combined into a single LVP train that serves both melters. The primary functions of the LOP trains are to cool the melter off-gas and provide initial removal of radioactive particulates.

The LVP offgas consists of the combined LOP and vessel ventilation offgas streams. The primary functions of the LVP train are to provide high-efficiency particulate air (HEPA) filtration of radioactive particulates, treat/abate nonradioactive chemical constituents, and cool the offgas prior to discharge to the environment.

The AMR system supplies ammonia to the NO_x abatement equipment within the LVP System.

Although the LOP, LVP, and AMR systems are technically separate systems, they are considered together for purposes of this review due to the high degree of interdependence between these systems.

There were no substantive functionality/operability vulnerabilities identified in the review of the Balance of Facilities (BOF) component of the AMR system, and this system is considered by the review team to fully meet functionality and operability requirements and is not discussed further. The ammonia skid, which is within the LAW Facility, was reviewed separately as part of the LVP System.

5.1.1 Low-Activity Waste Primary Offgas Process System (LOP)/Secondary Offgas/Vessel Vent Process System (LVP) Key Results/Consequences

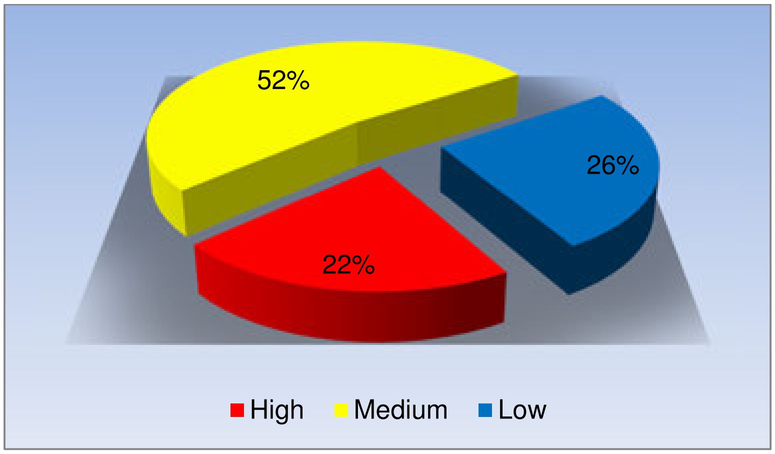

Figure 5-1. Unmitigated Vulnerabilities Identified for the Primary Offgas Process and Secondary Offgas/Vessel Vent Process Systems.

Without mitigating actions, there is collective evidence from this review that the current design of the combined LOP/LVP systems is likely to chronically limit the overall production capability of the LAW Facility.

The summarized principal evidence is as follows:

- There were a total of 46 vulnerabilities identified in these systems. Thirty-four of these are considered to require corrective action, including some significant reanalysis/redesign, prior to startup testing. Figure 5-1 shows the ratio of high-, medium-, and low-impact vulnerabilities identified for the two systems. See Appendix B for a list of vulnerabilities and OFIs.
  - A reliable and fully technically defensible strategy for safe operation of the carbon bed adsorber units (under normal and abnormal operating conditions) has not yet been defined or documented as evidenced by the following:
    - A carbon bed fire is a hazard identified in the PDSA; however, the review found no clear definition of this hazard in the design documents. It is not possible to evaluate a detection strategy without a clear definition of the hazard.
    - The design documents provide a limited definition of the operating conditions that minimize the potential for experiencing a carbon bed fire.
    - Monitoring a CO_x concentration difference across carbon beds as an indication of fire may prove to be difficult to successfully implement based on vendor information and results of pilot scale testing.
    - The carbon bed temperature elements have not been demonstrated to be a sufficient or effective means to determine the progress/condition of a fire or support recovery efforts.
    - No minimum gas flow rate has been defined for safely operating the carbon beds.

- The complex abatement system design with numerous safety and permit affecting controls is judged likely to impact the ability to sustain operations and meet throughput requirements as evidenced by the following:
  - The adequacy of the design to capably and reliably support control of integrated system equipment/components under startup, shutdown, and abnormal operating conditions (e.g., during low flow or melter surges) was not demonstrated/documented.
  - There appears to be insufficient redundancy available to avoid single point equipment failures affecting both melters with unaccounted throughput impacts.
  - Single point instrument failures, interlocks, required calibrations, and surveillances can result in unaccounted throughput impacts.
  - The collective significance of project self-identified issues from a Reliability Validation Process review previously completed by the WTP Project indicates the overall functionality of LOP/LVP systems is indeterminate.

The thermal qualification of the SBS is questionable because it is indeterminate that the O-ring gasket provided by the vendor for the SBS top flat head and mating flange can withstand the thermal loading from the offgas system during some operating conditions.

5.1.2 Low-Activity Waste Primary Offgas Process System/Secondary Offgas/Vessel Vent Process System (LOP/LVP) Conclusions

The combined LOP/LVP systems are determined by this review to require potentially complex mitigating actions to be capable of fully meeting their intended functions. This is necessary so that some equipment (e.g., carbon bed units) can be safely operated and throughput requirements can be met.

The vulnerabilities stem from one or more of the following issues:

- Complexity of the design
- Inadequate evidence that the treatment units (either individually or collectively as an integrated system) will meet the intended level of performance
- Potential consequences of a carbon bed fire (or false positive indication of a fire)
- Potentially complex maintenance requirements.

Many similar issues have been self-identified within the project; however, they have yet to be completely resolved.

The primary anticipated consequence of the identified vulnerabilities is that failure of this system will cause frequent and persistent outages resulting in significant facility production impacts.

5.1.3 Low-Activity Waste Primary Offgas Process System/Secondary Offgas/Vessel Vent Process System (LOP/LVP) Recommended Path Forward

Further construction and procurement of the LOP/LVP systems will put the project at risk until actions have been completed such that the identified vulnerabilities have been mitigated and system functionality independently confirmed. Some specific recommended tasks include, but are not limited to, the following:

- Revisit the decision to rely on a CO_x concentration difference rather than a CO concentration difference as an indication of a potential carbon bed fire. The pilot scale test experience indicates that a CO concentration difference is more stable to measure, is consistent with recommendations from the literature and would be less likely to be affected by interactions with the currently proposed guard bed. However, safety basis development may require testing of actual oxidation reactions in a configuration equivalent to the plant equipment to define a bounding ratio between CO and CO_2 reaction products in order to use a CO concentration difference as a fire detection set point.
- Consider a multi-attribute monitoring approach for fire detection. This could involve something like a three out of four voting approach using gas temperature difference, combined with CO, mercury, and sulfur dioxide concentration difference.
- Consider developing a method for determining if carbon oxidations are occurring within the isolated carbon beds as an indication that a fire is actually occurring or, if occurring, has stopped. Possible alternatives could be:
  - Modeling the actual plant equipment to determine if carbon bed or gas phase temperature probes could become a more accurate indication of a localized hot spot when gas flow through the bed is stopped.
  - Determine if gas pressure monitoring could be used as a method for evaluating the isolated carbon bed equipment for localized oxidation reactions, recognizing the potential for leakage of the isolation valves.
  - Determine if some type of thermal scan (e.g., infrared) could indicate the presence of localized carbon oxidation reactions.
  - Determine if monitoring for convective gas flow from the beds could be used to indicate the presence of localized carbon oxidation reactions.
- Determine if a gas sample loop, with CO gas composition monitoring, activated only when an automatic carbon bed bypass has occurred, could be used to indicate the presence of localized carbon oxidation reactions.
- Consider developing and implementing a test program, combined with modeling, where carbon bed fires are actually generated to define the system characteristics expected to be observed during a real fire.
- Develop a system testing approach that avoids passing offgas through the carbon beds during Destruction and Removal Efficiency testing. This would likely involve establishing the carbon bed performance for organic removal in an offline equipment setup (not installed plant equipment).
- Develop a model of the actual plant equipment for evaluating conditions that could result in a carbon bed fire in the actual plant scale equipment/geometry. Based on input from project personnel, it appears that some consideration of simulation tools to accomplish this activity has been considered in the past, but not implemented.

- Incorporate control logic into the current system that precludes operation of the carbon bed units in a parallel configuration.
- Consider addition of a controlled air (or inert gas) purge to maintain a minimum gas flow rate through the carbon adsorber to protect against gas flow mal-distribution. The set point for a controlled air bleed could be revised based on a flow distribution test each time the carbon bed media is replaced.
- Complete analysis to establish reliability requirements of instrumentation based on conservative forecast of Authorization Basis requirements.
- Formally evaluate options to condition the LAW feed to remove mercury such that carbon beds are not required and the risk of a carbon bed fire is eliminated. Engage with regulators to revisit best available control technology to reassess and balance the risk/ complexity of the secondary treatment system with the environmental benefit and permitting requirements.
- Consider overall effectiveness of the LOP/LVP systems to remove constituents of concern as opposed to selecting an individual unit operation to address each individual constituent of concern. This approach may justify elimination of some unit operations, thereby simplifying the system without sacrificing overall effectiveness.
- Evaluate the lifetime LOP/LVP systems demonstration requirements for permitting and safety basis compliance testing, and ensure engineered methods are implemented for test fluid introduction, sampling or process measurement points, and other engineering methods.
- Develop an OR model that informs the design and confirms the design will support the mission. The model should be used to investigate a range of normal and anticipated off-normal operating conditions.
- Conduct formal reassessment of the residual commissioning and operations risks associated with previously closed and currently open technical issues. Initiate actions to eliminate or provide appropriate mitigation for residual commissioning/operating risks. Assessment results and resulting actions should be independently confirmed.
- Continue development of “Technical Manuals” as a means to develop and integrate start-up/shut-down sequences and responses to abnormal conditions.
- Specific to the SBS:
  - Consider an alternative high temperature gasket material compatible with existing flange surfaces such as Perfluoroelastomer or high temperature resistant silicone.
  - In conjunction with new O-Ring material, re-analyze thermal worst-case-steady-state calculation to see if temperature at the flange can be reduced.
  - If necessary, reanalyze and remanufacture SBS Top Flat Head flange and mating flange to support high temperature flat gasket (such as Metaflex used on the SBS inlet line connections).

5.2 INSTRUMENTATION & CONTROL

The WTP Project uses the ICN, comprising several subsystems, to monitor and control the plant equipment and process. The ICN is a large distributed control system that controls all five facilities: Pretreatment, LAW, HLW, BOF, and Analytical Laboratory. While this operability review was only performed on the LAW control systems and their components, the Software Quality Assurance vulnerabilities for the ICN apply to the entire WTP.

The PPJ is the Safety Instrumented System for the WTP. This system is required to be developed under rigorous life-cycle requirements commensurate with the safety-related nature of the application.

5.2.1 Instrumentation and Control Key Results/Consequences

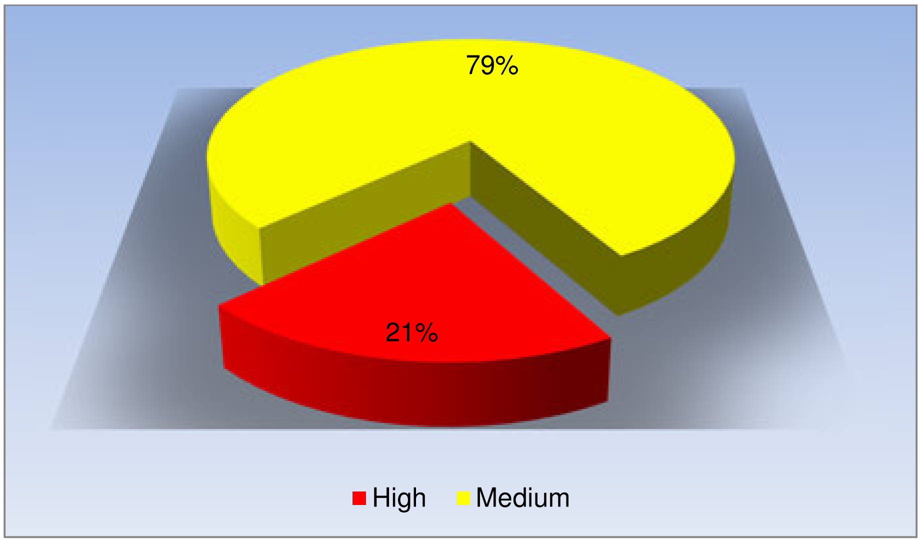

Figure 5-2. Unmitigated Vulnerabilities Identified for the Instrument and Control System.

Without mitigating actions, there is collective evidence from this review that the current design of the WTP instrument and control (I&C) system is likely to significantly delay startup and commissioning, increase the risk of safety and regulatory noncompliance and limit the throughput capability of the LAW Facility.

The summarized principal evidence is as follows:

- There were a total of 14 vulnerabilities identified in this system. All are considered to require corrective action, including some significant reanalysis/redesign, prior to startup testing. Figure 5-2 shows the ratio of high- and medium- impact vulnerabilities identified for the system. See Appendix B for a list of vulnerabilities and OFIs.
- Software Quality Assurance classification of the ICN has been categorized inappropriately at a level below that required by DOE O 414.1C.
  - Only hazards and hazard controls identified in the PDSA, controlled by the PPJ, are used to assign safety software classification and software quality assurance grading level, which inadequately describes all hazards and hazard controls in the plant that involve ICN actions.
  - Layers of protection relied upon to satisfy the safety instrumented function and associated safety integrity level required by the safety basis are developed to a quality level inappropriate to their safety function

  - The ICN is involved in documenting adherence to permitting requirements, which are imposed to protect the environment, these should be categorized as a minimum quality level C but are currently categorized at the lower level of D or even F for some functions.
  - Software Quality Assurance Level evaluation is insufficient to demonstrate that 10 CFR 830 or DOE O 414.1C requirements have been met.
- Inappropriate use of CSLD/“J3” as requirements:
  - WTP currently plans to procure the custom PPJ from a safety-system vendor by providing only logic diagrams supplemented with input/output and setpoint lists.
  - The CSLD/J3s do not distinguish between design choices and requirements derived from upper tier bases documents, essentially severing traceability to the Authorization Basis.
  - CSLD/J3 do not adequately communicate the Functional Requirements across disciplines without recourse to the originator/ICN subject matter expert, which is likely to result in erroneous and unintended functionality.
- I&C system does not meet needs for general plant usability:
  - Review of the LAW Facility heating, ventilation, and air conditioning (HVAC) System design does not indicate that Human Factors Engineering principles have been adequately implemented for HMI control screens or faceplates.
  - The level of automation (the degree control functions require operator intervention) is not consistently defined by the design basis documents, with some document sections, e.g., the operations requirements document, requiring maximum automation, with other document sections specifying minimal automation. This leads to significantly different approaches for different applications and increases the potential for operator error. Consistency throughout the design is one of the primary reasons for developing higher level documents.
  - The current level of automation maximizes manual operation including many functions that are typically automated, which is likely to lead to increased operator errors, rework, and suboptimal performance.
  - The boundaries and scope of the ICN are not consistently defined, resulting in different interpretations of the ICN functions and therefore misunderstandings regarding the reliance placed on the ICN in support of the Authorization Basis generally and level of importance to the facility mission.

5.2.2 Instrument and Control Conclusions

The vulnerabilities documented in this review, unless mitigated, will:

- Significantly delay Startup and Commissioning because of extensive redesign due to the potential for reconfiguration of both the ICN and the PPJ to demonstrate readiness.
- Increase the risk of operating permit noncompliance because the software for permit affecting systems has been developed and tested to an inappropriate quality level.
- Significantly impact LAW Facility production due to:

- Increased rework and reduced performance as a result of the reliance on manual operations and operator responses.
- Inappropriate application of software quality standards leading to increased level of software errors.
- Human Machine Interfaces that require the operator to react rather than providing the tools to proactively identify and correct off normal conditions before they become problems.

5.2.3 Instrument and Control Recommended Path Forward

Unmitigated consequences found by the review team can be avoided by:

- Define the ICN boundaries and interfaces, consistently and commensurate with the functions attributed to the ICN.
- Evaluate (or reevaluate) the hazards, risk, safety, and permitting compliance controlled or affected by the ICN and its subsystems and develop software to the appropriate quality classification level.
- Define (or redefine) the LAW Facility specific functions requirements performed and controlled by the ICN and the PPJ, carefully tracking the flow down of requirements from upper-tier documents. Use these requirements to provide the detailed test criteria when functionality is confirmed during software development or for vendor acceptance criteria.
- Use an industry standard hierarchy of documents to document requirements rather than distributing them over many CSLDs/J3s, making it practical for review without recourse to the designer or maintainer.

5.3 CONFINEMENT VENTILATION SYSTEMS (C1V, C2V, C3V, C5V)

The LAW Facility confinement ventilation (i.e., HVAC) systems are designed to provide confinement of radiological material by maintaining a prescribed differential pressure between confinement zones. They support radioactive contamination control by providing airflow from areas of lesser contamination potential to areas of greater contamination potential in order to provide confinement of contamination at or near the source. Consequently, LAW Facility rooms and corridors (zones) are classified based on their potential for radiological contamination. The contamination classifications zones C1, C2, C3, and C5. Zones classified as C5 are potentially the most contaminated, while zones classified as C1 have the lowest potential for contamination.

5.3.1 Confinement Ventilation Key Results/Consequences

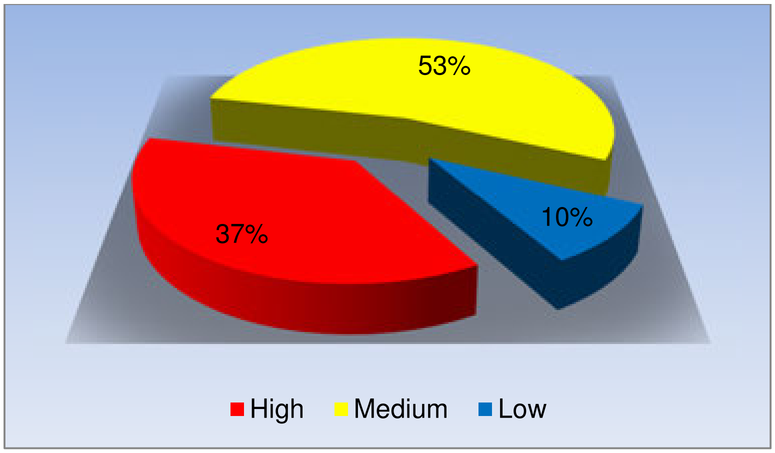

Figure 5-3. Unmitigated Vulnerabilities Identified for the Confinement Ventilation System.

The LAW Facility Confinement Ventilation System has been determined to be incapable of meeting its intended function unless corrective actions are taken. The extent and number of perturbations induced in the ventilation system as a result of routine operations are expected to result in an unstable system. The current ventilation system design may cause delays to facility startup and commissioning and impact facility operation during the life of the facility.

The summarized principal evidence is as follows:

- There were a total of 73 vulnerabilities identified in this system. Sixty-six of these require corrective action, including some significant reanalysis/redesign, prior to startup testing. Figure 5-3 shows the ratio of high-, medium-, and low-impact vulnerabilities identified for the system. See Appendix B for a list of vulnerabilities and OFIs.
- **LAW Facility HVAC hazard analysis**: A number of hazardous conditions associated with upset and accident scenarios in the LAW offgas system were identified in the PDSA hazard analysis with high toxicological unmitigated consequences to the facility worker and chemical exposures above threshold limits for the co-located worker. There is a strong potential that currently unidentified HVAC controls will be needed to mitigate the hazards identified in the hazard analysis. A final hazards analysis of the LAW Facility ventilation system needs to be performed. Normal and off-normal operations as well as accident conditions need to be evaluated and all HVAC controls need to be identified.
- **Maintaining confinement:** The LAW Facility confinement strategy relies on carefully controlling dynamic operation within the facility administratively; developing entry/exit sequences instead of isolating ventilation zones. The proposed confinement strategy routinely changes the system configuration, flow balance and thermal loads resulting in a configuration that may not be consistent with operational safety, challenges the life safety requirements, impacts space cooling and reduces air velocities through open doors. A dynamic computer simulation model of the LAW Facility ventilation system is needed to understand the ability for the ventilation system to accommodate dynamic operations including opening of single/multiple doors and hatches, duty/standby fan changeover and activation of differential pressure interlocks.
- **LAW Facility stack sampling and monitoring system operation:** To date a stack sampling and monitoring system has not been identified that will meet the temperature

requirements of the LAW Facility ventilation airflow (this is also true of the LAW offgas system). The originally specified stack sampling and monitoring system was not adequate for the anticipated stack temperatures. New stack sampling and monitoring system requirements have been developed. A vendor has been selected and provided the design requirements and is working to provide a system, but the LAW Facility stack temperature is above the standard sampling equipment temperature ratings so there is some risk a new system cannot be developed to meet the LAW Facility requirements.

- **Lack of redundancy:** Several areas in the LAW Facility have been identified where redundant systems that my affect production are lacking. The filled container buffer storage area has only a single commercial grade cooling unit. If this system were to fail with several recently filled containers stored in this area, the airstream temperature could rise enough to affect the C5V exhaust fan capacity. There are only two C2V exhaust fans and both have to run continuously. These fans will have to be shut down periodically for maintenance, which will impact the entire facility exhaust flow. The C3V fan and filter rooms have only a single cooling unit in each room. If one of these units were to fail, elevated temperatures in the area could impact facility operation and exceed temperature limits for multiple facility SSCs.
- **Thermal analysis/high temperatures:** There is a lack of documentation to indicate a comprehensive understanding of all the thermal issues that exist in a facility, which produces molten glass, especially in the process areas. While calculations have been performed to analyze temperature conditions in some facility areas, there is no single document to provide bounding operating and temperature conditions to confirm the facility will remain within an acceptable operating range. Lack of understanding of temperature conditions will have a significant impact on the ventilation system performance and ability to maintain confinement as well as facility throughput.
- **Off-normal operations:** Several off-normal events, including maintenance configurations and accident conditions, have not been evaluated to ensure facility temperatures and confinement can be maintained within required limits during anticipated off-normal events. Periodic entries will be required into the pour caves and process cells for maintenance activities. During these entries airflow will be adjusted, which could have a significant impact on ventilation capability to maintain confinement and space temperatures.
- **Zone C5V inbleeds:** The C5V inbleeds are engineered flow paths that cascade air from zone C3 to C5. There are twenty-five inbleeds consisting of a filter, a cooling coil, and a volume damper to adjust the flow rate. As the inbleed filters load, the total C5V flow through the inbleeds decreases, which impacts not only the C5V flow but all other flows cascading into the C5 areas. This will disrupt the overall LAW Facility ventilation flow. The proposed method is to monitor the flow through the inbleeds and make periodic adjustments to the flow rate using the manual volume damper. This is a challenge since many of these dampers are located high above the floor and will require scaffolding or ladders to adjust.
- **Sub-changes/airlocks:** Routine facility maintenance activities require maintenance personnel to access C5 contamination areas through sub-change rooms. These sub-change rooms require manual operation of ventilation dampers to adjust the depression within the sub-change to match the depression in the area being accessed. This process is reversed at completion of the entry. The manual adjustment of dampers between rooms

of significant differential pressure increases the potential for operator error and changes in C5V ventilation flow, which will likely challenge confinement. Additionally, since the sub-change room depression is set to match the cell area, further access to the sub-change is not allowed during the entry. This prevents entry and exit of additional personnel and prevents the introduction of tools and equipment that may be needed to support the entry.

- **Failure to follow ventilation codes and guidelines and project design documents:** A number of deficiencies in the following ventilation codes and guidelines have been identified in the LAW Facility. DOE-STD-1066 requires pre-filters and a deluge system to limit soot reaching the HEPA filters during a fire event. These have not been included in the LAW Facility design. DOE guidelines recommend minimum duct velocities to limit the settling out of radionuclides in the duct, which could result in high does rates. In addition, the DOE guidelines recommend filters in the airstream from high contamination areas such as the pour caves and process cells, to limit the potential for dose in the duct. These recommendations were not applied to the LAW Facility.
- **C5V fan size:** The C5V exhaust fans are potentially undersized. Originally the C5V fans were specified with nearly 20% margin. Due to design changes the fan margin has been eroded. There are still other factors that could further reduce C5V fan margin. For example, infiltration through some doors and hatches was not accounted for in the design. Finishing line flows have not been completely defined. C5V flow may need to be increased to provide sufficient flow to maintain confinement across zone boundaries, such as open door and hatches. There are still a number of facility conditions that have yet to be completely evaluated that could challenge the C5V fan flow.
- **Airflow velocity through open doors:** The Basis of Design specifies a minimum flow rate of 100 fpm for a single open door into a C2/C3 area in order to confine contamination within the higher contamination area. These doors, as well as doors between C2 and C3 areas, have been evaluated and several have been identified as having less than 100 fpm flow rate through them. Doors and hatches between C3 and C5 areas have not been evaluated and it is anticipated that many of these doors have well under 100 fpm flow across them. These doors need to be evaluated and adjustments made for adequate flow to maintain confinement.
- **Complex LAW HVAC control system**: The Ventilation control systems for C1V, C2V, C3V and C5V are located within the process control system (PCJ) portion of the distributed control system (DCS). Thirty-two additional process systems are included within the PCJ portion of the DCS, with some of the ventilation I/O points coming through other system controllers. This arrangement could challenge startup and commissioning of the ventilation system since all systems will have to be in place and online prior to ventilation startup. Additionally, changes to the ventilation control system or any of the other control systems has the potential to cause delays in startup and commissioning in order to verify changes to one system do not affect any of the other systems. The control systems should be separated to the extent possible and potential impacts/conflicts between the ventilation controllers and the other PCJ controllers should be thoroughly reviewed and understood prior to commencement of startup and commissioning.
- **Design Basis documents**: In order to safely perform facility startup testing and system commissioning turnover activities, accurate, complete, and consistent design basis documents need to be completed and placed under configuration control. Functions and

Requirements and Alarm and Interlock set-points are not fully defined. System Descriptions, Failure Modes and Effects, and the LAW Documented Safety Analysis are not fully developed, consistent, and integrated together. Accurate piping and instrumentation diagrams are essential to establish system test boundaries, controls and parameters. During this review a number of discrepancies were noted between documents. Equipment numbers do not match, airflow rates and design depression values are not consistent, notes are included in some documents and not in others, and values in calculations were not properly transcribed. The Design Basis documents are essential for training of personnel and preparation of operations, maintenance and testing procedures.

- **HVAC instrument control issues:** Individual instrument and control loop uncertainties were not properly implemented in the development of the control system design. As a result the designs will not function properly and will result in frequent interlock breaches resulting in shutdown of LAW Facility glass production. In addition, a non-standard approach has been incorporated for controlling parallel fans that has the potential to lead to instable operation of the C2V exhaust fans.

5.3.2 Confinement Ventilation Conclusions

The number of significant issues identified during the review suggests that the LAW Facility confinement ventilation systems are not capable of achieving required performance, and will result in a high frequency of ventilation perturbations and shutdowns as currently designed resulting in a potential spread of contamination outside the primary confinement areas. The review team anticipates that frequently placing the LAW Facility in a limited action status (e.g., idle the melter, cease waste movements) as a result of ventilation perturbations, or to support performance of operability/surveillance requirements, will significantly impact LAW production.

5.3.3 Confinement Ventilation Recommended Path Forward

Specific recommendations to strengthen the LAW Facility confinement ventilation system design and to mitigate the consequences of the identified system vulnerabilities are provided below:

- Implement integrated multidisciplinary design reviews to evaluate design changes required as a result of the LAW Facility D&O review.
- Identify complete set of baseline documents. Generate those that do not exist (e.g., Code of Record, Functions and Requirements, Failure Mode and Effects, etc.). Update and maintain all baseline documents, including Basis of Design, System Description, PDSA/Documented Safety Analysis, etc.
- Perform multi-discipline Hazard Analysis and develop control strategies for mitigation of identified hazards including chemical hazards. Determine if the LAW Facility confinement ventilation system performs a safety significant or defense in depth function.
- Develop a dynamic simulation model of the LAW Facility ventilation system in order to confirm operating parameters, such as zone depressions and flow rates, can be maintained under both normal and off-normal operating conditions.
- Revisit subchange operating strategy based on dynamic simulation model results to identify where airlocks will be required to maintain confinement.

- Identify off-normal operations, including, for example, loss of power, maintenance activities, such as process cell and pour cave entries, and perform an evaluation to determine the impact on the confinement ventilation system.
- Modify ventilation design to ensure airflow through doors and hatches between zones comply with Basis of Design requirements.
- Create and maintain an accurate thermal analysis to ensure a thorough understanding of heat loads within the facility. Update of the thermal models, including computational fluid dynamics (CFD) analyses, as required to integrate all process related heat loads.
- Evaluate buffer storage cooling, stack sampling and monitoring, and C3 exhaust fan and filter room cooling for redundancy and reliability.
- Evaluate the advantages of a separate and independent ventilation control system both for expediting commissioning and for future modifications and upgrades that will be required as control systems become obsolete.
- Establish control loop parameters and perform instrument loop uncertainty calculations to ensure the control loops will function within the specified parameters.
- Confirm C5V stack sampling and monitoring system meets thermal requirements and has sufficient redundancy to minimize impact to production during routine maintenance and calibration.
- Expedite and complete radial HEPA filter testing and confirm the HEPA filter fits properly and the filter seal can be maintained in the filter housings currently installed in the LAW Facility.

5.4 ELECTRICAL DISTRIBUTION SYSTEM

The LAW Facility obtains electrical utility power from the WTP BOF infrastructure via the BOF (Building 87) or LAW Facility switchgear buildings. Service power enters the LAW Facility at two different voltage levels: 13.8 kV and 480V. The LAW Facility Melter Power Supplies obtain power from the LAW switchgear building at 13.8 kV, while the remaining LAW Facility loads obtain power from the BOF switchgear after being transformed from 13.8 kV to 480V via four facility service transformers. Two of these four service transformers are also connected to a BOF standby diesel generator that can provide backup power to the transformer inputs in the event of loss of off-site power. This electrical distribution system provides power to all LAW Facility electrical loads.

The systems investigated by the team were carefully selected to provide a thorough review of the backbone of the LAW Facility's electrical distribution system. These electrical distribution components feeding the following systems were selected for review:

- The electrical distribution systems feeding the LOP/LVP exhauster fan motors.
- The electrical distribution system feeding power to both LAW melter power supplies.
- The electrical distribution system feeding power to both LAW melters.
- The electrical distribution systems feeding the C2V, C3V, and C5V confinement ventilation system (HVAC) exhaust motors.

The team reviewed these specific systems and their supporting electrical equipment starting at the system loads and backtracking to the facility service transformers. By following this outline the review included: all four facility service transformers, all four facility feeder buses, all four facility switchboards, the two melter power supplies, the melter electrode supply bus, the melter assemblies, and the facility's important to safety (ITS) electrical equipment.

5.4.1 Electrical Distribution System Key Results/Consequences

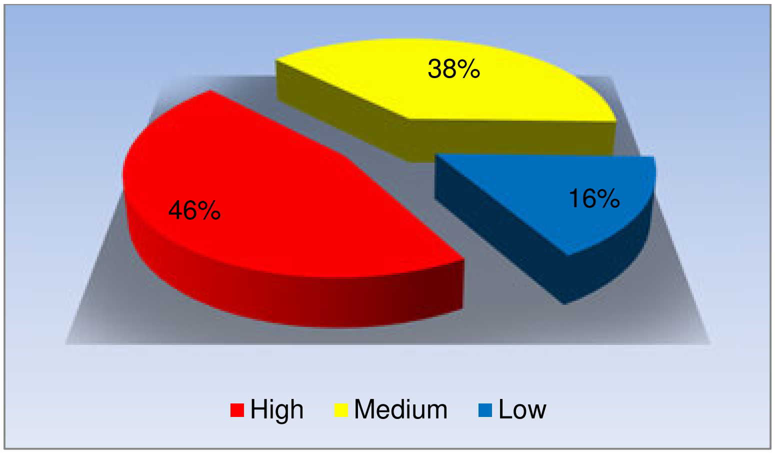

Figure 5-4. Unmitigated Vulnerabilities Identified for the Electrical Distribution System.

The review team found the electrical distribution system at the LAW Facility is capable of supplying the electrical equipment presently connected, with the exception of the facility service transformers, which are loaded at or above design capacity. Although the electrical system is generally sound, a number of significant vulnerabilities were discovered that the review team feels must be addressed prior to startup testing.

It should be noted that many of the vulnerabilities are related, and performing corrective actions on one can resolve multiple vulnerabilities. Many of the vulnerabilities identified in the review had been previously self-identified by BNI and for those issues where evidence is available that resolutions are in process, those issues are not addressed in this report.

The summarized principal evidence is as follows:

- There were a total of 37 vulnerabilities identified in this system. Thirty-one of these are considered to require corrective action, including some significant reanalysis/redesign, prior to startup testing. Figure 5-4 shows the ratio of high-, medium-, and low-impact vulnerabilities identified for the system. See Appendix B for a list of vulnerabilities and OFIs.
- The LAW electrical distribution system lacks spare capacity. Three of the four LAW 13.8 kV-480V electrical system service transformers are presently at, or above, design load capacity. The LAW Facility design is not yet complete and should additional power be required to complete the design of the facility, the existing electrical service equipment may not have the capability to support the additional loads. Additionally, it is reasonable to assume that during the 40 year operational life of the facility; additional electrical capacity will be needed for facility modifications and process/program changes.
- The LAW Facility ITS UPS units lack the battery capacity needed to support safety-significant design loads, and UPS rated output for the prescribed 2-hour loss of

power design basis event. Additionally the climate-controlled battery rooms, in which the UPS batteries are installed, are too small to accept additional battery system expansion. An associated concern with the UPS batteries is that BNI has no plans to conduct post-installation service testing for the ITS UPS system batteries. Without testing the UPS and the Battery System's combined ability to support the connected load for the design basis run time, there is no assurance that the safety significant UPS units will be able to perform their function during a loss of power design basis event.

- LAW melter power supplies cannot be isolated for maintenance activities, while still providing melter idle power. This configuration will negatively affect facility throughput and may pose challenges to maintaining worker safety during maintenance activities and present risk of melter cooling beyond the recovery threshold.
- Spare Power Supply Capacity: The melter power supplies do not have installed spare capacity to carry the production load electrical current in the event of component failure or routine maintenance.
- LAW electrical equipment located in the lidding, decontamination, and finishing line areas lack adequate design consideration for anticipated high ambient temperatures and high radiant process equipment temperatures.
- LAW melter electrode bus electrical ratings may not be adequate for the expected melter loads when operated at potentially higher than anticipated temperatures in the melter gallery. The design margin for amperage on the center electrode bus is only 6.8 percent; this design margin can quickly erode if equipment or container temperatures raise the surrounding area above the 95°F ambient temperature basis temperature for the melter gallery. As a result high melter gallery temperatures may cause the area around the center melter electrode bus to exceed the 104°F electrical bus design basis temperature.
- There is not presently any backup power provided to the melter power supplies, and facility power losses of more than 3 hours may result in significant melter damage and long term impacts to facility throughput. This vulnerability is well known to the WTP Project; however, a previous decision to remove melter backup diesel generator power from the design was not well supported. It should also be noted that there does not seem to be any analysis of the safety basis assumption for cold cap burn off during a loss of melter power and if the two hour value incorporates adequate margin to ensure a cold cap burn off with no power to the melter.
- LAW Facility switchboard feeder circuit breakers and BOF switchgear feeder breakers are equipped with low voltage release mechanisms that open the feeder breakers upon loss of offsite power, shedding noncritical loads that do not require back up power support from the standby diesel generator and isolating the generator system from the utility. Once the breakers open they require manual manipulation by electricians to initiate reclosure. This process can take a significant amount of time as it may require paperwork approval, travel time to the switchboard room, donning of Arc Flash PPE, and establishing breaker line up and sequencing to ensure loads are reinstated in the proper order. During this time a large percentage of the facility electrical loads will be without electrical power, including some facility process and cooling systems. The low voltage release mechanisms do not have an adjustable time delay, and can trip in any low voltage situation including brown outs and/or sags on the electrical grid.

- There are presently no conduit/wire-run drawings in the LAW Facility design documentation, instead the WTP Project uses a proprietary program called SETROUTE to maintain configuration control of conduit and wire run information. This software is a good construction tool, however, at the end of construction the project will turn over a database printout from SETROUTE to Operations. This data base printout will be extremely difficult for Operations to use in maintaining configuration management of the facility when performing future modifications. This vulnerability was self-identified by the WTP Project years ago and has been discussed with DOE many times, however, no evidence was provided to the review team to suggest an adequate resolution has ever been reached.
- There is no formal Code of Record for the WTP Project. While the electrical review team did not find extensive contradictory code references within the many separate design basis and system description documents, it was often difficult to ascertain the code revision that was applicable, as often codes are referenced within documents without mention of the code's revision or issue date.

5.4.2 Electrical Distribution System Conclusions

The LAW Facility electrical distribution system presently lacks the ability to support necessary maintenance activities without affecting throughput, lacks spare design capacity that may be needed for design completion and future facility modifications, lacks adequate design consideration for loss of power events, and lacks adequate design consideration for high process thermal temperatures.

5.4.3 Electrical Distribution System Recommended Path Forward

To address these observations, the design baseline should be strengthened in the following manner:

- Spare capacity may be needed to complete the facility design, and support facility modifications post construction. The review team recommends DOE and the WTP Project consider an electrical upgrade to the facility that would provide additional electrical capacity within the facility. DOE and the WTP Project should carefully coordinate the electrical equipment upgrade with potential design basis change considerations. For example, should the C2V, C3V, and C5V confinement system fans become credited as safety significant, then the electrical upgrades would need to include installation of redundant safety-significant diesel generators. If adding safety significant generators takes place, the review team recommends changing the backup power philosophy to a "facility level" philosophy (instead of BOF philosophy), which opens the option of eliminating the low voltage release mechanisms on the switchgear and motor control centers, preventing unnecessary facility level power loss in the event of sags or brownouts on the electrical grid.
- To address the ITS UPS battery sizing vulnerabilities, the review team recommends that the WTP Project perform battery run/capacity calculations for ITS UPS units to ensure batteries proposed by the UPS vendor have the capacity to meet the run time requirements of a design basis event. Additionally, a battery service test must be performed on all ITS UPS batteries, prior to turn over from construction. This test method will ensure batteries were not damaged in shipping or installation and have an appropriate load profile matched to the facility ITS electrical equipment. Complete

system acceptability cannot be demonstrated by a manufactures capacity test performed on UPS batteries prior to shipping.

- Install spare inverter sections in the empty (spare) melter power supply cabinets, and install a complete backup inverter to enable a short-duration inverter swap-out shutdown should one of the power supply inverters fail. Additionally, a complete spare melter power supply could be installed in the third melter bay power supply location, in a cold (non-energized) configuration that could be used as a training tool to perform dry runs on maintenance activities, and also serve as a spare parts storage location.
- Procure the SETROUTE software from BNI for use post construction. If SETROUTE is unavailable for purchase, additional conduit/wiring drawings should be produced for the facility.
- Complete a comprehensive thermal analysis of the facility to determine if process equipment thermal radiation poses a risk to degrading/damaging electrical equipment in the facility C5 areas and around the melter galleries.
- Develop and approve a Code of Record for the electrical system design. Review and modify as required, all implementing requirement documents for consistency with the Code of Record.

5.5 RADIOLOGICAL CONTROL AND INDUSTRIAL SAFETY AND HYGIENE

The application of Radiological Control and Industrial Safety and Hygiene in the design and operability impacts was evaluated for each process system, but also from a collective significance perspective. Additional emphasis was placed on evaluating whether there were any systematic vulnerabilities that could impact the overall design and facility throughput. This subsection describes those vulnerabilities that could be systemic or of significant importance; additionally, individual Radiological Control and Industrial Safety and Hygiene vulnerabilities are identified within the appropriate system subsection.

5.5.1 Radiological Control and Industrial Safety and Hygiene Key Results/Consequences

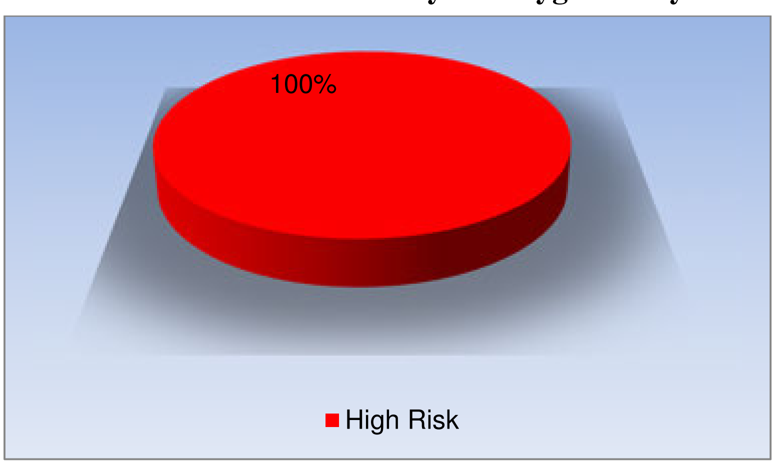

Figure 5-5. Unmitigated Vulnerabilities Identified for Radiological Control and Industrial Safety and Hygiene.

A total of eight vulnerabilities were identified for the radiological control and industrial safety review area. Figure 5-5 shows that the vulnerabilities identified for the system were all considered high impact for which mitigation is recommended prior to cold commissioning and preferably prior to startup testing. See Appendix B for a list of vulnerabilities and OFIs. All identified vulnerabilities discussed below, if left unmitigated, could impact either the design functionality or, as was more often the case, operating throughput.

5.5.1.1 Radiological Control

The review team identified specific issues with the radiological control approach all of which will require correction prior to startup testing. Listed below are summarized vulnerabilities:

- The potential for contamination to migrate to adjacent lower classification contamination zones are a key concern of the review team and the design of the low flow ventilation system further compounds this issue. This vulnerability was evident in a majority of the facility systems reviewed and includes examples such as:
  - The application of a special protective coating only to the seven and one half feet height level on many of the facility walls, will impact the ability to effectively decontaminate the facility,
  - Low flow ventilation increases the quantity of material that settles in the facility rather than being captured on the HEPA filters,
  - Potential contamination migration as equipment or material traverse from higher to lower contamination zones, and
  - The activity level of the glass suggests that the potential contamination levels will be higher than are currently being assumed in the design (anticipated alpha activity concentration for LAW incoming waste stream is greater than 600,000 dpm/ml and beta activity concentration is greater than 20,000,000 dpm/ml).
- Inability to meet contamination control limits for container release. The container swabbing system smears a container over a 500 square centimeters surface area as opposed to the 100 square centimeters surface area regulatory limit for release to controlled areas. Currently no technical basis exists for the release criteria to meet regulatory requirements or the smear media planned to be used for surveying. A more rigorous swabbing regime is likely to challenge the facility throughput further.
- The project is in the process of developing radiation dose rates for specific areas of the facility but there has been no targeted assessment to understand the ability to effectively perform hands-on maintenance activities for the higher risk tasks. Dose rates have recently been calculated for areas like the melter but these rates have not been applied to a conservative task analysis to understand if there are chronic exposure concerns. Similarly there is no assessment of the implications of manual bagging operations of contaminated bubblers. For areas like the process cells, which are also manually maintained, there may be a more significant dose management challenge. Additionally, the effort to de-inventory and decontaminate areas (like the process cells, pour cells, buffer stores etc.) to facilitate maintenance will have an unanalyzed impact on throughput and the radiation levels may restrict some maintenance evolutions even after de-inventorying.
- Issues identified in this review were similar to and consistent with those found during the HLW Design and Operability Review that concluded:
  - Administrative controls appear to be favored over engineered controls; and

  - The confinement ventilation system design philosophy drives the need for frequent radiological cleanup to maintain radiological control and confinement, in excess of that normally anticipated at analogous facilities.

5.5.1.2 Industrial Safety and Hygiene

For Industrial Safety, the review team also identified four vulnerabilities of high significance that will require correction prior to startup testing. Listed below are summarized vulnerabilities:

- Insufficient evidence of compliance with operational safety and health requirements in the design process. Walk throughs of the constructed facility found several locations where code requirements were overlooked as part of system design on individual pieces of equipment, and more importantly on the system as a whole. Examples include:
  - Thermal protection from burns due to potentially hot surfaces, motors, etc.,
  - Inadequate workspace ergonomics and engineered features to enable workers to safely and efficiently fill and empty the carbon bed media,
  - Inadequate access to maintain/operate elevated equipment e.g., ventilation dampers, cranes, etc.
- Inadequate implementation of the hazards analysis process. Examples identified include:
  - Limited or no task analysis of planned hands on maintenance tasks to assess the viability of the existing design to support safe maintenance/operation. Experience on vitrification facilities in the nuclear industry require remote maintenance there is no precedent or relevant experience for the LAW Facility approach so additional conservative analysis is warranted.
  - Lack of a defined chemical source term incoming to the LAW Facility.
  - Lack of identified chemical area monitoring, throughout the facility, to ensure workers are appropriately protected (greatest risk are work areas upstream of the melter).
  - Two completed WTP chemical exposure assessments used incorrect data, which only considered the off gas component and ignored the incoming waste feed. This waste is currently causing significant health concerns due to vapors at the Tank Farms and must be considered for WTP.
  - There is no evidence that worker heat stress potential has been considered in the design and there is no task analysis that considers the anticipated temperatures applied to a detailed task analysis.
- The assessment for replacement of the melter implies Level A PPE will be required, yet Design Engineering has assumed that minimal PPE would be needed. This means that the current design may be incompatible with performance of tasks in this level of PPE.

5.5.2 Radiological Control and Industrial Safety and Hygiene Conclusions

Several Radiological Control vulnerabilities were identified that are applicable to more than one process system. Primarily the vulnerabilities are related to contamination control and minimizing exposure of personnel to radiation. It is anticipated that frequent decontamination, daily in some cases, will be required to minimize the continued spread of contamination, especially ensuring contamination does not migrate during replacement of melter consumables and the transition of personnel and material across confinement zone boundaries. The additional measures required to minimize the potential for contamination spread and to safely accomplish hands on maintenance are anticipated to have a considerable impact on the overall efficiency and throughput of the facility.

All of the industrial safety and hygiene vulnerabilities identified were applicable to more than one process system. The WTP Project is currently in the process of implementing a revised hazard identification and control process that needs to be expeditiously implemented; however, equipment that has been previously installed will need to be reevaluated to ensure engineering controls were appropriately considered as part of the design process. The WTP Project needs to have a defined chemical source term incoming to the LAW Facility so that exposures can be appropriately mitigated and monitored. Thermal concerns will always be a significant worker hazard and additional evaluation of the process systems is needed to ensure personnel are adequately protected.

5.5.3 Radiological Control and Industrial Safety and Hygiene Recommended Path Forward

Specific Radiological Control related tasks include, but are not limited to the following:

- Define and document the chemical source term coming into the LAW Facility. In addition, the Contractor should review the suite of technical documents and chemical vapor controls developed over the past decade for the Hanford Tank Farms. WTP should evaluate the potential for similar organic vapors to be present during operations and maintenance activities at the LAW Facility and the need for mitigation controls.
- Develop a formal process that requires Engineering and Safety and Health organizations to identify and mitigate safety and health/hygiene hazards as part of the design process. This recommendation has been identified as part of an issue related to leakage of ammonia within the LAW Facility offgas equipment rooms; however, at the time of this review the corrective action plan had not yet been approved.
- Revise existing exposure assessments to accurately reflect anticipated environmental conditions and evolutions, and document new exposure assessments for all the process systems. In addition, WTP should develop an administrative process that incorporates the results of qualitative exposure assessments into the Engineering Design Process.
- Perform a LAW Facility thermal analysis study to define and understand both acute (burns) and chronic (heat stress) hazards and any needed required mitigation controls. In addition, it is recommended WTP work with the Occupational Medical Provider and together evaluate industry best practices for applicability to the LAW Facility planned hands-on maintenance activities.
- Develop a LAW Facility contamination control strategy document that evaluates currently defined work processes for each system, identifies potential areas where contamination may buildup and migrate, and defines any needed additional engineering or administrative controls. In addition, the contractor should conservatively postulate anticipated airborne levels to be encountered in the facility and controls to mitigate them, and evaluate the use of a mock up facility for work evolutions where there is significant potential for contamination and dose.

- Accelerate the identification, definition and analysis of operation, maintenance, and waste management tasks to better understand anticipated dose. In addition, the Contractor should consider the establishment of a mockup facility to minimize the exposure of workers to radiation for tasks expected to be high risk.
- Develop a technical basis that documents the statistical representative sampling to be used to meet the legal release criteria, and the adequacy of the sampling media use for swabbing the container. The approach used for release of the container should be coordinated with other Hanford contractors who will receive the containers to ensure they understand the release technique. In addition, the contractor should evaluate the potential that the container can be contaminated (from the finishing line) from the time when the smear samples were taken to when the sample results are received and the container is ready for export.
- Verify and validate (i.e., walk down) those systems where design is substantially complete and identify equipment that will need to be retrofitted (e.g., work platforms, safe access/egress routes, crane inspections, etc.) to ensure compliance to regulatory requirements prior to commissioning. The WTP Project should develop a technical basis, and seek approval from DOE, for those activities whereby an engineered or administrative control cannot be reasonably achieved, e.g. use of ladders for routine access, waving of inspection requirements etc.

5.6 MELTER EQUIPMENT SUPPORT HANDLING SYSTEM (LSH)

The LSH System provides the equipment necessary to complete maintenance tasks on the LAW melters and on other equipment located in the LAW melter gallery. The LSH System provides the mechanical handling equipment to support removal of spent consumables from the melters, packaging of spent consumables, and the installation of new consumables. The LSH System provides equipment for replacement of the off-gas spray nozzle and various thermocouples, removal of start-up heaters, and loading glass frit into the melter during melter start-up. The LSH System equipment includes the truck bay crane, the two melter gallery cranes and their associated maintenance cranes, and the equipment associated with importing, replacing, and exporting melter consumables.

5.6.1 Low-Activity Waste Melter Equipment Handling (LSH) Key Results/Consequences

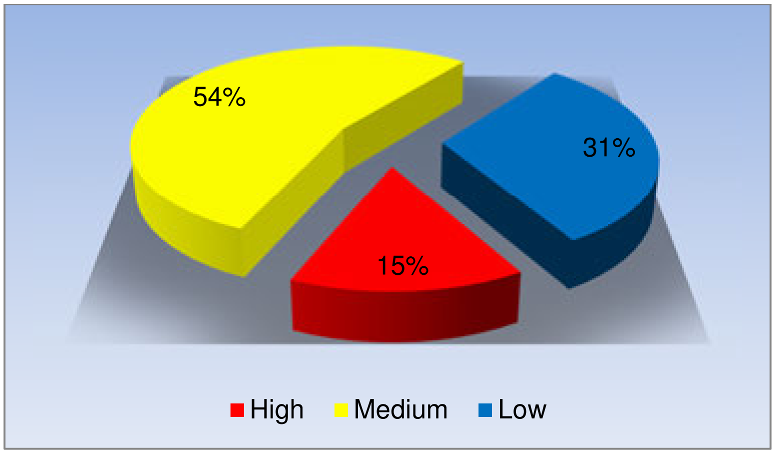

Figure 5-6. Unmitigated Vulnerabilities Identified for the Melter Support Handling System.

The LSH System design may limit the production capability of the LAW Facility for the following reasons:

- The review team identified 61 vulnerabilities for the LSH System. Forty-two require remediation prior to startup testing. Figure 5-6 shows the ratio of high-, medium-, and low-impact vulnerabilities identified for the LSH System. See Appendix B for a list of vulnerabilities and OFIs.
- The ability of the LSH System to provide the support necessary to assure sustained operation of the LAW Facility such that immobilized low-activity waste (ILAW) throughput requirements can be met has not been demonstrated. Some examples include:
  - The current equipment availability assessment results and OR models on melter consumable replacement are not supportable based upon WTP assumed melter cool-down and heat-up rates.
  - Reduced efficiency of manual operations due to limited manned entry times when accounting for elevated workspace temperature and increased levels of PPE required due to chemical exposure and contamination considerations.
  - Off-normal and accident recovery scenarios have not been evaluated, nor have mitigation strategies been developed.
- The suitability of designed and delivered equipment for contact maintenance of the melter has not been demonstrated. For example, the spray nozzle changeout box must be redesigned as it does not provide adequate confinement or protection to the worker from thermal and chemical hazards.
- Integrated and interdisciplinary design reviews that incorporate operations, industrial safety, industrial hygiene considerations, and system interfaces have not been documented.
- Configuration management of design documentation was demonstrated to be insufficient since multiple obsolete, cancelled, and superseded documents were provided to the review teams.

- Equipment refurbishment prior to commissioning will be required due to equipment obsolescence and limited preventive maintenance.
- Critical spares have not been defined or provided as required for commissioning and initial operations.

5.6.2 Low-Activity Waste Melter Equipment Handling (LSH) Conclusions

The current LSH System design restricts operational flexibility and maintainability to the extent that ILAW glass production operations cannot be sustained and throughput requirements will not be achieved without resolution of identified vulnerabilities.

5.6.3 Low-Activity Waste Melter Equipment Handling (LSH) Recommended Path Forward

Specific recommendations to mitigate LSH System vulnerabilities include the following:

- Provide a comprehensive system description such that all project disciplines are uniform in their understanding of the requirements, functions, design, and operational intent.
- Develop detailed work plans for key plant evolutions and identify all critical functions, laydown space requirements, workspace environment hazards, logistics, efficiencies, and other areas.
- Model operations and maintenance activities using detailed work plans that account for manned entry limitations, required PPE, and melter operating constraints to validate design functionality, space availability, accessibility, and throughput.
- Develop an OR model with the goals to:
  - Determine the true availability for key plant equipment and the overall performance capability of the facility independent of any contractually required performance figures.
  - Identify and prioritize potential issues impacting the performance of key equipment and processes. Develop mitigation strategies for each major issue.
  - Inform the design regarding potential bottlenecks, critical spares, and margin on required response and unit operation times.
- Evaluate anticipated off-normal events, and develop corresponding mitigation strategies.
- Develop a plan for implementing full-scale simulation/mockup/demonstration capability of critical plant components and activities accounting for physical and system interface constraints to ensure design functionality and operability.

5.7 CONTAINER POUR HANDLING SYSTEM (LPH)

The LPH System supports the vitrification process by accepting empty containers from the LRH System, moving empty/filled containers into and out of the pour caves, placing containers under the melter pour spouts to be filled with glass, and allowing for preliminary container cooling prior to transporting filled containers to the LFH System.

5.7.1 Low-Activity Waste Container Pour Handling (LPH) Key Results/Consequences

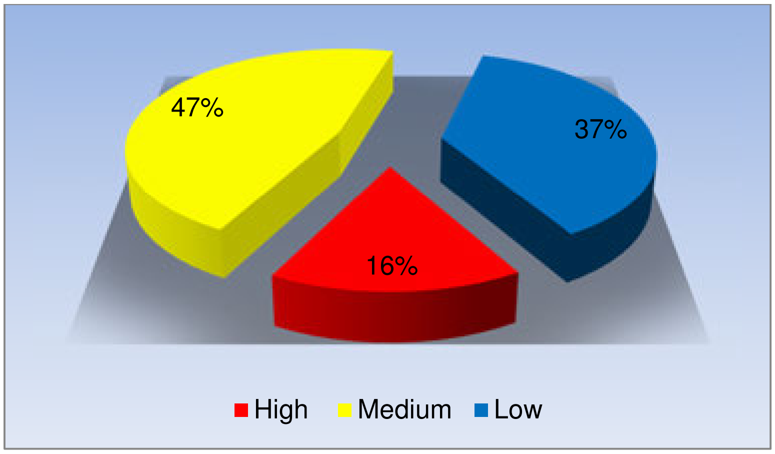

Figure 5-7. Unmitigated Vulnerabilities Identified for the Low-Activity Waste Container Pour Handling System.

The current LPH System design may limit the overall production capability of the LAW Facility based on the following evidence:

- The review team identified 88 vulnerabilities, 55 of which require remediation prior to initiating production operations and preferably before startup testing. Fourteen of the 55 vulnerabilities require some level of significant redesign. See Appendix B for a list of vulnerabilities and OFIs. Figure 5-7 shows the ratio of high-, medium-, and low-impact vulnerabilities identified for the LPH System.
- Vulnerabilities attributed to thermal issues include:
  - Lack of adequate and complete thermal analyses within the LPH System, including all buffer storage areas.
  - Use of non-prototypic results from Duratek container glass fill trials as a basis for cooling times and container flange strength values to support safe lifting temperatures.
  - The Lower Container Overpacks do not provide adequate thermal shielding for the LPH turntables and associated equipment
  - Hot containers are routinely positioned near uninsulated concrete walls of the LPH transfer corridor.
- Vulnerabilities attributed to container filling operations and overfilling scenarios include:
  - Overfilling a container will impact the overall facility throughput, require immediate maintenance actions, and require a large contamination cleanup effort, resulting in unplanned delays and costs.
  - Failure to detect glass build-up in a melter pour spout bellows can lead to blockage of the bellows and render the pour spout inoperable.
- Vulnerabilities attributed to handling of abnormal product containers include:
  - A workable Container Recovery Lifting Frame has not been designed and will not be procured until it is needed.

- Moving a non-conforming container from the pour cave to the finishing line will be a lengthy and complex operation as currently designed as no engineered method has been developed.
- Incomplete Factory Acceptance Testing of pour cave hoists, particularly relating to recovery following hoist failure.
- There is currently no equipment designed to remove a container from the turntable in the pour cave if the flange is distorted, a buildup of glass interferes with the engagement of the grapple, or if a glass overflow occurs and locks the container or lower container overpack to the turntable.

- Vulnerabilities attributed to contamination control issues include:
  - Non-finished surfaces of the LPH transfer corridor walls will trap contamination migrating from pour caves.
  - Use of Bogie Recovery Systems will transfer contamination into the Bogie Maintenance Area.

5.7.2 Low-Activity Waste Container Pour Handling (LPH) Conclusions

The most complicated and highest impact to the LPH System is related to the thermal issues. The complexity of the thermal interaction of the glass filled containers within the system, coupled with the current HVAC design, indicates that sustained operation of the LPH System at the design production rate cannot be assured. Further reanalysis will be needed to define where additional cooling and controls are necessary. If left unchanged, it is anticipated that frequent system intervention and interruption to melter feed operations will be required to achieve a limited level of system operability, thereby leading to significant LAW Facility throughput impacts.

5.7.3 Low-Activity Waste Container Pour Handling (LPH) Recommended Path Forward

The following recommendations are examples of specific OFIs relative to the vulnerabilities found during the LPH System review. Specific recommendations to mitigate vulnerabilities attributed to thermal issues include:

- Perform a CFD analysis of the Container Transfer Corridor and all four pour caves, at full LAW Facility throughput and upset conditions, to assess HVAC system interaction with container operations. Install additional cooling in the LAW Facility and modify the HVAC C5V system as required to preclude excessive temperatures based on the CFD analysis. Convert all the process "delay time" requirements in the container handling HVAC CFD scenarios to actual container temperatures requirements to ensure operations understand all system and equipment thermal limitations. The OR model can then assess any impacts on throughput based on CFD generated data.
- Increase cooling to the filled container flange area to reduce the time it takes for the container flange to cool and regain its structural strength. Install an instrument to measure the temperature of the filled container in the pour cave cooling position on the turntable.
- Conduct a thermal analysis, validate the concrete surface temperature of the Container Transfer Corridor walls near hold position 15, and define the needs for adding insulation material and stainless steel liner in this area during the construction phase prior to

commissioning (similar to the wall configuration at the east end of the Corridor near the Export Stands). Alternatively, the design basis for the container hold position 15 can be evaluated to mitigate the hold requirements through other control means and completely eliminate the need for the hold position.

- Specific recommendations to mitigate vulnerabilities attributed to container filling operations and overfilling scenarios include:
  - Install an overfill spout to direct the molten glass to a safe accumulation area. A system similar to the WTP HLW melter installation could be used.
  - Install a camera in the pour caves to look upward into the bellows when the container is lowered to the turntable to allow the Operator to determine if any glass is building up on the melter pour spout bellows internals.
- Specific recommendations to mitigate vulnerabilities attributed to the handling of abnormal product containers include:
  - Identify an alternate storage location for the Container Recovery Lifting Frame that will allow the current conceptual design to be utilized, or redesign the lifting frame so it can be transferred through the Buffer Store Maintenance Facility door.
  - Design a new way to move abnormal containers/overpacks, using a lightweight, high strength, and remotely operated lifting frame to/from the Pour Cave Turntable.
- Specific recommendations to mitigate vulnerabilities attributed to contamination control issues include:
  - Evaluate the need for applying decontamination-resistant coating to the unfinished upper surfaces of the Container Transfer Corridor since the natural convection plume will carry contamination out of the pour caves into the corridor.
  - Develop disposable sleeves and/or maintenance procedures to remove the contamination from the bogie recovery wire ropes before it is dispersed inside the components of the Bogie Recovery Systems located in the Bogie Maintenance Area.

5.8 MELTER HANDLING SYSTEM (LMH)

The dedicated LMH provides the mechanical handling equipment associated with the import of new locally shielded melters and the export of failed or spent locally shielded melters from the LAW Facility. Key components of the LMH System include the locally shielded melter rails and associated winch and pulley block arrangement.

5.8.1 Low-Activity Waste Melter Handling System (LMH) Key Results/Consequences

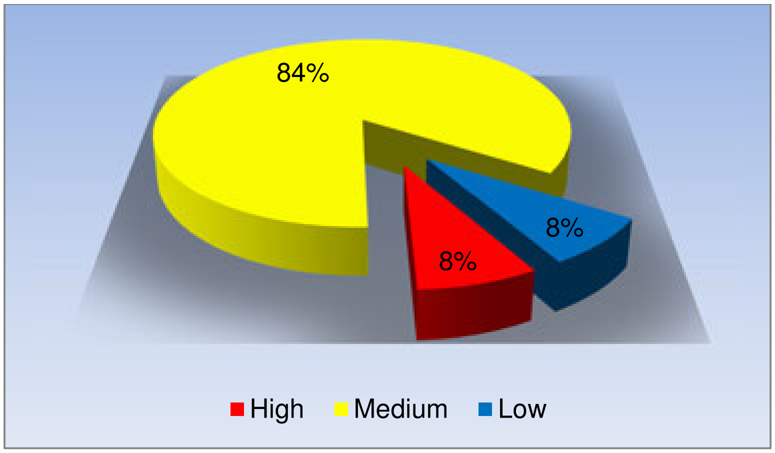

Figure 5-8. Unmitigated Vulnerabilities Identified for the Low-Activity Waste Melter Handling System.

Prolonged LAW Facility outages with attendant impacts to LAW production are anticipated in order to recover from existing shortcomings in LMH System design based on the following:

- The review team identified 13 vulnerabilities for the LMH System, 12 of which require remediation prior to initiating production operations and preferably before startup testing. Figure 5-8 shows the percentages of high-, medium- and low-impact vulnerabilities identified for the LMH System. See Appendix B for a list of vulnerabilities and OFIs.
- The decision to not develop the capability to replace melters at this stage of the project presents a significant risk to sustainable facility operations. For example:
  - Current melter fabrication and assembly is taking significantly longer than anticipated under less restrictive conditions than will be in place at the time of replacement.
  - It is not clear whether the melter will be assembled local to LAW in which case the assembly building and transportation system must be developed or if assembled remotely the additional complexity of the melter transporter must be considered.
  - Specialist expertise available for melter assembly is limited and subject to attrition.
  - Draining of melter coolant has not been considered and liquid is incompatible with the Land Disposal regulations.
  - Melter decontamination capabilities have not been adequately considered or addressed.
  - Failure to demonstrate the melter replacement process prior to active operations represents a serious risk in an active and hazardous environment.

5.8.2 Low-Activity Waste Melter Handling System (LMH) Conclusions

The failure to plan and design early for replacement of a melter presents a significant risk to continued sustainable operation of the LAW Facility. Undertaking the design and changeout in an active facility without demonstrating key features prior to active operations is likely to reveal significant problems and omissions and take a significant period to effect a change, with attendant losses to production.

Other concerns arise from melter decontamination activities from the perspectives of where it will be done, what medium will be used, etc. In addition there are system gaps in delineating responsibilities for all aspects of spent melter removal and impact on operability of the other melter.

5.8.3 Low-Activity Waste Melter Handling System (LMH) Recommended Path Forward

Specific recommendations to mitigate LMH System vulnerabilities include the following:

- Redesign necessary equipment and systems to support operation of a third melter.
- Consider adding an installed spare melter into the third melter position and keep it isolated from the LAW Facility until it is needed to replace a spent or failed melter. Possibly, the pre-staged melter could be operable and brought online relatively quickly, so that throughput could be maintained during the outage necessary to remove the spent or failed melter and build/install the next spare.
- Determine a schedule of need, a location for melter assembly, parts availability, and a method of transport for replacement melters.

5.9 CONTAINER FINISHING HANDLING SYSTEM (LFH)

The LFH System receives filled containers from the LPH System, provides glass sampling functionality, measures container fill level, inert fill addition, installs lid, decontaminates, swabs, and monitors contamination/radiation dose prior to transporting containers to the LEH System.

5.9.1 Low-Activity Waste Container Finishing Handling (LFH) Key Results/Consequences

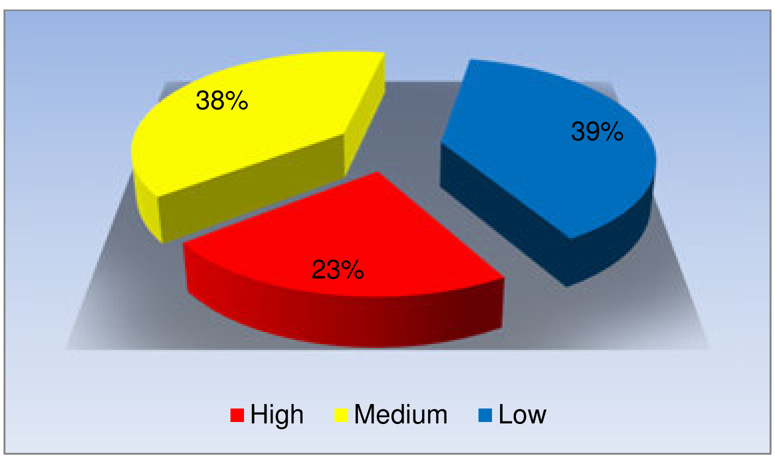

Figure 5-9. Unmitigated Vulnerabilities Identified for the Low-Activity Waste Container Finishing Handling System.

The LFH System cannot meet throughput requirements, unless significant changes are made. Decontamination issues, thermal issues, contamination control and product container handling issues, if unmitigated, will render this system unable to support throughput requirements for the following reasons:

- The review team identified 70 vulnerabilities, 43 of which require remediation before CD-4 and preferably before startup testing. Sixteen of the 43 vulnerabilities are high impact and require some level of significant redesign. Figure 5-9 shows the percentages of high-, medium-, and low-significance vulnerabilities identified for the LFH System. See Appendix B for a list of vulnerabilities and OFIs.

- Vulnerabilities attributed to CO_2 decontamination ineffectiveness include:
  - Container decontamination may be ineffective based on a low Technology Readiness Assessment Level assignment by DOE, and the integrated system has not been tested and operation may not adequately contain contamination spread.
- Vulnerabilities attributed to thermal issues include:
  - Flexible electrical conduits routed to junction boxes near the LFH container lidding area are not correctly specified for the environmental temperature conditions.
  - Inconsistent temperature bases used for LFH equipment air tubing and sampling/inert fill equipment data sheets.
- Vulnerabilities attributed to contamination control issues include:
  - Configuration of the recessed rails in the LFH finishing lines will promote the accumulation of contamination.
  - Maintenance on Bogies in Swabbing and Export Rooms may be problematic due to contamination potentially pulled from Container Lidding Areas.
  - Compressed air required to cool the LFH swabbing robot arm instrumentation may spread contamination on the container surface instead of cooling instruments.
- Vulnerabilities attributed to product container handling issues include:
  - Glass shard sampling is not capable of sampling under-filled containers, and these non-conforming containers are likely to require sampling more frequently.
  - The lid holder magazine decontamination and refilling process design has not been finalized or the methodology determined.
  - The lid recovery tool has not been proven for all anticipated failure modes.
  - The LFH swabbing robot is programmed to swab the curved bottom, vertical sides, and tops of the product containers only, not when the container must be exported with the lower container overpack attached to it.
  - Daily crane and hoist inspections required by the Vendor with a "SHALL" in the maintenance manual will mean daily personnel entries into a C5 area.
  - Incorrect type of isolation valve is specified and installed in the inert fill day tank. The day tank upper isolation valve is a butterfly valve. If the inert material is flowing through the rotary feeder and moving past the isolation valve the valve may be able to be closed, but once the rotary feeder is stopped the spool piece and isolation valve will become packed solid with inert material, preventing closure of the isolation butterfly valve as operating instructions indicate.

5.9.2 Low-Activity Waste Container Finishing Handling (LFH) Conclusions

The lack of proven effectiveness of the LFH product container decontamination process poses a significant risk to facility throughput. Surface contamination is expected on the containers and a proven decontamination method is vital to meeting mission goals. Without additional testing and validation of the current system and other mitigating actions, the review team anticipates the

LAW Facility will undergo frequent production interruptions and may never achieve the required performance objectives.

5.9.3 Low-Activity Waste Container Finishing Handling (LFH) Recommended Path Forward

The following recommendations are examples of specific OFIs relative to the vulnerabilities found during the LFH review. Specific recommendations to mitigate vulnerabilities attributed to CO_2 decontamination ineffectiveness include:

- Provide fully integrated demonstration tests to prove the capability of the CO_2 container decontamination system to decontaminate containers, grapples, and turntables while completely capturing the mobilized contamination. Develop a method to decontaminate and export a non-conforming ILAW container.
- Specific recommendations to mitigate vulnerabilities attributed to thermal issues include:
  - Reassess the environmental temperature (including container proximity to equipment) of the finishing line. Design and provide required insulation or high temperature specific electrical conduits for all junction boxes in the finishing line.
  - Perform CFD thermal analysis to establish valid container cooling temperature profiles through the finishing line and evaluate against the LFH equipment thermal limits.
- Specific recommendations to mitigate vulnerabilities attributed to contamination control issues include:
  - Develop procedures for frequent periodic decontamination work activities to prevent contamination buildup along the bogie tracks and rooms.
  - Analyze air velocity at the surface of the container created by the swabbing robot arm cooling system to ensure surface contamination is not disturbed. If required, modify the cooling system to keep temperature sensitive proximity sensors below critical temperatures and eliminate surface contamination spread.
  - Replace the inert fill day tank upper butterfly valve with a slide gate valve that can operate with a full pipe of dense inert fill material. Full functional testing should be performed during commissioning.
- Specific recommendations to mitigate vulnerabilities attributed to product container handling issues include:
  - Redesign the glass shard pickup assembly to meet the glass sample requirement regardless of the glass height in the product container.
  - Retest the shard pickup assembly using a prototypical Master Slave Manipulator (MSM) and prove the tool design can be controlled and glass shards can be generated for sample pickup. These tests should be performed on actual solid glass samples not on glass frit to ensure the tool can be used to generate glass shards for pickup.
- Provide an effective method to safely decontaminate the LFH lid holders. Install a fixed lid magazine stand, along with a jib crane dedicated for lid handling to safely refill the lid holder. Purchase two spare lid holders (one for each lidding line) to minimize downtime associated with lid holder decontamination/refilling.

- Provide a proof of principle test to validate the current lid recovery tool design can remove a “mis-installed”/canted lid.
- Create and test swabbing programs for the lower container overpacks prior to commissioning activities.
- Apply for relief from crane and hoist ASME code; 29 CFR 1910.178, “Occupational Safety and Health Standards,” “Powered Industrial Trucks”; and vendor manual requirements in DOE/RL-92-36 and then tailor the crane and hoist “SHALL” requirements in the SRD.

5.10 RADIOACTIVE SOLID WASTE HANDLING SYSTEM (RWH)

The purpose of the RWH System is to provide the mechanical handling equipment necessary to facilitate handling and packaging of secondary radioactive solid waste (RSW). Examples of RSW include failed equipment, consumable items, and maintenance wastes.

5.10.1 Low-Activity Waste Radioactive Solid Waste Handling (RWH) Key Results/Consequences

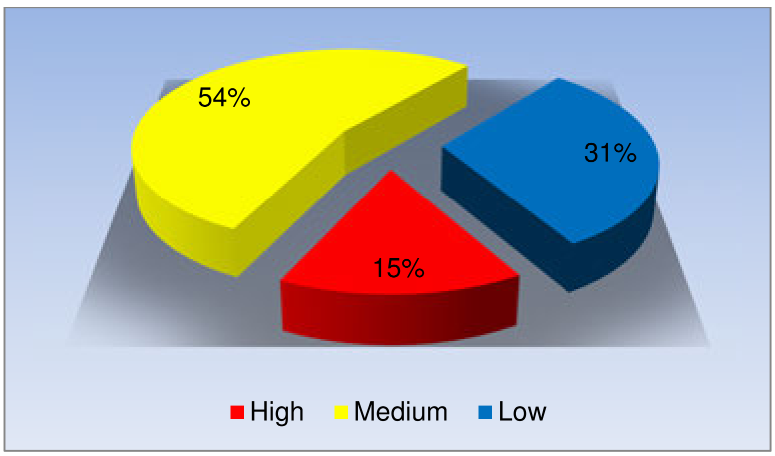

Figure 5-10. Unmitigated Vulnerabilities Identified for the Low-Activity Waste Radioactive Solid Waste Handling System.

The functionality of the RWH System is not adequate to fully support life-cycle operations. Specifically, the RWH System may prevent the LAW Facility from achieving throughput requirements for the following reasons:

- The review team identified 13 vulnerabilities for the RWH System, nine of which require resolution before startup testing. Figure 5-10 shows the ratio of unmitigated high-, medium-, and low-impact vulnerabilities identified for the RWH System. See Appendix B for a list of vulnerabilities and OFIs.
- Design for secondary solid waste management (e.g., decontamination, size reduction, packaging, export and staging) is incomplete and not inclusive of all RSW that will be generated in the LAW Facility (e.g., failed equipment too large to package in a 55-gallon drum, B-25 box or S-0480-1376 box). An inadequate waste management capability will result in a backlog of RSW. This backlog will grow until the RWH System cannot accommodate additional waste generation (i.e., the RWH System reaches a state of gridlock). Resolution of RWH System gridlock situations likely will require frequent and

prolonged interruption to LAW production operations. Some of the identified waste management issues that will contribute to RWH System gridlock include the following:

- The RWH System design includes two cranes that do not adequately support lifting and handling the various waste containers and their movement through the facility;
- HEPA filters may develop too high of a radioactive loading before differential pressure monitoring indicates a heavy particulate loading. HEPA filters are bagged out using a hands-on method and this change-out is currently assumed to be scheduled before the filters have accumulated excessive radioactive loading; however, how this will be achieved is not defined as dust loading alone is and not an effective indicator and no monitoring facility is available on the housings to identify radioactive build up.

* WTP is not following the DOE Hoisting and Rigging program, and no WTP specific hoisting and rigging program and/or critical lift program for the RWH System have been defined nor is currently under development.
* Adequate funding and resources do not appear to have been allocated to address equipment preservation and degradation. Equipment is experiencing degradation such as corrosion and false brinelling.
* Key LAW documents contradict each other regarding RWH System scope. Examples of the contradictions are listed below:
  - The LAW Facility Description and RWH System description are inconsistent regarding the discussion of "bagging, packaging, decontamination, swabbing, etc." The current contract requires WTP only to package the waste for transportation and not for ultimate disposal. This means that the waste will require unpacking, inspection and repackaging by the Tank Operating Contractor for disposal. This is neither efficient or ALARA compliant.
  - The RWH System description specifies that crane decontamination can be accomplished with CO_2, pressurized warm water, steam, etc. However, no such capability exists within RWH and the SME states that no decontamination beyond wet wipes will be done.

5.10.2 Low-Activity Waste Radioactive Solid Waste Handling (RWH) Conclusions

The RWH System design has not adequately demonstrated the ability to handle projected waste volumes in high maintenance years and does not address export of all secondary waste forms. The RWH System has inadequate functionality for handling, packaging, and exporting the secondary wastes designated to be exported through this system. The lack of adequate system functionality may quickly result in a backlog of secondary RSW. This backlog may grow until the RWH System cannot accommodate additional waste generation (i.e., the RWH System reaches a state of gridlock). Resolution of RWH System gridlock situations may require frequent and prolonged halts to the LAW Facility production operations to clear out stored waste material.

5.10.3 Low-Activity Waste Radioactive Solid Waste Handling (RWH) Recommended Path Forward

Specific recommendations to mitigate RWH System vulnerabilities include:

- Perform a conservative and comprehensive assessment of all secondary radiological and hazardous waste volumes and types, and benchmark against other similar facilities, and produce a conservative secondary waste baseline document.
- Develop a waste disposition plan that identifies the export and disposition paths for all secondary wastes, including the levels of decontamination required to meet anticipated disposal requirements, needed size reduction, and appropriate transportation packaging.
- Provide disposition paths for all equipment that is reasonably expected to fail during the operational life of the facility, and document the paths in a comprehensive waste management plan.
- Define the requirements and compliance approach for meeting the transportation and disposal requirements in the plan.
- Develop long term plans that address replacement and/or refurbishment of obsolete or degraded equipment.
- Produce a system capability report, including an OR model, that can be used to describe the design and confirm that all secondary waste peak volumes and waste forms can be exported from the facility with no negative impact to ILAW glass production. Account for the availability of interfacing systems and organizations, and provide a nominal and bounding result based on realistic, documented, and supported inputs.
- Develop a methodology to export spent consumables that supports the requirement to transition the consumable between a vertical and horizontal position which appears to be required to effect export of large items.
- Define, design, and provide lifting and handling equipment for each identified waste package.
- Consider packaging all or some of the secondary waste generated at the LAW Facility for disposal rather than transportation. This will reduce cost and demonstrates an ALARA approach.

5.11 CONCENTRATE RECEIPT (LCP) AND MELTER FEED PREPARATION (LFP) SYSTEMS

The overall function of the combined LCP and LFP systems is to receive, prepare and deliver LAW feed to the melters. The specific key functions assigned to the LCP system include:

- Receive LAW concentrate from Pretreatment Facility.
- Store, mix and sample LAW concentrate (sample hold point to determine glass former requirements).
- Transfer LAW concentrate forward to LFP System or back to pretreatment via the radioactive liquid waste disposal system.
- Provide flush capability for vessels, piping and in-line components to prevent plugging and provide decontamination.

The specific key functions assigned to the LFP System include:

- Receive LAW concentrate from LCP.
- Receive glass formers and mix to meet product compliance requirements.
- Sample melter feed to verify correct glass former mixture (not a hold point).
- Transfer feed to melters.
- Provide flushing capability to prevent plugging and provide decontamination capability.

There are two independent and duplicate arrays of LCP and LFP components for each melter. There is capability provided to transfer process fluids between various vessels which provides for process flexibility. Although the LCP and LFP systems are technically separate, they are considered together for purposes of this review due to their high degree of interdependence.

5.11.1 Low-Activity Waste Concentrate Receipt Process System/Melter Feed Process System (LCP/LFP) Key Results/Consequences

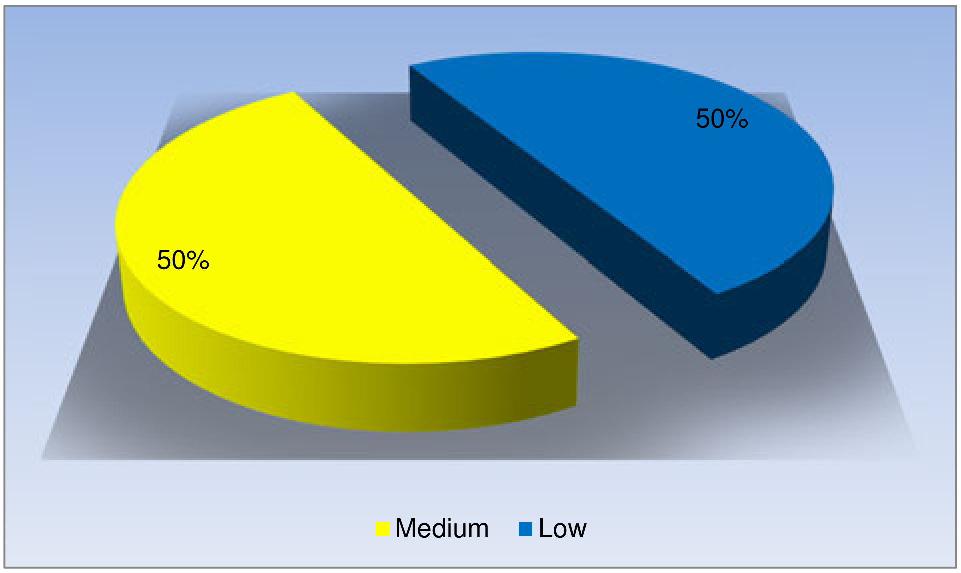

Figure 5-11. Unmitigated Vulnerabilities Identified for the Low-Activity Waste Concentrate Receipt and Melter Feed Preparation Systems.

Some vulnerabilities were identified that may lead to periodic operational interruptions or long term equipment functionality concerns. The summarized principal results are as follows:

- There were 16 vulnerabilities identified in this system with eight requiring remediation prior to startup testing. No major design changes were identified and most if not all of the identified vulnerabilities have uncomplicated mitigation actions available. Figure 5-11 shows the ratio of unmitigated medium- and low-impact vulnerabilities identified for the LCP/LFP System. See Attachment B for a list of vulnerabilities and OFIs.

- It is uncertain that LCP/LFP vessel design can reliably achieve structural integrity requirements over a 40-year design life because:

  – The 40 year design life of the LFP vessels is in question due to the lack of credible data specific to LFP process conditions to accurately predict the erosion wear for the stainless-steel material used.

- The design basis temperature of 150°F for Condensate Receipt Vessel, Melter Feed Preparation Vessel (MFPV), and Melter Feed Vessel may not be adequately conservative under off-normal conditions (e.g., extended melter idle periods).
- The ability of the LAW LFP feed preparation and feed vessels to structurally support the external cooling panel sections has not been demonstrated.
- The cooling jackets for MFPV and Melter Feed Vessel tanks do not currently include pressure relief.

- The effectiveness of design features to reliably ensure adequate equipment performance and process control under normal and abnormal operating conditions is questionable because:
  - Fixed speed agitators may not provide adequate flexibility to address variations in process conditions or recover after prolonged down time.
  - The operating envelope has not been defined to ensure the requirement for mixing homogeneity can be met during normal plant operations
  - The current approach to Air Displacement Slurry pump monitoring/trending may not be adequately indicative of performance.
  - A comprehensive equipment condition monitoring strategy/system is not evident in the documents provided/reviewed.
  - There is a lack of process control information available to prevent the potential for glass former reagent component omission to cause premature melter failure under worst case conditions.
  - The basis/definition of acceptable gear oil leakage rates and process impacts is not evident.
  - The ability to automate using existing design features appears to be underutilized.
  - The LCP/LFP bulge drain systems do not appear to have adequate drain capacity when spray rings are turned on.
- Contact maintenance approaches for complex/high risk activities have not been developed to the extent necessary to confirm that maintenance can be performed in an efficient manner consistent with the OR model assumptions and that unacceptable production impacts will not result because:
  - The requirement to de-inventory and flush vessels and pipework prior to entry has not been evaluated or included in availability assumptions.
  - A comprehensive equipment condition monitoring strategy/system is not evident so that process cell entries can be minimized.
  - The ability to install/replace pumps/agitators and other internal components that require alignment with the vessel base (such as bubbler tubes and thermowells) has not been adequately demonstrated.
  - Adequate mock-up/testing facilities are not available or planned to support high risk contact maintenance activities (such as pump/agitator replacement) and testing/run-in of mechanical equipment so that personnel exposure to in-cell hazards can be minimized.

5.11.2 Low-Activity Waste Concentrate Receipt Process System/Melter Feed Process System (LCP/LFP) Conclusions

The combined LCP/LFP systems are considered to be capable of meeting their intended functions with some limitations:

- Weaknesses associated with undemonstrated equipment availability
- Restricted process cell access to perform contact maintenance (due to thermal, chemical and radiological conditions)
- Incomplete use of automation or equipment condition/performance monitoring features that could reduce the potential for process upsets or cell entries to determine/confirm performance.

There were no singular vulnerabilities identified that appear to result in a high impact to facility functionality, but the WTP Project should consider the cumulative impacts of the identified vulnerabilities in determining any improvement/risk reduction plan for the system. In the judgment of the review team, most if not all of the identified vulnerabilities have uncomplicated mitigation actions available.

5.11.3 Low-Activity Waste Concentrate Receipt Process System/Melter Feed Process System (LCP/LFP) Recommended Path Forward

The identified vulnerabilities and associated forecasted impacts are likely to be realized until mitigation actions have been completed and system functionality independently confirmed. Some specific recommended mitigation options include, but are not limited to, the following:

- For vulnerabilities associated with LCP/LFP vessel design reliably achieving structural integrity requirements over a 40-year design life:
  - Conduct additional CFD analysis with appurtenances modeled per vessel in the actual configurations to identify potential areas of accelerated erosion.
    - Based on the CFD analysis, consider remote vessel wall thickness monitoring (e.g., ultrasonic thickness transducers) permanently mounted to lower head and shell.
  - Conduct additional prototypic testing with relevant simulant to confirm relationship of agitator speed to fluid velocity at vessel head/walls.
  - Perform post-commissioning vessel inspections to determine evidence of premature erosion.
  - If warranted, consider thermal spray hard coating of vessels and internals.
    - If thermal spray is considered, then also consider increasing the vessel design temperature to eliminate the need for the add-on cooling panels.
  - Re-evaluate design basis temperature limits for vessels to increase operating margin and operational flexibility. Vessels appear adequately robust to support increasing the design basis temperature to 200°F.
  - Establish operational procedures and protocols to deal with prolonged periods of agitation operation in both Condensate Receipt Vessel and LFP tanks (i.e., add water, temporary termination of agitation, etc.).

  - Re-analyze LCP/LFP tank equilibrium temperature for the possibility of extended periods for melter idling. Calculate the tank equilibrium temperature using agitator heat input, latent heat of evaporation inside the tank, plant service air flow rate, and vessel vent flow rates.
  - Evaluate the impact that the boric acid exothermic reaction has on the operation of the MFPV tank temperature.
  - Consider feeding glass formers into the MFPV tank over a longer period of time (5-7 hours) to prevent tank temperature approaching or exceeding the tank design temperature limit.
  - Confirm unverified assumptions in structural analysis for installation of external cooling panel sections for LFP feed preparation and melter feed vessels.
    - Update analysis and verify adequacy of vessel design.
  - Evaluate the need for pressure relief for the MFPV and Melter Feed Vessel cooling jackets.
  - Add pressure relief on the demineralized water system downstream of the PCV-2101 to control pressure for SBS as well as LFP cooling jackets.
- For vulnerabilities regarding the effectiveness of design features to reliably ensure adequate equipment performance and process control under normal and abnormal operating conditions:
  - Define the operating envelope for mixing and how much deviation can be allowed.
  - Consider alternative level detection in vessels that are relied upon to meet mixing requirements such as using existing dip tubes (add transmitter to long leg of specific gravity dip tubes).
  - Consider adjustable speed drive (ASD) on agitators to allow flexibility to achieve required mixing performance and to provide additional performance monitoring capability.
  - Consider using a two or more point comparison of Air Displacement Slurry pump air-line pressure as a better indicator of overall performance and as an operator aid, as a single point is not considered an adequate indicator of acceptable performance, e.g. the apex of the pump discharge pressure.
  - Develop a formal comprehensive strategy for equipment performance monitoring. Optimize the use of available instrumentation etc., and consider using reliability centered maintenance techniques to maximize equipment availability and minimize intrusive or breakdown maintenance requirements.
  - Conduct impact assessment that defines the time period associated with omitting each glass forming component that could result in a premature melter failure.
  - Define receipt of MFPV sample analysis results as hold point for initiating the next (or a fixed number of batches) glass former addition to mitigate potential for multiple mis-batch additions in a row based on the omission time periods that could result in premature melter failure.

- Use control system to identify gross changes in batch to batch glass former component additions as method of warning that a potential input error has occurred (i.e., use control system to flag large variances in expected inputs such as glass former weights).
- Perform calculations to quantify acceptable limits for gearbox oil leak rates and/or amounts each vessel can tolerate.
- Finalize design features for checking and replacing gearbox oil, utilizing existing riser piping at the 28-foot level.
- Consider fully automating transfer and flush sequences.
- Incorporate remote monitoring/power option for auto-lubrication system.
- Consider additional controls for the flush water flow to the bulge spray rings such as:
  - Install level monitoring in the bulge and change manual valve to a control valve that could be shut off automatically whenever the level in the bulge gets too high.
  - Install smaller capacity spray nozzles.
  - Install local liquid level gauge for operator to monitor liquid level.
  - Install orifice to reduce flow and pressure to spray nozzles.
  - Automate water spray system to limit time of flush and/or sequence flushes for short flushes followed by time drainage periods in a series of two to three cycles.

- For vulnerabilities associated with contact maintenance approaches:
  - Further develop and implement the out-cell ability to diagnose equipment performance trends using multiple, diverse parameters to reduce the need to enter the process cells and avoid the attendant personnel hazards and facility throughput impacts. Examples may include:
    - Providing equipment performance trending/monitoring parameters that are inherent in current design for display to operators.
    - Providing ASD on agitators will provide additional condition/performance monitoring flexibility and capability.
  - Confirm the ability to change a pump/agitator under various vessel operating conditions during commissioning or as a mock-up.
  - Consider the viability of incorporating additional alignment aids such as inverted cone to the base of the pump/agitator flanges with the stabilizer guide.
  - Conduct a formal and systematic analysis of maintenance infrastructure needs.
  - Identify and prepare an existing Hanford Area facility for use as a WTP mock-up/testing facility (e.g., 2101M, Maintenance and Storage Facility at Fast Flux Test Facility, etc.) or; design and build (e.g., pre-fab building) a testing/mockup facility at WTP.
  - Consider working with the tank farm contractor to establish a shared/consolidated mock-up facility.

5.12 CONTAINER EXPORT HANDLING SYSTEM (LEH)

The LEH System provides mechanical handling equipment to remove filled and lidded LAW product containers from the finishing line and place the container on TOC-supplied transport vehicles.

5.12.1 Low-Activity Waste Container Export Handling (LEH) Key Results/Consequences

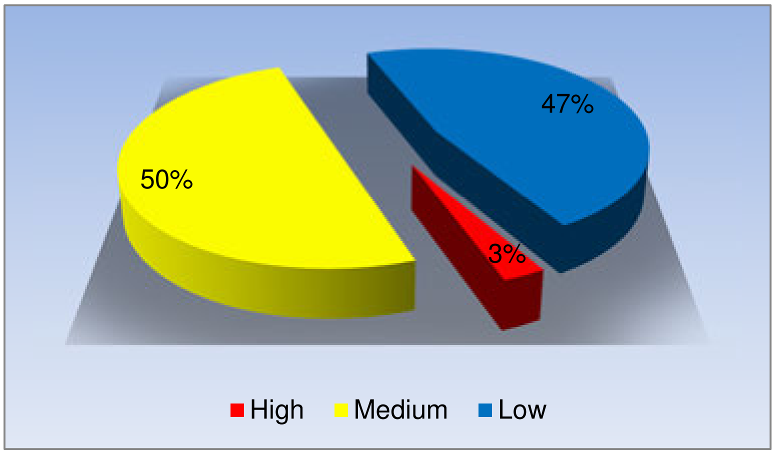

Figure 5-12. Unmitigated Vulnerabilities Identified for the Low-Activity Waste Container Export Handling System.

The current design of the LEH System should meet production goals if container temperatures are kept low and a viable transportation system is developed. The overall effectiveness of system operations may be most significantly impacted by product container handling and contamination control issues.

The summarized principal results are as follows:

- The review team identified 36 vulnerabilities, 19 of which require remediation before initiating production operations and preferably before startup testing. One of the vulnerabilities will likely require significant redesign. Figure 5-12 shows the percentages of high-, medium-, and low-significance vulnerabilities identified for the LEH System. See Appendix B for a list of vulnerabilities and OFIs.
- Vulnerabilities attributed to thermal issues include:
  - Filled ILAW container export temperature may affect container loading, transportation, and/or TOC Integrated Disposal Facility operations.
- Vulnerabilities attributed to product container handling issues include:
  - The structural analysis of the export bay embeds and wall design is inconsistent with LEH jib crane reaction forces.
  - LEH Export Bay Crane maintenance activities may be impacted by de-rating the maintenance jib cranes caused by limited load bearing capability of the embeds.
  - The reach of the jib cranes is limited and a large portion of the Export Bay Crane cannot be reached by either jib crane. In addition, the permanent maintenance platform blocks the path to lower components from the Export Bay to the floor below.

  - LEH Export Bay Crane capacity may not be sufficient for cases where a filled ILAW product container cannot be decontaminated to export limits and an overpack must be used.
- Vulnerabilities attributed to contamination control issues include:
  - There are no interlocks that prevent one of the two roll-up doors to the Export Truck Bay from being opened while one or both of the finishing line export hatches are open.
  - The potential for contamination migration exists when transferring ILAW product containers through the export hatches.

5.12.2 Low-Activity Waste Container Export Handling (LEH) Conclusions

The LEH System can meet throughput requirements, as long as challenges in exporting and transporting high temperature containers are met. The current site transporter system does not have an effective design to accept high temperature containers (an effective overpack or transporter design does not exist). Although this last vulnerability is not a WTP design issue, it is included in this report because it affects WTP operability and throughput.

5.12.3 Low-Activity Waste Container Export Handling (LEH) Recommended Path Forward

The following recommendations are examples of specific OFIs relative to the vulnerabilities found during the LEH System review.

Specific recommendations to mitigate vulnerabilities attributed to thermal issues include:

- Resolve temperature inconsistencies within the ICD 15, develop a viable transporter system to handle high temperature containers (including remote features within WTP), resolve temperature inconsistencies within the LPH/LFH process so containers that are exported meet the 200°F expectation for Integrated Disposal Facility receipt, and/or provide adequate buffer space at either export (WTP) or receipt (Integrated Disposal Facility) to handle 550°F containers and allow sufficient cooling time.

Specific recommendations to mitigate vulnerabilities attributed to product container handling issues include:

- Revise all issued documents to reflect the de-rated capacity of the maintenance jib cranes Provide a full extent of condition analysis on embeds that support loads on vertical walls of the LAW Export Bay to ensure the embed design meets equipment loads.
- Investigate the feasibility of a different lifting system to replace the LEH maintenance jib cranes; this could include a single underhung or under-running type to support the maintenance of the LAW Export Bay Crane designed to work within the limits of the facility and lifting capacity requirements. This might require additional structural support or utilizing other structural steel already in place. The new lifting system should have the ability to move over the entire range of the intended work zone.
- Define and design a method for exporting non-compliant containers and validate the existing 10-ton Export Bay Crane capacity is not exceeded.

Specific recommendations to mitigate vulnerabilities attributed to contamination control issues include:

- Add interlocks to the design to allow only one LFH export hatch to be open at a time, prohibit the opening of an Export Bay roll-up door when a hatch is open, and prohibit the opening of a hatch when a door is open.
- Evaluate the currently defined work processes and ensure an engineered or administratively-defined process is adequate for controlling and monitoring contamination migration when transferring the ILAW product container from the LFH System to the Transport Trailer.

5.13 CONTAINER RECEIPT HANDLING (LRH)

The LRH System receives empty containers into the LAW Facility and transfers the containers to the LPH System where glass-filling operations are performed. The system consists of two redundant and parallel conveyor lines that work together to inspect and stage containers prior to transfer to the LPH System.

5.13.1 Low-Activity Waste Container Receipt Handling (LRH) Key Results/Consequences

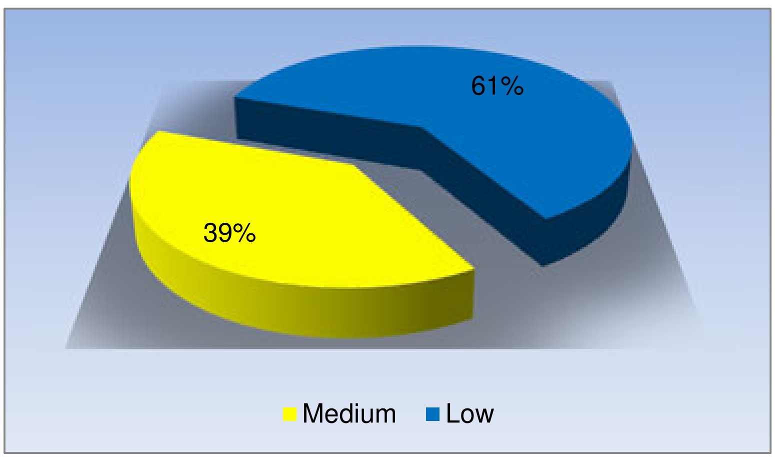

Figure 5-13. Unmitigated Vulnerabilities Identified for the Low-Activity Waste Container Receipt Handling System.

The current LRH System design may limit the overall production capability of the LAW Facility based on some common themes found in the medium impact vulnerabilities. These include empty container handling operations, container receipt inspection operations, and design calculations/component testing issues.

The summarized principal results are as follows:

- The review team identified 54 vulnerabilities in this system, 21 of which require remediation before initiating production operations. None of the vulnerabilities resulted in a high impact consequence. Figure 5-13 shows the percentages of medium- and low-significance vulnerabilities identified the LRH System. See Appendix B for a list of vulnerabilities and OFIs.
- Vulnerabilities attributed to empty container handling operations:

  - A delivery of empty LAW containers will block the LAW import bay loading dock until all the containers are removed from the truck. Blockage of the truck bay with a container delivery will affect competing LSH and RWH operations that share the same space (both in loading dock and overhead crane use).
  - The overhead crane in the LAW import bay does not have enough lift clearance to move a LAW container over another container on an over-the-road truck, which will reduce flexibility during the unloading process.
- Vulnerabilities attributed to container receipt inspection operations:
  - The lack of adequate interlocks in the Container Receipt Area allows for the potential of an empty container to be remotely moved while being manually inspected.
  - There is neither an inspection procedure available nor description of any toolkit that would be necessary to deal with the required detection and removal of any liquid or solid material present inside the 7.5-foot tall LAW containers. Inspection of empty containers cannot be executed with the current design of the inspection platform.
  - There is nothing in the current design that prevents foreign material from entering the containers once they have been unloaded on the import conveyor(s).
- Vulnerabilities attributed to calculations and component testing:
  - The conveyor roller impact loading is exceeded when the weight of the grapple is included in the allowable stress calculation.
  - The factory acceptance testing of the LRH conveyor system was incomplete transferring risk to the commissioning phase.
  - It is indeterminate if the building structural steel design meets shear/moment/deflection limits.

5.13.2 Low-Activity Waste Container Receipt Handling (LRH) Conclusions

The LRH System generally has the ability to import empty containers into the LAW Facility, but it does not currently have the specific equipment in place to perform all intended functions to meet the design intent. The system will be challenged by the inspection requirements, and in the (off-normal) event of foreign material within a container, there is no equipment in place to easily clean/remove it. The use of a shared overhead crane with LSH System and space constraints within the import bay will also challenge operations.

5.13.3 Low-Activity Waste Container Receipt Handling (LRH) Recommended Path Forward

The following recommendations are examples of OFIs relative to the vulnerabilities found during the LRH review.

Specific recommendations to mitigate vulnerabilities attributed to empty container handling operations include:

- Perform a detailed task analysis of all operations performed in the receiving truck bay to support all LAW Facility operations. Use the task analysis to understand operating needs, inform the design regarding any additional features needed and ultimately be used to develop integrated operating procedures across the LRH, LSH, and RWH systems.

- Develop operating processes to facilitate unloading containers from the over-the-road trucks.

Specific recommendations to mitigate vulnerabilities attributed to container receipt inspection operations include:

- Add ICN monitored, hard-wired, interlocks to each of the two Container Receipt Conveyor lines that will be activated prior to manned operations at that station, and must be deactivated by the receipt inspector before the conveyor can be operated.
- Identify a viable inspection process and provide features for removal of foreign material for the incoming containers. Provide an inspection station that can meet all the inspection requirements while the containers are located on the receipt conveyors.
- Provide a cover/shield over the staging conveyor area to eliminate the chances of material falling into containers that have already been inspected.

Specific recommendations to mitigate vulnerabilities attributed to calculations and component testing include:

- Update the vendor calculation to include the weight of the grapple and the correct weight of the container as the bounding scenario for the clean container handling conveyor roller impact loading calculation. Compare the bounding scenario against the current design to assess the adequacy of the installed equipment.
- Reassess factory acceptance test requirements in specification for the LRH conveyor system. Perform a valid startup test to meet the requirements and undertake the test using the accepted requirements.
- Validate floor loads in the LAW Facility to assess if the structural steel framing is adequate.

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6.0 RECOMMENDED PATH FORWARD DECISIONS AND ACTIONS FOR THE OFFICE OF RIVER PROTECTION

The design and operability review teams identified 362 system specific design vulnerabilities that could limit LAW Facility functionality and operability for which mitigation is recommended prior to initiating nuclear operations. Some of these vulnerabilities, as described below are considered essential for achieving approval for hot operations while others are essential for achieving an acceptable level of operational efficiency subsequent to start of hot operations. A larger number of actions have been identified as potential mitigation for vulnerabilities. In many cases the potential mitigating actions can be implemented in a straight forward manner, others will typically require additional review and analysis and potentially a cost benefit analysis prior to implementation as part of any overall plan to address the vulnerabilities.

A systematic approach, in light of limited resource availability, is needed to develop and implement a plan to address the identified LAW Facility vulnerabilities. Further, it is important to note that the overall impact of such a plan is limited to the LAW systems actually reviewed.

The D&O review teams recommend that the ORP consider a limited number of decisions and remedial actions required to support the development of a systematic plan for addressing the results of this review and to provide a foundation for prioritizing and scheduling additional analysis and potential facility design changes and upgrades. These recommended ORP decisions and actions are intended to provide confidence that adequate functionality can be achieved to support safe LAW Facility operations without obviating the potential for gradual improvements in facility performance post CD-4.

The recommended path forward should consider the following:

1. The risk to the accuracy and adequacy of the LAW Facility design as a result of the design process deficiencies identified in Section 4 should be systematically assessed and action taken on those areas which have the potential for significantly delaying active commissioning of the facility or present an unacceptable challenge to the overall facility throughput.
   a. BNI should develop a plan to identify, segregate and validate those documents that will form the design basis and essential document set for operation of the LAW Facility, Balance of Facilities, and Analytical Laboratory (LBL). This is essential as the existing document set and storage and retrieval mechanism are currently incapable of supporting an operational readiness review or to provide a demonstrable design basis for operation and maintenance of the facility. This will also provide the structure to ensure that the future design activities will be implementable and demonstrably compliant with the revised WTP procedures.
   b. DOE should provide significant, critical oversight with appropriate authority to ensure that WTP Design Authority function is effectively and objectively executing the role in the best interests of DOE, the owner.
   c. The primary Requirements documents should be updated, with an assurance that they define the high level facility requirements consistently and accurately. This is particularly important for the Authorization Basis documents. If the primary Authorization Basis documents (Safety Basis and Permit) cannot be updated quickly

then conservative assumptions must be made regarding candidate safety and permit affecting systems to allow the design to progress with minimal risk of significant rework.

d. An extent of condition review should be undertaken by BNI to evaluate the impact of the above actions on the existing constructed and procured systems and a plan developed to bring the facility back into line with the agreed and validated requirements.

2. Multiple independent reviews identified the control system software specification, implementation and testing as being potentially inadequate.

    a. DOE should direct BNI to implement industry best practice in the development of lifecycle documentation, implementation and testing of the control system and the associated Human Machine Interfaces.

    b. DOE should increase the level of oversight on the WTP control system software development until satisfied that adequate processes are in place to ensure compliant and effective design. DOE should include independent industry and DOE complex contractor expertise in this oversight role.

3. The anticipated performance of WTP (including LAW) and the basis for the assumptions underpinning the performance has been questioned on multiple occasions.

    a. DOE should modify/develop the operational research model to objectively assess the true potential throughput/production capacity of the facility as designed and more importantly assess the potential facility bottlenecks that have the most impact on long term production.

    b. DOE should review the throughput of other nuclear facilities and benchmark the throughput achieved against those facilities. Any significant differences identified as a result of the benchmarking activities should be technically justified.

    c. DOE may need to consider a reduced throughput target at the start of operations with a detailed strategy and timeline to maximize throughput during the operational phase. This will require a detailed analysis of the changes anticipated during the operational phase and a measured approach to the risk cost and lifecycle schedule impacts introduced due to the higher degree of difficulty introduced in executing change in a radioactive/hazardous environment and the overall ALARA implications of this strategy.

    d. DOE should undertake a cost benefit analysis based on the cost to remove bottlenecks, the overall improvement to throughput and the impact of deferring the improvement until the operations phase. This should form the basis of planned improvements to the facility prior to and post CD-4.

4. A number of potential worker safety issues have been identified. It is not suggested that workers will be placed in harm's way when the facility is operational, rather there is a likelihood that design changes may be identified late and cause schedule delays and/or compromises on throughput and required staffing levels to minimize the risk to workers during operation and maintenance of the facility.

    a. DOE should direct BNI to undertake detailed ALARA analysis of selected areas and tasks to ensure that the "hands on" versus remote maintenance and operations philosophy is demonstrably supportable. This would involve developing conservative but realistic radiation dose calculations and maintenance assumptions for all areas where personnel are expected to work. Developing and documenting management strategies and time commitments for these areas e.g., de-inventory before entry, flushing requirements, remote tooling etc. Developing or use existing task analysis to estimate the radiation exposure to the work force to establish if dose management is a significant concern which requires mitigation through design changes. The results of this review would inform the mean time to repair (MTTR) durations expected and the potential throughput impacts. Decisions could then be made on if or how these impacts should be mitigated.

b. Conservative estimates should be developed by BNI for the facility of the anticipated radiological contamination levels anticipated for the various areas of the facility based on extrapolations from similar high level facilities. There appears to be a prevalent assumption within the project that the contamination levels will be at or near zero with minimal documented justification for this assumption. This assumption appears to be informing important project decisions on relaxation of basis of design assumptions without a clear documented rationale. Based on the anticipated levels the confinement ventilation requirements and operations and maintenance assumptions for the facility should be reevaluated and if necessary adjusted to be compatible with the identified risk.

c. Activities in the Hanford Tank Farms are significantly challenged as a result of fugitive vapor emissions and the need to protect workers from these emissions. Using the information and source term data available from the Tank Farms BNI should assess the potential impacts for the LAW Facility and consider the implications for worker protection undertaking operation and maintenance tasks. This should be used to inform the design regarding the reliance on and significance of the confinement ventilation system and the anticipated PPE requirements for work required to be carried out in various facility areas.

d. The challenge of working in high temperature environments is well known and creates challenges to the TOC currently due to the extreme summer temperatures. Similar challenges exist at WTP due to the thermal processes, there are also concerns regarding burn hazards. BNI should undertake a critical analysis of the tasks required to be completed in high temperature areas using a conservative assessment of the expected ambient working temperature. This should identify if there are areas where it is unreasonable to expect workers to safely perform operational and maintenance tasks or where maintenance tasks may be significantly restricted. This will inform the design regarding the need for additional cooling and/or the potential impact on throughput.

5. The commissioning phase of a project by its very nature is always on the critical path and is the point in a project when many unanticipated issues are identified; therefore, a flexible and rapid response is required to maintain schedule and cost. Wherever possible, known issues should be resolved prior to the commissioning phase.

   a. DOE should identify all current activities and risk mitigation actions that are currently deferred to the commissioning phase and develop plans to remove these activities to the extent possible out of the commissioning phase and off the project critical path. Through a cost benefit analysis it may be prudent to allow some issues to remain, these issues should be carefully planned and integrated in the commissioning schedule, with adequate contingency for unanticipated results, in a way that minimizes the impact to the project critical path.

6. The current CFD Model and its use along with the applicability of physical non prototypical analysis is particularly significant as it is used to bound many assumptions regarding procurement specifications, civil design, throughput, personnel safety, structural material safety limits etc. This analysis requires further evaluation and justification.

7. BNI should be directed to reassess and/or expand the documented validation of the existing thermal model for LAW to ensure the modeling assumptions and analysis is representative of the anticipated operating conditions.

   a. Based on the validated CFD analysis BNI should reassess the impact of potentially elevated temperatures on Structures Systems and Components within the facility to ensure adequate performance under all anticipated normal, abnormal and accident conditions.

   b. The container cooling rate should be evaluated by BNI using the same model for representative waste forms and any impacts to throughput should be assessed.

   c. Where temperatures are outside the SSC specification for acceptable performance or throughput is impacted, cost benefit analysis and specific action plans should be prepared to:

      i. Improve cooling to maintain the SSC or area within acceptable temperature limits (BNI).

      ii. Redesign SSCs to tolerate the higher temperatures (BNI).

      iii. Accept the impact to throughput (DOE).

8. The Melter offgas processes have been driven to be overly complex, which has introduced safety and reliability challenges that seem to be disproportionate to the system hazards. Because the system is driven to meet the Best Available Control Technology as a result of the melter being designated a thermal treatment unit, the system is unlikely to support the facility throughput demand and may actually result in a system that places the facility worker and potentially the environment at a higher level of risk than if a less complex system were used.

   a. DOE should renegotiate with the state the regulatory designation of the melter to allow a less restrictive and hazardous system to be utilized that minimizes the risk to the public the worker and the environment.

9. The LAW Confinement Ventilation System low flow design is not typical for DOE facilities. It utilizes low flow principles developed in the UK as a legacy of the initial facility contractor. The LAW Confinement Ventilation System design has evolved into a hybrid system with low air flow but without the design features normally required to ensure a robust and functional low flow confinement ventilation system.

   a. BNI should develop an accurate simulation model for the confinement ventilation system to assess if the capacity, mode of operation and control philosophy of the facility is tenable.

   b. In conjunction with 1c above, BNI should perform a critical analysis of the potential for all or parts of the confinement ventilation system to be safety significant. If there is reasonable potential that the system may perform or support a safety significant function for hazardous chemical or radiological confinement, dilution, cooling, etc., BNI should immediately be directed to treat the system as a candidate safety significant system and modify the design accordingly.

c. BNI should develop a clear and justifiable basis for ventilation confinement velocities at confinement boundaries (the dominant consideration for a low flow system); see also 4b above. Currently there is no requirement for confinement velocities across C5 boundaries and velocities across C3 boundaries are not consistently achieved and the rationale for lower values are not effectively documented.

d. Any conditions where the design fails to meet the designated minimum requirements for confinement or any other function identified by the upper tier requirements documentation should be approved by DOE.

10. The primary output of the design and operability review process was the identification of system specific vulnerabilities and generation of recommended OFIs.

    a. DOE should ensure that all vulnerabilities are considered and that a conscious decision is made to either resolve the issue or provide justification for not resolving the issue. Figure 6-1 represents a summarized vulnerability and issues management process, with proposed responsibilities.

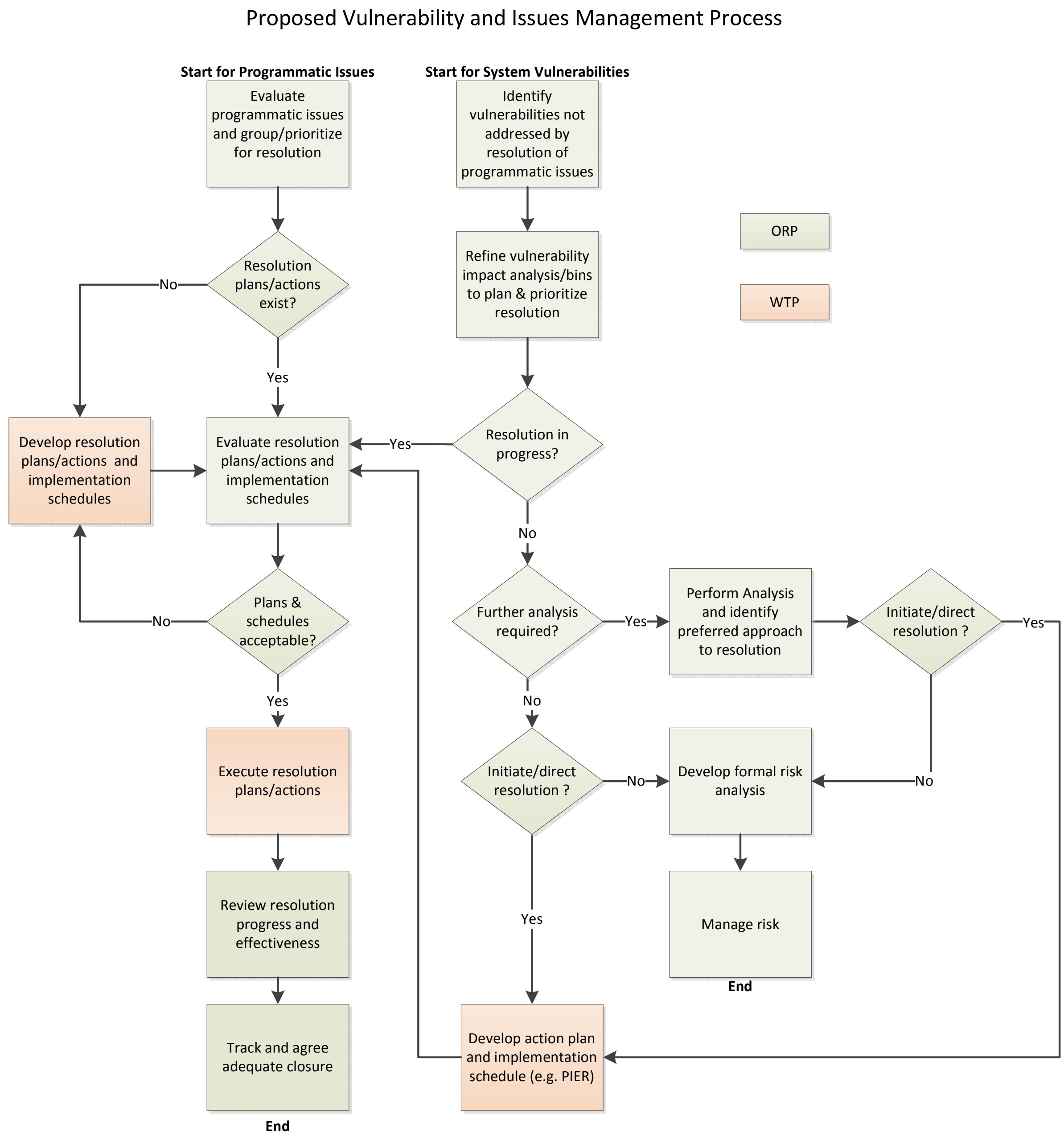

Figure 6-1. Summary Vulnerability and Issues Management Process.

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APPENDIX A

LOW-ACTIVITY WASTE FACILITY DESIGN AND OPERABILITY REVIEW TEAM BIOGRAPHIES

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APPENDIX A

LOW-ACTIVITY WASTE FACILITY DESIGN AND OPERABILITY REVIEW TEAM

Leadership

Gary Olsen, PMP, PE
U.S. Department of Energy, Office of River Protection

Mr. Olsen is the Federal Project Director for Special Projects at the Waste Treatment and Immobilization Plant (WTP) in Richland, Washington. He has more than 25 years of experience in government and private industry, primarily supporting National Priority List environmental cleanup projects. Mr. Olsen previously served as Federal Project Director of the High-Level Waste Facility, and prior to that, the Low-Activity Waste Facility, Balance of Facilities, and Analytical Laboratory at the WTP. Before joining the Office of River Protection, Mr. Olsen worked on commissioning and operating a plant that safely destroyed chemical-agent-filled weapons of mass destruction at the Umatilla Chemical Agent Disposal Facility in Umatilla, Oregon. Mr. Olsen has a Bachelor of Science in Chemical Engineering from the University of Utah, and a Master of Science in Environmental Engineering from the University of Kansas. Mr. Olsen is a certified Project Management Professional and a registered Professional Engineer.

Allan Exley, PMP
Washington River Protection Solutions LLC

Mr. Exley is the WTP Design and Operability Manager for Washington River Protection Solutions in Richland, Washington. He also serves as Energy*Solutions*' Project Director. Mr. Exley has more than 30 years of experience in nuclear facility startup and operations in the United Kingdom and the United States. He previously served as the Client Project Manager and Facility Manager for the Waste Treatment Complex at Sellafield in the United Kingdom, and as Facility Operations Manager for the Advanced Mixed Waste Treatment Project in Idaho Falls, Idaho. Mr. Exley has a Higher National Diploma in Electrical Engineering, and is a certified Project Management Professional.

Senior Review Team

Barry Naft, Ph.D., PE
Environment International, Inc.

Dr. Barry Naft has 47 years of experience in chemical and nuclear engineering. For the past 12 years, Dr. Naft has served as Senior Consultant to the U.S. Department of Energy (DOE) Headquarters, field offices, and prime contractors, providing technical support on engineering, procurement, and construction cost, schedule, and technical issues for tank waste and related nuclear waste management projects. Recent relevant experience includes the supporting the Department in the following capacities:

- Chairman of an independent review committee on the cost, schedule, and technical status of the WTP
- Senior Technical Authority to the Office of River Protection, participating in several dozen external independent reviews for WTP design and construction
- Ex-officio member representing DOE on each of the three “Best and “Brightest” teams chartered by Secretary Bodman

- Member of both the Environmental Management Advisory Board Tank Waste Subcommittee reviews of the WTP and related tank waste activities
- Chairman of the Independent Review Board to assess and certify Tank Operations Contract Line Item Number 3.2.

Dr. Naft previously served as Director of the American Nuclear Society and Chairman of its Waste Management and Fuel Cycle Division; Atomic Energy Commission Fellow; and Professor at the Catholic University Graduate School of Engineering.

Dr. Naft has a Bachelor and Master of Science in Chemical Engineering from Clarkson University and a Ph.D. in Nuclear Engineering from Purdue University. He has completed the Advanced Management Program at Wharton School, and is a registered Professional Engineer in Nuclear Engineering.

Len Jones, CE
DBD Limited

Mr. Jones has over 46 years of unbroken experience in a range of nuclear technologies, which includes technical expertise and project management. This experience has been gained both domestically in the United Kingdom and internationally, and is derived from the management of major projects in the UK, Germany, Brazil, and Japan. He has taken projects from conception to design, to installation and commissioning, and then to full operation.

At Sellafield, he was the Commissioning Director for the High Level Waste Evaporation Plant, the Head of BNFL Engineering, and the Head of Commissioning and Operations for the Low Level Waste Treatment Plants (5 plants). In northern Japan at the JNFL reprocessing plant, he was the General Manager of BNFL Rokkasho KK Japan, leading the HLW and ILW evaporator commissioning team.

During the past four years Mr. Jones has undertaken several lead review roles for the UK Government; these have included extended work for the Ministry of Defense in Whitehall reviewing Nuclear Capabilities in the Middle East and leading a review team of the commissioning and management processes, their implementation and the commissionability for a number of new plants currently under design, and construction at the MoD Atomic Weapons Establishments.

Mr. Jones has a Bachelor’s degree from Liverpool University in Mechanical Engineering, with a specialty in Nuclear Engineering; and he is a Chartered Engineer and a Fellow of the Institution of Mechanical Engineering.

Anthony (Tony) M. Umek, PE
CEO, AKU Enterprises, LLC

Mr. Umek has over 40 years of experience in leading and managing extensive nuclear and chemical processing projects in both the commercial nuclear and the U.S. Department of Energy complex.

As an executive with Fluor Corporation he supported environmental and nuclear projects at DOE’s Hanford, Savannah River, Portsmouth, Strategic Petroleum Reserve and Paducah sites; and also supported International government work. He administered the Fluor labor agreement with the National AFL/CIO Building & Construction Trades Council (as part of the Hanford Site

Program). He was Project Director of the Hanford Tank Waste Remediation Project for four years, prior to the formation of the DOE Office of River Protection. He has also worked at the DOE Savannah River Site, Idaho National Laboratory and Lawrence Livermore National Laboratory.

He has supported the DOE as a member of the DOE-EM Corporate QA; and as a Chair of the EFCOG Environment, Safety & Health Working Group. He has received formal recognition for his contributions and achievements, including:

- The first DOE Contractor to be an invited (twice) to present at the Washington State Governor's Safety Conference in 2005 and 2006.
- The Energy Secretary's Appreciation Award, 2008, for his leadership in improving electrical safety, DOE Complex wide.
- The DOE VPP Contractor Champion's Award for 2013.

Mr. Umek has a Bachelor of Science in Mechanical Engineering from Carnegie Mellon University and an MBA from the University of Pittsburgh. He leads several Community Non Profit Boards and is a Life Member and PE with the American Society of Mechanical Engineers.

Radiological Control and Safety & Health

Emily Millikin, CSP
URS Professional Solutions

Ms. Millikin has over 29 years of experience in radiation protection, safety and health, environmental, and regulatory experience at U.S. Department of Energy (DOE) and Department of Defense (DOD) chemically- and radiologically-contaminated sites. Ms. Millikin has significant experience in both program and field implementation of both radiological and safety and health disciplines and has served as a subject matter expert on numerous reviews related to Safety and Health, Radiological Control, and Quality. Most recently Ms. Millikin was the Safety, Health, and Quality Director for Washington Closure Hanford and the Safety and Health Manager for the Umatilla Chemical Weapons Disposal Facility. Ms. Millikin holds a Bachelor of Science degree in Environmental Health with double majors in Health Physics and Industrial Hygiene from Purdue University, and is a Certified Safety Professional.

Electrical Distribution Systems

Mark D. Johnson
Columbia Energy and Environmental Services

Mr. Johnson is the Electrical Engineering Department Manager for Columbia Energy and Environmental Services, an Engineering and Fabrication Contractor in Richland, Washington, with a business core focus on supporting engineering projects at Department of Energy, Defense Nuclear Facilities. Mr. Johnson has 23 years of experience as an Electrical Engineer, and over 25 years of engineering and technical experience at DOE nuclear facilities, which includes 4 years at the Los Alamos National Laboratory in Los Alamos, New Mexico, 7 years at the Pantex Plant, in Amarillo Texas, and over 16 years of direct and indirect experience at the Hanford Site. Mr. Johnson has performed the roles of: Electrical Distribution System, Control System, and NDE System Design Authorities at the Hanford Waste Receiving and Packaging (WRAP) facility; Systems Engineer and Facilities Engineer at the DOE Pantex Facility; and

Electrical Technician at the Los Alamos National Laboratory. Mr. Johnson has a Bachelor of Science degree in Electrical Engineering Technology from New Mexico State University's College of Engineering.

Raymond Merriman, PE (Washington)
AEM Consultants, LLC
Mr. Merriman has over 30 years of experience in electrical power and control engineering for nuclear, electrical utility, industrial, and commercial facilities. His experience includes electrical system studies, design, operation, maintenance, compliance reviews, and design authority oversight. Past projects include nuclear waste processing facility design, tank farm electrical upgrades, general nuclear site support, and heavy industrial system design and upgrades. DOE sites supported include Los Alamos, Paducah, Fernald, Idaho Falls, and Hanford. Mr. Merriman has a Bachelor of Science in Electrical Engineering and he is a licensed Professional Engineer.

Instrumentation & Controls

Stephen Wolfe
Mid-Columbia Engineering MCE
Mr. Wolfe has more than 25 years of experience in process and process control engineering, with expertise in facility and system design, specification, testing, commissioning and start-up. He is an expert on control systems, software quality assurance and testing, having successfully designed, tested, commissioned, and documented dozens of NQA-1 control systems and software packages used by the DOE, DOD, US military, universities and internationally. Mr. Wolfe has conducted control system design, development and testing under nuclear industry rules (10 CFR 830), quality assurance (NQA-1, 10CFR50, ISO9001), DOE orders and site-specific requirements. Mr. Wolfe has managed two I&C Engineering groups and two UL508A industrial control panel shops. Mr. Wolfe has successful commissioned controls systems through reviews by the DNFSB, NQA-1 Audits, Software Review Boards, ORR and customer acceptance processes. He has led successful acceptance testing, commissioning, MSA, Affidavit Review Boards and ORR efforts at the Hanford Site, and started numerous private sector facilities. Mr. Wolfe holds numerous U.S. and International Patents. Mr. Wolfe has a Bachelor of Science in Chemical Engineering.

John Wootton
John Wootton Integration
Mr. Wootton is an Instrumentation and Control Systems Engineer with over 14 years of experience. John has broad-based skills encompassing facility network architecture design, commissioning of software and hardware, facility start-up, and operational project phases. His expertise includes team leadership, staff supervision, design and implementation, training/support, and troubleshooting software and hardware. John has been involved in numerous commissioning efforts on large projects and has been part of facility ORRs on the Idaho National Laboratory (INL) site. Mr. Wootton has a Bachelor of Science (BSc) in Engineering Physics.

Container Systems Team

Steven Cross, PE
Container Systems Team Lead
Energy*Solutions*

Mr. Cross has 24 years of experience in the pulp and paper, aluminum, semiconductor, chemical, and nuclear industries. His experience includes capital project management, project justification, estimating, value engineering, and return on investment analysis. Mr. Cross' experience includes developing technical and cost basis proposals; providing independent design verification; and developing engineering design guides for flow, pump sizing, vessel sizing, and piping design for the Federal Government. Previous positions include Lead Engineer for the design of chemical and bulk specialty gas systems, and Process Engineer for the design of waste neutralization and industrial water systems. Mr. Cross co-authored the initial High-Level Waste Facility hazard analysis for the Global Nuclear Energy Partnership. Mr. Cross has a Bachelor of Science in Mechanical Engineering and is a registered Professional Engineer.

Gary Buss
Energy*Solutions*

Mr. Buss has 18 years of facility operations and maintenance, design authority, and project construction experience. He has performed as a design engineer for mechanical equipment on facilities and plant modifications, including risk, design, systems support, construction contractors, startup/testing, and regulatory and code compliance. Mr. Buss has a Bachelor of Science in Engineering.

Nick Camarata, PE
HukariAscendent, Inc.

Mr. Camarata has 15 years of experience providing instrumentation and programming expertise for automation process control. He developed the logic control for Hanford's Cold Vacuum Drying Facility, using historical trending to support troubleshooting, trending, and process improvements. During the campaign to dry knockout pot material, he served as a process control engineer. He provided programmable logic controller programming for Hanford's pump-and-treat plants. He also designed the instrumentation and control system for the Radioactive Liquid Waste Facility at the Los Alamos National Laboratory. Additional experience includes supporting the National Aeronautics and Space Administration's Arc-Jet Facility, and the U.S. Department of Defense. Mr. Camarata has a Bachelor of Arts in Mass Media and History; a certificate in instrumentation, automation, and process control; and is a registered Professional Engineer.

Tim Eichhorn, PE (Illinois)
Polestar Technical Services

Mr. Eichhorn has 40 years of experience in nuclear waste treatment, and nuclear and conventional power plant industries. His experience includes mechanical systems, mechanical handling, process, nuclear, and fire protection engineering. Previous positions include Washington River Protection Solutions LLC (WRPS) Senior Engineer performing WTP CLIN 3.2 review work of the WTP Project; Senior Process Engineer at SNC Lavalin Thermal Division (combined cycle power plants); Senior Engineer at Bechtel BNI – WTP Project Mechanical Systems group (Design Verifications and compliance); Mechanical Department Head at R. W. Cooper & Associates (Industrial Plants); Senior Technical Staff Engineer at the Braidwood Nuclear Station (Thermal group); and Senior Engineer & SUBSAFE Design Review

Piping Flexibility group lead at Puget Sound Naval Shipyard (overhaul of nuclear submarines). Mr. Eichhorn has a Bachelor of Science in Mechanical Engineering and is a registered Professional Engineer.

Eric Tchemitcheff
AREVA Federal Services LLC
Mr. Tchemitcheff has 35 years of experience in nuclear engineering, possessing in-depth expertise in all aspects of radioactive waste management (including retrieval, treatment, conditioning, packaging, storage, transport, and disposal activities) and of decontamination and dismantling of nuclear facilities. His management experience includes developing technical strategies, performing project definition, conceptual and detailed design, and supporting nuclear facilities operations. He was a member of the External Flowsheet Review Team, which conducted a comprehensive review of the WTP flowsheet and throughput in 2005/2006. Mr. Tchemitcheff focuses on transferring French technologies to U.S. facilities, applying lessons learned from sites such as La Hague and Marcoule. Mr. Tchemitcheff has a Master of Science in Chemical Engineering.

Mark VanderZanden, PE (Washington)
AREVA Federal Services LLC
Mr. VanderZanden is the Director of Engineering for AREVA Federal Services in Richland, Washington. He has more than 26 years of experience in the nuclear industry. He has performed work for the Department of Defense, various operating contractors of the Hanford Nuclear Reservation, Department of Energy national laboratories, and private sector companies (medical isotopes and environmental services). His experience includes the design of new nuclear waste processing facilities and systems, fabrication and testing of nuclear waste processing systems and components, maintenance of existing nuclear equipment and systems, and supervision of nuclear operations. Mr. VanderZanden has a Bachelor of Science in Mechanical Engineering from Gonzaga University and is a registered Professional Engineer.

Mechanical Systems Team

Steve Doebler, PE
Mechanical Systems Team Lead
Polestar Technical Services
Mr. Doebler has over 34 years of nuclear industry experience focused on reactor operation and decontamination and decommissioning activities. At the Hanford Site, Mr. Doebler was involved in plant operations, defueling, and decommissioning facilities, including the Fast Flux Test Facility. His experience in decontamination and decommissioning includes facility hazards disposition, waste disposal, demolition, and final site closeout at numerous nuclear fuel processing facilities and associated machine shops. Mr. Doebler served as mentor on the principles of conduct of operations at Hanford facilities and other DOE sites, including the West Valley Demonstration Project in New York, and the Savannah River Site in South Carolina. He prepared a technical watch report on Nuclear Regulatory Commission activities, and was involved in design work for spent nuclear fuel cask disposition. Mr. Doebler holds a Bachelor of Science in Nuclear Engineering and is a registered Professional Engineer.

Shad Harp,
ANR Group Inc.
Mr. Harp has two years of experience on the Waste Treatment Plant Project. Mr. Harp is pursuing a Bachelor of Science degree in Mechanical Engineering at Washington State University Tri-Cities.

Daniel Richey, PMP
AREVA Federal Services
Mr. Richey has 27 years of experience in project and construction management for government and commercial clients. He has managed all facets of mixed oxide fresh fuel packaging design, procurement, fabrication, and testing, and has directed the development of procedures that focus on a graded approach to project management. Mr. Richey's government experience includes auxiliary handling equipment, alpha caisson mobile hot cell technology, core sampling, and X-ray systems. Previous commercial experience includes serving as Senior Site Manager of an ethanol biorefinery, Reactor Fuels/Engineering Manager, and Outage Maintenance Coordinator. Mr. Richey holds a Bachelor of Science in Mechanical and Nuclear Engineering.

Kyle Roberson, Ph.D.
K Zero LLC
Dr. Roberson has 36 years of private and government sector experience, including 18 years at the Hanford Site. At Hanford, he supported the Tank Farms and WTP Projects, addressing seismic, fluid dynamics, thermal detonation/deflagration and analysis, and melter design. He was the principal investigator for the design and evaluation project under the DOE's Volatile Organic Compound-Arid Integrated Demonstration Program. He also has experience in food processing and chemical waste industries. Dr. Roberson holds a Bachelor of Science in Maritime Systems Engineering, and a Master of Science and Ph.D. in Mechanical Engineering.

Robert Sherman, PE, SRO
HukariAscendent, Inc.
Mr. Sherman has 37 years of nuclear industry experience, comprising commercial nuclear power plants and the government sector. His commercial experience includes Trojan Nuclear Plant, Columbia Generating Station, and Humboldt Bay Power Plant. At Hanford, he supported the Tank Farms, and at both Rocky Flats and Hanford he provided regulatory analysis and enforcement. The majority of his experience is in radiological safety analysis, nuclear safety assessment, licensing, operation, regulatory compliance, and decommissioning. Mr. Sherman holds a Bachelor of Science in Nuclear Engineering and he is a Registered Professional Nuclear Engineer. Mr. Sherman also holds a Senior Reactor Operator certification on a large 4-loop pressurized water reactor.

Larry Ulbricht, PE
Columbia Energy and Environmental Services
Mr. Ulbricht has 24 years of nuclear engineering experience ranging from individual components to entire facilities. He has lead project experience for the Portable Evaporation-Wiped Film Evaporator and for a fuel-grade ethanol production facility. He was also the Lead Project Engineer for a Hanford shipping facility study and for an immobilized low-activity waste transportation study. Other Hanford Site experience includes supporting the Accelerated Tank Closure Demonstration, Tank Closure and Fast Flux Test Facility environmental impact statements, the tank farms Mobile Arm Retrieval System component design development, Low-

Activity Waste Facility mechanical handling construction, and K Basin fuel retrieval. Mr. Ulbricht holds a Bachelor of Science in Mechanical Engineering.

Ventilation Systems Team

Steven Christensen, PE (Idaho and Washington)
Ventilation Systems Team Lead
Lucas Engineering

Mr. Christensen has 25 years of mechanical engineering experience, with 15 years in the nuclear industry. He has experience with Mechanical Design, Structural Analysis, Systems Engineering, and Nuclear Design Analysis. He has performed flow and design verification calculations and system evaluations; designed processing and handling equipment, and lateral force resisting systems; written software programs for inspection equipment and operation and instruction manuals; and specified operating parameters and developed test plans.

He has been the System Engineer and Design Authority for a nuclear confinement ventilation system, ensuring safety basis and code compliance. His DOE experience includes Idaho Falls and Hanford. He has a Bachelor of Science in Mechanical Engineering.

Robert Bevins
TradeWind Services LLC

Mr. Bevins has 35 years of design, testing, construction, and startup experience in government and private settings. His experience includes serving as Engineer, Manager, and Startup/Test Engineer for the government's Breeder Reactor Program, nuclear waste processing and storage facilities, and early efforts to design a vitrification plant at Hanford. Private industry experience includes engineering and project management positions in the pulp and paper, food processing, and waste processing industries. Mr. Bevins' expertise includes a working knowledge of ANSI/ISA 84.00 and IEC 61511, and government quality assurance programs such as NQA-1. Mr. Bevins has a Bachelor of Science in Mechanical Engineering and a Bachelor of Science in Electrical Engineering.

Robert Gregonis
TradeWind Services LLC

Mr. Gregonis has 30 years of Hanford Site experience. He has been the design authority for mechanical system design, installation, operation, and maintenance for HVAC, steam, compressed gas, fire suppression, process vacuum, and process/sanity water systems. He has been the technical authority for HVAC, steam, compressed air, breathing air, nitrogen, vacuum sampling pumps, and fire systems. In addition, Mr. Gregonis has prepared conceptual HVAC designs for proposed upgrades and been the Vital Safety System Engineer for hot cell high-efficiency particulate air filters. Mr. Gregonis holds a Bachelor of Science in Mechanical Engineering.

William M. Harty
Polestar Technical Services

Mr. Harty has 40 years of nuclear facility experience at the Hanford site. From 1974 to 1994 he has served in numerous management roles; Radiation Monitoring Manager at the Plutonium Finishing Plant, Operations and Engineering Manager at PUREX, and start-up and operations design engineer for the Hanford Waste Vitrification Plant. From 1994 to 2013, Mr. Harty provided engineering support to the day-to-day operations of the 200 East Area Double-Shell

Tank Farms, including since 2007 being the cognizant system engineer for ventilation upgrade projects and operations. Mr. Harty has a Bachelor of Science in Environmental Science and Health Physics from Washington State University.

Timothy Kot
Energy*Solutions*
Mr. Kot is an experienced engineer, with a background in both government and private settings. He has served as mechanical design engineer and HVAC lead engineer for systems in hospitals, office buildings, and higher education buildings, as well as steam CUP design. Mr. Kot's HVAC expertise includes analyzing and selecting HVAC system components. He has provided an HVAC Lead Engineer support to the Savannah River Site, Los Alamos National Laboratory, Hanford Site projects, and internationally. This includes performing calculations and developing drawings to ensure an environment with appropriate temperature, humidity, and airflow and air change rate for clean and contaminated areas; providing datasheets and specifications for HVAC equipment; analyzing redundancy, controls, interlocks, and instrumentation for major equipment; and performing studies for cooling and heat transfer. Mr. Kot has a Master of Science in Mechanical Engineering.

Mahendra Patel, PE (Colorado)
URS Corporation
Mr. has more than 40 years of experience in government and private industry, primarily in the HVAC design, procurement, commissioning and start-up of projects. Mr. Patel previously served as Lead HVAC Engineer for the Pit Disassembly and Conversion Facility (PDCF) at Savannah River Site, and prior to that, Lead HVAC Engineer and decommissioning HVAC Engineer of a plant that safely destroyed chemical-agent-filled weapons of mass destruction at the Johnston Atoll. Mr. Patel has a Bachelor of Science in Mechanical Engineering from Gujarat University India, a Master of Science in Mechanical Engineering from the University of Missouri, and Master's degree in Environmental Project Management from the University of Denver. Mr. Patel is a registered Professional Engineer.

Process Support Systems Team

William Peiffer
Process Support Systems Team Lead
Polestar Technical Services
Mr. Peiffer has 34 years of diverse international operations, engineering, and project management experience that includes nuclear facility design, startup, operation, and decommissioning. He has a broad knowledge of nuclear safety, engineering, operations, and project management standards. Mr. Peiffer's Hanford experience includes evaluating operational readiness plans, optimization startup, analyzing technical risks, and developing remediation strategies for waste burial grounds. He also worked an 18-month assignment at the BNFL Sellafield Site in the United Kingdom, and was selected to participate on an international World Association of Nuclear Operators team to perform a peer review assessment of operations at the Thermal Oxide Reprocessing Plant at Sellafield in the United Kingdom. Mr. Peiffer has a Bachelor of Science in Chemical Engineering.

Rob Carter
Energy*Solutions*

Mr. Carter is the lead process modeler for EnergySolutions. He has been in the nuclear industry for nearly 25 years, initially in the United Kingdom (U.K.) with BNFL, then transferring to the U.S. in 1990 with EnergySolutions (formally BNFL Inc.). Whilst in the U.K., he worked on the UO2 fuel manufacturing site in both a plant support role and as a process modeler. He came to the U.S. to support the modeling efforts on WTP and during his time there developed and maintained the WTP Steady-State Flowsheet model. This model leveraged the OLI Systems electrolyte thermodynamics system to predict speciation/precipitation in key areas of the WTP process flowsheet. Later, for EnergySolutions, he developed the steady-state flowsheet model of an integrated used nuclear fuel recycling plant for the GNEP project. Since then, he has worked for WRPS in the capacity of process modeling lead and developed a dynamic flowsheet model of the WTP LAW Facility. This model was developed for assessing the operational readiness of the LAW plant and focused on the information available to future operators. During his time with WRPS, Mr. Carter developed the Pitzer Thermodynamic database for incorporation into the System Planning tool HTWOS. Mr. Carter holds a B.Sc. 'Honours' Degree in Chemical Engineering from Salford University and he is currently a member of the U.K. based Institute of Chemical Engineers.

Paul Fallows
AREVA Federal Services LLC

Mr. Fallows has more than 30 years of experience in the design, development, testing, installation, commissioning, and operation of nuclear and non-nuclear facilities and equipment. He has extensive empirical knowledge of fluidic mixers and pumping systems, as well as expertise in research and development. He previously held positions with the UK Atomic Energy Authority, AEA Technology, and NuVision Engineering. Mr. Fallows has supported Hanford Site projects since 2001, including the WTP. Mr. Fallows has a Bachelor of Science degree. He is a Chartered Engineer and a Chartered Scientist, and is a Fellow of the Institution of Chemical Engineers.

Charles Kelly
URS Professional Solutions LLC

Mr. Kelly has more than 40 years of experience in the nuclear and petrochemical industries, functioning in a variety of operations, maintenance, engineering, and project roles. He has 19 years of experience with high-level waste associated with the following facilities at the Savannah River Site: FTF, HTF-W, HTF-E, CIF, BGI, ETF, DWPF, and 299-H. He has also served in assignments at Sellafield in the UK and several DOE sites across the complex as a maintenance subject matter expert. He is experienced in distributive control systems, programmable logic controllers, and instrumentation applications as well as data collection and analysis. Mr. Kelly has a Bachelor of Science in Electrical and Computer Engineering from the University of South Carolina.

Trevor Kilgannon
URS

Mr. Kilgannon is a Cognizant System Engineer with URS for the WTP Project. He has 5 years of experience working for government contractors at the Hanford Site. Before joining URS, Mr. Kilgannon worked for Washington River Protection Solutions supporting waste feed delivery projects and studies. He previously worked at the Integrated Waste Treatment Unit in

Idaho Falls during final stages of construction and testing. Mr. Kilgannon holds a Bachelor of Science in Chemical Engineering.

Harold Mashaw
Aspen Resources Limited, Inc.
Mr. Mashaw is a mechanical engineer with 30 years of experience in project management, engineering, pressure vessel design, and waste handling. He has strong hands-on experience as a project manager and project engineer in NQA-1 shop fabrication, testing/nondestructive examination, and related design processes. Mr. Mashaw's expertise includes mixed waste-handling operations, procedure development, and NQA-1 requirements. His DOE experience includes supporting Hanford Site projects and the Waste Isolation Pilot Plant. Mr. Mashaw holds an Associate in Arts and Sciences in Health Physics, and a Bachelor of Science in Mechanical Engineering.

Albin Pajunen, PE
AEM Consulting
Mr. Pajunen is a licensed professional chemical engineer with 35 years of process engineering experience in chemical processing and waste management activities at nuclear facilities. He has a strong background in flowsheet development, including unit operations, kinetics, mass transfer, heat transfer, ion exchange, and drying used in radioactive waste processing, spent nuclear fuel reprocessing, and plutonium processing, and is an expert in model verification and validation. Mr. Pajunen holds a Bachelor of Science in Chemical Engineering and Mathematics, a Master of Science in Chemical Engineering, and is a registered Professional Engineer.

Gary Tardiff
AEM Consulting LLC
Mr. Tardiff has 39 years of experience in the chemical and nuclear industries. His experience includes startup and shutdown of the PUREX facility from 1981-1993 working as a shift engineer and Cognizant Engineer, and then transitioning to Tank Farms as a Cognizant and System Engineer for 241-AY, 241-AZ and 241-SY DSTs from 1993-2012. Previous positions include experience in chemical processing plants, process development, and plant startup work for the WR Grace and Dupont companies. Mr. Tardiff has a Bachelor of Science, in Chemical Engineering from the University of New Hampshire.

Stephen Turner, CEng
Energy*Solutions*
Mr. Turner is a professionally registered engineer with over 35 years of experience in engineering and project management in the nuclear and chemical industry. He recently led the team that produced an alternatives analysis and conceptual design for waste feed delivery from the tank farms to the WTP. He previously delivered the design, fabrication and testing of the cementation gloveboxes for the Waste Stabilization Building at the Savannah River Site, and supported project design and operations at Sellafield in the United Kingdom. Other experience includes delivering a Global Nuclear Energy Partnership siting study, fluidic components for the WTP, and supporting Hanford's K Basins and fuel sludge treatment and packaging. Mr. Turner has a Bachelor of Engineering in Chemical Engineering and a Master of Business Administration.

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APPENDIX B

SUMMARY VULNERABILITY TABLES

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Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LOP/LVP-01	The collective significance of project self-identified issues indicates overall functionality of LOP/LVP systems is indeterminate	• RVP process identified 275 issues • Approximately 70 of the 275 were directly related to plant functionality/operability – a number would be considered high impact using the design and operability team impact analysis process. • RVP concluded that: - Some issues were identified that could potentially impact the overall function of the system. - The system is not fully in alignment with the requirements and its design documentation to meet configuration control • See RVP discussion in Background section	LOP/LVP system functionality is indeterminate with unaccounted impacts to plant throughput.	• Complete self-identified actions. • Implement independent confirmation of effectiveness of issue resolution actions.
LOP/LVP-02	The complex abatement system design with numerous safety and permit affecting controls is likely to impact ability to sustain operations and meet throughput requirements.	• Abatement system equipment/unit operation selection decisions made early in project (circa 2001) based on preliminary and evolving process information (flowsheet) • Abatement system results in postulated safety events with Hg off-site consequences that otherwise would not exist (e.g., carbon bed fire event). • Pilot testing indicates the highest known potential for experiencing a carbon bed fire occurs, as indicated by carbon bed temperature increases, during MACT/DRE testing when high concentrations of organic are intentionally introduced to the melter feed. Other operating periods with higher fire risk, is after replacement of the carbon bed material and during transition from an idled melter to steady state operation • Postulated safety events and associated confinement requirements result in complex control schemes (e.g., bypass interlocks, low flow reconfiguration, etc.) exacerbated by associated permit affecting controls. • Abatement requirements basis and equipment selection not formally revisited to consider flowsheet evolution and technology developments in intervening decade.	• In this case, the usually mutually reinforcing objectives of safety and environmental protection appear to be in conflict, thereby resulting in potentially unnecessary hazards to workers and the public. • Likely significant throughput impacts due to inability to maintain operability of necessary safety and permit affecting equipment and control systems. • Failure to pass MACT/DRE test during commissioning or during operations could lead to prolonged delays (months).	Revisit permit conditions and abatement system requirements to consider: • Current/evolving safety concerns and flowsheet conditions. This may justify elimination, substitution or simplification of the equipment selected to address some constituents of concern. For example, substitution of the carbon beds with alternatives for Hg abatement that are less hazardous and more compatible with achieving throughput objectives. • Costs associated with throughput impacts as part of any associated economic evaluation. • Regulatory basis for including abatement equipment currently identified in the permits, and eliminate from the permit those that do not clearly perform an abatement function (such as the WESP which removes particulates from the offgas, thus reducing changeout frequencies of HEPA filters). Equipment such as the WESP would then be operated as non-permit affecting. • Crediting the inherent/overall abatement effectiveness of the melter in

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				combination with the LOP/LVP system (such as for halides and organics). This may justify elimination, substitution or simplification of the equipment selected to address individual constituents of concern. • Potential to implement alternative regulatory strategies to minimize risks associated with MACT testing.
LOP/LVP-03	There appears to be insufficient redundancy available to avoid single point equipment failures affecting both melters	• Dual LOP trains but intrusive maintenance on one train (e.g., WESP, SBS) will require feed shut-off to both melters (until train under maintenance can be isolated/placed in safe state). • Single LVP train serves both melters. Failures impact both melters. • As per the RVP findings, the LVP bypass valves are not considered maintainable because these valves cannot be adequately isolated, thereby requiring both melters to be idled.	Unaccounted throughput impacts	• Generally, the single point failures are an inherent aspect of the design and therefore specific meaningful OFIs are not apparent. OR modeling would aid in understanding the full extent of the throughput impacts and potential options to minimize those impacts. • Evaluate the viability of installing a reduced flow capacity bypass line around the entire LVP system downstream of the HEPA filters as a possible means to improve the ability to safely perform intrusive maintenance on the LVP system bypass valves and equipment.
LOP/LVP-04	Single point instrument failures, interlocks, required calibrations and surveillances can result in unaccounted throughput impacts.	• 50 LOP/LVP system feed trip interlocks were identified that will initiate termination of feed to one or both melters upon exceeding defined operational parameters. • Other factors such as instrument failures, maintenance, bad quality signals or spurious trips associated with these interlocks will also likely result in terminating feed. • There are currently ~50 individual draft TSRs defined that will likely drive some level of periodic calibration and testing (e.g., stroke testing) of the safety instrumentation and interlocks. • Permit requirements will also likely result in additional conditions, instrument testing and calibrations that could interrupt melter feed operation (permit driven automatic waste feed cut-offs not fully defined).	Throughput reductions, loss of production and availability	• Confirm, via hazard analysis and discussions with regulators, that all interlocks are required or warranted. • Verify that the OR Model considers impacts due to maintenance and calibrations. • Plan mini-outages for instrument maintenance, loop calibrations, and surveillances (account for these in OR model). • Consider procedural approach to allow one loop out of service for redundant loops (i.e., designate primary and secondary loops in the DCS).

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Where redundant instruments are provided, either of the two instruments can initiate a melter feed cut-off interlock trip (no voting system which would require additional instrumentation to achieve acceptable spurious trip frequencies). • Spurious trip analysis not complete but will likely exacerbate this vulnerability (estimate of spurious trip rate is underway and will be reported separately).		
LOP/LVP-05	Adequacy of design to support control of integrated system equipment/components under various expected operating conditions (e.g., startup, shutdown, low flow, melter surges, etc.) and abnormal operating conditions not demonstrated.	• Lack of evidence of full-scale analysis or prototypic testing to confirm ability to control heat, moisture, flow, gas composition such that the integrated unit operations are controllable under start-up, shutdown and recognizable abnormal conditions. • Generally a lack of understanding of flowsheet dynamics and control interactions under various start-up and shut down modes/scenarios. - The design basis flowsheets are all at steady state conditions. For sizing equipment these are valid in that they consider a number of cases and in general the use of the 2 melter maximum case provides conservatism in design but does not support looking at what-ifs across the process or aiding in developing start-up and shut down strategies. Further, evaluation of a flowsheet condition for which both melters are in idle mode (expected condition) was not evident. - Equipment design generally based on nominal and maximum flowsheet conditions. Therefore, equipment performance and control under low flow conditions is not typically analyzed. -	• Unanticipated but recognizable abnormal events result in loss of control and prolonged shut-down for recovery (unaccounted throughput impacts) • Ineffective equipment performance or equipment damage (due to high heat, humidity, elevated corrosive constituents, etc., during start-up and shutdown). • Start up and shut down may be more difficult to establish with extensive trial and error required to understand the dynamic system interactions thereby resulting in extended commissioning durations and/or unanticipated throughput impacts. • Future changes to operating conditions cannot easily be evaluated prior to their implementation and thus increase the risk of maloperation and greater than anticipated throughput impacts	• Develop a dynamic process model with control features to aid planning of commissioning, operational start up and shut down and as a tool to aid future alternate process operating scenarios. • Continue development of "Technical Manuals" as a means to develop and integrate start-up/shut-down sequences and responses to abnormal conditions. • Consider developing a "reduced scope" WTP Integrated Processing Strategy Description (WIPSD) to develop system level integrated start-up/shut-down sequences and responses to abnormal conditions.
LOP/LVP-06	Lack of functional testing of LOP equipment performance at vendors.	• No evidence was found that sufficient individual or collective LOP equipment	• Unanticipated but recognizable abnormal events result in loss of	• Review compliance with the performance specifications for each

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		environmental performance tests were undertaken at vendors prior to delivery and installation. Although procured against a performance specification, the first time this will be demonstrated will be during start-up and commissioning. • The RVP review specifically identified the lack of vendor performance testing for the WESP.	control and prolonged shut-down for recovery (unaccounted throughput impacts). • Ineffective equipment performance or equipment damage (due to high heat, humidity, elevated corrosive constituents, etc., during start-up and shutdown). • Start up and shut down may be more difficult to establish with extensive trial and error required to understand the dynamic system interactions thereby resulting in extended commissioning durations and/or unanticipated throughput impacts. • Future changes to operating conditions cannot easily be evaluated prior to their implementation and thus increase the risk of maloperation and greater than anticipated throughput impacts. • Lack of known performance on individual unit operations may make fault finding during start-up and commissioning more complex and lengthy. • Without prior environmental performance testing the functionality of the system is indeterminate until operated collectively	piece of equipment to determine if some level of performance testing should be completed prior to commissioning • Establish performance criteria on individual units and overall system as part of start-up and commissioning planning. • Develop a dynamic process model as a tool to improve confidence that equipment performance requirements can be achieved.
LOP/LVP-07	Intrusive maintenance performed on the LOP System (including the Condensate Receipt vessel) will require both melters to be in idle with the cold cap burned off. Other non-intrusive maintenance requiring a process cell entry could also result in idling both melters.	• In order to perform maintenance on the LOP system, the offgas system must be diverted to the other melter and SBS for cooling. Opening the maintenance by-pass valve (YV-1002) will automatically shut-down both melter feeds. • Due to the interconnected nature of the LOP, Wet Process Cell, C5 Ventilation, and the Vessel Vent System it is indeterminate as to the impacts on system throughput	Unaccounted production impacts	• Add associated maintenance to the OR Model which reflects both melters off-line. • Determine if additional design features are necessary to facilitate maintenance on the LOP system. • Conduct detailed task analysis and methodically identify potential hazardous situations to confirm that entry to wet process cell vessels (LCP

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		when a process cell entry is required for non-intrusive maintenance. The current project perspective is that only the associated melter will be idled when entry into the process cell is required for non-intrusive activities. • Requirements for entry into an area with the Special Relief Devices that may vent melter off-gas as result of a pressure event have not been fully defined but may ultimately require idling of both melters.		and LFP) is possible without shutting down both melters. • Consider relocating the pressure relief devices to another C5 area (3rd wet process cell), or piping them directly into the C5 header would decrease the exposure potential to the maintenance workers during an entry into the wet process cell and would allow one melter to be operational during wet process cell maintenance activities (note that this may drive re-evaluation of the safety significance of the C5 system). • Consider crediting the C5 ventilation system in the melter annulus as the final mitigation of a pressure event. This would allow for the removal of the pressure relief devices, thereby eliminating the hazard of off-gas releases into an occupied wet process cell (note that this may drive re-evaluation of the safety significance of the C5 system).
LOP/LVP-09	The Melter Film Cooler, Offgas lines (including Wall Penetrations) and the SBS Down-Comer can be removed and replaced mechanically (i.e., bolted and threaded connections) but these components are currently reflected to last the life of the melter. WTP has not demonstrated that these components can be removed and replaced with active melters during operations.	• VSL testing showed that increasing the melter glass production rate (increase temperature and/or more aggressive bubbler operation) has an adverse effect on deposition of solids in the vent path to the SBS. • A request for technology development was submitted for additional VSL testing. This recommendation was declined. • The Final VSL test report stated “film cooler blockages requiring mechanical clean-out occurred less frequently as compared to previous tests due to lower feed and bubbling rates.” • Upon post-test inspection of the film cooler it was discovered to be damaged/corroded to the extent that it could not be reused. • VSL recommendation was that although testing showed improvement from plugging through the process changes, this	• Unaccounted throughput impacts due to the potential need to remove solids or replace film cooler and other off-gas piping. • Since features to facilitate cleanout of solids accumulations or film cooler and off-gas piping replacement are not evident, throughput impacts to conduct these activities could be significant. • If the Film Cooler, Offgas Line (including Wall Penetrations) or SBS Down-Comer cannot be cleaned or replaced during operations, in a worst case, it could prematurely limit the life of the melter.	Demonstrate during commissioning that the Film Cooler, Offgas line (including Wall Penetration) and SBS Down-Comer can be removed, cleaned or replaced and put back in service under operational conditions. Note that this will further challenge the commissioning durations. This risk to commissioning could be reduced through additional testing at VSL.

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		observation should not be considered definitive given the short duration of the tests. Thereby implying a potential open issue. •		
LOP/LVP-10	The "special" pressure relief devices (LOP-SP-00003/8) that vent melter gas in an off-normal event to the C5 Wet Cell cannot be isolated for maintenance, calibration or replacement.	• Although these devices (LOP-SP-00003/8) are non-safety, they provide overpressure protection to the melter by relieving at plus 10 (+3/-0) in. w.g. to the C5 Wet Cell. The assumption is that these devices protect the equipment from either damaging the melter refractory material and/or prevent an inadvertent glass pour. • There is not an identified means to isolate the special relief devices. • The DM 1200 test work (24590-101-TSA-W000-0009-166-00001 Regulatory Off-Gas Emissions Testing on the DM1200 Melter System Using HLW and LAW Simulants) showed a continuous accumulation of solids in the SBS with no trend towards a steady-state. • The suction line end effector design in the SBS was modified to a simpler design but there is only one 2-inch line for transfer of solids located near the center of the tank. Similarly there is only a single eductor in the condensate vessel to promote mixing and any return of solids back to the SBS in the recirculation line. Both are single point failure items. • While accumulation of solids in the SBS can be inferred from increases in pressure drop over time there is no direct measurement of solids. • The capability to remove solids with the procured equipment was not demonstrated as part of an integrated factory acceptance test so the first proof will be in commissioning or operation.	• Both melters would likely need to be idled to support maintenance/replacement, thereby resulting in unaccounted throughput impacts • If not maintained or maintenance is extended to support production operations, the devices may not relieve pressure when challenged thereby damaging the melter and/or an inadvertent glass release into the pour tunnel.	• Since these are non-safety devices, consider installing duplicate relief devices that include isolation devices to minimize impacts to production during maintenance. • During commissioning, develop and demonstrate method for replacement and/or testing of the special relief devices. Note that this will further challenge the commissioning durations. This risk to commissioning could be reduced through additional testing at VSL.
LOP/LVP-11	The impact of solids accumulation and the effectiveness of their removal within the SBS and SBS	• The DM 1200 test work (24590-101-TSA-W000-0009-166-00001) showed a	• Investigation and/or entry for ad-hoc solids removal or modifications into either of the SBS and condensate	• The use of surrogate solids to demonstrate solids recirculation and removal behavior should be factored into

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	Condensate Vessel is not demonstrated other than over limited pilot scale test durations.	continuous accumulation of solids in the SBS with no trend towards a steady-state. • The suction line end effector design in the SBS was modified to a simpler design but there is only one 2-inch line for transfer of solids located near the center of the tank. Similarly there is only a single eductor in the condensate vessel to promote mixing and any return of solids back to the SBS in the recirculation line. Both are single point failure items. • While accumulation of solids in the SBS can be inferred from increases in pressure drop over time there is no direct measurement of solids. • The capability to remove solids with the procured equipment was not demonstrated as part of an integrated factory acceptance test so the first proof will be in commissioning or operation.	vessels would require both melters to be shut down and is likely to be a protracted event with unaccounted production impacts. • Production level/full-scale issues associated with solids accumulation and removal will be not encountered until commissioning or nuclear operations, thereby prolonging commissioning or impacting throughput.	commissioning of the SBS system prior to taking the melter into cold operation. This would provide the earliest opportunity to identify and make any modifications to vessel internals or potentially adding additional instruments or sensors using existing spare nozzles. Further checks should then be made in cold commissioning to minimize the risk of needing changes later in hot operations. Note that this will further challenge the commissioning durations. This risk to commissioning could be reduced through additional testing. • Convert a spare SBS vessel port to allow periodic camera inspection of the internals.
LOP/LVP-12	The cooling margins for the SBS cooling jacket, cooling coil and condensate vessel appears to be eroded. This condition also impacts the current/expected margin on the associated BOF chilled water exchangers CHW-HX-00003A/B.	• The calculation for the maximum heat duty for the SBS system only included sensible heat and omitted the latent heat of condensation component. This effectively doubles the duty. • The chilled water at minimum flow cooling capability will not be sufficient to cool the SBS contents much more than a couple of degrees below the maximum operating temperature of 140°F. Using maximum chilled water flow will be able to achieve the normal operating temperature of 122°F but may not reach the 104°F minimum. • The associated BOF chilled water exchangers were incorrectly assessed on a maximum duty associated with the low flow chilled water cooling case for the SBS. Consequently rather than each having a 6 % margin they will likely needed to be operated simultaneously rather than as a duty and a stand-by system.	• The chilled water supply to the SBS system will need to be run much closer to maximum flow to achieve the desired normal operating temperature (i.e., reduced operating margin). • The increase in required cooling duty on the chilled water will require both exchangers to be run simultaneously rather than as a duty and stand-by. This may require modifications to valves, piping and control systems. • If there is a need for a stand-by unit, then a third exchanger may need to be installed which would further complicate equipment and control. • Higher operating temperatures in the SBS system increases the absolute humidity of the off-gas in the downstream systems and potential for causing condensate in lines if the	• Confirm via project analysis that the sizing of the BOF chillers is adequate and that there is adequate cooling margin for control of the SBS system. • Evaluate the impact of operating the chillers simultaneously rather than in a duty/standby mode on the plant availability, power demands, control approach, etc. • Evaluate the need for equipment changes and the revised control approach if simultaneous operation of the chillers is an acceptable work around.

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			off-gas is inadvertently cooled (e.g., using LVP equipment bypasses).	
LOP/LVP-14	It is indeterminate if the O-ring gasket provided by the Vendor for the SBS Top Flat Head and Mating Flange can withstand the thermal loading from the Offgas System during operations.	• The Top Flat Head Gasket (Ø ½" X 78-7/16" OD) is made of Ethylene Propylene Diene Monomer (EPDM). • The gasket has a maximum temperature rating of 250°F and the Top Flat Head and Mating Flange are currently rated at 1250°F and 400°F respectively • When the SBS is receiving offgas from the secondary offgas line (Nozzle N1), the 1250°F flange is less than 4 linear inches away from the O-Ring gasket. • Evidence was not available that indicated radiant and conductive heat effects on the O-ring gasket have been adequately considered.	• During operations, the SBS Top Flat Head could exceed the temperature rating of the O-Ring resulting in premature failure of the seal thereby allowing excessive air in-leakage into the SBS head space and potentially stopping the flow of melter offgas through the SBS due to lack of adequate differential pressure available for gases to pass through the SBS. This could result in release of untreated hazardous off-gas into the C5 ventilation system (non-safety). • Unanticipated throughput impacts due to recovery and replacement of the O-ring gasket.	• Consider alternative high temperature gasket materials compatible with existing flange surfaces such as Perfluoroelastomer (FFKM) or High Temperature Resistant Silicone. • In conjunction with new O-Ring material, re-analyze thermal worst case-steady state calculation to see if temperature at the flange can be reduced. • If necessary, reanalyze and remanufacture SBS Top Flat Head flange and mating flange to support high temperature flat gasket (such as Metaflex used on the SBS inlet line connections). • Review hazard analysis for SBS to confirm that potential failure of O-ring has been considered
LOP/LVP-15	VSL SBS down-comer testing design changes not carried forward or incorporated into SBS design	VSL SBS experienced pressure pulsations as much as 3-4 inches water column which heightened their concern that at high gas flow rates the overall off-gas and melter system pressure may become positive. VSL made a design change of a perforated down comer which greatly reduce the liquid displacement underneath the diffuser plate and de creasing the magnitude of the pressure pulsation. The modified VSL SBS down-comer design does not appear to be incorporated into the WTP SBS design.	• Offgas pulsation through the SBS could create pressure surges creating difficulties in control of downstream equipment or more importantly the melter plenum pressure thereby tripping feed to the melter. • Unaccounted throughput impacts	Evaluate and incorporate proposed VSL design changes to the offgas down-comer (i.e., adding perforations at the bottom of the down-comer).
LOP/LVP-16	Documented analysis not evident to discount Ozone as a potential corrosion agent within and downstream of WESP.	• VSL Testing did not identify Ozone generation in the WESP (a known event). Appears sampling not deliberate for ozone. • Configuration differences between VSL test rig and full scale unit may contribute to Ozone generation (i.e., 10 tubes in test rig vs. 123 in full scale unit, 100-250 cfm in test rig vs. 2000 cfm full scale)	Potential deleterious effects to downstream equipment such as the HEPA Filters or carbon beds.	Conduct and document analysis to determine impact of ozone generated in WESP

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Ozone is highly reactive and may not survive to become an issue but no analysis evident.		
LOP/LVP-17	Inconsistencies in design documents could lead to design errors that impact the functionality of the equipment or impact future design changes.	• Isometric drawings were used to evaluate pipe line lengths from WESP-0001 to the combined header (LOP-PW-00004) and from WESP-0002 to the combined header (LOP-PW-01506). The evaluated lengths were compared to same line lengths provided in the project calculation “Offgas Pipe and Exhauster Sizing for LOP and LVP Systems” (24590-LAW-M6C-LVP-00004, Attachment D). The evaluated pipe lengths did not match those given in Attachment D of the project calculation. The length of one segment of pipe (PW00004) was under estimated by 10% while another segment (PW01506) was under estimated by 13%. • Three ECCNs against the project calculation were reviewed. The changes did not correct the table in Attachment D of the calculation. There are at least twelve RVP issues dealing with isometric drawing issues.	• The discrepancy between the evaluated pipe lengths and those provided in the project calculation indicates that the validity of some design information is questionable. • Engineering and designs are based on information and data presented in documents such as that given in the project calculation for offgas pipe sizing (24590-LAW-M6C-LVP-00004, Attachment D). • Using outdated information may lead to the propagation of design errors. If these errors are not identified and resolved, then engineering margins may be eroded that may ultimately impact the operation of the facility.	An extent of condition review should be conducted to determine if there are other design media problems.
LOP/LVP-18	Ammonium nitrate formation may be possible in the preheater and HEPA filter systems and also downstream of the caustic scrubber (i.e., in the exhaust stack and stack sampling/monitoring system). The rate of build-up, if any, is unknown but, based on lessons learned could require periodic removal/flushing in the future.	• Ammonium nitrate formation has been a problem in facilities such as PUREX, 242-A Evaporator and 241-AZ-702 Primary Vent systems. There is significant collective evidence that ammonium nitrate may present a slow developing (years) “nuisance” regardless of conditions that normally indicate that ammonium nitrate will not form. • The Design Basis flowsheet shows that NH3 and NO2 gases are present in the LVP offgas system. • If the Design Basis flowsheet models are indeed accurate and ammonia gas is present in WESP units discharge stream, then this facility will need some type of an	• Based on experience, after ~3 to 6 years of LAW production, the preheater elements or piping could be fouled with ammonium nitrate solids reducing heat transfer efficiency. • Fouling could also lead to the failure of heating elements. The heating element surface temperature may be hot enough to allow ammonium nitrate to melt and drip off the heating elements or cause decomposition of ammonium nitrate. • Consequently, the bottom of the preheater housings and possibly the heating elements could become	• Evaluate the need for an ammonium nitrate detection and removal system for the preheaters and 1st stage HEPA filter units. This could be as simple as a view ports (either sight glass or ball valve ports for fiber optic cameras could be used) and a water flushing systems since ammonium nitrate is water soluble. A drainage system into a collection tank may be needed for the flushing option but this could be retrofitted into the plant when and if needed. • Evaluate means to flush the exhaust stack and associated sampling and monitoring system piping.

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		ammonium nitrate cleaning system for the LVP Preheater and HEPA filter systems • Above 93ºC ammonium nitrate formation is not likely. However, the operation of the preheaters will range between 50ºC to 70ºC which is a very favorable temperature range for ammonium nitrate to form. • Ammonia slip coupled with SCR NO_x reduction inefficiencies and off-gas temperature conditions are considered likely to result in conditions favorable to ammonium nitrate formation downstream of the caustic scrubber (especially during transient conditions such as startup and shutdown). The mitigating impact of the caustic scrubber is indeterminate.	coated with ammonium nitrate or decomposition products. HEPA filter elements may plug faster requiring more frequent HEPA filter replacements. In addition, there are no drains or flushing capability for the HEPA filter housings as well. • There is currently no design for flushing these systems. The preheater drain valves can only be opened in the HEPA filter room and drain into a container. • There are no drains for the HEPA filter housing shown in the P&IDs. In addition, there are no inspection ports for detection of the ammonium nitrate buildup in any system.	• Consider incorporation of periodic inspection of selected systems on an opportunistic basis. • Evaluate other areas of potential ammonium nitrate accumulation and determine if inspection and/or clean-out capability should be incorporated prior to start-up.
LOP/LVP-22	The HEPA filter qualification limits for low flow may be challenged under certain operating conditions thereby impacting filter performance.	• The HEPA filter low flow requirement is set by ASME AG-1, section FK, ASME Code on Nuclear Air Gas Treatment, at 20% the capacity of the HEPA filter housing or 20% for each filter element. Based on Flanders test data the LVP HEPA filters are typically tested at 1600 and 8000 ACFM. So operating below this range is unqualified by Flanders and not acceptable by AG-1 requirements. • Five Design Bases Flowsheet cases are identified that could apply to LAW Facility operations. Assuming the plant will operate using the A train HEPA filters, the one melter nominal flowsheet case and the two melter minimum flow case would not meet the 1600 AFCM low flow requirement. • Melter idle could be another potential condition that may not meet the low flow requirement for the HEPA filters. • The other flowsheet cases would meet the low flow requirement. • A minimum flow of around 3200 ACFM (1600 through each of the two parallel filters in train A) is required to ensure the facility is always operation the LVP offgas	If operated outside the minimum AG-1 flow rate for any length of time the filter may not be adequately efficient, which may lead to possible contamination which could spread to the secondary HEPA filters.	• Exhauster controls could be preset for minimum flow rate of ~4600 ACFM at the exhauster (accounts for additional air introduced downstream of the HEPA filters). This would ensure minimum flow requirements for A train is always being met. In addition, provide an alarm for low flow conditions at the HEPA filters. • Below are several other options to be considered for improvement in HEPA filter Operation. - Switch operations to the backup HEPA B train during periods of low flow (Admin Control). - Remove one of the HEPA Filter banks in parallel making both the main and backup banks identical (Engineering Control). - Add additional valves around HEPA filters 1A and 2A to allow operation of each one separately (more operational flexibility) so 2 trains in parallel is still viable for the higher flow conditions. DP monitoring equipment would also have to be

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		system above the minimum flow requirement for the HEPA filters.		added so each unit could run independently. • If the second or third option (above) is implemented then the minimum flow rate of ~4600 ACFM could be reduced to ~2800 ACFM at the exhausters.
LOP/LVP-24	Monitoring a CO_x concentration difference across carbon beds as an indication of fire may prove to be difficult to successfully implement.	• During pilot scale testing: - Observed off-gas concentrations ranged from 30 to 500 ppm CO and 6,000 to 28,000 ppm CO_2. CO concentration differences ranged from < 0 to 220 ppm and COx concentration differences ranged from < 0 to ~6,000 ppm. - Melter off-gas COx composition variability observed during testing indicates a set point for defining the presence of a fire, with minimal false positive indication, could be difficult to develop. • Vendor information indicates the currently proposed guard bed material (Sofnolime RG) has the potential to react with CO2.	Inlet gas composition variability increases the potential for observing false positive fire indications, while guard bed reactions produce the potential to under-estimate the COx concentration difference across a carbon bed and delay the indication of an actual fire.	• Revisit the decision to rely on a COx concentration difference rather than a CO concentration difference as an indication of a potential carbon bed fire. The pilot scale test experience indicates that a CO concentration difference is more stable to measure, is consistent with recommendations from the literature, and would be less likely to be affected by interactions with the currently proposed guard bed. However, safety basis development may require testing of actual oxidation reactions in a configuration equivalent to the plant equipment to define a bounding ratio between CO and CO2 reaction products in order to use a CO concentration difference as a fire detection set point. • Consider a multi-attribute monitoring approach for fire detection. This could involve something like a 3 out of 4 voting approach using gas temperature difference, combined with CO, Hg, and SO_2 concentration difference. • Continue with planned testing to identify performance of the proposed guard bed material. It is possible that the guard bed material will not adsorb CO2 after a predetermined "conditioning time period" and not interfere with COx concentration differences (depends on air flow through guard bed producing complete reaction of lime bed to CaCO3 prior to being placed into service). Use currently planned test data as input to address the identified vulnerability.

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LOP/LVP-25	The carbon bed temperature elements have not been demonstrated to be a sufficient or effective means to determine the progress/condition of a fire or support recovery efforts.	• Carbon bed temperature probes may not provide reliable fire indication of localized hot spots due to insulating properties of the carbon material. • Not evident that design features have been formally considered that support safe recovery and restart of the carbon beds following trips (real or false) of the SS interlocks that isolate the carbon bed.	• Once the adsorber units are isolated by bypass activation, operating personnel will not have a tool to determine whether a fire has occurred or is continuing. • Creates the potential for prolonged interruption of plant operation due to a false positive fire indication.	Consider developing a method for determining if carbon oxidations are occurring within the isolated carbon beds as an indication that a fire is actually occurring or, if occurring, has stopped. Possible alternatives could be • Modeling the actual plant equipment to determine if carbon bed or gas phase temperature probes could become a more accurate indication of a localized hot spot when gas flow through the bed is stopped • Determine if gas pressure monitoring could be used as a method for evaluating the isolated carbon bed equipment for localized oxidation reactions, recognizing the potential for leakage of the isolation valves. • Determine if some type of thermal scan (e.g., infrared) could indicate the presence of localized carbon oxidation reactions. • Determine if monitoring for convective gas flow from bed could be used to indicate the presence of localized carbon oxidation reactions. • Determine if a gas sample loop, with CO gas composition monitoring, that is activated only when an automatic carbon bed bypass has occurred, could be used to indicate the presence of localized carbon oxidation reactions.
LOP/LVP-26	No clear definition of a carbon bed fire has been found in the documents reviewed.	• The vendor has proposed one definition that is equivalent to a carbon oxidation rate of 0.2035 lb/min. The project fire analysis suggests another factor to consider in the definition of a fire, but does not yet expand the observation into a monitored set point. • It appears that the project has deferred definition of a fire to a later date as part of a set point analysis, but this can influence and impact the identification of the appropriate monitoring instrumentation.	Impacts selection of the fire detection approach and instrumentation selected to implement the approach.	• Complete planned set point analysis to define a carbon bed fire. • Consider developing and implementing a test program, combined with modelling, where carbon bed fires are actually generated to define the system characteristics expected to be observed during a real fire.

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LOP/LVP-27	There is only a limited definition of the operating conditions that minimize the potential for experiencing a carbon bed fire.	• A systematic evaluation of potential conditions to avoid/prevent a carbon bed fire was not found in the reviewed documents. • The current control input appears to rely heavily on data from test equipment, without scaling to the geometry used by actual plant equipment. Tests were performed in cylindrical beds with vertical, axial flow. Actual equipment represented by slab bed with horizontal flow and potential regions for stagnant gas [charge and discharge bins]at top and bottom • Evidence exists that some activities are being pursued to partially resolve this vulnerability. Inlet gas temperature monitoring and response control (set point not yet developed) represents one aspect. Another is represented by a carbon bed conditioning procedure identified based on the pilot scale melter test program.	Potential for plant operations to perform activities that create carbon bed operating conditions that increase the likelihood of experiencing a fire.	• Develop a system testing approach that avoids passing off-gas through the carbon beds during DRE Testing. This would likely involve establishing the carbon bed performance for organic removal in an off-line equipment set-up (not installed plant equipment). • Develop a model of the actual plant equipment for evaluating conditions that could result in a carbon bed fire in the actual plant scale equipment/geometry. • Based on input from project personnel, it appears that some consideration of simulation tools to accomplish this activity has been considered in the past, but not implemented. Input data to validate modeling would be available from the VSL pilot-scale tests (24590-101-TSA-W000-0009-166-00001) and the ongoing test program described in 24590-WTP-3PN-MWK0-00010, Scope Changes To Warranty (Appendix B) and Permit (Appendix C) Carbon Media Testing. Factory acceptance flow distribution tests are available to approximate the flow characteristics of non-ideal bed packing. It would be anticipated that the model could be used to: - Determine a minimum total gas flow rate to avoid the potential for gas mal-distribution. - Determine if an actual plant equipment test with high risk gas component compositions is warranted - Identify organic, nitrate/nitrite, and other component limits in the melter feed that could be evaluated on a batch by batch basis during operation to reduce the risk of experiencing a carbon bed fire

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				- Identify potential constraints on transients that occur during changes in the operating mode. Examples include: carbon bed start up after adsorbent replacement and transition of the melter from idle to operating mode (the carbon bed characteristics may impose a limit on how rapidly the melter feed rate can be increased) - Evaluate the risk of fire for the guard bed material ultimately selected
LOP/LVP-28	No minimum gas flow rate has been defined for safely operating the carbon beds.	• Reduced gas flow rate increases the potential for mal-distribution of gases passing through the carbon bed and increases the potential for experiencing a fire by generating local regions with decreased convective cooling. • No basis has been found for defining a minimum gas flow rate for operating the carbon bed adsorbers. • Vendor tests of gas distribution have only been performed at the equipment design (maximum) total gas flow rate.	Condition that increases the potential for experiencing a carbon bed fire.	• Once a flow mal-distribution condition is identified by modeling, incorporate a gas distribution test, similar to that performed by the vendor acceptance test, in the bed replacement procedures that determines the minimum gas flow required to avoid conditions that increase the potential for experiencing a fire (could vary each time a bed is replaced). • Incorporate control logic into the current system that precludes operation of the carbon bed units in a parallel configuration. • Consider addition of a controlled air (or inert gas) purge to maintain a minimum gas flow rate through the carbon adsorber to protect against gas flow mal-distribution. The set point for a controlled air bleed could be revised based on a flow distribution test each time the carbon bed media is replaced.
LOP/LVP-29	There are no gas temperature monitoring instruments evident in the piping between adsorber units.	• Exothermic reactions in the lead unit primary or guard bed have the potential to increase gas temperatures entering the lag carbon bed. • The current plant equipment configuration produces an un-monitored inlet gas temperature for a carbon bed operating in the lag position.	Condition that increases the potential for experiencing a carbon bed fire.	Consider installation of gas temperature monitoring and control response instrumentation on off gas lines between the two adsorber units (LVP-ADBR-00001A and LVP-ADBR-00001B) or only allow operation of a single adsorber unit at a time (preclude lead-lag operating configuration).

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Vulnerability likely only exists if all adsorber beds are new at the same time. There appears to be a potential for significant heat to be generated by the proposed guard bed material during startup after bed material replacement due to reaction with CO_2.		
LOP/LVP-30	There is no evidence that limits are identified/established for allowable rate changes of component concentrations in the carbon adsorber inlet gas.	• This is partially considered in current project documentation as described by the conditioning procedure identified from test program experience. • Selected component heats of adsorption reactions have the potential to modify the heat balance within the carbon bed. • No evidence was found that investigations are planned to determine if carbon bed constraints may restrict the melter operation to control off-gas composition changes.	Rapidly changing off-gas conditions may increase the potential of a carbon bed fire.	Based on plant equipment modelling proposed in OFI- LOP/LVP 27[.2], adjust operating procedures as needed to eliminate operating conditions that could initiate a carbon bed fire.
LOP/LVP-31	It appears that the current OR model understates the potential impact of carbon bed operation on the calculated plant availability.	The current OR model does not appear to identify the potential impact of observing a carbon bed fire indication, whether real or false positive indication, which is likely to result in substantial downtime.	Unaccounted throughput impacts.	Define a documented basis for a false positive indication of a carbon bed fire, or an actual fire, based on experience with carbon beds in other industries. It is likely that there will be considerable uncertainty in application of this type of input to the plant equipment configuration. Consider addressing the carbon bed fire issue as part of a sensitivity study in the OR modelling effort as a method of evaluating the uncertainty in input information.
LOP/LVP-32	The presence of carbon fines representing a source of ignition has not been thoroughly analyzed	• A discussion of carbon fines was not found in the documentation reviewed. • Equipment design information indicates that carbon fines, on the order of 10 µm. can be collected on the discharge filters. • Literature data indicate that fines are expected to exhibit an ignition temperature that may be on the order of 100 °C less than the bulk material. • Fines collection does not currently appear to represent a problem beyond representing a topic that has not been discussed by the safety analysis documentation due to the	• Potential for initiating a carbon bed fire is increased. • Carbon bed fire indication upon initial startup after bed replacement.	• The Donau BAT37 bulk material is reported to have a measured ignition temperature of 409 °C. It appears that fines accumulations in the carbon adsorber system would not be a fire ignition temperature issue based on the simplified evaluation. However, it is recommended that a formal consideration of carbon fines accumulation be added to the project safety documentation for completeness. This issue could become more important upon collection of more information on the guard bed material based on the

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		high (409 °C) reported ignition temperature for the bulk material. • However, fines generation does have the potential to separate carbon from the heat sink zeolite. In this case, carbon fines would likely be captured on the face of the guard bed where the fines could become susceptible to heating from exothermic guard bed reactions. • The proposed guard bed material currently appears to be susceptible to the largest heat generation rates when first exposed to air flows (after replacement). • Carbon fines generated during bed replacement have potential to collect on front face of guard bed. These carbon fines potentially have a reduced ignition temperature.		currently planned configuration (with guard bed following the carbon bed). • There is an indication that there may be a preferred order for bed replacements during unloading/loading sequence. The scenario is potentially controlled by replacing the carbon bed first (depositing carbon bed fines on the front face of a used guard bed), the guard bed second (removing carbon fines that may have deposited with the discarded guard bed), and the discharge filter last.
LOP/LVP-34	The mercury monitor represents a single point failure.	• Equipment layout drawings and the size of temporary equipment used during bed loading and unloading activities indicates that personnel egress may be limited • The current P&ID indicates that a high mercury concentration indication on the mercury monitor (AE-0423) results in a control action to stop feed to both melters. • Only a single mercury monitor is provided.	Potential to reduce plant availability and result in unaccounted throughput impacts.	Install a duplicate mercury monitor.
LOP/LVP-35	There appears to be inadequate isolation of carbon beds upon detection of a potential fire.	The mercury monitor sample transfer line represents an open path to the carbon bed interior. This line compromises the carbon bed isolation boundary unless the valves (YV-0423A and YC-0423B, or YV-0423) are integrated into the isolation valve control system.	Isolation requirements defined by PDSA are not satisfied.	Expand the carbon bed isolation control system to include valves YV-0423A and YV-0423B, or YV-0423C.
LOP/LVP-36	Shrinkage of the proposed guard bed particles could occur after loading.	Vendor information reports that the proposed guard bed material reacts with air converting calcium hydroxide to calcium carbonate. Particle density differences indicate particle shrinkage on the order of 15% could occur during the chemical conversion process.	Guard bed shrinkage during operation could result in mal-distribution of the gas passing through the bed, thereby reducing halide component removal efficiency.	• The significance of this vulnerability should be indicated by the currently defined test program. • Consider investigating a guard bed material that begins as calcium carbonate.
LOP/LVP-37	Condensed water may collect within the carbon beds during time periods when the carbon bed is	• Bypassing isolates adsorber unit gas phase within equipment such that the water vapor	• The impact on function is indeterminate due to potential competing effects.	• The significance of condensate collection in the carbon bed is indeterminate at this time and the

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	bypassed and cooled, thereby impacting the ability to complete bed replacement activities.	inventory can condense on cooling to ambient temperature. • Reduced gas phase water vapor pressure in isolated units produces conditions to partially desorb water captured by carbon during operation, producing additional condensate beyond that from the isolated gas phase inventory. • Rough estimates indicate that potential for condensate generation could range from 0.3 to 6 gal water each time adsorber units are bypassed and cooled, depending on quantity of water desorbed from carbon.	• Significance depends on where condensate can physically collect. Potential for water to collect in regions that do not evaporate on equipment restart (e.g., carbon bed discharge bin condensed water accumulations = carbon does not flow when attempting to replace carbon). This may complicate bed change out procedures.	location of condensate collection is difficult to predict. It is likely that operating experience will be required to identify if condensate collection will become an actual issue. If identified in the future, some potential methods of resolution could be considered: • Operate the off-gas system at a reduced SBS temperature for a time period prior to by-pass of the carbon beds during a routine shut-down. • Periodic monitoring/purging of differential pressure/sample lines and addition of insulation to instrumentation lines prone to collecting condensate. • Develop a dry air purge of bed discharge ports as part of the bed replacement procedure.
LOP/LVP-39	The basis for carbon bed sizing appears to be uncertain.	• Uncertainties in data from mercury pathway assessments/reports coupled with inaccuracies/miscalculation of factors applied for conservatism appear to result in potentially non-conservative values for mercury concentration in the nominal LAW flowsheet. • The potentially non-conservative mercury values were provided to the carbon bed supplier for sizing calculations. • Therefore, the sizing basis for the carbon beds is questionable and could require more frequent replacement of the carbon media than planned.	The frequency of carbon media replacement could be greater than anticipated (if mercury loading on the bed is higher due to higher mercury concentrations in the off-gas) thereby resulting in unaccounted throughput impacts.	• Re-evaluate the Hg basis for the LAW facility flowsheet. Consider updating 24590-WTP-RPT-PR-01-011, Mercury Pathway and Treatment Assessment for the WTP, as a means to re-evaluate the mercury pathway and concentrations at LAW and to re-visit the viability of previously discounted alternative technologies/approaches for mercury removal and abatement (see notes section above regarding potential alternatives for mercury removal/abatement). • Re-evaluate and confirm the accuracy/adequacy of the sizing basis for the carbon beds.
LOP/LVP-41	Heat-up and cool-down temperature profiles for TCO skid not considered in OR model.	• From a cold state, the heater takes about 11 hours to heat to operational temperature (750 °F). • Required heat up time for gas flow increases when transitioning the melters from idle mode to operation or under other transient conditions is undefined but will likely be a requirement of the system.	Unaccounted start-up/shutdown and throughput impacts	• Consider the ability to invoke operational conditions/controls that would reduce the need to cool down the TCO skid. • Model the startup sequence of the LVP equipment to see if the 11 hour heat up time is a critical time for system start up. If this time is prohibitive for startup

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		• Heat up time will likely be required following an event that results in bypassing the TCO skid. The TCO bypass is interlocked with Caustic Scrubber operation. Therefore, the TCO bypass may be activated by control or operational issues with either the TCO skid or the Caustic Scrubber. When the TCO bypass is initiated, the heaters are turned off, and the skid will begin to cool down. • Getting the heater to operational temperature seems to be the longest single startup operation in the LVP system. As the LVP startup sequence is undefined, the knock on effects of this long startup operation is unclear. • There may be additional requirements imposed upon startup/operations/maintenance activities with regards to flow rate increase. This will impact the time required to restart melter operations		consider installing higher capacity heaters (this could be done as a post CD-4 modification). • Conduct analysis to determine the maximum flow increase that can be accommodated by the electric heater to remain above the catalyst operating temperature. A new limit on flow rate increase may result.
LOP/LVP-42	The viability of the current TCO maintenance approach and associated throughput impacts are indeterminate.	• Waste disposal paths for removed equipment (160 catalyst modules for full replacement) have not been developed. It is not clear that the 60 hours allotted for catalyst change in the OR model is adequate given the large number of modules and the potential for waste packaging impacts. • Method of testing for requalification of equipment as functional and operational has not been developed. This may also impact the maintenance time allotted in the OR model.	Unaccounted throughput impacts	• Complete evaluation of maintenance evolutions so impacts are understood and included in the OR model. • Determine the disposal paths for removed equipment (e.g., catalysts) • Generate plans for qualifying replaced or repaired equipment/components.
LOP/LVP-08	Over time, the film cooler may build-up insoluble vitreous deposits not removed by the existing water sprays. Ability or need to manage the vitreous build –up is indeterminate based on the length of testing and a lack of	• VSL testing noted that in the short period of their test some vitreous deposits were observed, although for the bulk of the deposits water flushing was generally effective. • Film cooler was designed and installed to be removable, but no procedure has been prepared for such an eventuality.	Film cooler life is less than required/expected i.e., does not last the life of the melter and requires changeout or a mechanical cleaning. Control of vitreous build-up may result in unaccounted throughput reduction.	• Demonstrate and confirm whether vitreous build-up is a problem or not (rate of accumulation not quantified in testing). • Write procedures to perform inspection of film cooler during annual spray nozzle replacement.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	quantification of the quantity of the vitreous deposits.			• Prepare design for device/procedure to remove build up in film cooler/offgas lines – if required.
LOP/LVP-13	The Vendor changed the SBS design temperature inputs for the top head without formal WTP approval. Therefore, the design may be out of conformance with requirements.	• The SBS Vendor submitted a "Request for Information" (RFI) to deviate from the datasheet that specified that the SBS Top Flat Head temperature be analyzed at 1250°F because at that temperature it "produced undesirable results in seismic and nozzle load analysis". • The Vendor performed a thermal analysis through unconfirmed/unapproved inputs that reduced the maximum temperature of the SBS Top Flat Head to 1100°F to be able to then produce acceptable results for the seismic and nozzle load analysis. • The current SBS Datasheet still reflects that the SBS Top Flat Head temperature is 1250°F.	• The design inputs provided to the vendor (by WTP) and the vendor adjusted inputs used for analysis of the heads are not in alignment. • Temperature tolerance of the SBS vessel top flat head may not meet design requirements.	Verify design inputs to the Vendor calculation are valid and the Vendor Thermal analysis outputs are accurate and reasonable per project approved procedures.
LOP/LVP-19	Replacement and repair of pre-heater elements will likely require both melters to be placed in idle mode, thereby potentially impacting throughput.	• Replacing, repairing or cleaning the preheaters without both melters in idle mode would be beneficial to the operational goals of the LAW facility. • Room L-0304H layout for the HEPA filters and preheaters may not be favorable for preheater maintenance work. The common outlet pipe may be very hot (including radiant heat) especially if one of the preheaters is still operating. If any of the closed manual valves leak and a pressure spike were to occur then hot gases could affect the work and personnel safety. • Double valve isolation is not evident in the current design. Although it may be possible to replace the preheater without double valve operation, by relying on negative pressure in the system, there isn't assurance that maintenance without double valve isolation will be acceptable. • The following factors contribute to the difficulty to work on one heater while the other one is operating:	It is possible for 18 inch butterfly valves over time to leak. Consequently, single valve isolation may not provide enough personnel safety when replacing preheater elements with one or both melters operating. If double valve isolation is required, melter throughput will likely be impacted since both melters would need to be placed in idle mode.	Install additional isolation valves to allow preheaters to be changed out whenever needed without having to place both melters in idle (however, it is recognized that there may be space constraints to implement this option). This approach may give personnel more buffer space from the operating preheater system. It would be practical to install isolation valves during construction to ensure there is adequate room to install additional valves.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		- Close proximity to each other with common outlet - High temperature pipe - Single isolation valve - Tight space to work around HEPA Filters		
LOP/LVP-20	A number of instruments, valves and test ports for the HEPA filters are elevated (10-14 feet off the HEPA filter room floor). Using ladders or temporary scaffolding to perform maintenance at elevation will be less efficient and potentially more dangerous to personnel.	• The LVP off-gas piping drawings indicate the elevation of the piping, valves and instrumentation is 10-14 feet from the floor. • With the current design, HEPA filter instrumentation (flow meters and pressure transmitters) and automated valves as well as performing aerosol testing of the HEPA filters will require personnel on ladders or on scaffolding to perform routine maintenance.	Likely unaccounted throughput impacts as a result of maintenance inefficiencies.	Design permanent scaffolding or mezzanine to allow safe access to all instrumentation, valves and test ports in the HEPA filter room L-0304H. Other LVP areas may have similar piping configurations and permanent scaffolding or mezzanines will have to be installed here as well.
LOP/LVP-21	There may be an insufficient number of isolation valves to safely replace the B train HEPA filters without placing both melters in idle mode.	• The WTP Operations Requirements Document indicates that filter system design should allow for change out of either HEPA train while the other HEPA train is still on line. • No manual isolation valves were evident for the B train that would enable double valve isolation in conjunction with the control valves. • The control valves are interlocked to allow only one train at a time to be operated. The 2 manual valves can be closed in conjunction with 2 of the 4 control valves to isolate A train. With the 2 control valves and 2 manual valves closed this would achieve double valve isolation for A train. • The control system allows all control valves (for both the A and B trains) to be open at the same time. This situation is possible if the operating train becomes plugged, then the alternate train control valves will open. If B train was being changed out when this happens then an unsafe condition is possible. • Even with the control valves locked out for B train its possible for these valves not to	Although it may be possible to replace the B train HEPA filters without double valve operation, by relying on negative pressure in the system, there isn't assurance that maintenance without double valve isolation will be acceptable for all operational modes thereby resulting in unaccounted throughput impacts.	• Double valve isolation should be required to protect people from the potential gas temperature hazard in all types of operational scenarios. • Manual valves across the B train HEPA filter banks need to be installed similar to the ones planned for A HEPA filter train. • The manual valves and control valves for A train could be swapped around to allow the manual valves to isolate the control valves. This will provide better isolation to repair/replace the internals parts of the control valves when needed.

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		be fully closed thus potentially exposing personnel to a high temperature (120ºF-170°F) gas stream. This situation could also be made worse if a gas surge from a process upset occurred during B Train filters change out.		
LOP/LVP-23	Vendor requirements for minimum straight pipe lengths needed to achieve accurate flow measurements do not appear to be met for the flowmeters located downstream of the HEPA filters	• There appears to be conflicting information between the HEPA Filter isometric drawings, the Control Instrumentation drawing and manufactures recommendations for the minimum length of straight pipe before and after a flow meter. • For thermal insertion type flowmeters (as those used for the HEPA filters), project documents require 10 pipe diameters of straight pipe before the flow meter and 5 pipe diameters of straight pipe after the flowmeter. Most manufactures also generally require the same 10 and 5 pipe diameters but other manufacturers may be able to custom fit their flowmeters for a specific piping arrangement. • For 18 inch (schedule 10) pipe used to house the flowmeters, the minimum straight pipe sections needed is 14.7 feet and 7.35 feet respectively. . None of the three flowmeters evaluated meet these requirements	The main consequence is flowmeter accuracy. Inaccurate flow measurements could result in operating the HEPA outside their qualified flow range of 1600 to 8000 ACFM with associated potential contamination control issues downstream.	Review minimum straight piping requirements for flowmeters manufacturer/vendor to ensure performance under current piping configuration. Modify piping drawings and/or Control and Instrument drawing 24590-WTP-JO-50-00012 as required.
LOP/LVP-33	Maintaining personnel egress routes during carbon bed replacement activities may be challenging.	Equipment layout drawings and the size of temporary equipment used during bed loading and unloading activities indicates that personnel egress may be limited.	• May require redesign of loading/unloading equipment or use of smaller package sizes to maintain personnel egress routes. • If egress not suitable, could prolong adsorber bed replacement process with unaccounted throughput impacts.	• There appear to be limited opportunities to address the limited space available around the adsorber units. One approach could be to perform an evaluation of the loading and unloading procedures to identify where the required temporary equipment, supporting the activity, can be located while maintaining required egress routes throughout the activity. As an alternative, the carbon bed supplier does appear to offer a smaller package for receipt of fresh material. It may be possible to design a loading system that

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				uses a smaller receipt package that can be directly maneuvered over a carbon bed inlet port and eliminate the intermediate transfer from super sack to hopper (followed by transfer of hopper to the inlet port) as a method to reduce loading equipment space requirements at the expense of needing to handle additional receipt packages.
LOP/LVP-38	No dedicated ports supporting the carbon bed loading bypass test were found.	The vendor procedures indicate a bypass test, introducing a challenge gas upstream and challenge gas detection downstream of the bed, should be performed anytime adsorbent is loaded into the adsorber units.	Inadequate loading of replacement adsorbent beds results in excessive gas bypass and poor contaminant recovery efficiency.	Install or identify ports for challenge gas detection equipment installation.
LOP/LVP-40	Underestimation of TCO skid thermal cycling	According to the mechanical data sheet, the number of thermal cycles assumed for the TCO skid is 100 for the 40 year life of the equipment which appears to be low given that this is equivalent to 2.5 thermal cycles per year. It is judged that start-up and shut-down evolutions contributing to the thermal cycles will on average likely be more frequent than 2.5 times per year.	Extra thermal loads will be experienced the TCO skid due to start up and shut down of the heaters. This unanalyzed condition of operation can cause unexpected wear and degradation of the equipment. The assumed life of the equipment could be in question.	• An analysis of the thermal loading on the TCO skid should be performed to determine whether the materials of construction can accommodate the stresses imposed by the thermal cycling. Although considered unlikely, this analysis may result in redesign of equipment. • Use the DCS to track thermal cycles of the equipment, if this is determined to be an important parameter for equipment longevity. • Consider opportunistic based periodic inspection of stress points to confirm that thermal cycling is not affecting equipment.
LOP/LVP-43	The current and proposed design of pH control suffer from an unknown lag time between addition of caustic and the resulting change of pH as indicated by the pH meter. The WTP proposed change relies on the operator to observe changes in the pH reading and react accordingly.	• The basis for this can be found in the LVP Caustic Scrubber System Technical Manual (draft) and is shown on the current P&ID, 24590-LAW-M6-LVP-00002003 LVP, Systems Technical Manual –P&ID LAW – LAW Secondary OffGas/Vessel Vent Process System Caustic Collection Tank LVP-TK-00001. • Due to (unknown) lag time between adjustments to caustic addition and response of pH. Operator adjustments are	• Depending on the operator's response, the scrubbing liquor may become acidic if insufficient caustic is added. This could have corrosion issues in the scrubber system or downstream in the RLD system. If too much caustic is added, the pH would rise above 10 leading to more CO2 removal and could result in precipitation issues.	• pH control could be improved if caustic addition is carried out in the suction line of pumps LVP-PMP-00003A/B (using a vortex mixer) upstream of the pH meter. This will ensure a minimum lag time between caustic addition and the pH meter. • Adding mechanical agitation to the vessel would improve mixing and may allow for automatic control in current configuration.

Table B-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		relied upon versus automatic control. Operator has no guidance or variable other than pH.	• May require significant tuning of controller during commissioning.	
LOP/LVP-44	There is no way apparent to remove an accumulation of insoluble solids, potentially, in LVP-TK-00001 (caustic scrubber recirculation vessel).	• The basis for this can be found in the draft LVP Caustic Scrubber System Technical Manual (draft) and on the current P&ID (24590-LAW-M6-LVP-00002003). • Solids could be corrosion byproducts or particulates from upstream Carbon Bed or SCO/SCR catalysts.	Slow buildup of insoluble solids could lead to eventual blockage of the packed bed, increased erosion in lines and/or valves. Could lead to increased wear on pump internals. Potential unaccounted throughput impacts to remove solids.	• Consider alternate means of agitating the tank inventory to ensure insoluble solids stay suspended so that they are removed during transfers to RLD-VSL-00017A/B. • Consider periodic/opportunistic inspections to determine if solids are accumulating.
LOP/LVP-45	The effects from other unit operations on the startup and shutdown of caustic scrubber have not been fully analyzed/determined.	No mention in the System Description (24590-LAW-M6-LVP-00002003) or Technical Manual (draft) of how the caustic scrubber system startup or shutdown impacts other LOP or LVP systems.	Consequence to plant wide startup or shutdown is unknown at this time. Design features may be necessary to support compatible startup/shutdown – could prolong commissioning period.	Consider performing a system wide study/model on the effect of startup/shutdown of individual units has on the whole LOP/LVP system.
LOP/LVP-46	There is no direct means evident to monitor the condition of packing or mist eliminators within the caustic scrubber.	Both the Corrosion Evaluation (24590-LAW-N1D-LVP-00001, LVP-SCB-00001 (LAW) - LAW Melter OffGas Caustic Scrubber – Corrosion Evaluation) and the Safety Evaluation (24590-WTP-SE-ENS-12-0068, Safety Evaluation - LAW Melter Offgas Caustic Scrubber) state that the column “packing and mist eliminator filters are considered consumables”.	Packing could collapse on itself after prolonged corrosion if not detected.	Consider periodic/opportunistic inspections of packing integrity.

Table B-2. Vulnerabilities Identified for Instrument and Control (I&C). (9 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
IC-CO-01-V-01	Industrial HMI Human Factor Engineering principles have not been adequately implemented in HMI screens. Situational awareness of the operator will be reduced hindering the ability to make operational or process decisions quickly and accurately.	• Review of SDD's, for the HVAC system specifically, has highlighted a lack of process related data and its relevance to overall normal operation. Basic informational aids such as fan speed, system trip levels and device status are missing from certain HMI screens but are then included on others indicating a lack of consistency in implementation. • Process related functional descriptors appear to have been omitted altogether further reducing the user's ability to obtain situational awareness. • There are no process related trends on control graphics to assist operators in determining the predicted status of the system. Only current process values are displayed.	Potential for mistakes to be made during normal and, more importantly, off-normal operations which could reduce or interrupt operational throughput of the facility. Equipment protection could be compromised if the current system state is not adequately represented and displayed to the operator with appropriate context.	• Modify HMI objects to include all relevant information for equipment and instruments. Add English worded equipment status to all objects. (Stopped, Running, Failed etc.) • Incorporate process relevant trends on overviews that include process goals and alarm/trip levels. • Only include information on overviews relevant to the goals for the system. Indicate system trip status, process status and equipment status. Omit information not relevant to the operation of the system such as miscellaneous room temperatures. • Perform assessment of current HMI configuration for all systems and implement NUREG-0700 Rev 2, Human-System Interface Design Review Guidelines, recommendations for HMIs. Review other industry standards for HMIs including ASM Consortium recommendations for HMIs, OPTO 22 White Paper – Form 2061-140306 Building an HMI that Works: New Best Practices for Operator Interface Design and ASEE HMI Good Practices.
IC-CO-01-V-02	• A requirement of the BOD is that 'Simple, common-sense design modes of operational control to ease operability in both normal and abnormal situation will be factored into the design'. • System wide implementation of parallel device operation (fans, pumps etc.) utilizes a non-standard approach as identified in CLIN 3.2 Table 2 – 16 Error analyses	• For all instances of parallel operations into a common header, regardless of the process medium, the control has been split by device resulting in multiple PI controllers for a single process variable (i.e., flow, pressure). Since each device controls independently, and is unaware of the influence the other device has on the process, the requirement to control devices in a 50% duty arrangement cannot be accomplished.	• The system requirements have not been implemented such that the normal operations can be accomplished in a simple, common-sense fashion. The requirement for parallel operation is that the two devices operate at the same speed; the implementation guarantees that they cannot be sent the exact same speed.	• Implement single PI controllers logically for all instances of dual controllers for parallel devices into a common header with single process variable feedback. • Remove all dual control faceplates from the HMI screens, CSLDs, CDIs and other related documentation prior to startup and commissioning.

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	following testing Error Ref #2, 3. This approach has not changed and is still present in the LAW parallel operation of devices.	• The intended operation to mitigate this process control difficulty is to operate the fans outside of their intended design. In order to modify any process set points for the system a procedure will need to be followed similar to the following: - place Device A in Manual mode - change the set point of Device B (in Auto) - wait for Device B (in Auto) to adjust to new set point - place Device B in Manual mode - adjust set point of Device A - place Device A in auto mode - wait for Device A to adjust to new set point - place Device B in Auto to allow normal system control • The steps required to prevent the system from becoming unstable are unwieldy and will still result in the two fans operating at different speeds. This intended method for operational control of these systems is in direct conflict with the BOD requirement to ease operability in both normal and abnormal situations.	• In order to operate the system and maintain some control of the process a procedure is required to ensure the set points for each fan are changed individually. Normal operations, such as changing a set point for a process, will not be simple or common sense. • Without simple and common sense controls the likelihood of human error, resulting in off normal operations, increases greatly. The system is currently not designed to maximize the probability of operator success.	• Assess controls for basic day to day operations to determine if procedures will be required to accomplish the tasks. If simple tasks require procedures to ensure that they are completed without error then they should be re-worked to assist the operators to be successful in operating the system.
IC-CO-01-V-03	CLIN 3.2, Ref RPP-44491 3.8.7, Semi-Annual Waste Treatment and Immobilization Plant (WTP) Operational Readiness Evaluation Report(S) identified an issue regarding the supervisor override of interlocks. This issue has not been addressed within the current system and will be exacerbated by the lack of functional descriptors within the system.	• Due to the lack of automation within the control system, interlocks are being relied upon to dictate normal operational control. If an off-normal event occurs it is likely that a supervisor override will be required to return to normal operations. Interlock overrides can be accomplished in one of two ways, all interlocks for a device can be overridden or a single interlock can be overridden but the override applies for all instances of that interlock. • When an interlock is required to be overridden the onus will be on the supervisor to determine which interlock is causing the problem and also how that interlock affects other operations. Since there is no differentiation between interlocks and their importance, nor	• Without differentiating interlock importance the supervisor will not be able to make an informed decision regarding the validity or consequences of the specific override. An override of an interlock, even for a brief period of time, could allow another device to perform an unintended function that was not considered. • The minimal automation within the systems has created an excess of interlocks to drive correct operation of systems. When off-normal events occur overriding interlocks will become common place fostering a culture of	Enhance all graphics to display English word descriptors for interlocks and create a standardized method for determining at a glance hazard assessment for the interlocks.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		are there sufficient descriptors for information on HMI screens, this determination will be cumbersome and will be prone to human error.	convenience regarding interlock overrides.	
IC-O-01-V-01	There appears to be no protection from an event that could cause an excessive depression in a C5 area. Any obstruction of flow could create a situation where the cell depression exceeds the readable range of the pressure instrument.	Analysis of the HVAC SDD, CSLDs, PDSA and CDI documents has failed to identify any mitigation of an excessive depression in a C5 area. The system design is such that the C5V fans will continue to operate after the rest of the ventilation system has shut down. In this situation there is no protection from cascade airflow blockages rapidly increasing the depression beyond the readable limits of the instruments.	Potential to damage structural components of the building (windows, doors, in-bleed assemblies and associated components) due to excessive differentials between zones.	Include additional requirements in the functional requirements specification (FRS) and requirements traceability matrix (RTM) for prevention of excessive depression in C5 areas. Prevention can be achieved either logically (via ICN), hardwired (power interrupts to the drives) or preferably using both methods in a nested fashion.
IC-O-02-V-01	The cascaded startup of the HVAC system is an entirely manual process. The onus is completely on the operating user to perform the repeatable steps, in the correct order, at the correct time to facilitate a successful startup of the HVAC system. Furthermore the startup is not sufficiently defined to establish steps for a coherent HVAC system startup.	• The HVAC system description details the prerequisites and steps required to perform the startup of each of the HVAC systems individually. The startup description does not reference the startup of the HVAC system as a cohesive set of equipment with process related triggers that link independent system startups. • For example, according to the CSLD requirements, logically the C3V fans may be started once the C5V fans are running but there will be additional process triggers/prompts that will need identification such as the relevant zone depression/flows to meet or exceed a threshold value. These thresholds are currently not identified in the CDI documents or on the CSLDs.	If the startup of the HVAC system remains a manual operation the likelihood of unsuccessful startups is increased. If the HVAC system is not running the plant operations will stop until an operational HVAC system is re-established. Without a HVAC system startup procedure, or a reliable startup sequence that can perform the repeatable steps required to establish HVAC operations, the operator is placed under un-due pressure to perform complex steps to establish cascaded confinement.	• Author a master procedure to start the HVAC as a coherent system that considers the expected flows and depressions throughout the system during startups and what initiators are required to provide cascaded startup of the system. • Once a satisfactory procedure is established new sequences should be programmed that will initiate the HVAC startup based on a combined set of system prerequisites and a step/transition based sequential function chart (SFC) logic. Each fan set startup routine will comprise its own 'sub-sequence' that will be initiated by a master scheduler.
IC-O-02-V-02	The cascaded shutdown of the HVAC system is not controlled in a manner to ensure cascaded confinement of radiological materials. Certain logical trips will shut down the C2 supply and extract fans simultaneously with the remaining equipment tripping out of service due to process anomalies.	• The HVAC system description details the procedure required for a manual shutdown of each system individually. The CSLDs indicate a cascaded shutdown of the fans under certain conditions. However the fan override trips only stop individual pieces of equipment and rely on the cascade shutdown to stop all other equipment. The shutdown of the pieces of equipment, once initiated, does not consider any process conditions as part of the shutdown.	Without process considerations as part of the cascade shutdown and an actual shutdown sequence to manage the fan stop commands a controlled shutdown of the HVAC cannot be guaranteed or controlled. The lack of cascaded management of the shutdown could challenge the ALARA principal applied to cascaded confinement in the BOD (Section 12.3.1.1 - Confinement).	• Author a master procedure to shut down the HVAC as a coherent system that considers the expected flows and depressions throughout the system during shut downs and what initiators are required to provide cascaded shutdown of the system. • Once a satisfactory procedure is established new sequences should be programmed that will

Table B-2. Vulnerabilities Identified for Instrument and Control (I&C). (9 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• The cascade occurs once the fans required as part of the startup prerequisites are no longer running. For example, C2 extract fan cannot run without C3 extract fan running first, consequently the C2 extract fan will not cascade stop until the running signal from the C3 extract fan is removed. The cascaded shutdown of the HVAC system appears to consist with a semi-controlled crash since it is not based on any process variables and thresholds, instead being based on the running feedback of ASD's. • There are other trips of fans that initiate override stops of fans simultaneously which are independent of running feedback of fans. These situations will only exacerbate the lack of cascaded confinement. The C2V supply and extract system is an example of simultaneous trips. • (IC-O-02-N-01, 02, 03, 04, 05)		initiate the HVAC shut down based on a combined set of system/ fan set trips and step/transition based logic. Each fan set shutdown routine will comprise its own 'sub-sequence' that will be initiated by a master scheduler. In the event that the shutdown sequence does not operate correctly a set of bounding fan trip conditions will exist to override-stop the fans to ensure the system is ultimately shut down.
IC-O-02-V-03	• The currently proposed parallel fan operation is fundamentally flawed in its execution. Industry engineering practices indicate dual process control into a common header with a single process variable to result in unstable control. • This issue was identified in CLIN 3.2 RPP-50775 Rev: 2 (CLIN 3.2), Annual Waste Treatment and Immobilization Plant (WTP) Operational Support Report, and is still present system wide (not restricted to LAW systems).control.	• Although this control philosophy has been identified in previous reviews as problematic the issue persists in the current design and implementation. The issue has been identified, tracked and resolved through the PIER process but the resolution was not underpinned by engineering principles. The use of an integral term for control will result in diverging fan speeds if the performance characteristics between fans are different. • The PIER applied the principle that each fan control loop will see the same error between the set point and the feedback value and will therefore send the same speed to each fan (proportional to the ratio of the output response and the error). Using a proportional term only will result in 'droop' (offset from set point) since the controller requires a non-zero error to work. The 'droop' can be compensated through the use of a bias or dynamically using an integral term. All the design documentation for LAW implies the use of an integral term for pressure control of HVAC fans. The integral component sums the error over time resulting in a small error causing the integral	• If the system is not intended to be operated using PI controllers then the design documentation (CSLDs, system descriptions etc.) must be updated to reflect this. This task would be substantial and is not in the best interests of controlling the HVAC equipment. Alternatively the current control method should be replaced by a single controller per process variable feedback, regardless of the number of devices being controlled. This solution also involves considerable work since this implementation is defined on a CSLD for each instance instead of being defined in a requirements specification only once. • If PI control is to be used then the independent controllers per device will result in unstable and unpredictable operations. The	• Eliminate all instances of independent PI control throughout the project (WTP in its entirety) as identified in CLIN 3.2, Table 2-16. • Simulate situation conforming to target environmental conditions to provide adequate proof of concept for control of parallel fans into a common header using new control scheme.

Table B-2. Vulnerabilities Identified for Instrument and Control (I&C). (9 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		component to increase over time and the system to meet its intended set point. Using proportional and integral terms (as implied by the design) is the best way to control the closed loop system in this instance. The PIER however seems to imply that the chosen controls will not be of this type. • There are multiple industry articles that state the reasons for proportioning parallel fans at the same rate. CLIN 3.2 stated that 'If variable speed control is used, then all fans must proportion at the same rate. In other words, if fan #1 is running at 50% then fan #2 and every other fan in parallel must be running at 50% also. If this is not done you run a very high risk of the faster fan stalling the slower fan.' • A second reference states 'It should be understood that pumps in parallel must always operate at the same speed. There may be some unusual, sophisticated cases where parallel pumps are operated at different speeds, but only experienced pump designers should make evaluations for such a proposed operation. Variable speed pumps should be controlled so that pumps operating in parallel never have over a 1 percent difference in actual operating speeds.'	instability may be avoidable through modification of tuning parameters (although unlikely) but the system will then be optimized aiming to avoid the loss of control rather than aiming to control effectively and efficiently. • The only way to ensure parallel devices operating in unison is to drive them to a single speed set point derived from a single feedback loop.	
IC-O-02-V-04	The current control schemes identified in the CSLD requirement documents identify responses to process anomalies re: fan trips, failed dampers etc. that will likely not provide adequate response times necessary to maintain HVAC operations without interruption.	• During process upsets that require changeovers of the duty extract/supply fans the response time will be critical. The triggers for a duty changeover include: - Duty inlet & discharge dampers not open w/ fan running - High bearing temperatures - 2oo3 conditions for lolo DP, lolo fan speed and lolo flow, all conditional on fan running • Since the majority of the above conditions are conditional on the fan running they will not be detected rapidly if a failure were to occur during startup of each system. If there is a system failure during operations, and the fan running signal is on, the process trips will not initiate the standby fan until the process is already shutdown to some extent triggering the	Without an immediate response to process anomalies the probability of successfully maintaining HVAC operations, and therefore plant throughput is reduced.	• Establish new baseline for initiating a duty/standby changeover. The AHUs and Fan Sets should be treated as a single operating unit of which any failed component constitutes a failure. For example, a failed discharge damper during startup should initiate the changeover, currently the damper failing would only cause a failover once the fan running signal is on which could cause a delay of seconds or minutes. • Expand error trapping for devices associated with fans to capture failures as soon as possible. For example, a

Table B-2. Vulnerabilities Identified for Instrument and Control (I&C). (9 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		Low Low trips (the set points for these trips are to be determined and refined during startup and commissioning). • If a fan is determined to be failed via the error handling in the drive or other deterministic methods and the changeover is not initiated immediately then the window for a successful changeover will be considerably smaller and the probability of maintaining normal HVAC operations is reduced		discharge damper that fails to move off the closed limit could be captured with a secondary, shorter, timer. This would allow a response to a predictable outcome to be almost instant (within 5s) without waiting for the fan to be running and the process to be insufficient to maintain pressure differentials.
IC-S-01-V-01	• System descriptions (SD) are no longer the source for system requirements. Since the CSLDs are used as both the requirements and the basis for test documents there is no longer complete correlation back to system requirements defined in the SD. • Discrepancies between upper tier documents and implementation documents indicate that requirements, critical or non-critical, could have been overlooked and will not be identified as incorrect during testing.	• There are multiple instances of discrepancies between the SD and the implementation defined on the CSLDs for the HVAC system. There are currently no processes in place to validate and verify that the requirements are implemented and tested beyond the scope of the CSLDs. Without a Requirements Traceability Matrix (RTM) that contains the explicit requirements for a system, the baseline documentation and the derivation of those requirements the software testing cannot take full credit for requirements implementation, verification or testing. • The current method for specifying requirements (CSLDs) is not conducive to inter-discipline understanding that the implementation meets the design intent. Other disciplines that must review the requirements to ensure correct and full implementation must first be trained how to read the CSLDs before they can assess their completeness. Once the related disciplines have been trained there is no guarantee that their interpretation of the logic diagrams will be the same and that they will conclude the same functional requirements after reviewing them.	• Without functional requirements derived from baseline documentation that are easily reviewed by disciplines other than the software group there cannot be a guarantee that the software is accomplishing the system requirements. Furthermore without validation to upper tier requirements implementation errors/discrepancies will persist through to the software being installed on plant. • A disconnect between the functional requirements and the software requirements and their associated testing documentation will guarantee that the testing of the software will not demonstrate the required performance of the system over the range of operation of the controlled function or process. • NQA-1 2000, *Quality Assurance Requirements for Nuclear Facility Applications*, compliance cannot be accomplished without detailed flow down of requirements. Therefore adequate testing to verify and validate the functions of the software cannot be demonstrated.	• .Identify critical design requirements from baseline documentation and create a requirements traceability matrix (RTM) that can be used to re-validate the software to verify functionality of each system per NQA-1 2000 Requirement 3, Section 400. • Re-evaluate test acceptance criteria on a functional system basis to ensure that the functional requirements of each system are met based on the derived requirements from upper tier documents. • For computer programs used for operational control, computer program test procedures should be created that demonstrate the required performance over the range of operation of the controlled function or process per NQA-1 2000 Requirement 11, Section 400.
IC-S-02-V-01	The Integrated Control Network, the plant system control system, has been	• The process used to grade software is documented in a CCN and is not equivalent to	Incorrect grading of the plant control software discovered during a	• Define the ICN boundaries and interfaces, consistently and

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	developed using an inappropriate software QA level because the software QA grade was determined incorrectly.	the process specified in project procedures, which is not allowed by WTP QAM. The software level, resulting from the grading process, was determined without analysis of hazards and risks. This analyses are only performed if the initial assigned level is not Level D (i.e., Level A, B, or C), which is an inadequate implementation of DOE O 414.1C, Quality Assurance. • Software Quality Assurance Level evaluation is insufficient to demonstrate that 10 CFR 830 "Nuclear Safety Management" Code of Federal Regulations, or DOE O 414.1C, Quality Assurance , requirements have been met. • The ICN is used to monitor, alarm, log, or control hazards incommensurate with its current software QA level. • The ICN is used to provide additional SIL protection incommensurate with its current software QA level. • The ICN is used to ensure adherence to permitting requirements, which are imposed to protect the environment, incommensurate with its current software QA level. Recourse to originators or maintainers is necessary to obtain necessary information, contrary to NQA-1, 2000 and the WTP QAM requirements.	readiness review or preparation for one will result in a reclassification to a higher software level, which will require software, equipment, and embedded software to be extensively reviewed and documented or replaced and rewritten. Plant control software will not be of sufficient quality to support the operation and throughput requirements, jeopardizing mission success. Continued work will result in more rework.	commensurate with the functions attributed to the ICN. • Define (or redefine) the WTP specific functions requirements performed and controlled by the ICN. Flow down of requirements from upper-tier documents will provide the test criteria when functionality is confirmed during software development. • Evaluate (or reevaluate) the hazards, risk, safety, and permitting compliance controlled or affected by the ICN and its subsystems without regard to the likelihood or credibility of accident scenarios or consequence mitigation, per 10 CFR 830. Generate a full list of questions to evaluate software compliance. Use a full implementation of DOE O 414.1C and ask all the compliance questions generated above prior to assigning a software grade. • Use a standard set of documents, such as ISO/IEEE, to organize required software documents, descriptions, etc. An experienced software engineer would then be able to navigate without recourse to the originators or maintainers.
IC-S-06-V-01	• The programmable protection system (PPJ) control system is Level A software which requires full implementation of DOE Safety Software Guide and Software Quality Assurance (SQA) Work Activities. • The requirements being supplied to the contractor do not contain traceability to upper tier documents	• The procurement specification for the PPJ control system does not provide, and does not plan to provide, the safety software requirements specification (SSRS) and traceability to upper tier documents. Furthermore the spec requests that the supplier derive the requirements from the supporting documentation for approval by BNI. This is not in compliance with the software lifecycle identified in ISA-84 or IEEE 1012-2004	• There is not a clear software life cycle implementation for the PPJ software. Without a cascade of upper tier requirements derived from hazard analyses and control selection the validation and verification of the safety software cannot be accomplished. • ISA-84, NQA-1 and the V-model lifecycle cannot be implemented	• Derive PPJ requirements from baseline documentation, hazard, risk assessment and allocation of safety functions to protection layers. This can be accomplished through updates to the SSRS or generation of new SSRS that define what the requirements are but not how they are going to be accomplished.

Table B-2. Vulnerabilities Identified for Instrument and Control (I&C). (9 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	and do not convey the requirements in a manner that is clear and concise to any discipline that may be required to perform a review.	Standard for Software Verification and Validation which defines a V-model lifecycle (adopted by the WTP project) where development and testing procedures are derived from requirements, not the other way around. • Without a clear set of requirements derived from hazard and risk assessments and allocation of safety functions to protection layers it is not clear how the CSLDs were created in the first place or how their development has been verified against upper tier requirements. • Section 3.1.2.7.1 of 24590-WTP-QAM-QA-06-001, 2008, Quality Assurance Manual, states that 'Design analyses shall be sufficiently detailed such that a person technically qualified in the subject can review and understand the analyses and verify the adequacy of the results without recourse to the originator. (NQA-1-2000, RQMT 3, 400; DOE/RW-0333P, 2008, Quality Assurance Requirements and Description, Rev. 20, Rev 20, 3.2.3.C).'The use of CSLDs as definitions of requirements does not comply with the above statement. There are several support documents that define the symbols, functions and structural components that comprise a CSLD and its functions that cannot be reviewed and verified without recourse to the originator.	in a robust defendable manner using the currently proposed method in the PPJ Engineering Specification. Software requirements cannot be derived from logic diagrams and then implemented, after approval from BNI, without breaking links to upper level requirements. The risks associated with hazard analysis cannot be actively managed unless they are the driver for the requirements. • The current method for developing software does not appear to be in compliance with the WTP QAM.	• Base all software development and testing criteria on software requirements to ensure functionality is met and hazards identified during risk assessment are implemented, verified and validated. • Eliminate the use of CSLDs as requirements for PPJ software development. They do not clearly define the requirements or their delineation from upper tier documentation. The SSRSs already developed (used in conjunction with Desk Instructions to develop the CSLDs) are a clear, concise, traceable, English worded document set that can be used to derive the requirement of an individual SIS/SIF and remain independent of the actual implementation. The current proposed mechanism for development of the PPJ software requires the supplier to recreate documentation that already exists in the SSRS documents.
IC-S-07-V-01	Current life cycle documentation will be cumbersome to maintain and update during startup, commissioning and operations*	• The SPP for the ICN lists the life cycle documentation, all of which will need to be kept up to date during startup and commissioning. Every change to the plant installed software will incur a modification to some or all of the documentation. Specifically, any logic changes that also affect the functional requirements of a system will have an effect on the CSLDs, CDIs and SDDs for the Plant System Sub-Projects and possibly the SDDs for the Facility Systems. • During startup, commissioning and initial operation phases the number of changes to the facility control system, given previous	• During startup and commissioning, when multiple personnel are working on systems at the same time, the paperwork required as part of making software changes will create delays to the changes themselves or will create configuration issues for associated lifecycle documentation. • It is probable that software changes would affect multiple requirements documents	Eliminate and/or replace all requirements and design documentation that will be affected by software modifications that do not affect higher level requirements. Day to day software modifications to meet functional requirements, as designed, should not incur additional paperwork. Review design document sets for the control system software to establish the level of effort required to make a software change and how the accumulation of these types of

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		experience, will be in the order of hundreds or thousands a year (estimate of 10-20 software modifications per week). The changes may be driven by software errors that were not tested during development, by enhancements requested by operations, by anomalies between plant equipment and software as configured or any combination thereof. • In either case the documentation associated with any change will become difficult to manage and track if the current document set is continued into those phases of the project. A requirements traceability matrix for the software functions, paired with the current software specification and implementation documents, would allow plant changes to be made without affecting the fundamental requirements and therefore would minimize document changes. Any changes to requirements would be captured and flowed down into the software implementation.	(CSLDs) simultaneously which would require updating in order to maintain configuration control. The additional tasks associated with the documentation updates will increase the startup and commissioning durations for the facilities.	changes will impact the commissioning schedule.
IC-S-09-V-01	There is currently no scope or procedure for implementing cyber security for the WTP control system. Compatibility and implementation issues related to the control system software could result in extended implementation of NIST and DOE requirements.	• The current scope of work for the WTP software and hardware does not include considerations for cyber security outside the scope of the EDMS. The ICN and PPJ software and hardware (both computer equipment and controller hardware) remains part of the critical infrastructure for the WTP mission and should have security implemented beyond the scope of username and passwords. • The username and password access to the ICN system will be used to restrict access to system functions but this level of security cannot be considered cyber security since the user would already have been added and have access to the system. Consideration must be given to inadvertent security breaches such as the use of personal USB thumb drives with ICN computer equipment. • Cyber security must be assessed from an external perspective and any potential weaknesses mitigated through the use of administrative or engineered controls. Industry standards and practice should be given due	• Adequate consideration of cyber security from the perspective of external or internal malicious intent must be considered in order for the WTP control system to comply with DOE and NIST requirements for critical infrastructure. • The advanced state of the design of the LAW control system makes integration of security features more difficult and may only occur during or after commissioning. • The WTP mission could be compromised through an external or internal malicious attack if the control system is compromised.	Establish a means of providing adequate cyber security measures for the selected software and hardware that comprises the ICN for WTP that complies with DOE Order 205.1B, Department of Energy Cyber Security Program

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		consideration as part of the development of an implementation plan		
IC-S-10-V-01	The documentation that defines the SIS and corresponding layers of protection does not appear to be consistent with the CSLDs or CDIs in all cases.	• The LPS SIS interlock definition takes credit for functionality within the ICN that is not represented on the CSLDs or in the CDIs. There is no additional equipment indicated in design documents that would provide interlocking functions using the ICN software. • The SIS requires a SIL-2 level of protection from the PPJ safety significant software. This level of protection is being provided by that system according to PPJ logic diagrams. The level of protection was SIL-2 because of the additional layer of protection provided by the ICN but this layer of protection is not provided by ICN logic according to the CSLD and CDI documentation. • The caustic scrubber high differential pressure interlock contains two layers of protection to reduce the SIL required to SIL-1. The high differential pressure interlock (ICN) does not appear to be represented on the P&IDs, only the caustic collection tank low low level is represented on the P&IDs. The CSLDs (PPJ and ICN) indicate that the safety interlock, derived from PDSHH-0047 & 0094, initiates an override stop of the pumps. There is a discrepancy between the requirements documents (P&ID's and CSLDs).	• The SIS will not provide the level of protection expected without the functionality defined in the layer of protection. In some cases functionality is not reflected in the documentation and is expected to be missing from the logic. In other cases there is functionality in the logic that is not represented in the documentation. • The functions defined for the SIS and the functions required of and implemented in the ICN software do not appear consistent. • Without full implementation of SIS layers of protection the probability of the accident scenario occurring increases.	• Re-evaluate LPs identified within the SISs to verify their implementation in the respective systems. Create functional requirement documents linking LPs with ICN design documents to provide traceability and tracking of these functions. • Eliminate any ICN functions that are part of an SIS to establish a clear delineation between the safety systems and the plant control system.

Table B-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (17 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-01-1	Instrument uncertainties are calculated incorrectly to control loop design challenging instruments ability to work properly	Failure to calculate individual instrument and complete control loop uncertainties has resulted in: • Zone to zone monitors (C2/C3) will routinely be breached. • Instrument datasheets with incorrect instrument accuracy statements. Twenty three datasheets examined twenty three with incorrect instrument accuracy statements. • Alarm and Interlock Set Points in the Configuration Data Index (CDI) database that cannot be met	C2/C3 Zone Differential Pressure Monitors not working will lead to Plant Production interruptions.	Perform an evaluation that includes uncertainty analysis for all fan control loops including alarm and interlock set points. This ensures chosen set points are reasonable and control loops can operate as designed without routinely challenging interlock setpoints.
HVAC-01-2	The C2/C3 DP monitor scheme, as currently designed, will not work.	The Foxboro instruments selected are as good as any and probably better than most on the market. However the small differential design pressures between the rooms being monitor coupled with the instrument uncertainties does not allow sufficient margin to establish workable alarm and interlock set points, per the guidance in 24590-WTP-GPG--J-0057, Setpoint Calculations. Consequently if the current C2/C3 DP monitoring design is implemented it will result in frequent ventilation shutdowns resulting in interruption of plant production and/or undetectable flow reversals.	Frequent breaching of C2/C3 DP Monitoring will shut the fans down resulting in production stoppage.	Perform a market search to find instruments with less uncertainty or raise the C2 depressions particularly in the rooms where DP Monitors are located.
HVAC-02-4	Controlling parallel fans with two separate controllers results in unstable fan control	C2V, C3V and C5V exhaust fans each have their own unique controller. Even though the fans are using the same process variable, differences in the integral term of the PI controller will result in different fan speeds. This arrangement is difficult to tune and is expected to result in erratic control when other attributes of the system are taken into account. Perturbations in the system will cause the fans to respond differently as they are operating on different fan curves. This can result in the fans producing different pressures and erratic control.	One fan will be running at max speed while the other fan is operating at lower speed.	Use one control and split the signal between the two Adjustable Speed Drives (ASD).
HVAC-12-3	Zone C2 to C3 doors have less than 100 fpm	Section 12.3.4 of the Basis of Design states the flow rate through a single open door should be at least 100 fpm. If this is not practicable for routine operations, a compensatory process should be developed and documented. Several doors in the LAW facility between C2 and C3 areas have been identified as having less than 100 fpm air velocity through them, which increases the risk of spreading contamination from C2 to C3 areas.	Low velocities through the doors remove the level of protection against radioactive contamination	Make sure volumetric flow rate into C2/C3 areas is 100 fpm (minimum) through a single open door.
HVAC-11-4	Risk of contamination backflow in a Swabbing/Finishing Line	Low flow velocity, missing airlocks, undersized in-bleed, and no interlocks make this flow path	Contamination spread to outside environment	Increase flow from swabbing cells to finishing line, provide airlocks

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		vulnerable for contamination spread from finishing line.		when feasible, increase in-bleed filter capacity.
HVAC-12-4 HVAC-31-6	No airflow parameter identified for the open doors between C3 and C5 zones	Doors and hatches between C3 and C5 areas are routinely opened during operation of the LAW facility. While a parameter has been given for single door openings between C2 and C3 and for "gaps" between C3 and C5, no parameter has been identified for open doors and hatches between C3 and C5. There is not a consistent application of flow rate between these openings. This increases the potential for contamination migration from C5 to C3 areas when these door and hatches are open.	Low velocities through the doors and hatches remove the level of protection against radioactive contamination spread between C3/C5 zones during both normal and abnormal operations	Provide at least 125 linear fpm through the open C3/C5 door and hatch to ensure adequate inflow to prevent the escape of contamination.
HVAC-32-2	Airflow through the canister import hatch has not been evaluated	The design shows airflow of 2200 cfm into rooms L-0117B and L-0117D. The hatch openings are approximately 5.5'x 5.5', which is 30 square feet. With an airflow rate of 2200 cfm, the flow rate across the open hatch is approximately 75 fpm. This has not been documented and evaluated to determine if it is sufficient in this application.	Potential migration of contamination from the transfer tunnel into the canister import areas.	Define the flow rate through the rollup doors and add it to the design flow rates. Make other adjustments to depression values and transfer grill and inbleed flow rates to reflect modified depression values.
HVAC-25-1 HVAC-25-2	C2 supply fan bypass not adequately evaluated and appears it will not work	The V&ID does not account for in-leakage when the ventilation is operating with only the C5V exhaust fan and C2 supply bypass operating. It indicates the total exhaust fan flow will be through the bypass and does not include in-leakage. In addition, the depression in the various zones does not appear to be calculated. The V&ID indicates the C5 flow will be equal to the normal operation flow, which does not appear practical.	• C5 flow will be less than the minimum operating speed of the C5V exhaust fans when bypass is in service. • C2 zone pressure will exceed allowable limits when bypass is in service.	Evaluate airflow through the open hatches to determine if it is acceptable. Provide justification for airflow rate or revise design to increase airflow rate to an acceptable level.
HVAC-31-1	Lack of engineered controls for cell entries through sub-changes	Each entry into cell areas will require manual adjustment of the transfer gill damper in order to balance the depression between the sub-change and the corridor or the cell. Both the timing of the damper adjustment and the position of the damper are administratively controlled.	• Loss of confinement due to sudden increase in airflow into the cell area through the sub-change. • Concurrent zone entries through different sub-changes may challenge the ventilation system.	• Convert sub-change rooms to cell entry rooms with standalone airlocks. Airlocks would eliminate the need to adjust the dampers. They can be set up so there is virtually no opportunity for operator error. • Develop a system model to determine the impact of opening sub-change doors. • Add indicating lights to the damper and door position to indicate the door and damper are in the correct position prior to opening the door or adjusting the damper. • Add positioning equipment to the cell doors and sub-change

Table B-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (17 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				dampers that prevents the door from being opened prior to the damper being in the correct position and prevents the damper being adjusted before the cell door is closed. • Add engineered positioning equipment to the damper to position the damper automatically based on cell door position.
HVAC-31-2 HVAC-31-3	Life safety and emergency response issues related to sub-changes	• While breaker bars are included on the cell entry door, no breaker bars have been included on the sub-change doors even though the sub-change will be subject to depressions that will prevent the door from being opened without a breaker bar. • Emergency response, whether responding to an emergency in the cell or egressing from the cell, is delayed due to manual adjustment of the transfer grill damper.	• Delay in providing emergency care. • Delay in egressing from the cell during an emergency. • Personnel become trapped in the sub-change during an emergency.	• Convert sub-change rooms to cell entry rooms with standalone airlocks. This would allow personnel to enter the cell entry room from the corridor and vice versa without having to adjust damper or door position. • Convert sub-changes to airlocks to eliminate the need to install breaker bars. • Install breaker bars on sub-change doors
HVAC-31-4	Sub-change rooms too small to accommodate all personnel and equipment associated with typical entries	Sub-change rooms are too small to accommodate all of the personnel and equipment expected to be part of the entry without having to make multiple adjustments to the doors and dampers.	• Reduced production and delays in facility operation due to extended or delayed entries into the cell area. What may be done in a single entry may require multiple entries to complete. • Sub-change crowded with personnel and equipment, which impacts worker productivity, comfort, and safety.	Convert sub-change rooms to cell entry rooms with standalone airlocks. This would allow personnel to enter the cell entry room from the corridor and vice versa without having to adjust damper or door position.
HVAC-31-5	Cell entry doors to not have hose pass-throughs	Hose pass-throughs are necessary to allow the cell door to be closed when personnel in the cell are wearing supplied air respirators and additional personnel or equipment need to enter the sub-change from the corridor.	• Delays in cell entry activity in order to bring all entry personnel back into the sub-change so sub-change door can be opened. • Reduced production due to entries that may be cancelled or extended to another shift in order to include necessary personnel or material that cannot be included because of lack of access through the sub-change door.	• Convert sub-change rooms to cell entry rooms with standalone airlocks in order to allow personnel to enter the cell entry room from the corridor and vice versa without having to close the cell entry door. • Note: This would eliminate the need to close the cell door during entries.

Table B-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (17 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-31-8	Adjusting of subchange dampers along with opening and closing doors causes changes in the C5V flow	Each time a damper is adjusted or a cell entry door is opened or closed, the C5V airflow changes. While the changes may be a small percentage of the total C5V airflow, these changes will cause the system to adjust to compensate for the change in flow. The changes in airflow and impacts to the cell depression and the depression to adjacent areas have not been quantified and documented. Depending on the amount of the change in flow, these changes would result in upsets to some facility areas. This issue is magnified when two or more areas are accessed at the same time.	• Changing flow rates challenge the flow balance between the cell and adjacent areas. • Changing flow rates may challenge the C5 ventilation system.	Develop a ventilation system model to demonstrate the change in airflow and the impact on depression when adjusting sub-change dampers and opening and closing cell entry doors. Convert sub-changes to airlocks where the cells are completely isolated from the corridors.
HVAC-31-9	Function of transfer duct between L-0108 and L-0109 (and L-0114 and L-0115) is not evaluated	The current design for sub-changes L-0108 and L-0109 shows a nominal flow of 1100 cfm through each sub-change during normal operating conditions – neither sub-change is accessed. There is a transfer duct between the two sub-changes. It appears the purpose is to divert airflow from the sub-change not being accessed to the sub-change being used for cell entry in order to achieve the 2200 cfm flow rate through the open cell door. No evaluation has been performed to confirm this operation is possible without adjusting dampers in both sub-change rooms. The same condition exists for sub-changes L-0114 and L-0115.	• Reduced airflow through sub-change door results in contamination migrating from the cell area into the sub-change. • Adjustments to the damper in the adjacent sub-change are required in order to make cell entries.	• Develop a model to validate the current system configuration. • Provide evaluation to demonstrate the proper function of the transfer duct between rooms L-0108 and L-0109 (and L-0114 and L 0115).
HVAC-32-1	Airflow through canister import rollup doors is not included in the design.	The current design anticipates no leakage through the doors. It shows all flow between room L-0117 and rooms L-0117A and L-0117C as passing through transfer grills. The size of the rollup doors is such that flow through the doors will be considerable. This is not as critical as the flow through the inbleed between rooms L-0117A and L-0117C and rooms L-0117B and L-0117D. While these rollup doors are smaller, leakage through the doors will be significant, especially at the pressure drop shown between these rooms. The depression in rooms L-0117A and L-0117C is -0.2 inches w.g. while the depression in rooms L-0117B and L-0117D is -1.4 inches w.g. At this pressure differential, if it can even be maintained, all flow will be through the rollup doors and there will be no flow through the inbleed. Flow through the inbleed is critical since it provides cooling for the transfer tunnel.	• Excessive flow through the canister import doors will result in excess air cascading into the transfer tunnel. C5V fan capacity may not be sufficient to maintain the transfer tunnel at the design depression. • Lack of flow through the inbleed results in a lack of cooling in the transfer tunnel.	• Define the flow rate through the rollup doors and add it to the design flow rates. Make other adjustments to depression values and transfer grill and inbleed flow rates to reflect modified depression values. • Modify or replace rollup doors to eliminate leakage through the doors.
HVAC-33-1	Variation in airflow through the finishing lines as a result of opening and closing finishing line doors is not quantified as part of the design.	Variation in airflow through the finishing line will affect the overall C5V airflow. Calculations or evaluations of the change in finishing line flows that	• Excessive flow through the canister import doors will result in excess air cascading into the transfer tunnel. C5V fan	• Define the flow rate through the rollup doors and add it to the design flow rates. Make other adjustments to depression values

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		result from the opening and closing finishing line doors was not performed as part of the design.	capacity may not be sufficient to maintain the transfer tunnel at the design depression. • Lack of flow through the inbleed results in a lack of cooling in the transfer tunnel.	and transfer grill and inbleed flow rates to reflect modified depression values. • Modify or replace rollup doors to eliminate leakage through the doors.
HVAC-42-1	C5 exhaust fans are not sized based on the latest calculated exhaust temperatures at the exit of Pour Caves	CFD analysis of Pour Caves and Finishing Lines.	C5V exhaust temperature may rise above their design requirements and may impact capacity margins of C5V exhaust fans, ductwork, insulation and stack monitoring instruments based on temperature criteria shown in Change Notice 24590-LAW-MAE-C5V-00005.	• Revise calculations to incorporate a maximum realized exhaust air temperatures based on the worst case off-normal operating condition with a margin of safety assigned to the pressure drop calculations and determine if redesign of the current C5V exhaust fans is required. • Investigation and validation is required to ensure that all confinement ventilation system instruments, wiring and sensors are specified to meet the temperature limits as calculated by the optimum off-normal condition to achieve the required performance and reliability.
HVAC-44-2	Lack of redundant cooling in Buffer Storage and Canister Rework areas	The buffer storage area and container rework area each have single general service commercial grade fan coil units that provide area cooling. The buffer storage and canister rework areas have the potential to contain up to 18 thermally hot containers. If one of these fan coil units fails under certain anticipated load conditions, the temperatures in these areas will exceed design temperatures.	• The Buffer Storage Area and the Rework Area space temperatures will be substantially higher than design temperature of 113°F. • Pour Cave C5V exhaust air temperature will be higher than the CFD analysis calculated figures due to rise in supply air temperature to the Pour Cave from the Container Transfer Corridor. • Container Transfer Corridor space temperature will exceed 113°F.	• Evaluate the feasibility of installing 100% standby FCUs for the Container Buffer Storage and the Container Rework Area. Availability of additional space to house redundant FCUs and associated ductwork must be investigated. • Investigation and validation is required to ensure that ASTM (24590-WTP-DB-ENG-01-001, Basis of Design) requirements are complied with for all Buffer Storage ventilation system which may be exposed to temperatures higher than 140^0 F. External surface of Buffer Storage ventilation system will be provided with adequate insulation to protect the workers

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				from contact with hot surfaces above 140°F where applicable.
HVAC-45-1 HVAC-46-1	Off-normal operations analysis not performed	Several off-normal events, such as …., are described in the System Description. These events have not been analyzed to determine the impact on facility ventilation to determine if zone pressures and flow rates can be maintained at levels needed to ensure confinement.	• Elevated C5 space temperatures above design requirement of 113°F. • Elevated C5V exhaust air temperature may impact ductwork, insulation, exhaust fan and stack monitoring margins. • Pressure and air flow imbalance may result in loss of confinement. • Concrete temperature limits may be exceeded in certain C5 areas.	• Identify all possible off-normal conditions • Provide evaluation for each off-normal condition to determine impact on facility depression and temperatures. This evaluation may include assessing C5V component capacities. • Provide facility modifications or work around to ensure facility confinement and temperature limits are satisfied. • Evaluate the impacts on the balance of plant chilled water system flow, pumps and power requirements. • Analyze the recovery mode after occurrence of an off-normal event with any control modifications and system hardware modifications if any.
HVAC-48-1	Unverified cooling capacity for safety significant equipment rooms and Non-Safety Battery Rooms	The DX cooling units were sized for certain loads. It appears some of the loads have changed yet the sizing has not been verified to be adequate for the revised heat loads.	Excess heat in safety significant equipment rooms and Non-safety battery rooms may exceed equipment rating temperature, resulting in failure of equipment.	• Evaluate the current electrical heat loads and verify the capacities and available margins of all purchased SS Air Conditioning equipment serving SS spaces as well as Non-safety battery rooms • Redesign the SS Units as necessary to meet the SS functional requirements.
HVAC-51-1	Radial HEPA filters are not qualified for use	Radial flow HEPA Filters for nuclear facility applications have been used in Europe for some time, however, a limited amount of data exists with respect to the performance of the radial HEPA Filters to the AG-1 new section FK. Of particular concern is the lack of particle loading and structural failure data for the radial flow HEPA Filters. Radial HEPA Filter Testing in 2011 at the Institute for Clean Energy Technology at Mississippi State University revealed that the filters failed within 5-minutes when exposed to environmental conditions of 130°F, 50% relative humidity and loading of 4-inches water column.	• Potential redesign of radial HEPA filters and housings for the C2V, C3V, C5V, LOP, Buffer Storage and Canister CO2 decontamination systems. • Frequent or premature failure of Radial HEPA Filters can cause spread of contamination to the C5V ducting or eventual release of radionuclides to the environment.	Radial HEPA Filter technical issues and testing is managed by a separate engineering design group. WDOH approval will be required for use of radial HEPA filters in LAW.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-53-1 HVAC-53-3	Lack of redundancy in stack sampling and monitoring equipment results in increased downtime since these components require extensive maintenance	ANSI N13.-2012 Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities requires that sample probes and sample transport piping be inspected, cleaned and leak tested on quarterly and annual frequencies. Additionally, quarterly calibration of flow control valves and stack monitoring interlocks is required. Maintenance requires shutdown of the C5V exhauster which required the melter be idled. Calibration or maintenance while the C5 ventilation system is operating can cause personnel to be exposed to hazardous chemical vapors and high temperatures. There is no redundancy to allow one set of components to be put into service while the others are taken off-line for maintenance.	• Violation of the Radioactive Air Emissions Notice of Construction Permit Application for the Hanford Tank Waste Treatment and Immobilization Plant. • Potential failure and shutdown of the stack monitoring system can lead to idling of the melters.	• Revise Radioactive Air Emissions Notice of Construction Permit Application for the Hanford Tank Waste Treatment and Immobilization Plant. • Add redundant stack sampling and monitoring systems so that inspections and maintenance can be performed while the standby system operates. Install inspection ports and develop remote inspection techniques using boroscope cameras. • Design an enclosure to capture thermally hot hazardous chemical vapors to protect employees during removal of sample probes for inspection. • Add redundant stack sampling and monitoring systems so that maintenance can be performed while the standby system operates
HVAC-53-2	C5V air stream temperature exceeds stack monitoring equipment rating	Elevated C5V exhaust air temperatures result in elevated stack discharge temperatures (greater than 130° F). High temperatures can cause premature failure of CAM detectors and Masstron Flowmeters and Hastings flow control valves.	• Potential failure and shutdown of the stack monitoring system, resulting in shutdown of melter feed.	• Develop a computer simulation of the facility HVAC System and evaluate thermal loads going to the C5V exhaust system.
HVAC-54-1	Low Air Flow Confinement ventilation design	One of the challenges of a low flow HVAC system is the contaminants in the air stream to settle out of the air and onto the surfaces of the work area. This results in increased housekeeping, especially when the facility is a contact-maintenance facility.	• An operating policy of housekeeping that requires regular cleaning of surfaces and cleanup campaigns is needed to remove the buildup of contamination. • Air locks are needed at the entrance and exit from ventilation zones to prevent or mitigate upsets in the ventilation air flows. • Inability to perform maintenance due to reduced worker stay times caused by elevated temperatures and contamination buildup.	• Develop remote decontamination techniques such as HEPA vacuum cleaners deployed from the overhead crane. • Prior to hot commissioning operations should perform detailed clean-up and inspect and repair any damage to cell coatings.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			• Routine decontamination will cause generation of radioactive waste and increased combustible loading.	
HVAC-55-1	LAW C1V, C2V, C3V and C5V Cascade Low Air Flow HVAC System design causes the control system to be complex	Designing a Cascade low flow HVAC system causes control systems to be complex.	Difficult start-up testing and operability testing during commissioning. Redesign the LAW ventilation control system during startup and commissioning	A recommended design change would be to combine the C1V, C2V, C3V and C5V ventilation systems into a separate, independent dedicated PLC. Having a separate PLC for the C1V, C2V, C3V and C5V ventilation systems will allow early start-up testing and identification of control systems deficiencies. Modifications to the ventilation system controls could be completed earlier in the commissioning phase to minimize cost and schedule impacts
HVAC-55-2	LAW HVAC control Systems are currently combined with 32 other process control systems	Startup and commissioning activities require the operational testing of the LAW C1V, C2V, C3V and C5V ventilation control systems. Software control changes from the 32 other process control systems can affect the LAW ventilation systems and potentially cause uncontrolled shutdown of the LAW Ventilation systems.	Vent system shutdowns can result in the loss of confinement and release of radioactive contamination to the environment. Ventilation shutdown could expose the on-site worker to hazardous chemical vapors and airborne radioactive contamination.	A recommended design change would be to combine the C1V, C2V, C3V and C5V ventilation systems into a separate, independent dedicated PLC. Having a separate PLC for the C1V, C2V, C3V and C5V ventilation systems will allow early start-up testing and identification of control systems deficiencies. Modifications to the ventilation system controls could be completed earlier in the commissioning phase to minimize cost and schedule impacts
HVAC-56-1	The LAW Ventilation system needs to have a Hazard analysis performed to identify the Failure Modes and Effects for normal and off normal operations, start-up, production, clean-out & flushing and maintenance	• ORP Letter 267961 Assessment Report S-13-NSD-RPPWTP-003 Functions and Requirements of the Environmental Monitoring System for the LAW Primary/Secondary Off-gas system, states that the LAW Preliminary Documented Safety Analysis identified numerous (over 100) off-gas hazardous chemical events with facility worker "HIGH" and co-located worker above threshold for unmitigated consequences. • When any melter maintenance requiring removal of hatch cover occurs, ventilation becomes the only engineering control between personnel in the melter bay and the off-gas system, potentially	• Potential for major redesign of the LAW HVAC systems if the Ventilation systems are determined to be safety significant. • Failure to perform Hazards Analysis could cause uncontrolled shutdown of the LAW Ventilation systems resulting in loss of confinement and release of radioactive contamination to the environment. Ventilation shutdown could expose the on-	It is recommended that a hazards analysis be performed on the LAW Ventilation system to identify the Failure Modes and Effects for normal and off normal operations, start-up, production, clean-out & flushing and maintenance. Functions and Requirements and accurate V & IDs with alarms and interlock set points must be developed and documented

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		containing high levels of NOx exceeding the NIOSH IDLH.	site worker to hazardous chemical vapors and airborne radioactive contamination.	
HVAC-01-3	Instrument range should be a compound range (e.g., -5 to +5) rather than recording only one direction (e.g., 0 to +5)	The pressure differential recording instruments are set to record only from zero to some numerical value. At times it is useful to know the magnitude of the reversal. Since these instruments are capable of recording both sides of the zero mark, the range should be set up to capture both sides.	Current control system differential pressure monitor cannot measure range of pressure reversal.	Re range the differential pressure transmitters to include a compound range. This would capture the magnitude of differential pressure reversals.
HVAC-01-4 HVAC-02-5 HVAC-02-6 HVAC-03-1 HVAC-11-5 HVAC-24-1	Documentation Discrepancies	There are a variety of errors in documentation. For example, there is inconsistency between drawings such as different flows, different part numbers, and so forth. Some calculations reference other calculations that have been modified. J3 documents reference things that are not on drawing and vice versa. System description not consistent with J3s and V&IDs. Etc. See individual RORs for specific issues.	Design rework.	Review and fix documentation discrepancies.
HVAC-02-1	C2V fan control will not work	• The C2V supply fan senses room/zone depressions and modulates the supply fan in an effort to maintain the zone depression at -0.10 inches w.g. Instrument uncertainty coupled with the low set point makes this control system unlikely to function correctly. • The C2V exhaust fan is controlled by a differential pressure transmitter sensing exhaust header pressure. The goal is to maintain 0.10 inches w.g. in the C2 areas. Measuring the header pressure is far too insensitive to adequately control the C2 zone at 0.10 inches w.g. Exhaust Header pressure expected to be in the range of -4.0 to -6.0 inches w.g.	C2V control philosophy will result in frequent shutdown of the C2V supply and exhaust as well as the C3V exhaust system because of zone to zone interlocks.	Consider using a different control scheme. Perhaps running the C2V AHUs at a fixed speed and control the exhaust by sensing header pressure. Or consider controlling on flow using a flow element.
HVAC-35-2	C2 exhaust flow control method will not provide accurate flow control	The LAW C2 exhaust is maintained at a constant flow rate while the C2 zone pressure is maintained by controlling the C2 supply fan speed and flow rate. The C2 exhaust flow is controlled by monitoring the duct pressure at a single point upstream of the C2 HEPA filter banks. While there is a correlation between duct pressure and flow rate through the duct, this correlation is not always constant or consistent. Depending on the upstream and downstream duct pressure, the flow could vary with the same duct pressure. If the upstream dampers are adjusted, the flow to pressure correlation will need to be adjusted. If inlet grills get dirty, the pressure drop across them will vary, which is equivalent to adjusting the C2	Variation in C2 exhaust flow resulting in zone pressure and flow variation and inconsistent heating and cooling control in C2 areas.	Switch C2 exhaust flow control from maintaining duct pressure to a using flow element

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		exhaust inlet dampers. This will all have an impact on the C2 exhaust flow rate. The more practical option for controlling C2 exhaust flow is to install a flow element downstream of the HEPA filters. This will ensure a constant C2 exhaust flow regardless of the variation in HEPA filter loading, adjustment of dampers, or any other system change.		
HVAC-02-2	Lack of safeguards against excessive depression	There do not appear to be any interlocks or alarms for excessive depression.	Equipment failure could cause a fan to continue to ramp up and develop excessive depression which could cause structural damage or cause personnel to be trapped in rooms.	Add interlocks and or alarms to prevent excessive depression due to loss of control of the fan.
HVAC-02-3	As currently designed C3V Fan Control Pressure Transmitter (C3V-PDT-2117) will not work to control C3V depression	One of the C3 depression transmitters is located in room L-202, which is a C3 space exhausted by the C5V system.	If the signal from this transmitter is used to control C3V fan, varying the speed of the C3V fan will have no effect on the depression in this room.	Place C3V-PDT-2117 in a C3 area or room that is exhausted by C3V.
HVAC-02-7	Loss of Power results in C5V at a fixed speed rather than controlling flow or zone differential pressure	During a loss of power event, the C5V exhaust fan defaults to a fixed speed rather than controlling to a fixed flow or fixed depression. There does seem to be any analysis to establish a basis for the fixed speed. Final fixed speed must consider the impact maintaining confinement as well as heat removal to protect equipment and structures from damage due to excess temperatures.	Setting the fixed speed too low could result in insufficient heat removal or jeopardize confinement. Setting the speed too high could result in personnel access issues or physical damage to the facility.	Determine the driving factors (heat removal, confinement etc.) for determining the fix speed value and establish the fixed speed value.
HVAC-11-1	The LAW Facility secondary to tertiary zone differential pressure exceeds the recommended differential pressure range of- 0.1 to -0.15 inches w.g. from DOE-HDBK-1169-2003, Nuclear Air Cleaning Handbook, resulting in excessive door opening pressures (life safety concern).	Review of the LAW facility design indicates the nominal Tertiary (C2) zone has a nominal differential pressure of -0.1 inches w.g. and the Secondary (C3) zone has a nominal differential pressure of -1.5 inches w.g. (and -1.4 inches w.g.); both relative to atmospheric pressure. This results in a differential pressure of -1.4 inches w.g. and -1.3 inches w.g. between the Secondary and the Tertiary zones which is not consistent with DOE-HDBK-1169-2003. DOE-HDBK-1169-2003 identifies a differential pressure range for Secondary/Tertiary of -0.1 to -0.15 inches w.g. Using this high of a differential pressure creates issues with respect to life safety requirements related to force required to open doors across zone boundaries.	Life safety concern.	Evaluate the basis for the nominal differential pressure requirement identified for the Secondary (C3) zones of 1.6, -1.4, and -1.5 inches w.g. relative to atmospheric pressure. Lowering the differential pressure between C2 zones and C3 zones will result in a lower force required to open zone transition doors. If it's not feasible install breaker bar for each door exceeding force (above required) to set door in motion.
HVAC-11-2	Low duct air velocities will result in deposition of radionuclides in the ductwork	• Air velocities through many of the C5V ducts is significantly below the recommended minimum duct velocity of 2,500 fpm from DOE-HDBK-1169-2003 increasing the likelihood of hazardous particulates settling within the ductwork.	Settling of hazardous particulates in the ductwork can lead to unnecessary exposure to workers and potentially require cleaning of the ductwork during the operating life of the facility.	Evaluate ductwork configuration to identify opportunities to modify duct sizes, or air flows, in an effort to improve transport velocities to better align with the recommended

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Ducts for most nuclear exhaust and post-accident air cleanup systems should be sized for transport velocities needed to convey particulate contaminates to filter media while minimizing the settling of those contaminants in the ductwork during operation		2,500 fpm minimum duct velocity criteria.
HVAC-11-3	Flow cascades directly from a C2 zone to a C5 zone through an inbleed	Current design is not consistent with the confinement zone schematics located in the BOD and DOE-HDBK-1169-2003.	By cascading ventilation flow directly from a C2 zone to a C5 zone removes the level of protection against radioactive contamination spread gained by including a C3 zone in the cascade path during both normal and abnormal operations. Elimination of the C3 zone from the cascade path permits migration of contamination out of the C5 zone directly to the C2 zone.	Evaluate LAW facility structure to identify opportunities to relocate existing C2 to C5 in-bleeds such that the cascade flow path includes a C3 zone to prevent migration of contamination directly from the C5 zone to the C2 zone. If it is not practical to relocate C2 to C5 in-bleeds, evaluate feasibility for installation of HEPA filtration to minimize migration of contamination through in-bleed.
HVAC-12-1	Combustion and inhalation hazard not considered in establishing ventilation rates	• DOE-HDBK-1169-2003, Section 2.2.9. • Section 2.2.9 Confinement Selection Methodology - "Workroom ventilation rates are based primarily on cooling requirements, the potential combustion hazard, and the potential inhalation hazard of substances that are present in or could be released to the workroom". - "Concentration of the radioactive gases and aerosols on the air of occupied and occasionally occupied areas should not exceed the derived air concentrations (DAC) established for occupationally exposed person under normal or abnormal operating conditions". • Review of the LAW facility design indicates that the ventilation rates were considered based on cooling requirement only. The WTP CLASSIFICATION OF AREAS report states that it does not reflect accident conditions (page 4) and does not establish limits on a derived air concentration (DAC) for normal and abnormal conditions that should not be exceeded.	Without knowing potential combustion and inhalation hazard of present substances for normal and abnormal operating conditions the whole confinement strategy considered vulnerable.	Evaluate the potential of combustion hazard, and the potential inhalation hazard of substances that are present in or could be released to the workroom (DAC, Hydrogen, CO_2, NO_x.).
HVAC-12-2	No HEPA filters on C5V exhaust duct inlet	If a high airborne contamination level is present in processes it does have a potential to build up within the duct. Typically, highly contaminated areas like glove boxes, canyons or cells must have localized HEPA filtration in conjunction with 2,500 fpm velocity to reduce buildup of molecules within HVAC	Settling of hazardous particulates in the ductwork can lead to unnecessary exposure to workers and potentially require cleaning of the ductwork during the operating life of the facility.	Provide "Out-bleed" HEPA filtration for the primary confinement areas. Increase velocity in the exhaust ductwork

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		ducts. In the LAW facility C5V exhaust duct (out of the Pour cave) is routed through the C3 and C2 before it reaches HEPA filters.		
HVAC-12-5	Some areas in the LAW facility have been labeled as C2/C3 and as C3/C5 resulting in inconsistent application of design values	Typical ventilation design establishes a zone depression depending on the level of contamination within the air space. Areas of higher potential contamination are given a more negative depression to ensure airflow is from areas of less contamination to areas of greater contamination. Dual labeling of areas has resulted in inconsistent application of depression values and has also made it difficult to apply the correct flow rate through open doors, as described in vulnerability HVAC-12-4 and HVAC-31-6.	Low velocities across zone boundaries reducing the protection against contamination migration.	Establish ventilation zones in a three-tiered manner in conjunction with single zoning where each zone is based on the worst case scenario
HVAC-12-6	Potential for flow from C3 to C2 areas upon loss of power	• There are multiple C3 areas exhausted by C3V fans bordering with C2 areas exhausted by C5V fans. • If the C2V and C3V exhaust fans shut down due to the loss of power, it is possible that C3 air migrates to C2 zone exhausted by C5V fans.	C3 to C2 backflow.	Develop a computer simulation (model) of the LAW facility HVAC system to evaluate the safety and operability of the system. Computer simulation should evaluate the facility HVAC systems ability to accommodate dynamic operations (e.g., personnel access, routing of waste canisters and drums), failure of equipment (e.g., supply and exhaust fans), and safety requirements (e.g., hydrogen mitigation, heat removal and confinement).
HVAC-12-7	C5 exhaust fans/motors could be undersized based on collective vulnerabilities.	• Pre-Filter stage is missing on HEPA filters housings. To resolve this issue an extra 1.5-2 inches w.g. of pressure will be added to the existing exhaust system to overcome resistance. • Low duct air velocities will result in deposition of radionuclides in the ductwork. Increasing velocity in the exhaust duct could increase duct pressure up to 0.5-0.75 inches w.g. per (or 0.2 inches w.g. per 100 ft of duct). • No HEPA filters on C5V exhaust duct may result in high contamination and dose build up in ducts and HEPA filters. Placing nuclear grade HEPA filters would add an extra 3-4 inches w.g. of resistance to the C5V exhaust fans/motors. • C5V exhaust fans are not sized based on the latest calculated exhaust temperatures at the exit of Pour Caves. C5V exhaust fans sized based on the 150^0 F temperature using air density correction factor for that temperature. Temperature increase in the	Collectively, in worst case scenario, all of those vulnerabilities have a significant potential to affect C5V exhaust fans size (approximately by 6-8 inches w.g. of extra resistance). If so, new fans will be needed.	Evaluate all aspects affecting C5V exhaust fans size and capabilities.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		processes (above expected) affects density correction factor and respectively C5V fans size. • Individually, each of this vulnerability has a potential to impact size of C5V exhaust fans.		
HVAC-21-1	Installed inbleed configurations cannot be verified to match pressure drop calculations	The formulas and calculations used in the analysis are imbedded in an Excel spread sheet. Other than the basic methodology, the calculations could not be verified. Also, there are no dimensional drawings describing each Inbleed that was analyzed in the calculations. Since the Inbleeds are the main supply for the C5V ventilation system, the correct geometry is critical for the design air flow rate and pressure drop. The information flow down of the Inbleed design to the sheet metal contractor and the acceptance of the installed Inbleed was not available. The “as-built” design drawings should be verified against the original design and any changes need to be reanalyzed to verify that the installed Inbleeds will perform as designed.	• Reduced airflow in C5 areas. • Inability to balance ventilation zones. • Insufficient airflow for cooling load.	Compare “as built” Inbleed design to the original “as calculated design” and evaluate any changes that may affect performance.
HVAC-21-2 HVAC-21-4 HVAC-21-6	Flow through inbleeds will decrease as inbleed filters load	Zone C5 ventilation flow rate is controlled by the pressure in the transfer tunnel. As the filters load on the inbleeds that cascade to the transfer tunnel, the pressure in the transfer tunnel will be more negative. The fan speed controllers will adjust to maintain the pressure at the predetermined set point. Continual loading of the filters has the potential to significantly reduce the C5 flow rate, which will impact cooling and may affect confinement. The inbleed filter loading is monitored by a differential pressure gauge across the filter. However, this may not be an effective method if there is a low pressure drop across the other components in the inbleed air stream. The flow is measured by a single hot wire anemometer, which will also require some adjusting and tuning to get a representative flow rate. Maintaining consistent flow through the inbleeds will be difficult with the local instrumentation.	• Inadequate flow to maintain confinement. • Reduced overall building cooling. • Labor intensive work to maintain flow through Inbleeds by adjusting dampers and changing filters. • Difficult to troubleshoot control issues.	• Install an automatic damper on the Inbleed to control filter loading by measuring air flow rate through the Inbleed allowing the damper to open as the filter loads increase until the damper is wide open or install fan powered supply on the Inbleed or replace filter with electrostatic precipitator (ESP). • Change C5 exhaust control from zone depression to zone flow
HVAC-21-3	Fire damper inspection and maintenance will result in bypassing the inbleed and may result in surges in C5 flow	The access door for inspecting the fire damper is located downstream of the inbleed filters, cooling coil, manual damper, etc. Opening the inspection door will bypass the Inbleed internal pressure drops allowing the air flow rate to increase substantially. For example Inbleed L-008 operating normally at 2200 cfm, the air flow rate through the inspection door could increase to greater than 4100 cfm.	• Opening the inspection door will increase C5V flow, which will impact the differential pressure. • Unable to inspect fire damper.	• Install “windows” on access doors for visual inspections. • Enlarge access doors to facilitate fire damper maintenance.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-21-5	Inbleed filter loading affects HEPA filter differential pressure making it difficult to monitor HEPA filter loading	As the Inbleed filters load, the C5 depression will increase. Once the C5 differential pressure exceeds the set point the control system will decrease the C5 depression by reducing the speed of the C5V fan, which decreases the airflow rate through the primary and secondary filters. This will cause the HEPA filter differential pressure to drop. The opposite occurs when the Inbleed filters are changed and the air flow rate through the Inbleeds increases. In this case, the C5V exhaust fan speed is increased and the primary and secondary HEPA filters pressure increases as the C5 differential pressure returns to the set point. This will make it difficult to determine the actual C5V HEPA filter loading.	Inaccurate assessment of HEPA filter loading.	Modify Inbleed for automatic damper control, supply fan to eliminate the effect of filter loading or replace the filter with an electrostatic precipitator (ESP).
HVAC-21-8	The INBLEED pressure drop calculation did not include dirty filter loading and additional sub-change damper DP	The INBLEED's are designed based on their required air flow rate. The pressure drop through each INBLEED was calculated with a wide open damper and a clean filter. The pressure drop for a dirty filter is 0.5" W.G. per the filter manufacturer submittal 24590-LAW-MKD-C5V-00020, Upstream Filtration for C5V-CCL-00049 at INBLD-L020. The pressure drop from Zone 2 to Zone 3 through a sub-change damper was also not included in the calculation. Based on this differential pressure (outlet-inlet) as shown on the VFDs, the INBLEED filter loading capacity is marginal and many filters cannot be fully utilized.	• Excessive change out frequency needed maintain INBLEED air flow rate. • Limits increasing the C5V depression if needed to balance differential pressures during start up.	Consider alternate means of filtration such as ESPs or roll filters to minimize pressure drop through INBLEEDS.
HVAC-23-1	Strength of walls for L-0305 room may not be adequate for high differential pressure created when opening plenum doors to C2V supply air handlers while the supply fans are operating	• The C2V supply air handlers are located in a closed room (L-0305). The room is a C2 ventilation area balanced to -0.1 inches w.g. (Zone 2) based on a review of calculations, the walls were sized to withstand a differential pressure of 2 inches w.g. creating 10.4 psf loading pressure on the wall. With plenum doors open the fans have the capacity to lower the room depression to -10 inches w.g. creating a ~52 psf loading pressure on the wall. Opening doors while performing inspections, maintenance or trouble shooting is sometimes required when the system is operating. • Room is exhausted by the C3V exhaust. A high differential pressure in the room will also cause a flow reversal where the C3V exhaust will be drawn back into the C2 Zone. • Opening the doors to corridor prior to opening the C2V plenum doors in order to minimize the large differential pressure in the room will exacerbate	• Catastrophic failure of room walls. • Cross contamination. • Life safety code issues for egress through doors.	• Strengthen room walls meet increased differential pressure requirements. • Install relief dampers to connect to outside atmosphere.

Table B-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (17 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		the problem. When doors are open, the air will short circuit within the fan causing a shortage of air flow to the rest of the building. Control system shut down of the ventilation will result.		
HVAC-25-3	Zone pressure controls for cascading zone will be unstable	Control for C2V Supply fans and C2V, C3V and C5V exhaust fans relies on ASDs to control fan speed, which controls pressures within these spaces. Changes in the differential pressures of each air space will affect the other airspaces because of the cascading flows. Any one of the exhaust fans or the supply fans can adjust during one condition while the other fans could adjust for another condition. This could result in unstable ventilation control system operation.	• Continuously varying air flow rates supplying C2 areas and exhausting the C3 and C5 areas • Large variations in C2V and C3V exhaust stack air flow rate.	• Revisit control strategy by utilizing branch dampers to provide pressure control for C2, C3 and C5 areas. • Modify INBLEED s for automatic control for filter loading replacing the pressure gauges.
HVAC-25-4	LAW C2V Supply System Pressure Drop calculation error	LAW C2V Supply System Pressure Drop calculation failed to include additional pressure drop of 1.5 inches w.g. for additional bank of pre filters.	The supply fans may be under sized and will not supply the air flow rate required.	Revise the pressure drop calculation for additional filter differential pressure for the supply fans.
HVAC-31-10	Opening of door L-0106-2 between subchange L-0106 and buffer crane maintenance area in L-0110 was not considered in subchange operation	When subchange L-0106 is used to access the buffer crane maintenance platform in L-0110, airflow will be diverted from the effluent cell (L-0126) to the buffer crane maintenance room. This is a redirection of airflow into the transfer tunnel, which is where the C5 zone pressure is measured. This will have an impact on the C5 ventilation, which has not been evaluated as part of the design.	Upset ventilation conditions due to airflow diverted from the effluent cell to the transfer tunnel and pour caves when accessing the buffer crane maintenance cell (L-0110) through subchange L-0106.	Develop a model to evaluate the impact of facility operations, such as accessing the buffer crane maintenance through subchange L-0106, on the ventilation system.
HVAC-31-7	Inbleeds don't function during entries	Cooling in cell areas is provided by the inbleeds. During entries airflow bypasses inbleeds and passes directly through the open cell door. Depending on the length of the entry and the amount of cooling by the inbleed, the cell area could become warm without the cooling provided by the inbleed.	• Cell area where entry is taking place could become warm resulting in worker discomfort and fatigue. • Limited cell entry time because of warm work conditions.	Convert subchanges to airlocks where the inbleed is located between the corridor and cell entry room. This would allow the inbleed to function continuously.
HVAC-34-1	Lack of airlocks between rooms of different differential pressures may result in ventilation upsets	Some rooms in the facility that will likely be accessed on a regular basis are adjacent to corridors with C2 depression sensors. These rooms either have more negative depressions than the corridor by design or have the potential to have a different depression when other doors in the room are open. When doors are opened to access these rooms, the pressure in the corridor will be impacted. This will cause the ventilation controller to fluctuate, leading to potential ventilation system upsets.	Ventilation system upset resulting in a potential lack of confinement in some areas.	• Add an airlock for accessing rooms LCB004 and L B009. • Add an airlock for accessing rooms L-0117 from LC0109 and L-0119 from LC0111.
HVAC-35-1	Lack of redundancy of C2V exhaust fans	The LAW HVAC system has only two C2V exhaust fans and both have to be running for normal operation. There is no backup fan and a single fan is not large enough to provide adequate airflow for normal	Failure, or even the planned outage, of a single C2V exhaust fan will require production be stopped until the fan is restored.	• Provide a calculation demonstrating the facility can continue in normal operation

Table B-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (17 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		operation. These fans will require regular maintenance. While running a single fan is not a safety hazard, it does require the facility operation to be stopped since the overall ventilation flow is reduced. A single fan is sufficient to maintain adequate zone depression, but it is not sufficient for facility operation.		with a single operating C2V exhaust fan. • Install larger fans that have the capacity to provide full C2V exhaust flow with a single fan operating. • Install a backup fan. • Construct some sort of protection over the fans to prolong the operating life of the fans and motors.
HVAC-35-3	Lack of pre-filters to protect HEPA filters	It is anticipated that Zone C2 will have dust issues since it is the closest zone to the building exterior and is the most frequently occupied zone with doors opening and closing regularly. As exhaust air is drawn into the C2 exhaust, dust particles will be drawn in as well. There does not appear to be any type of pre-filter in the C2 exhaust airstream to filter out any of the dust and dirt particles that would shorten the life of the HEPA filters.	Frequent loading and changing of C2 HEPA filters.	• Provide an evaluation to demonstrate why pre-filters are not necessary in the C2V exhaust airstream. • Modify the C2V exhaust system design to include pre-filters.
HVAC-41-1	Lack of Deluge Spray System to protect the C5V HEPA from soot loading	Per DOE-STD-1066-2012 Fire Protection Standard, a deluge system is required upstream of the HEPA filters to delay the soot loading of HEPA filters during a fire event. BNI presented the use of a fire suppression system as an alternative approach for PT and HLW and were directed by DOE to implement the alternate approach. BNI carried the alternative approach over to LAW, which does not have fire suppression and soot mitigation systems that are identical to PT and HLW.	Possible rupture of C5V HEPA filters due to fire event and release of radioactive materials to ambient exposing them to public. (Low Dose)	• Investigate if deluge spray system can be added to the current design if the HEPA Filter housings. • Investigate if the current Fire Suppression System reliability can be improved.
HVAC-41-2	Lack of smoke dampers on inbleeds to protect C5V HEPA filters from soot loading	BNI's alternative approach to mitigation of fire consequences assumed that the majority of the smoke stays in the C3 areas and the propagation to C5 area is stopped via smoke dampers in the inbleed. While this is true for HLW and possibly PT, it is not true for LAW. The LAW facility does not have smoke dampers in the inbleeds between the C3 and C5 areas.	C5V HEPA will not be protected against fire soot effluents thereby exposing the HEPA directly to soot in the event of fire.	To make the design consistent with the PT and HLW, add smoke dampers and associated controls for the LAW in-bleed assemblies.
HVAC-43-1	Ventilation System Evaluation not performed per the DOE Implementation Plan of DNFSB 2004-2 Recommendation	When the DNFSB 2004-2 recommendation was implemented, LAW was a Category 3 facility and no evaluation was required. It has since been modified to a Category 2 Facility. All Category 2 facilities with active confinement ventilation systems require and evaluation per the DOE implementation plan of DNFSB recommendation 2004-2.	DOE non-compliance may result in performing the needed evaluation at a later date, which may require redesign of certain gap related issues.	• Recommend that the 2004-2 evaluation be performed for the LAW facility. • Based on the new 2004-2 evaluation reconcile any gaps which are identified.

Table B-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (17 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-44-1	Inadequate Buffer Storage and Canister Rework area cooling capacity for anticipated heat loads	The calculations show that the purchased fan coil units do not provide adequate cooling to offset the heat loads in the Buffer Storage Area and Canister Rework Area.	• Buffer Storage Area and Container Rework Area temperatures exceed the bulk area design temperature of 113^0 F. • Pour Cave C5V exhaust air temperature will be higher than the CFD analysis calculated figures in normal operation due rise in supply air temperature to the Pour Cave cascaded from the Container Transfer Corridor. • The C5V exhaust fan flow margin will be reduced.	• Evaluate if the purchased FCUs can be modified to make up for the shortage of cooling capacity. This option will add to the current power requirement including replacing the current motor. This change will also increase the chilled water flow to the balance of plant, thereby impacting the pumps and chiller capacity. • Redesign and replace existing FCUs will be necessary if modifications to purchased FCUs is not achievable. This option will require motors larger than the current 50 HP and 25 HP respectively. This change will also increase the chilled water flow to the balance of plant, thereby impacting the pumps and chiller capacity.
HVAC-47-1 HVAC-47-2	Lack of standby fan coil units in C2 and C3 airspaces	Some C2 and C3 spaces do not have standby fan coil units (FCUs). These are commercial grade units with no backup or standby units. When these units fail, the air temperature in spaces cooled by the FCUs will increase. Some of these are critical areas, such as exhaust fan and HEPA filter rooms.	Elevated temperatures will prevail in the space upon failure of the FCU (greater than 80°F in C2 and greater than 95°F in C3) and will impact maintenance operation.	• A 100% standby FCU is recommended for L0121 C2V Filter Room, L0317- C3V Fan Room, L0319A- C3V Filter Room, LB029-C5V Filter Room and LB028-C5V Fan Room, but if it is not feasible then a high temperature alarm in the space to alert the maintenance staff for repairing the failed FCU in a timely manner. • Evaluate the possibility of increasing the cascade airflow coming into spaces to offset heat loads during failure of the FCU. • Investigation and validation is required to ensure that ASTM requirements are complied with for all exhaust system which may be exposed to temperatures higher than 140^0 F. External surface of Exhaust System components will be provided with adequate insulation to

Table B-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (17 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				protect the workers from contact with hot surface
HVAC-51-2	C5V design may result in non-uniform loading of the multiple filter banks	The supply and exhaust ducting to the C5V filter housings creates unbalanced air flows to the 10 banks of first and second stage HEPA Filters.	Potential to exceed rated flow if filters do not load evenly or during filter replacement when the standby housing is placed into operation.	Evaluate opportunities to install balancing dampers on the C5V exhaust.
HVAC-51-3	Contamination traps in HEPA filter housings	The design of the C5V Flanders HEPA Filter housing creates a trap in the bottom of the housing where contamination can accumulate	• Radiation levels can increase over time and replacement of HEPA filters will not remove this contamination trap. • Vacuum cleaning or flushing of the filter housing may be required to remove the contamination.	Evaluate modifications that can be made to the filter housing to prevent build-up of contamination or cleaning the housing inner floor
HVAC-51-4	C5V design does not include the ability to balance air flow through filter housing	Design includes isolation dampers but not dampers to balance airflow to the HEPA filters.	Potential to exceed rated flow if filters do not load evenly or during filter replacement when the standby housing is placed into operation.	• Develop technical justification to confirm that the HEPA filter rated flow will not be exceeded during all operation and maintenance modes. • Install balancing dampers. • HVAC Operating procedures will be prepared to monitor HEPA filter DPs and adjust damper positions periodically to balance air flows and pressure drops.
HVAC-52-1	Radiation Source Term values are inconsistent and may require additional evaluation	• LAW Facility Shielding Confirmation Table 7-1 states that the worst case LAW glass unshielded dose rate at 12-inches is 1135 mrem/hour. • Table 2-3 provides a scaled source term on a C5 HEPA Filter resulting in a 2.5 mrem/hour dose rate at 12-inches. • Radiation Safety has stated that the maximum glass canister dose rate is expected to be less than 15 mrem/hour.	• Increased exposure and dose rates for personnel changing HEPA filters and performing maintenance on ventilation equipment. • More frequent changing of HEPA filters due to dose rate.	Perform radiation dose rate calculations for expected normal operating conditions and upset conditions. Evaluate installing HEPA filters on the C5V ducting where the air from the process cell enters the C5 ducting.
HVAC-52-2 HVAC-52-3	C5V HEPA Filter Radiation Source Term and filter operating parameters are not integrated for LAW operation	Replacement strategy for the C5V ventilation system Radial HEPA filters based on radiation dose rates, pressure drop, air flow, shelf storage life, operational life, and filter efficiency needs to be evaluated and documented for LAW facility. Radiation dose rate may be high enough that shielding is required on filter housings.	• ALARA. Personnel radiation exposures are increased due to elevated dose rates and more frequent HEPA Filter replacements. • Personnel radiation exposures are increased due to elevated dose rates. • Limited facility operations due to increased dose rates.	C5V HEPA Filter operating and replacement strategy needs to be developed for LAW Operation

Table B-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (17 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-52-4	Lack of HEPA filter replacement strategy for LAW commissioning	A comprehensive plan for HEPA filter replacement has not been developed. Three distinct phases need to be considered with potential replacement of filters at each phase: 1. Installation of filters to remove duct work debris and dirt from C2V, C3V and C5V ventilation ducting that could damage HVAC components or create flow imbalance or contamination traps prior to flow testing 2. Installation of clean HEPA filters to perform ventilation air flow balancing 3. Installation of installing clean HEPA filters prior to hot startup.	HVAC flow balancing can be compromised and testing can be delayed.	C5V HEPA Filter replacement strategy needs to be developed for LAW commissioning and startup. Ducting needs to be inspected for debris removal before startup testing is performed.
HVAC-03-2	Temperature Controller does not meet +/-3°F control tolerance required by System Description	Schneider Electric Series TC-4211 Cooling Temperature Controller will not control to the requirements in the System Description (+/- 3°F). No evidence of temperature control testing during Commercial Grade Dedication process.	Temperature control will not meet requirements in the System Description.	Evaluate the design requirements to determine if a broader range of control is acceptable.
HVAC-21-7	Inbleed back draft dampers cannot be checked for leakage	There is no provision to test back draft dampers for leakage making it difficult to ensure confinement is maintained upon loss of ventilation.	Backflow from C5 to C2 and C3 areas upon loss of ventilation.	Redesign Inbleed to facilitate back draft damper testing.
HVAC-22-1 HVAC-22-2	C5V fan motor, bearings, and adjustable speed drive may exceed rated temperatures	It is anticipated that the C5V exhaust air stream temperature will exceed 150^0 F. When the air stream reaches this temperature, high heat loads will be transferred into the room through the duct and the fan housing. While the duct and fan housings are insulated and the room does have fan coil units that are supposed to maintain temperatures at or below 95^0 F, there is the potential that room temperatures will exceed the 104°F rating typical of most adjustable speed drives (ASD) or exceeds the recommended operating conditions of the exhaust fan motor and fan bearing grease. It does not appear these conditions have been evaluated as part of the design.	• Loss of C5 ventilation. • Reduced life of fan motor, fan bearings, and/or adjustable speed drive.	• Evaluate temperatures and heat transfer effect on fan motor, fan bearings and ASD. • Move ASDs to corridor and away from heat sources. • Provide supplemental cooling to the ASD's and fan motors. • Convert fan bearing lubricant from grease to oil.
HVAC-23-2	Lack of filters in the C2V bypass duct	If off-site power is lost, all ventilation fans shut down except C5V exhaust. An outside air bypass duct with a separate intake louver and backdraft damper connects to the supply header to provide makeup air for C5V exhaust in the event of loss of off-site power. This air is not filtered.	High dust loading of Inbleed filters due to dust storms and smoke from range fires during a loss of loss of off-site power occurrence.	Install means of filtration for bypass duct such as an ESP.
HVAC-42-2	C5V duct and equipment burn hazards	C5V airstream temperatures may exceed 140°F. Exposed duct, filter housings, fans, and other ventilation related equipment may reach temperatures high enough to burn maintenance and operating personnel on contact.	Burn hazard to maintenance and operating personnel.	• Investigation and validation is required to ensure that ASTM requirements are complied with for all ventilation system which

Table B-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (17 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				may be exposed to temperatures higher than 140^0 F. • External surface will be provided with adequate insulation to protect the workers from contact with hot surfaces, where applicable.
HVAC-44-3	Contamination trap in buffer storage cooling ductwork section	The ductwork between Container Transfer Corridor and the inlet to HEPA Housings for the Buffer Storage is unprotected without inlet filter at the entrance. Contamination from the Transfer Corridor could be trapped in this section of duct and could be difficult to remove.	• HEPA Housing may have accumulation of radiological contamination at the base of the units. • Periodic sampling of duct contamination will be required.	Redesign the ducting arrangement for the Buffer Storage Area FCU to avoid accumulation of radiological contamination.
HVAC-49-1	Code Compliance Matrix did not include Safety Significant Direct Expansion Air Conditioning Units used for the E & I Rooms & Secondary Off-gas Room	Per System Description the Direct expansion Air Conditioning Units utilized for E & I Room and Secondary Off-Gas Room cooling. The safety function of the equipment is to supply filtered and conditioned air to the SS spaces under normal and off-normal condition.	The components design, construction, testing or operation of DX Air Conditioning Units is not approved and if carried out, may not meet the WAC control technology code requirements.	Revise the current Code Compliance Matrix to include SS Air Conditioning Units and their compliance in a timely manner for WDOH approval.

Table B-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
ROR-ELEC-1: Vulnerability #4, #5, and #6	The ITS UPS units: # UPE-UPS-20301, -20302, and -20303 are undersized for design demand load.	• Calculation 24590-LAW-E1C-UPE-0002, Safety System – Uninterruptible Power Supply Sizing, which was used to size the ITS UPS units, identifies motors for off gas system fans (which are connected to the output of the UPS unit) as having 150hp ratings. Walk-down of these systems revealed that these fans are actually 200hp motors. The review team performed a summation of loading identified in drawings, 24590-LAW-E1-UPE-00003, -00004, and -00005(LAW Vitrification Buildings SS UPS UPE-UPS [20304, 20305, and 20306], Single Line Diagrams), and found that UPS loading now exceeds the rating of the UPS units. • This issue was previously self-identified by BNI, and BNI has issued a white paper recommending replacement of existing 200kVA UPS units with 400kVA UPS units to resolve the issue.	200 kVA ITS UPSs are unable to support Safety Significant loads in the event of loss of offsite power (LOOP).	The Review Team recommends performing the upgrade on ITS UPS units (200 kVA UPS units upgraded to 400 kVA UPS units), as identified in the Bechtel white paper. UPS feeders should be included in the replacement. WTP Electrical Engineering should evaluate feeding both UPS mains and UPS bypass inputs from the same load group to allow additional reductions in the load calculation permitted for "non-coincidental loads". WTP Electrical Engineering should also evaluate replacement of the downstream distribution panel UPE-PNL-20301 along with its panel feeders, which will likely be undersized for the UPS output breaker which protects them once the 400 kVA UPS units are installed.
ROR-ELEC-1: Vulnerability #8, #9, # 18	• UPS battery banks: # UPE-BATT-20301 and -20302 are undersized in the capacity needed to provide the required UPS run time required by the design load profile during a loss of offsite power DBE. • Additionally All ITS UPS battery banks: # UPE-BATT-20301, -20302, and -20303 have not been sized to provide the full UPS rated output for the required run time as directed by 24590-WTP-DB-ENG-01-001 Section 8.4.11. • This issue is compounded as it appears the equipment rooms in which the batteries are to be installed are too small to accept the number of batteries needed, when using the batteries identified in the drawings.	• Although final procurement of ITS UPS batteries UPE-BATT-20301, -20302, and -20303 have not yet been completed, it appears that the space available within the LAW facility is insufficient for installation of battery banks (when using the battery model number shown in drawings) with the capacity required to support the design requirements (either UPS rated load, or design profile load) for 2 hours as required by the BOD for a loss of power Design Basis Event (DBE). • Note: this issue will be compounded if the UPS units are upgraded from 200 kVA units to 400kVA units as proposed in the BNI white paper, as battery capacity and battery physical size, will need to greatly increase to meet the requirements of 24590-WTP-DB-ENG-01-001 Section 8.4.11.	UPS will be unable to support Safety Significant loads for length of time required in the design criteria in the event of a LOOP DBE.	• The Review Team recommends that WTP project perform battery run/capacity calculations for ITS UPS batteries to ensure batteries proposed by the UPS vendor have the capacity to meet the run time requirements for safe system shutdown during a LOOP DBE. • Note: As stated in the basis column, this issue will be compounded if the UPS units are upgraded from 200 kVA units to 400kVA units as proposed in the BNI white paper, as battery capacity, and battery physical size will need to greatly increase to meet the UPS full rated output run time requirements from 24590-WTP-DB-ENG-01-001 Section 8.4.11.

Table B-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
ROR-ELEC-1: Vulnerability #16, and ROR-ELEC-4 Vulnerability #8 and #9	Main LAW facility 13.8kV - 480V service transformers: MVE-XFMR-20603, -20604, and -20606 are undersized for existing design load	The design loads of 3682 Amps, 3645 Amps, and 3852 Amps respectively, calculated in accordance with NFPA 70 2014, National Electric Code, Article 220, "Branch Circuit and Feeder Calculations", exceed each transformer's capacity of 3609 Amps.	This configuration may result in transformer overheating and failure in peak demand situations.	The design team recommends that BNI consider feeding facility UPS Unit Mains, and Bypass Inputs from the same load group which will allow BNI to take a reduction in design loading calculations for non-coincidental loads. This, along with some minor load management, may reduce design loads below the transformer ratings; however, the concern over lack of spare facility electrical capacity identified in the previous vulnerability entry will still exist. Also it should be noted that if the ITS UPS units are upgraded from 200kVA to 400kVA as proposed, the transformer loading would once again be higher than the transformer ratings, and would not be correctable by UPS input changes or simple load management.
ROR-ELEC-2: Vulnerability #1	Elevated ambient temperatures negatively impact electrical equipment operation.	Ambient temperatures in C5 Areas, and areas around the melter galleries, are identified as having anticipated temperatures of 113˚F and 95˚F respectively. However; the Basis of Design (BOD) Table 12-1 states "The indicated summer maximum temperature does not apply to process areas where high radiation heat transfer loads, high container temperatures, or high canister temperatures make it impractical to attain this temperature". The LAW facility electrical equipment designs seem to be based predominately upon the ambient temperatures identified in the 12-1 table or the Electrical Design Criteria document 24590-WTP-DC-E-01-001, and don't take into account potentially higher ambient temperatures and radiant canister temperatures. .	Conductors and equipment operated at temperatures higher than those identified in the BOD would require additional de-rating to prevent conductor overheating and failure.	The electrical review team recommends that the BNI Electrical Engineering design group re-evaluate the ambient and radiant temperatures anticipated in these areas and ensure equipment is properly rated, or ensure supplemental cooling and/or insulation is added for the equipment as required.
ROR-ELEC-2: Vulnerability #2	Melter Electrode Bus Electrical Ratings may not be adequate for the expected melter loads when operated at potential temperatures in the melter gallery.	The electrode bus voltage ratings appear adequate (1000 V rated vs 321 V actual); however, the amperage rating of the bus in the melter base appears marginal, due to forecast margin, unbalance, and the higher ambient temperature issue raised in ROR-ELEC-2 Vulnerability #1. The design margin for amperage on the electrode bus is only 6.8%, this design margin can quickly erode if higher equipment, canister, or container temperatures raise the surrounding area above the 104°F design basis temperature of the melter bus.	The external bus in the vicinity of the melter (specifically the south center electrode bus within the base of the melter) may fail to carry melter maximum current.	Re-evaluate bus amperage rating for identified high risk areas. Provide supplemental cooling if justified.

Table B-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
ROR-ELEC-2: Vulnerability #4	No evidence of final NRTL listing and labeling exists for the melters.	A UL field evaluation of the melters is in process and identifies numerous deficiencies. The design team recommends that DOE continue to track the field evaluation of this equipment to completion, in order to ensure any discrepancies identified in the field evaluation are adequately addressed and that NRTL product listings are obtained.	Electrical Safety for personnel and equipment reliability may be compromised	Obtain final NRTL Field Evaluation product mark or procure equipment with the NRTL listing and labeling.
ROR-ELEC-3: Vulnerability #1	No spare melter power supply capacity.	The melter power supplies MVE-PSUP-20001 and -20002 do not have installed spare capacity to carry the production current load in the event of component failure or routine maintenance.	Melter power supply capacity will be limited below the production load during equipment failure and maintenance. This configuration impacts facility throughput in the cases of input transformer or inverter failures and maintenance.	The review team recommends BNI install output inverter and transformer units in each of the spare compartments of each power supply's lineups.
ROR-ELEC-3: Vulnerability #2	Melter power supply component isolation is inadequate.	Within the melter power supply cabinets for power supplies MVE-PSUP-20001 and -20002, the three 13.8 kV incoming isolation disconnects (S1, S2, S3) are all located in the same compartment. The output isolation switch is also located in the same compartment with other equipment and all will require maintenance. The load lugs on the output isolation switch cannot be de-energized, therefore it is not possible to isolate this cabinet for maintenance activities. Additionally there appears to be inadequate space for safe worker access.	Complete shutdown of melter power supply will be required for any maintenance activity requiring internal access of the melter power supply line ups	The review team recommends that BNI evaluate the worker safety requirements for these areas and develop barriers, procedures, or alternate isolation points.
ROR-ELEC-3: Vulnerability #4	No evidence of final NRTL listing and labeling exists for the melter power supplies MVE-PSUP-20001 and -20002.	A UL field evaluation of the melter power supplies is in process, but has identified numerous deficiencies in the supplies that still need to be addressed. The design team recommends that DOE continue to track the field evaluation of this equipment to completion, in order to ensure any discrepancies identified in the field evaluation are adequately addressed and that NRTL product listings are obtained.	Electrical Safety for personnel and equipment reliability may be compromised	Obtain final NRTL Field Evaluation product mark or procure equipment with the NRTL listing and labeling.
ROR-ELEC-3: Vulnerability #5	No Melter Standby Power provided.	Standby power for melter heating was removed based on a power reliability, and cost, evaluation. As a result of the evaluation a Trend Notice was issued that justified removing two standby diesel generators siting a cost savings of $1.9 million vs the 80% likely risk (over the 40 year life of the facility) of melter property losses of $27 million, plus $14 million per month of production losses while the melter is being replaced. With estimated replacement times of 2-5 years per melter, the total anticipated losses would be $363 million to $867 million depending on melter replacement duration. Currently replacement	Permanent Melter failures may occur, if utility power is lost for 3-6 hours during the melter 40 year life.	The review team recommends BNI, or DOE, perform another evaluation to determine if potential cost savings still outweigh potential costs of equipment and production losses. Should BNI and DOE decide to provide back-up power to the melters, switchgear MVE-SWGR-20603 and -20604 each have an available "equipped space" to which a standby diesel generator can be connected and configured to back feed the switchgear bus and provide backup support to both melter power supplies. Connection of a generator at either of the available "equipped spaces" would preclude the use of those spaces to feed a third melter power supply,

Table B-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		costs of the melters are projected to be substantially higher than previously estimated in the trend notice		however, the limited capacity of the LOP/LVP system in the LAW facility already makes connection of a third melter implausible without expanding the facility.
ROR-ELEC-4: Vulnerability #1	Low Voltage Release	Switchgear MVE-SWGR-87002A/B main breakers and the feeder breakers for LVE-MCC-20001, -20101, -20103, -20002, -20104, -20102, and -20204 (fed from switchboards LVE-SWBD-20101, and -20102) are equipped with low voltage release mechanisms which open the feeder breakers upon Loss Of Offsite Power(LOOP) shedding non critical loads that do not require back up power support from the standby diesel generator (SDG). Once the breakers open they require manual manipulation by electricians to initiate re-closure. This process can take a significant amount of time as it may require paperwork approval, travel time to the switchboard room, donning of Arc Flash PPE, and establishing breaker line up and sequencing to ensure loads are re-instated in the proper order. During this time a large percentage of the facility electrical loads will be without electrical power, including some facility process and cooling systems. The low voltage release mechanisms do not have an adjustable time delay, and will operate in any low voltage situation including brown outs and/or sags on the electrical grid.	This configuration may result in unanticipated interruptions to facility throughput as facility loads are shed following a brown out or voltage sag on the electrical grid or LAW electrical distribution system	Evaluate the addition of time delay circuits to the low voltage release mechanisms to permit the electrical system to ride through electrical grid sags and brownouts.
ROR-ELEC-1: Vulnerability #1	AHJ and NEC inspection Role performed by BNI Design Project personnel	The AHJ and code inspection at the WTP project is performed by employees of the project, which is not conducive to non-biased regulation.	Inspections and regulation determinations may be less stringent which could compromise the electrical system design and installation.	The review team feels that an independent AHJ and inspection program should be considered by DOE.
ROR-ELEC-1: Vulnerability #2	Lack of Conduit Schedules and Wire Run drawings	There are no conduit schedules or wire run lists in the LAW facility drawing sets; instead the WTP project uses a proprietary program called SetRoute to maintain configuration control and conduit runs and wiring information. This software is a wonderful tool for construction however, at the end of construction the project will turn over a database printout from SetRoute to Operations. This data base printout will be extremely difficult for operations to use in continued configuration management of the facility when performing future modifications.	Conduit run system configuration control will be difficult after turn over without having the SetRoute software	The review teams recommend that DOE attempt to negotiate procurement of the SetRoute software from Bechtel.
ROR-ELEC-1: Vulnerability #10	No post installation service test is planned for ITS UPS system batteries: UPE-BATT-20301, -	Per discussions from the 04/01/14 Electrical Review Team Introductory Meeting (Ref Meeting minutes), the WTP project plans to use	Without testing the UPS and Battery system's ability to support the connected load for the design basis run time, there is no assurance the safety	The Review Team feels it is imperative that a battery service test be performed on all ITS UPS batteries, prior to turn over from construction, to

Table B-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	20302, and -20303 to demonstrate capability of the batteries to provide 2 hours of run time upon LOOP.	manufacturers calculations and factory capacity tests to demonstrate adequacy of battery capacity instead of performing service testing, this method is unacceptable as manufacturer calculations and manufactures factory capacity tests cannot account for battery cells that may have been damaged in shipping and installation. IEEE-1188-2005 Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (Section 6.4) outlines the requirements for performing service tests on batteries.	significant UPS units will be able to perform their function during a LOOP. If batteries are not installed until the Start-up and Commissioning phase and batteries then fail a service test due to inadequate capacity, the project may be faced with a design that does not meet requirements, and a battery location too small to support the needed battery capacity.	ensure batteries were not damaged in shipping or installation.
ROR-ELEC-1: Vulnerability #11 and ROR Vulnerability #12	The feeder conductors for panels UPE-PNL-20301 and -20302 are undersized for the demand load.	NFPA 70, Article 220, "Branch Circuit and Feeder Calculations", and 215-2(a), "Feed Circuits".	Panel feeder conductors are undersized and are not in compliance with the national electrical code.	See OFI on ROR-ELEC-1 Vulnerability #4 and #5 above.
ROR-ELEC-1: Vulnerability #13	UPE-UPS-20301, -20302, and -20303 feeder conductors undersized for UPS full load currents and battery recharge currents.	NFPA 70, Article 215-2 "	Feeder conductor sizing not in compliance with National Electrical Code requirements.	The Review team recommends replacement of the ITS UPS main and bypass feeder conductors with two parallel sets of 500 kcmil conductors as part of the proposed UPS upgrade
ROR-ELEC-1: Vulnerability #14 and ROR-ELEC-4, Vulnerability #7	Very little to no spare capacity provided on Panels: UPE-PNL-20301, -20302, and on Switchboards LVE-SWBD-20101; LVE-SWBD-20102; Switchboard LVE-SWBD-20201; and on LVE-SWBD-20202.	NFPA-70, Article 220	No spare electrical capacity will be available for future process changes and facility modifications	There appears to be no requirement for spare capacity of the electrical system in the LAW facility, and none has been provided. The is not an issue if no changes are needed within the facility to support operations; however the likelihood of no additional loading being needed seems optimistic
ROR-ELEC-1: Vulnerability #15	General Systemization Layout of MCCs.	MCCs fed from switchboards are intelligent MCCs with single controllers that feed multiple systems within the LAW facility. This configuration can result in maintenance activities on one system affecting operations on other systems	This configuration may result in impacts to multiple systems when one system is taken down for maintenance or is modified for changes to the facility processes.	MCC systemization was identified as a concern in CLIN 3.2, RPP-44491, Rev 0, Section 3.8.6 and continues to be a concern for potential operability impacts at the LAW facility. WTP Electrical Engineering Design may evaluate adding additional controllers to the MCCs, or rearrange loads to permit system specific maintenance and control.
ROR-ELEC-1: Vulnerability #17	ITS UPS units not qualified for DBE flood conditions of 0.92 ft. of water.	UPS units are to be qualified for DBE flood conditions of 0.92 feet of water (or 11. 04") The qualification report 24590-QL-POA-EU00-00002-17-00001, Nutherm Qualification Report for Uninterruptible Power Supply (Ups) System for Hanford Site, page 6, states that "the UPS units will be mounted on platforms elevated above the maximum flood height, so flooding is not an event of concern; and, for that reason no flood qualification is performed." The mounting	This configuration may result in electrical bus shorting or UPS electrical component failure in the event of DBE flood conditions.	The review team recommends that the ITS UPS units be qualified for 5.04" flood levels or mounted on pedestals that are 11.04" or greater in height.

Table B-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		details for the platforms on which the UPS units are to be mounted indicate that the platforms are only 6" in height, which makes the top of the platforms 5.04" below than the anticipated flood height		
ROR-ELEC-2: Vulnerability #3	Single phase AC Bus passes thru ferrous metal enclosure, creating magnetic heating.	The single phase Melter AC Bus passes thru a ferrous metal CT support, creating magnetic heating. This configuration may result in heating of metal around a conductor, which results in damage to the conductor. This issue was previously identified during the UL field evaluation.	Heating of metal around a conductor which results in damage to the conductor.	The review team recommends BNI perform a review of all single phase conductors for inappropriately placed magnetic material.
ROR-ELEC-3: Vulnerability #6	Melter Power Supply Grounding.	The method of grounding the power supply output, as required by NEC Article 250-30 Grounding Separately Derived Alternating Current Systems-(b) "Ungrounded Systems", has not been addressed for the Grounding Electrode Conductor. Worker safety and proper equipment operation is dependent on the correctly engineered grounding system being installed. The National Electrical Code (NFPA-70) Article 250 is specific in requiring grounding and bonding of energized and equipment that could become energized. The melter power supply contains an incoming transformer which has an ungrounded 460 volt transformer secondary; this ungrounded voltage is of concern for detecting and isolating faults. The current NRTL Field Evaluation of this equipment should address this specific concern within the power supply enclosure.	Worker Safety and equipment reliability are compromised.	The review team recommends that BNI re-evaluate the supply output to determine if the melter power bus has been provided with an adequate equipment grounding conductor.
ROR-ELEC-4: Vulnerability #3	There is not currently a formal "Code of Record" for the Waste Treatment Plant.	While the electrical review team did not find extensive contradictory code references within the many separate design basis and system description documents, it was often difficult to ascertain which code revision was applicable, as often codes are referenced within documents without mention of the code's revision or issue date.	Without a formal code of record, application of the wrong standard revision is possible and may result in costly re-work at the time of commissioning	The review team feels that BNI should issue a formal code of record that identifies all applicable codes and revisions used in the design of the facility.
ROR-ELEC-4: Vulnerability #6	C5V-FAN-00005A, and C5V-FAN-00005B circuit conductors are not symmetrically shielded type cable, or not installed in metal conduit that is bonded across each joint, in accordance	Per the User Manual for the ABB ACS800 ASD drives feeding these motors [Ref 24590-QL-POA-EV00-0001-01-00004, Installation, Operation and Maintenance Manual for Non-Safety Q Adjustable Speed Drives For C5V-ASD-00001-A/B, page 67(pdf. Page 83)] these ASDs must be used with Symmetrically shielded	C5V fans may not function properly without motor circuits supplied in accordance with manufactures requirements.	The review team recommends replacement of the C5V motor circuit conductors, between the ASD units and the motors, with symmetrically shielded cables, or recommends the addition of bonding jumpers across conduit joints. In general the review team recommends that all larger ASD supplied

Table B-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	with manufacturer's instructions.	motor cable, or must be installed in metal conduit that is bonded across each joint. It appears from the drawings and the SetRoute information provided by WTP Engineering, that these conductors are not Symmetrically shielded cable, and no evidence of bonding across conduit joints was found during system walk downs, therefore the wiring method does not comply with manufactures requirements.		motors in the WTP use symmetrically shielded ASD/VFD cable.
ROR-ELEC-1: Vulnerability #3	General Drawing Discrepancies	This entry is for general drawing discrepancies found by the DOE Electrical Review Team during the LAW Facility review. • Offgas exhauster motors LVP-EXHR-00001A, -00001B, and -00001C are shown as 150hp on drawings, but were observed at 200hp in the field. • UPE-UPS-20301, -20302, and -20303 Bypass Input Source Locations Conflict between One-line Diagrams and MCC schedules [Ref Section 3(f)] • Battery Circuit Breaker is identified in VI info as being a 900A breaker, but is listed on one-line diagrams as an 820A breaker. [Ref Section 4(f)]	Documentation must be accurate to ensure general industrial safety within the facility.	The review team recommends correction of drawing errors.
ROR-ELEC-1: Vulnerability #7	• No Hydrogen monitoring or ventilation calculations available to demonstrate that potential VRLA battery off gassing can be alleviated. • Following the review period, DOE provided the review team with a draft copy of an initial ventilation analysis performed by BNI to address battery hydrogen venting. The draft calculation was rejected by DOE. Follow up analysis is pending.	IEEE-1187, Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications, Section 5.4.2	VRLA off gassing during recharge could generate enough hydrogen to create a fire hazard.	The design review team recommends finalizing hydrogen ventilation calculations to ensure VRLA potential off gassing is alleviated or add hydrogen monitoring if required.
ROR-ELEC-2: Vulnerability #5	Grounding & Isolation of electrical equipment around melter glass pool not adequately demonstrated or documented.	Proper grounding of selected glass pool isolation equipment is paramount to personnel safety and reliable melter operation. Final equipment grounding and isolation construction and testing	Personnel electrical safety and equipment operation are at risk without addressing these issues.	The review team recommends BNI perform grounding inspection and testing prior to operation to correct any discrepancies

Table B-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		documentation has not been identified at this time.		
ROR-ELEC-2 Vulnerability #6	Project Documentation may not be accurate, or may be obsolete and not marked as canceled or superseded.	With the documentation on this project as extensive as it is and covering the extended period of time that it has, users should be on the lookout for document inconsistencies. Users with unlimited access to the documentation data base are somewhat vulnerable, and must use due diligence.	Inaccurate documents contribute to errors by users resulting in additional cost and schedule, in some cases safety and production loss may be compromised.	Eliminate documentation errors to improve system performance.
ROR-ELEC-3: Vulnerability #3	Current Transformers (CT1s) do not support individual electrode current control in present configuration.	Current Transformers on the melter bus provide only limited control of each bus.	Monitoring electrode current flow prevents bus failure and allows for better electrode current balance between the zones. Direct current control will not be possible on the melter bus unless the power supply system is converted to Individual electrode control	The review team recommends BNI evaluate the recent CT installation configuration to determine if it is complete and incorporated into the control system.
ROR-ELEC-4: Vulnerability #2	Facility Power Study Input Files not in Hanford standard software.	The power study performed on the WTP LAW facility was performed by BNI using "ETAP" software. The Hanford Site uses a competing program "SKM Power Tools for Windows" (SKM) as a standard for facility power studies. The Hanford site maintains extensive Validation and Verification (V&V) documentation and software license keys for SKM software; but, does not maintain equivalent for "ETAP" Software. Therefore, the ETAP power study input files will be of no use to Operations post construction turn over; and, a duplicate study will likely need to be performed using SKM software, so that future modifications can be performed at the facility.	A duplicate power study will likely need to be performed by WRPS using SKM software, so that future modifications can be performed at the facility.	The review team recommends DOE issue a contract to perform a facility power study using SKM Power Tools for Windows, so that operations has useful input files to use in the facility during commissioning and operations. DOE has informed the review team that the Hanford Site standard software may be changing to ETAP, if that change takes place this vulnerability will go away. However, at the time of the review a discrepancy between software products used for the WTP project and at the Hanford Site exists; therefore, this will remain listed as a low consequence vulnerability.

Table B-5. Vulnerabilities Identified for Radiological Control (RC). (2 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
RC-1-V001	Potential for Contamination to Migrate Due to Adjacent Contamination Zones and Low Flow Ventilation Design	Review of all systems indicates vulnerabilities to facility Operations and Maintenance activities due to the potential for migration of contamination. Examples include maintenance on all systems, transfer of equipment between C2, C3, and C5 areas, painting of walls only up to eight feet, insufficient capture velocity, and movement of "clean containers" into the export area.	• Cannot confirm that contamination will not spread across contamination boundaries (i.e., C5 to C3 to C2) • Increased operational costs and decreased productivity • Unplanned outages for cleanup and significant impact to throughput and productivity • Unknown prediction of Airborne Radioactivity Areas • Potential noncompliance to 10 CFR 835 "Occupational Radiation Protection", Code of Federal Regulations, Subparts .1001, "Design and Control", .1002, "Facility Design and Modifications" and .1102, "Control of Areas:	• Evaluate the currently defined work processes for each process system, identify potential areas where contamination may migrate, and define any additional engineering or administrative controls that will be needed to ensure personnel are appropriately protected while minimizing the use of PPE. To evaluate the Project as a whole it is recommended these actions be documented in a Contamination Control Strategy Document. • The Project should define anticipated airborne levels to be anticipated in the facility and mitigating controls. • The Project should evaluate the use of a mock up facility for work evolutions where potential for significant dose can result.
RC-1-V-002	Inability to Meet Contamination Control Limits for Container Release	The swabbing of the container is performed over preprogrammed areas or patches of the container that are approximately 500 cm^2. Per 10 CFR 835.1101(a), " Control of Material and Equipment", containers will be required to achieve less than 20 dpm/100 cm2 for alpha and 1000 dpm/100 cm2 beta/gamma when being released to be transported by a DOE employee (occupation release limit). This results in an inconsistency between the current design criteria and the regulatory limit pertaining to surface area required for release of the canisters.	• Inability to ship containers to IDF • Impact to productivity and throughput • Design currently does not meet regulatory release criteria (as defined in current facility procedure) • Potential noncompliance to 10 CFR 835.1101.	• Develop a technical basis that documents statistical representative sampling and equivalency of surveying at 500 cm2 vs. 100 cm2 (legal release criteria) and also addresses the adequacy of the sampling media used for swabbing the container. The approach for release of the containers should be coordinated with other Hanford Contractors to ensure they understand the survey results prior to their accepting of the containers for disposal. • Evaluate the potential that the container can be contaminated (on the Finishing Line) from the time when the smear samples were taken to when the sample results were received.
RC-1-V-003	Radiation Doses to Personnel are Undetermined for Operations, Maintenance and Waste Management Activities	Little or no radiological implications or planning details have been developed for equipment and instrumentation maintenance/repair dose estimate. This is also true for Operational surveillances and Waste Management activities. PIER no. 24590-WTP-PIER-MGT-13-0825-D, LAW Pour Cave Monorail Hoists-Door Interlock Inadequate to Prevent Pinching Festoon, documents the DOE	Potential to not meet regulatory requirements related to incorporation of ALARA into the design review process per 10 CFR 835.1001 and .1002, Not meeting contractual requirements related to ALARA and not exceeding the 20 percent of the applicable	Accelerate the identification and definition of Operation, Maintenance, and Waste Management tasks and then revise the dose assessment report to accurately reflect anticipated dose. Establish a mockup facility/area to confirm anticipated dose and contamination levels and to reduce exposure to radiation by the workers for tasks

Table B-5. Vulnerabilities Identified for Radiological Control (RC). (2 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		observation (from their June review) and corrective actions are currently being conducted. Per corrective actions in the PIER the dose assessment document is scheduled to be revised mid-August, 2014, but until the revision occurs accurate values for anticipated dose are not available and the Project remains uncertain as to whether required operational parameters of the facility can be achieved. In addition, although the Project has a corrective action due the end of August that would define realistic dose assessments; Maintenance task analyses and work instructions are not scheduled to be completed until 9 months prior to construction turnover of each system– which will not be completed by August, 2014.	standards.Increased personnel needed to perform Operations, Maintenance, and Waste Management activities Potential need to redesign if dose is unacceptable Throughput may be impacted and significantly reduced	expected to be high risk or have high radiological consequences. Reconsider whether the contract limit of 500 mR/hr for the container will allow for contact-handled work (for both Operations and Maintenance)
RC-1-V-004	Inability to Effectively Perform Hands-On Maintenance Activities	Because of the undetermined amount of anticipated dose (vulnerability no. 3) and contamination (vulnerability no. 1) that may exist as part of Maintenance and some Operational activities, along with the lack of design controls to address these hazards, the intent to perform Hands-On Maintenance may not be possible. This vulnerability is of greatest emphasis to the following systems: LSH, LMH, LPH, and LMH.	• One or more of Maintenance evolutions may not be able to be performed. • Potential inability to operate the facility. • Throughput will be impacted.	• Accelerate the evaluation of Maintenance and Operational evolutions to understand hazards, mitigation techniques, and ability to perform required tasks. • Evaluate the ability to remotely perform Maintenance tasks (such as spray nozzle replacement). If not possible, identify alternative methods for maintenance. • Establish a mockup facility/area to confirm anticipated dose and contamination levels and to reduce exposure to radiation by the workers for tasks expected to be high risk or have high radiological consequences.

Table B-6. Vulnerabilities Identified for Safety and Hygiene (SH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
SH-1-V-001	Insufficient Evidence of Compliance with Operational Safety and Health Requirements in Design	Walkthroughs of the constructed facility found several locations where code requirements were overlooked on individual pieces of equipment, but more importantly on the systems as a whole. In particular, specific topical areas that may require additional protective measures include fall prevention, walking and working services, thermal, and means of egress in LRH, LFH, LMH, LPH, LSH, HVAC (not all the topical areas are in need of attention in each system).	• Inadequate design and operational procedures • Potential impacts to throughput and productivity • Not meeting 10 CFR 851.21 and .22 "Worker Safety and Health", Code of Federal Regulations, Subparts "Hazard Identification and Assessment" and "Hazard Prevention and Abatement"	• WTP should verify and validate (i.e., walk down) those systems where design is substantially complete and identify equipment that will need to be retrofitted (engineered solutions) to ensure compliance to regulatory requirements during commissioning activities. • For those activities whereby an engineered or administrative means cannot be achieved to perform the task, develop a technical basis process to seek a waiver from the requirement (i.e., daily crane inspections in the Finishing Line).
SH-1-V-002	Inadequate Implementation of the Hazards Analysis Process	Several examples were observed where the identification and mitigation of hazards was not appropriately implemented. These include design evolutions associated with the LCP, LFH, LPH, LRH, and LSH. Examples include: • Hazards not identified or understood for Operational and Maintenance evolutions for LCP, LFH, LPH, LSH • Lack of understanding of thermal, ventilation, and chemical hazards associated with LCP/LVP, LFH, LPH • Industrial hazards listed above • Lack of identified chemical area monitoring throughout the facility to ensure workers are appropriately protected, in particular in locations upstream of the melter, and downstream of the melter but prior to the offgas being released via the stack. • Lack of a defined chemical source term incoming to the LAW facility (the Review Team was provided a list of anions and cations, not chemical compounds which are regulated).	• Inadequate design and operational procedures • Impact to throughput and productivity • Not meeting 10 CFR 851.21 and .22	• BNI should define and document the chemical source term coming into the LAW and document for current and future use • As part of 24590-WTP-PIER-MGT-13-0964-C, 2013, Hazards Analysis Process Weakness Related To Standard Industrial Hazards, the Project has drafted a CAP that includes a corrective action to develop a formal process that requires engineering and ES&H, at specific points in the design process, to evaluate the 10 CFR 851.22 (b) hierarchy of controls and provide a basis for how each is being addressed. The process needs to be defined (as just mentioned) • The Project should consider either realigning the safety analysis process to appropriately evaluate industrial and chemical hazards and associated mitigating techniques as part of the design process or expanding the WTP Hazards Analysis Procedure (AHA) to include not only the

Table B-6. Vulnerabilities Identified for Safety and Hygiene (SH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				process for hazards identification to protect workers in the field, but also the newly developed hazards analysis process for design (including EA CPs feeding back into the design process). • The Project should also consider revising the title to one or both of the procedures to minimize personnel being confused with the duplicate titles or only have one procedure (versus two) which addresses the hazards identification and mitigation process for both design and field implementation.
SH-1-V-003	Deficient Exposure Assessments for Operational and Maintenance Activities	Review of documented exposure assessments for the LAW facility found them to be inadequate and in need of revision. Review of the existing exposure assessments (13 total) found they were inadequate due to the following: • Chemical source term of the waste feed into LAW is unknown to S&H and IH. • The source term used on two of the assessments is incorrect; one uses the high-level waste source term and the other uses the offgas source term to be representative of incoming LAW feed. • Inadequate definition of Operational and Maintenance Activities which leads to having the EAs at too high a level to adequately be effective in qualitatively assessing exposures. • The EA for replacement of the melter requires a fully encapsulated Level A suit, yet Engineering has assumed that minimal personal protective equipment (PPE) would be required (huge disconnect). • There is no place in the EA process whereby the recommendations from the exposure control plan are fed back into the Engineering design process (to drive engineering solutions to mitigating hazards).	• Inadequate design and operational procedures • Unnecessary exposure to chemicals • Impact to throughput and productivity • Not meeting 10 CFR 851.21	• Identify and define appropriate source terms for each of the exposure assessments (including defining the chemical source term feed for LAW), revise those incorrect exposure assessments (that currently exist), and complete qualitative exposure assessments for the remainder of the process systems. • It is recommended the Project identify key Operational and Maintenance Activities and incorporate into qualitative exposure assessments • Revise procedure(s) (institutionalize) to ensure controls identified in the exposure assessments are integrated and considered during the design as part of the Engineering and Industrial Hygiene processes.
SH-1-V-004	Potential Weakness in the Systematic Analysis of Thermal Stress/Heat Hazards to Personnel	• In the majority of the systems there is significant potential for personnel to be exposed above acceptable practices, if physically possible, to	• Potential for personnel to be overheated and significant safety and health issue	• The Project should perform a LAW Thermal Analysis Study to define and understand both

Table B-6. Vulnerabilities Identified for Safety and Hygiene (SH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		thermal hazards, in particular because of the hands-on maintenance approach. Examples include: - Securing of containers at LEH - Replacement of melter consumables (in particular bubbler changeout and film cooler spray nozzle replacement – direct exposure to small point-source opening with the melter) - Melter replacement - Pour Cave Maintenance - Finishing Line Maintenance - General Operational and Maintenance activities - Potential ineffective cooling by the HVAC system/HEPA changeout • The current basis of design states that the maximum temperature to be encountered is 113F; however the temperature analysis did not take into account heat generated as part of mechanical systems working together in one area or heat generated from specific maintenance activities such as bubbler change out, film cooler spray nozzle replacement, agitator replacement, maintenance within the Pour Caves and the Finishing Lines. BNI Matrix Comment from the 09/02/14 in support of Roundtable: "This is grossly incorrect as a large volume of work has been completed over many years in all aspects of thermal hazards in all areas of engineering. It also completely disregards the use of a heat stress program. This is summarized in the presentation provided. In addition the heat stress program has recently been commended by DOE in the field yet the review recommends that we revise the program?" D& O Team Rebuttal from BNI Matrix Comment on 09/02/14 in support of Roundtable: "The vulnerability was revised to more accurately reflect both the injury and illness safety and health consequence from being exposed to thermal hazards. A full discussion of the thermal vulnerability and the two separate issues included in this vulnerability is in the ROR. In addition, the ROR discusses the recommendation to	• Inability to effectively and efficiently perform Operations and Maintenance activities • Impact to throughput and productivity • Not meeting 10 CFR 851.10	individual and cumulative thermal hazards and needed mitigating techniques. Results of the evaluation should take into account existing design of the facility and possible needed design changes. • Upon identification of anticipated thermal conditions, it is recommended the Project work with the Medical Department and evaluate industry best practices and revise the existing heat stress program to more aggressively protect the workers (i.e., biological monitoring, medical determination of fitness, hydration requirements, etc.)

Table B-6. Vulnerabilities Identified for Safety and Hygiene (SH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		work with the Occupational Medical provider and to benchmark the current heat stress program to ensure it is appropriately protective of personnel given the potential that stay times will not be adequate. The vulnerability stands as revised.”		

Table B-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LSH-F-28-V-01	Configuration Management is inadequate	• The incorrect version of the ORD was provided to the review team. • Multiple revisions of the same drawing were provided to the review team. • Obsolete and superseded drawings were provided to the review team.	• Use of the incorrect version of primary documents will result in incorrect requirements applied to the design. • Use of the incorrect version of design documents will result in review and verification of the wrong design.	• Review and evaluate design documentation to ensure correct requirements were applied. Review design verification documents to ensure correct versions of design were reviewed and verified. • Revise configuration management system to ensure that: - Only current revisions of documents are retrievable (with exception for historical reviews) - Controlling documents are identified and maintained current - Applicable documentation is associated to and retrievable by the system designation and/or the equipment number.
LSH-M-14-V-15	• No acceptable means to secure the spray nozzle CCB to the melter surface has been identified. • Detailed spray nozzle changeout requirements, procedures and timelines have not been developed and evaluated. • There is no upper closure on the spray nozzle CCB, which can act as a chimney while lifting the spray nozzle. • The spray nozzle CCB as designed allows direct line of sight with the melter glass pool at some stages of the changeout. • The existing off-gas spray nozzle changeout system and process does not adequately control contamination release, thermal exposure, radiation exposure, air flow, or personnel access.	• No process has been defined for securing the spray nozzle CCB to the melter when positioned on the melter at the off-gas spray nozzle port location. It had been speculated by Operations personnel that the three (3) CCB base flange toggle clamps would be used in combination with eye-bolts threaded into the melter surface. However, no such threaded holes have been identified and the base flange toggle clamps are not adequate for holding the CCB and spray nozzle securely. • The existing off-gas spray nozzle replacement process presents more potential hazards than replacement of other consumables such as bubblers, yet has fewer protections for Ops personnel and equipment during this highly manual operation.	• Failure to secure the spray nozzle CCB to the melter could result in equipment damage and contamination or exposure (radiological or thermal radiation) of personnel and equipment. • The lack of requirements, procedures and timelines could lead to inefficient operations and increased thermal, radiation and contamination hazards, and/or steam explosion. • Melter and spray nozzle CCB containment are compromised. • Equipment damage and personnel hazards presented by uncontrolled contamination release, thermal exposure, radiation exposure, air flow and personnel access.	• Develop a secure method to stabilize the spray nozzle CCB on the melter surface. • Design and utilize a gamma-gate and closed changeout box that is compatible with the spray nozzle. • Develop a method and additional equipment to maximize efficiency and minimize personnel hazards. • Modify spray nozzle CCB and lift method to maintain containment during spray nozzle changeout. • Design and procure a ladder or platform to access the spray nozzle support plate and lid assembly.
LSH-M-14-V-16	During consumable changeout, both the clean and spent CCBs have the potential to become pressurized vessels. The +/- vessel pressures introduce the potential for the spread of contamination, CCB equipment damage and/or operations production impact.	When the bubbler air bottles discharge air inside the sealed CCB, it will potentially become a pressurized vessel. Likewise when a hot spent consumable is raised into the CCB and it is sealed, temperature and pressure will rise and the CCB will become pressurized and potentially leak contaminated material. As the hot spent consumable cools inside the CCB, a vacuum will lock the access panels and lower lid in place. The CCB	• The CCB is not a certified pressure vessel and damage could occur due to pressurization / depressurization. • Clean CCBs could become over-pressurized due to bubbler air system • Spent CCBs could become over-pressurized and potentially leak contaminated material.	A HEPA filtration system should be considered for design and installation on the CCB to mitigate pressurization / vacuum, and to reduce the potential for equipment damage and the spread of contaminated material.

Table B-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		design does not take pressure / vacuum or venting into account.	• During consumable cooldown, the CCB hatches and lid may become locked in place due to internal vacuum, making hatch and lid removal difficult.	
LSH-F-18-V-04	• The integrated design review of the LAW design is not documented. • The review team requested a copy of the LSH, LMH and RWH integrated design review documents and BNI has not provided the document to date.	• The review team met with BNI representatives on 7/1/14. During the meeting, BNI stated that the LAW integrated design review was complete. However, it was also noted that the current operability review identified an inadequate spray nozzle change-out box design and BNI will address the inadequacies. • The inadequate design of the spray nozzle change-out box may be an example of a larger problem regarding adequate recognition of hazards and design review effectiveness. WTP Contact No. DE-AC27-01RV14136, Design, Construction, and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant , Section C paragraph C.5(b)(5) states, "Design Reviews: The Contractor shall conduct periodic design, constructability, and operability reviews to status the design activities, and resolve design oversight comments from DOE in accordance with Standard 3, Design." • The review team did identify a memorandum (CCN: 100389) titled "ISM Concerns for System LSH" dated 10/24/04. The memo includes a list of LSH equipment, including the Spray Nozzle Changeout Equipment (24590-LAW-MH-LSH-MHAN-00037). The memo concludes "there are no outstanding issues or concerns with the listed equipment." The memo also notes the Spray Nozzle Changeout Equipment requires temporary ventilation equipment when it is in use, (commonly referred to as tenting).	• There may be additional design issues or concerns if all hazards associated with LAW operation are not recognized. In addition, other design deficiencies may exist if a thorough integrated design review is not completed. • Standard industry practice includes performance of periodic independent external design, construction and operability reviews. This project may or may not include an explicit requirement for such reviews. However, these reviews add value to a project. • The inadequate design of the spray nozzle changeout box was not identified as an issue or concern by the review associated with CCN 100389. ISM Concerns for System LSH. This is an example of an inadequacy that an integrated design review may have identified.	Complete an independent external integrated design review of all LAW systems.
LSH-S-08-V-01	PIER process is inadequate for tracking issues found in earlier reviews.	Previously identified issues resulting from external reviews, such as CLIN 3.2, are not being tracked using the PIER system.	Late rediscovery of these issues while on the critical path to system startup will likely be expensive in terms of cost and schedule.	Pick one tracking system, and log and track all issues that are found via any review process. Further classify the issues and assign closing criteria commiserate with the severity of the issue.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LSH-W-07-V-05	Inadequate Lift Capability in Consumables Import/Export Area	Capability for handling the disposal box lid is not provided.	Inability to safely export melter consumables.	Revise design to add a swing jib crane and specified laydown space for the spent consumable transport boxes.
LSH-M-14-V-09	Temperature limitations of the bubbler neoprene rubber air supply port gasket and Super O-Lube silicone grease are incompatible for expected bubbler port environment.	With the temperature at the top of the glass pool at >1900°F (1050-1200°C) just a few feet away from this bubbler neoprene rubber air supply port gasket and Super O-Lube silicone grease, it is expected the local temperature will significantly exceed the temperature limitations of these two materials.	Reduced throughput due to failure of the bubbler air supply port gasket and subsequent inadequate air supply to the bubbler.	Determine anticipated temperatures in the vicinity and resulting temperatures of the bubbler air supply port gasket and utilize appropriate materials.
LSH-M-14-V-08	No criteria or specs have been found for: • Inspection of the bubbler air supply ports during changeout • Application of the Super O-Lube silicone grease • Installation of the neoprene gasket • Verification of proper operation of the bubbler air supply.	The design of the bubbler air supply port requires a neoprene gasket/O-ring between the bubbler and the melter air supply port. To ensure this rubber gasket/O-ring does not gall or roll during installation in the bubbler air supply port, "Apply Super-O-Lube silicone grease to gasket prior to installing into the melter." The last opportunity to apply a lubricant is prior to insertion into the CCB, when the bubbler is in the Consumable Import Cart or as it is lowered into the Import Station. However, requirements for installation of the gasket and application of the silicone grease have not been specified.	Incorrect installation of the bubbler air supply port gasket and lubricant, and subsequent reduced air supply to the bubbler may reduce glass production and process throughput.	• Define specifications for application of Super O-Lube lubricant and installation of the neoprene gasket on the bubbler air supply port. • Develop means to verify proper operation of new bubblers after installation.
LSH-F-01-V-01	Issues found by the review of DOE-HBK-1132-99, Design Considerations, are issues that should be resolved by using this or a similar best practices handbook.	During the design process, following of a best practices handbook will limit the amount of design mistakes that will not be acceptable during operations.	Increase in worker exposure, equipment failure, and the decline of throughput	It is recommended that a best practices handbook be established and followed to limit amount of design errors.
LSH-M-14-V-11	There are no clear requirements for the engineered air gap beneath the gamma gate, and the complex high velocity air flow through the air gap has not been analyzed resulting in an unanalyzed impact to air balance and possible subsequent spread of contamination.	The four adjustable feet on the gamma gate are used to level the gamma gate on the melter and to adjust the engineered air gap between the bottom of the gamma gate and the top of the melter. No criteria or requirements for this engineered air gap or leveling were found.	• Inadequate leveling of the gamma gate and CCB. • Uncontrolled impact to air balance and the resulting uncontrolled spread of contaminated material on and around the gamma gate.	Define criteria for gamma gate engineered air gap and determine impact of turbulent air flow on the spread of contamination.
LSH-M-14-V-05	Alternative equipment is being provided by vendors without an equivalency analysis being conducted to assess the equipment's ability to meet the critical attributes.	The MDS specifies the powered dolly model number "or equivalent". The specified part number has been discontinued so an alternate powered dolly was provided by the vendor. However the critical attributes were not defined and no evaluation was conducted to ensure the new part was truly equivalent.	Alternative equipment may not possess the critical attributes required of the original equipment specified.	• Define critical attributes and requirements for all equipment. • Conduct equivalency analyses for all substitute equipment.
LSH-M-14-V-10	The characteristics of the Kevlar strap at the maximum normal and off-normal temperatures expected should be further evaluated and the basis documented on a Mechanical Data Sheet.	The basis for the choice of Kevlar strap and its characteristics when it reaches the maximum temperature in the CCB are unclear.	Inadequate / inconsistent expectations of the CCB Kevlar strap.	Define criteria for Kevlar strap and document on a Mechanical Data Sheet.
LSH-F-17-V-01	Normal System LSH maintenance evolutions will significantly impact production.	• Radiological control and industrial safety concerns have not been incorporated into the design. Current Radcon perspective is that respirators will be	• Increased personnel required to change out melter consumables increasing costs.	• Establish a detailed task analysis that addresses industrial safety, radcon,

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		required, significantly lengthening the time required to change out a melter consumable. • Industrial safety concerns have not been incorporated into the design, and different interpretations of Lock-out / Tag-out (LOTO) requirements for personnel safety significantly increase the duration of melter consumable changeout.	• Increased melter idle time directly impacts throughput.	operational, and staffing issues to evaluate impact on production. • Develop a remotely operated method to change melter consumables so that the requirement for de-energizing the melter will be for equipment protection purposes only and LOTO can be eliminated.
LSH-F-17-V-04	Heat-up / Cool-down rates for the melter glass pool have not been calculated for the actual case while doing System LSH maintenance evolutions.	• Cool down rate is derived from pilot data where the melter is in idle and the plenum temperature has been allowed to rise in balance. The case where the plenum is exposed to the C5V and C3V has not been analyzed. • Maximum heat up rate is derived from expected limit to prevent foaming problems.	System LSH maintenance evolutions will have uncertain durations.	Perform pilot melter tests that simulate actual conditions during melter consumable change out: melter idle and simulated C5V and C3V airflows to the plenum space from a bubbler hole. Scale up the results for the full-scale LAW Melter using Computational Fluid Dynamics simulations.
LSH-F-17-V-03	Melters idled for another reason, such as work on LOP or LVP, can't be used to "campaign" System LSH consumables.	• When working on LVP, the melter plenum gasses back up and leak back into the melter annulus to be exhausted by C5V. • When working on LOP in one Wet Process Cell, the bypass loop is open and both melters are connected.	Common campaign strategies will be limited for System LSH.	Identify maintenance evolutions for System LSH interfacing systems that are already compatible with a campaign-type strategy, and investigate mitigations that would enable simultaneous work for the currently incompatible ones.
LSH-F-17-V-02	Serious contamination releases will result in significant production interruptions.	Melter confinement has not been demonstrated during melter consumable replacement. Off normal and accident events have not been completely characterized.	Melters idled while release event is investigated and mitigating processes implemented.	Develop a remotely operated method to change melter consumables while maintaining confinement to the C5V annulus.
LSH-F-26-V-01	Melter containment has not been demonstrated during melter maintenance evolutions.	The LAW Melter is a unique design and there is no pilot or operational experience with an independently exhausted melter annulus. During maintenance evolutions, there is a direct path between the melter plenum and the melter gallery. Confinement depends on the dynamic interaction between C5V exhausting the melter annulus and the LOP exhausting the plenum, which do not seem to be coordinated. A detailed calculation demonstrating that the adjustable air gap between the melter gamma gate and the top of the melter shielded enclosure will provide containment, along with C5V and LOP, was not found.	Contamination of the melter gallery disrupts throughput by slowing down maintenance evolutions by necessary additional PPE and procedural requirements and/or by operations stand-downs for situational reviews as has occurred at other DOE facilities.	• Perform the necessary calculations and simulations to ensure containment, including how to coordinate LOP and C5V as well as what the air gap should be between the melter gamma gate and the melter shielded enclosure. • Redesign the melter consumable change out process to preserve a pressure seal between the CCB / melter gamma gate and the melter shielded enclosure while the melter plenum is exposed.
LSH-W-07-V-04	Hazard Analyses and ALARA Reviews are inadequately addressed for spent consumable handling.	Spent bubblers are enclosed within a plastic sleeve at the export/bagging station. The described bagging operation is a hands-on activity including 'pig-tailing' the bottom end of the plastic sleeve while the component is suspended from the crane. These activities will require personnel to work under a	• Personnel exposed to personal injury hazard while working under suspended load. • Personnel exposed to undefined radiation hazard.	Perform hazards analyses and ALARA Reviews; redesign system LSH as required to mitigate industrial and radiological hazards.

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		suspended load and to be in very close proximity to the portion of the bubbler that was in the melt pool and now has a coating of ILAW glass. This is not consistent with ALARA principles.		
LSH-M-14-V-07	• No plans have been developed for cleaning glass spall and drips from the melter shielded enclosure, melter port consumable seating surfaces, bubbler air supply ports, CCB lid/interior, gamma gate or bagging station surfaces. • Methods and equipment for decontaminating the interior of the CCB have not been provided.	• As hot spent consumables are raised spalling past the consumable seating surface on the melter port, and through the complex air flow from the gamma gate engineered air gap, the spalled glass will collect on the consumable seating surfaces as well as the bubbler air supply port. This contaminated material will collect on the melter port seating surface, the gamma gate, the CCB lid and interior, and the bagging station lower gate valve which will increase background exposure and could impact equipment operation. • After multiple uses, the CCB may become contaminated to the extent that personnel dose uptake from the CCB will be an issue. No capability for decontaminating the interior of the CCB is provided.	• Increased rad exposure to personnel and equipment • Failure of CCB lid seating surface and release of contamination • Increased contamination spread.	• Develop tools and processes for removing glass from melter and equipment surfaces including subsequent decontamination and inspection. • Evaluate the radiological issues associated with the CCB and provide capability to decontaminate the interior of the CCB if necessary.
LSH-M-14-V-14	Sufficient details regarding bagging station operations are not available, and the disposition of radioactive bagging station waste not defined.	Numerous questions remain regarding bagging station operations.	Bagging station operations may not be in keeping with Operations best practices and ALARA goals.	Develop processes and procedures for bagging station operations and radioactive waste disposition. A thermal sealing method should be considered.
LSH-M-14-V-02	There are insufficient funds & resources allocated to address; • Equipment obsolescence • Equipment preservation and degradation • Equipment re-inspection, refurbishment and/or replacement effort that will be required (9) months prior to startup.	• Equip. procured early in the project: - Is now becoming obsolete. - Is experiencing degradation such as corrosion and false brinelling. - May require additional re-inspection, refurbishment and/or replacement. • All equipment will be re-inspected and refurbished 9 months prior to plant startup. However, if plant startup is subsequently delayed additional inspection and refurbishment and additional spares may be required.	Increased cost and schedule due to numerous delays in WTP plant startup date projections since equipment procured early in the project is becoming obsolete and warranties have expired (e.g., plant cranes, process control computer software versions [i.e., ABB software, hardware, servers, and workstations])	Develop long term funding and plans that address obsolescence, warranties, and replacement or refurbishment for all equipment procured.
LSH-M-14-V-04	Funding and schedules for all periodic maintenance activities have not been developed, and critical spare parts and consumables such as bubblers are not yet scheduled to be ordered and held in-stock to support commissioning and startup.	Melter consumables will frequently require replacement (e.g., 36 bubblers per melter per year, 2 film cooler wash nozzles per melter per year, etc.). Currently, there is not an adequate number of consumable spares available to support commissioning and startup.	Inability to support commissioning and post commissioning startup activities.	Develop schedules for periodic maintenance activities and procure critical spare parts and consumables to be held in-stock to support commissioning and startup activities.
LSH-F-18-V-02	• Procedure completion and training needs are not aligned.	Interview with BNI Operations SME and e-mail from Operations Procedures and Training Manager.	• Initial LAW operational testing, commissioning and operation could be	Align procedure completion date, including validation and approval, with the date needed for training purposes.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	• Operating procedures and maintenance instructions are partially complete and the current scheduled completion date is not aligned with Operations need for operator training, in that, they are scheduled to be complete after they are needed for operator training.		delayed due to unavailability of operating procedures, maintenance instructions and training. • The design of the procedure development process has failed to ensure procedures are developed and validated in alignment with the need for them.	
LSH-M-13-V-03	Equipment and methods for replacement of "life of melter" components have not been provided.	Equipment for replacing a feed nozzle or a film cooler need to be engineered and provided. The capability to replace other melter components should be reviewed from a project risk consideration, including hoses in the melter lid annulus, electrode extension thermocouples, discharge chamber lid and heater, discharge chamber thermowells, and plenum pressure sensors	• Premature melter failure. • Lost production due to extended melter outage during development of tools and procedures for component replacement and for procurement of component. • Reduced production throughput due to reduced function (e.g., loss of feed nozzle).	• Develop engineered tools, equipment, and procedures for replacement of "life of melter" components. • Procure and maintain "life of melter" components in spares inventory, and equipment necessary for changeout.
LSH-F-21-V-01	System LSH will need defined interfaces with other systems, which are not documented in the system description.	The system has been designed and equipment purchased and installed without detailed task analyses or procedures for significant maintenance evolutions. Important interfaces with other systems are not described or are described in general non-specific ways.	Late discovery of serious operating incompatibilities between important systems just prior to commissioning will be expensive and will, by definition, disrupt the critical path to start-up operations.	• Form an interdisciplinary team with members that are familiar with all melter/throughput interfacing systems and plant operations and task them with developing detailed task analyses that document a safe way to perform all critical maintenance evolutions, using the existing design if possible. • Perform this work early enough to reduce upsets on the critical path as low as practicable and to provide lead time in case extensive redesign and rework efforts are necessary.
LSH-M-16-V-01	Maintenance equipment failure modes and incidents should be identified and understood prior to plant operation to mitigate or reduce equipment/plant down time.	Plant operation on a 24 hour per day, 7 days per week schedule is in jeopardy if maintenance failure modes and incidents are not known and understood.	Increase in off-line operation	Identify maintenance equipment failure modes and accidents prior to plant operation.
LSH-M-13-V-08	Basis of design is not adequately defined or implemented	Hazards analyses and ALARA reviews have not been performed and documented. The radiation dose rates, temperatures, and thermal environments that personnel will be exposed to throughout the maintenance evolutions have not been defined and documented.	Inadequate design	Establish and promulgate design requirements; redesign equipment, as applicable.
LSH-M-14-V-17	Insufficient priority, resources and funding have been given to the LSH maintenance program to ensure successful plant commissioning and startup	• Critical activities have not been adequately detailed, evaluated, or factored back into the plant and system designs.	• Failure of the LSH system to successfully perform critical path activities on schedule during commissioning and startup:	• Detail, model and evaluate all critical plant activities and factor the results of these evaluations back into the plant and system designs.

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		• Critical maintenance program activities and associated funding have been deferred until plant commissioning. • LSH System operability, accessibility, remotability and maintainability of critical O&M equipment has not been sufficiently modeled nor evaluated	• Failure of the LSH system to achieve glass production estimates and to meet throughput expectations	• Based upon the evaluation above, adequately fund and perform critical plant activities that would challenge the critical path schedule during plant commissioning and startup. • Perform adequate plant modeling and evaluations to ensure operability, accessibility, remotability and maintainability of all critical O&M equipment and spaces.
LSH-M-13-V-07	Equipment testing needs to be done in applicable thermal environment.	Tests need to be done on a thermally hot melter to ensure problems as a result of thermal growth are considered and especially for any component replacement to ensure industrial hazards are considered before doing it on a radioactively hot melter.	Inadequate equipment operation in actual environment.	Test equipment in expected environmental conditions with range of exposure times to verify equipment operation and to establish constraints on operations, as applicable
LSH-F-10-V-01	• Environmental qualifications have not been conducted or documented on plant equipment. • Most environmental and operating conditions such as temperature, dose rate, evolution sequence, rates and times, etc. have not been determined.	During this evaluation it was noted that most/many of the environmental and operating conditions such as temperature, dose rate, evolution sequence, rates and times, etc. have not been determined for LSH areas or equipment.	LSH equipment may not be designed for the tasks and environmental conditions that it is subjected to.	• All LSH area environmental conditions should be clearly defined and documented. • EQ analyses should be conducted for all LSH equipment to determine that it is qualified for the environments it is subject to.
LSH-W-07-V-01	An engineered solution to provide vertical to horizontal transition of long length equipment has not been adequately defined or equipment provided. Potential loss of confinement due to puncture of or pulling disposal bag off of consumable during bagging, pig- tailing, and export operations.	Vertical bagged consumable are transitioned to a horizontal disposal box while lowering through the hatch. The concept operation is that the bagged bubbler would be lowered through the hatch until the bottom end of the bubbler rests on the floor of the box and the box would be moved horizontally as the crane continues to lower the bubbler into the box. The corroded bubbler tubes will break off due to the imposed moment while laying down the bubbler as was experienced during scale melter testing, resulting in puncturing the confinement bag and uncontrolled movement of the heavy top end of the bubbler.	• Inability to export long length equipment such as spent melter consumables. • Potential loss of confinement due to breach of consumable disposal bag during vertical to horizontal transition.	Provide an engineered system, such as a strongback, to transition long length equipment from the vertical to horizontal position for the potentially structurally fragile spent consumables
LSH-W-07-V-03	Spent melter consumables and other secondary wastes are packaged for transportation but not for disposal.	Since consumables cannot be packaged for disposal in the current LAW Facility configuration, final disposal of this secondary waste cannot be accomplished until a disposal facility is defined or constructed to process the LAW secondary waste packages. The export of consumables from the facility may be restricted and/or	• An undefined facility is required for repackaging, void volume reduction, and/or treatment of secondary wastes to meet disposal requirements. • Inability to start operations due to insufficient waste disposition.	A disposal plan and disposal path for all LSH process waste and spent consumables should be clearly defined. Perform alternatives study including life cycle cost impacts for providing required waste characterization, volume reduction, and waste treatment, and packaging for

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		waste could be orphaned. The development of work-arounds and equipment mods will also be required.	• Orphan waste.	disposal functions at WTP, existing Hanford facility, new Hanford facility, or offsite vendors. Waste Incidental to Reprocessing (WIR) determinations should also be compiled as necessary.
LSH-S-15-V-01	Maintenance task evaluations and procedures have not been provided. Therefore, it could not be determined that maintenance best practices have been considered nor incorporated.	Most/many of the environmental and operating conditions such as temperature, dose rate, evolution sequence, rates and times, etc. have not been determined for LSH areas or equipment	Maintenance best practices have not been considered nor incorporated	Incorporate maintenance best practices into procedures and processes early and incorporate the conclusions into the design.
LSH-F-18-V-03	Detailed work plans, task analyses and corresponding schedules have not been developed to thoroughly evaluate all anticipated routine and non-routine O&M activities. Therefore realistic timelines and throughput expectations for glass production rates have not been established. Previously captured in CLIN 3.2 (see RPP-50775) and not yet resolved.	• Detailed work plans have not been developed for LSH operations, maintenance and repair activities to ensure adequate space, time and resources are available to support glass production rate commitments. Some operations and maintenance task analyses may have been conducted, but BNI would not release the documentation of these task analyses to the Review Team. • Critical personnel safety input from Rad Con, HP and ES&H has not been considered in the task analyses.	An accurate assessment of process throughput expectations cannot be developed.	Develop realistic expectations for glass production rates, using detailed task breakdowns.
LSH-M-14-V-03	The accessibility and maintainability of critical plant components have not been demonstrated, and equipment for O&M activities may not be practical. This issue was previously captured in CLIN 3.2 (RPP-50775) and has not yet been resolved.	The accessibility to critical plant components, has not been modeled or evaluated with regard to performing the design functions and maintenance in support of melter glass production, nor is such an evaluation currently planned. Also, modeling and evaluation have not been conducted of the tools necessary to access equipment components for routine operations and maintenance activities.	• Plant components may not be accessible and/or adequate space may not be available for routine and non-routine operations and maintenance activities. Also lag storage space for tools, equipment, waste boxes, etc. may be inadequate, leading to unsafe conditions and bottlenecking. • Protective garments, respirators, stay times, etc. that could impact operation timelines have not been clearly defined and evaluated.	Realistically model and evaluate anticipated O&M activities. Non-routine ops should be modeled and evaluated as well
LSH-M-14-V-01	Long term preservation maintenance requirements have not been addressed beyond basic storage requirements (environment), for 88% of equipment received to date.	88% of WTP equipment received to date relies primarily on environmental controls for preservation maintenance. Development of the remaining maintenance requirements has been deferred to startup. LAW facility startup is expected to be delayed until 2022 which increases probability of equipment obsolescence and decay.	Continual ongoing equipment degradation beyond acceptable levels, resulting in uncertain equipment conditions at the time of startup and increased project costs.	Develop long term preservation maintenance requirements and plans for all equipment in storage and upon receipt of new equipment.
LSH-F-20-V-05	Inadequate permitted waste storage area.	WA7890008967, Hanford Dangerous Waste Permit, identifies the import/export area (L-0119B) as the permitted containment building suitable for waste	Inadequate waste storage capacity will impact efficiency in exporting spent melter consumables and constrain melter	Perform work planning including consideration of schedules for bubbler replacement, spent bubbler export, ILAW

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		storage. The available area for waste storage in L-0119B is very limited with a practical storage capacity of one shipping box on the transfer cart holding 4 spent bubblers.	consumable replacement schedule resulting in loss of production.	container receipt, and RWH exports and evaluate impact from lack of waste storage.
LSH-CO-24-V-01	Workspace environment in and near the melter is not defined for proposed operator/maintenance technician actions to install/remove consumables for service.	Meetings with SME's, operations representatives, and others identified the need to identify the workspace environment regarding temperature and radiation as this information could not be provided when requested. It is reasonable to conclude that elevated temperatures and radiological conditions will be present at a manually operated vitrification facility using nuclear waste in the feed component.	• Operating procedures cannot be produced and used if consideration of PPE, remote handling tools, etc. is not known prior to work performance. • Operators may not be able to perform duties as currently assumed and described in the project documents. • Without a known workspace environment it is unlikely proper PPE can be identified which jeopardizes operator/maintenance technician health and safety. • Worst case, the work cannot be performed using the current facility design.	Define workspace environment and include in operations and maintenance procedures.
LSH-F-18-V-01	The operations and maintenance procedure (includes: EOP's, abnormal, alarm response, system task and technical safety requirements) development process is fundamentally flawed.	• The plant operations procedures development process, as described on 4/03/14 does not include industrial and radiological hazards in the task analysis process. Field validation, start-up testing and operations approval are scheduled prior to recognition of industrial and radiological hazards. • Hazards identification and task identification are fundamental requirements for determining PPE requirements and procedure development.	• Any procedure developed using this process is at risk of being substantially revised late in the process. This will add cost and extend the schedule to have useful procedures • In addition, 10 CFR 835 and 851 principles must be considered.	Include all job hazards analysis and job task analysis prior to developing procedures. Validate the procedures after all hazards and tasks are known and included in the procedure.
LSH-CO-24-V-04	• The assumption of an operator reaction time of 30 minutes for a casualty response may be insufficient regarding restoration of power and providing an air compressor upon loss of ISA system. • The operation of the bubblers is essential to melter operation per the 4/22/14 tele- con with VSL. • Failure of all bubblers within a single melter will result in loss of temperature control in respective melter.	Calculation 24590-LAW-M6C-ISA-00002 Rev 0, LAW Critical Instrument Service Air Backup Bottles Sizing, assumption.	All bubblers in operation at the time of a loss of ISA plus 30 minutes could exhibit glass backup and limit the operation of the melter.	• Revisit the 30 minute response assumption for operators regarding restoration of ISA or electrical service for reasonableness and validate the assumption by test. • Develop procedures and training regarding loss of ISA. • Identify the supply of back-up air. Identify proper air fittings and hardware to accommodate the supply of back- up air. • Identify the connection to the ISA for the back-up air supply.
LSH-CO-24-V-03	• HMI's and associated proposed operator actions, in aggregate, do not appear to	• The basis for this concern is: the physical layout of the melter operating deck when considered in	• Good work space design, good environmental design, and good man-	Take necessary steps to incorporate key principles of industry best practice to

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	sufficiently incorporate key principles of industry best practice to ensure operator response to normal evolutions. • The current design does not appear to consider Function Allocation (automated vs. human performance), Task Loading (demands of a given task), Precision Requirements (crane operation), error tolerance (interlocks), Environmental Conditions, Workspace Size, Geometry and Layout (Cable trip hazards associated with power and control lines to the Gamma Gate and CCB's).	relation to the tasks to be performed and the number of personnel performing the tasks, equipment design in terms of controls and indications and operator use and operator response, equipment accessibility (CCB's on the racks), dependability of proposed processes in terms of how it will influence operator actions. • Industry data, in general, shows a decrease in operator error rate when HMI and best practices are included in the design.	machine interfaces can reduce stresses noted with shift operations which contribute to errors. Consideration of the above elements of human factors engineering should improve operational safety by implementing man-machine interfaces that improve human performance and reduce human error. • The existing design without modification increases the probability of an error being made during installation and removal of melter consumables.	ensure operator response to normal evolutions.
LSH-S-06-V-01	Conduct of Operations Principles have not been adequately factored into the facility.	• No single shortcoming will lead to an incident but taken as a whole the Operator is not being placed in a position that is success oriented. • The equipment and facility logistics have not been developed with a Conduct of Operations perspective lending the situation to a condition where Operator error is more probable with the resultant equipment damage and delays.	Lack of incorporation of Conduct of Operations principles will result in equipment damage, production delays, and cost increases.	• Greater attention needs to be paid to incorporating Conduct of Operations principles into the design and logistics of the facility. • A simulation/mockup facility would aid in alleviating some of the concern.
LSH-S-12-V-01	Lack of a simulation, mockup, training facility increases the risk of error in performing new and/or complicated evolutions.	• The complexity, work environment, PPE, and extensive hands on nature of the work warrants a simulator or mockup facility to dry run evolutions and accommodate training. • The complexity and conditions of the tasks to be performed are ripe for error without a simulation/training facility.	Lack of a simulation facility combined with the lack of interlocks/alarms will result in operator errors and equipment damage.	Identify or construct a facility that can be used to simulate, mockup, and train on evolutions to be performed.
LSH-CO-24-V-05	• Current LSH mechanical handling equipment design does not include 2 specific elements of the design philosophy that are included in the Operations Requirements Document regarding decontamination and disposal of contaminated equipment. • The absence of space for decontamination and disposal of contaminated equipment will lead to a lack of function and will have a negative impact on operation, throughput, and spread of contamination and radiation exposure.	A tour of the LAW facility and input from SME's regarding decontamination and disposal of contaminated equipment did not identify space for either decontamination or disposal of contaminated equipment.	The final design may not include general design philosophy regarding space for decontamination and disposal of contaminated equipment	Review the design philosophy for this and other omissions in the LAW design and modify design as necessary.
LSH-F-11-V-05	If the LSH process crane is out of use for maintenance that can be performed using the limited functionality of the west platform, the	The trapdoor is the only planned way to import and export melter consumables and this trapdoor will not be able to be accessed by the CCB handler crane if the process crane is in maintenance.	The CCB handler crane will not be able to import or export consumables for routine maintenance on the melter.	• Time maintenance accordingly with delivery of consumables.

Table B-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	CCB handler crane will not be able to access import and export hatch.			• Evaluate different methods of importing and exporting consumables to allow access to the hatch during maintenance of LSH process crane.
LSH-F-09-V-01	Lack of info on the operation and failure modes of the Component Carrier (grapple for consumables).	There is very little information on the inner workings, reliability, and failure modes of the Component Carrier other than drawings and FAT testing results.	Lack of information on the inner workings of the Component Carrier may lead to a failed equipment, schedule delays, and additional costs.	Attain more information and operational understanding of the Component Carrier.
LSH-F-11-V-01	The current bubbler crate width (12') will not fit through the entrance door into the truck bay (12').	The width of the crate is equal to the width of the door and will not make it into the facility.	The crate will not fit through the entrance to the facility.	• Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH. • When a permanent bubbler manufacturer is identified, evaluate a new bubbler transport crate that will be able to meet the requirements of the system design.
LSH-F-11-V-02	Truck bay crane capacity (10 ton) will not be able to lift current bubbler crate (13.5 ton).	The current bubbler crate exceeds the capacity of the truck bay crane.	The crane will not be able to lift the bubbler crate off of the truck and onto the unloading platform.	• Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH. • When a permanent bubbler manufacturer is identified, evaluate a new bubbler transport crate that will be able to meet the requirements of the system design.
LSH-F-11-V-03	The current bubbler crate width (12') may or may not fit onto the width of the unloading platform (~12').	The width of the crate is approximately equal to the width of the unloading platform and may or may not be able to be placed on the platform.	The platform will not be able to be utilized in the unloading of bubblers.	• Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH. • When a permanent bubbler manufacturer is identified, evaluate a new bubbler transport crate that will be able to meet the requirements of the system design.
LSH-F-11-V-04	The current bubbler crate height will not allow the truck bay crane to pull the bubblers out of the crate (vertical orientation).	As planned by operations, the bubblers height will impede its ability to be unloaded from the bubbler crate.	The crane will not be able to unpack the bubblers for use as planned by operations.	• Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH. • When a permanent bubbler manufacturer is identified, evaluate a new bubbler transport crate that will

Table B-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				be able to meet the requirements of the system design.
LSH-M-14-V-12	One gamma gate per two melters will not be sufficient to support anticipated plant operations.	Currently only a single gamma gate is planned for consumable changeout on two melters. As per 24590-LAW-3YD-LMP-00001 Rev 3, System Description for the System LMP, Low Activity Waste Melter, Table 8-1, it is expected that this single Gamma Gate will be utilized a minimum of 72 times per year on the two melters for estimated consumable changeout (i.e., bubblers, etc.). No task analysis has been found that demonstrates only one gamma gate will be sufficient.	Operations and glass production rates will be negatively impacted.	Re-evaluate gamma gate usage and consider a second gamma gate for active use or as a spare.
LSH-F-20-V-03	Designated space for storage and local maintenance of contaminated equipment and tools in the melter gallery needs to be defined and maintained consistent with operational travel routes. Storage of lifting equipment needs to be provided in the truck bay and the melter gallery.	• Designated storage spaces for all equipment in the melter gallery should be established to provide a defined workflow and ensure adequate space for routine operations and maintenance activities. • Designated contaminated equipment storage and local maintenance locations need to be defined and maintained for the melter gamma gate, upper bagging shroud, small consumable adapters, and other contaminated equipment. • Lifting equipment and storage racks for lifting equipment will be required in the truck bay and the melter gallery. Laydown space for melter startup heaters also needs to be designated.	• Increased contamination spread. • Operational inefficiencies associated with varied or inefficient workflow.	• Designate storage areas for tools and equipment. • Provide controlled designated storage space for contaminated equipment
LSH-M-13-V-05	Methods and equipment for decontaminating the interior of the CCB have not been provided.	After multiple uses, the CCB may become contaminated to the extent that personnel dose uptake from the CCB will be an issue. No capability for decontaminating the interior of the CCB is provided.	• Increased personnel exposure. • Increased contamination spread.	Evaluate the radiological issues associated with the CCB and provide capability to decontaminate the interior of the CCB if necessary.
LSH-M-14-V-06	The criterion for the consumable cooling rate and time while being raised into a CCB has not been determined.	Per Operations personnel, trial and error will be used to determine the spent consumable hang time above the open melter port to accommodate glass dripping, spalling and cooling as the consumables are raised into a CCB. This delay will have a direct impact on glass production rates.	For every minute hang time, more than a minute will be required during melter reheating, impacting production rates and throughput.	Determine criterion for consumable cooling and factor into operations and throughput assessments.
LSH-W-19-V-01	Failed or spent LAW melters may not meet the requirements of the Hanford Dangerous Waste Permit.	• WTP doesn't have an explicit plan to remove LAW glass from a spent or failed melter. • The permitting requires that "residual molten glass will be removed as immobilized product, as much as is practical".	Failed or spent LAW melter could be out of compliance and may not be disposed of as planned.	Clarify the conditions to satisfy for successful LAW melter disposal when transitioning from construction permit to the start-up/commissioning/operating permit.
LSH-M-14-V-13	No form of thread protectors or covers in melter alignment pin locator holes are planned when the gamma gate alignment pins are not installed.	Currently there are no plans to protect the threaded holes for alignment pins in the melter surface.	When the gamma gate is not present, the melter alignment pin locator holes will be open to collect dirt and debris leading to galling of pin threads.	Design, procure and install threat protector inserts/caps on all unused alignment holes in the melter surface.

Table B-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LSH-W-07-V-02	No provision for removal of the air bottles on the spent bubblers or rendering them incapable of holding pressure prior to exporting for disposal.	Two air supply bottles are mounted on the top of each bubbler. Disposal restrictions require that such items be rendered incapable of holding pressure. There are no provisions for preparing the bottles for disposal.	Inability to dispose of spent bubblers.	• Provide means for removal of bottles or for rendering spent bottles incapable of holding pressure at WTP or at the yet to be defined secondary waste repackaging/treatment facility. • Delete on-board air supply system from the bubbler design.
LSH-M-13-V-02	Equipment and means for maintenance of the CCB lift head have not been provided; additional equipment needs to be provided.	• Access to the CCB lift head for maintenance and operations is not provided by the existing maintenance platforms. • Additional equipment: portable vacuum, lifting equipment (bare consumable lifting fixture, melter shield gate lift sling, crate slings, export box lifting equipment, frit pallet lifting equipment, and means of handling of offgas ductwork), special tooling (e.g., long reach tools, strongbacks for spent consumables), personnel platforms/ladders, etc.	Increased maintenance durations and personnel exposures due to limited accessibility afforded by temporary ladders or scaffolding.	A designated CCB maintenance station with an appropriate maintenance platform and CCB test panel needs to be provided. Similarly, a test panel should be provided to verify gamma gate function following servicing.
LSH-M-13-V-04	Capability to move equipment from the melter gallery to the contaminated equipment (C3) maintenance room has not been provided.	The access from the melter gallery to the C3 workshop at the 28' elevation is via stairs at the West melter gallery crane maintenance platform; there is no capability to move equipment by cart or to lift equipment to the platform at the 28' elevation.	• Increased personnel exposure to perform maintenance in the melter gallery instead of the C3 maintenance room. • Interruption of planned melter maintenance operations due to space management and work flow conflicts with performing equipment maintenance in the melter gallery.	Provide monorail or other means of lifting equipment from the melter gallery operating deck (19' el) to the 28' el.
LSH-M-13-V-01	Some maintenance activities on the Process Crane must be performed using the crane maintenance platform at the east end of the melter gallery, trapping the CCB Handler Crane, resulting in no crane coverage of the melter gallery while servicing the Process Crane.	The process crane maintenance platform in the West end of the melter gallery provides limited access to the process crane such that some process crane maintenance activities must be performed at the CCB crane maintenance platform at the East end of the melter gallery, trapping the CCB handler crane. The melter gallery will have no crane service during these process crane maintenance activities at the East crane maintenance platform.	• There will be no crane coverage of the melter gallery during some maintenance activities on the process crane • Lengthy interruption of melter support and consumable import/export operations may occur during major maintenance activities on the process crane	• Assess frequency and duration of crane maintenance activities and incorporate into production throughput estimates to determine need for alternate maintenance platform. • As necessary, modify west crane maintenance platform such that most if not all of the process crane maintenance activities can be performed.
LSH-F-20-V-02	Umbilical cables to the CCB while it is on the melter, import station, or export station are laid on the operating deck walking surface, creating a tripping hazard; similarly, umbilical cables to the gamma gate on the melter create a tripping hazard. These cables will also create obstructions for moving rolling platform	Four umbilical cables run from the control panel to the melter gamma gate and the CCB. These cables will lay on the walking surface of the melter and will be a trip hazard and an impediment to rolling equipment. Similarly, when the CCB is on the import station or the export/bagging station, 2 cables will run from the control panel to the CCB, presenting a trip hazard and an impediment to rolling equipment.	• Personnel trip hazards. • Operational inefficiencies.	• Provide conduit to import and export stations for the CCB, with junction and short umbilical jumpers for the CCB near the gate. • Provide umbilicals on swing booms or similar to the CCB and gamma gate when installed on the melter.

Table B-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	ladders, shielded cover removal tool, and other equipment.			
LSH-F-20-V-01	Access to the top of the CCB needs to be provided while it is on the melter, import station, or export station for routine and recovery operations.	The top access panel of CCB needs to be accessed to open the on-board bubbler air supply when installing a bubbler into the melter. While the CCB is on the melter gamma gate, the import station, or the export station, recovery operations for the component carrier require operation of a hand crank inserted into the component carrier winch. The ability to attach and detach the crane hook to the CCB while it is on the melter gamma gate, import station, or export station will increase operational flexibility.	Inability to safely disconnect the crane hook from the top of the CCB.	• Provide platforms at the import and export stations. • Provide rolling/moving platform for use on the melter.
LSH-F-20-V-04	The design of the consumables cart requires use of fall protection.	Personnel must access the top of the cart for installation of small consumable adapters and for melter consumable inspection. The top of the consumable import cart is approximately 9.5 ft above the floor. A fall protection tie-off point is provided at the top of each access ladder. Personnel will be required to be in fall protection harnesses and work from the access ladders to install the small consumables adapters and perform inspections.	Work process performed by operator while on the consumable cart ladder will be restricted leading to operational inefficiencies.	Verify required operations are consistent with provisions provided.
LSH-CO-24-V-02	Any necessary rotational orientation of the consumables (except the bubbler) is not identified to the operator prior to installation in the melter.	Meetings with SME's, operations representatives, and others identified the need to identify or clarify whether the air lift lance, feed nozzle, and level detector have a rotational orientation requirement as it is not clear whether the service connections (air, water, cables) are fixed. The details regarding the melter service connections are not defined in the documents reviewed. There may be a rotational orientation consideration for the consumables that is not identified.	• Any rotational orientation requirement that is not identified prior to consumable installation in the melter may require the operator to correct the rotational orientation by removing the consumable and installing it correctly. This result could: decrease throughput, increase radiation exposure, increase the spread of contamination and increase the operating budget to address the contamination. • Service connections between the Melter and melter support equipment may not be able to be made without consideration for rotational orientation.	• Identify rotational requirements. • Make appropriate modifications/markings on equipment that require rotational orientation.
LSH-M-13-V-06	Crane indexing capabilities have not been provided. Much of the crane use involves movement between discrete locations; increased operational efficiencies can be realized by addition of crane index features.	The greater portion of crane use in the melter gallery will be movement of items between discrete locations (e.g., import station, CCB rack, melter bubbler port, export station, import/export hatch). Increased operational efficiencies and reduced probability of human error could be realized by implementing crane indexing capability on the melter gallery cranes.	• Operational inefficiencies and premature crane wear. • Increase risk of operator error.	Provide crane indexing capability; preferably auto-indexing capability.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-IC-1-V001	There are many inconsistencies between the requirements documents such as the Mechanical Sequence Diagram (MSD) and the implementation of these requirements on the Logic Diagrams. Since there is no narrative or cross-walk between the requirements and the logic diagrams it is difficult to review, and will be difficult to verify and validate that the requirements are met.	Some interlock requirements are inconsistent, such as preventing a collision between pieces of equipment when going into a maintenance area but not when coming back out. Most often the implementation on the logic diagrams is correct but inconsistent with the requirement on the MSD. Some inputs to interlocks and some interlocks themselves are not correctly labeled on the logic diagrams potentially causing interpretation of how the interlock is implemented. Off-sheet connectors are often incorrectly labeled or inconsistently labeled from one sheet to another.	• This make it difficult for a reviewer to follow the logic and ensure that it performs as expected and performs the functions that are intended. It will also be difficult to write and verify a functional test plan as opposed to software testing. • If off-normal events and failure paths are not tested during commissioning and before, deficiencies in addition to those listed here will only be discovered when they occur.	• Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Scrub the logic diagrams to correct the labels and ensure consistency among the off-sheet connectors. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to “wring out” errors and identify improvements in operations and operator/control interfaces before operations begin.
LPH-IC-1-V002	Alarms and Interlocks for Elevator position mismatch not described on the Mechanical Handling Diagram can lead to loss of configuration control.	24590-CM-POA-MJW0-00001-11-00001, Turntable and Elevator Operating and Maintenance Manual, requires that the motors for both Serapid chain drives on the pour cave elevator be synchronized. Further, the Functional Diagram for the elevator position indicators, 24590-LAW-J3-LPH-01009, Functional Diagram LPH Elevator Absolute Encoder LPH-ELEV-00001, 00002, 00003, 00004, shows these signals being compared to display a mismatch alarm. However, the Mechanical Handling Diagram 24590-LAW-M7-LPH-00001013, Container Pour Handling System does not show a tie between the Right Hand and Left Hand Drives to synchronize the two drives. If the two drives are not synchronized and the motors operate at slightly different speeds or start/stop at different times, the elevator lift table can crab & cock in the elevator’s guides and bind. This required functionality should be shown on Mechanical Handling Diagram 24590-LAW-M7-LPH-00001013.	• Without proper documentation, operators and maintenance personnel will not be properly trained and software will not be properly tested • Alarms and Interlocks cannot be managed, over-ridden or protected from improper hardware or software changes if they are not properly understood. Software Testing cannot be performed against requirements that don’t appear on requirements documents.	• Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-IC-2-V001	The local control panels for the LPH Pour Cave Turntable and Elevator are located in R3/C3 areas. Since they are located immediately behind the Pour Cave Elevator, these rooms will also be thermally very hot. Since these locations do not provide a view of the equipment being operated, there is no reason for the panels to be located in these unhealthy areas.	According to 24590-LAW-P1-P23T-00006, Equipment Location Plan EL. (-) 21' – 0"/Area 6, the local control panels for the LPH Pour Cave Turntable and Elevator are located in rooms L-B012 and L-B014. According to the General Arrangement drawing, 24590-LAW–P1–P01T–00001, these rooms are R3/C3 zones. In 24590-CM-POA-MJW0-00001-07-02, Pour Caves Software Control Narrative for the LAW Vitrification System, Section 4.1 discusses operations at Local Control Panels LPH-PNL-0001/4/7/10. Section 4.1.7 states, "CAUTION: During Local mode, the operator is to visually monitor the elevator and turntable positioning while running locally since hardwired interlocks for stopping the equipment are limited to the elevator LPH-ELEV-0001, up over-travel proximity sensor LPH-ZS-3502 and down over-travel proximity sensor LPH-ZS-3504, which are respectively wired to control relays CR-OTS1 and CR-OTS2 which provide a fail-safe normally open interlock contact wired in series with the operator actuated Emergency Shut Down (ESD) pushbutton and the ASD high temperature switch RS-4L, etc., monitoring the braking resistor." However the panels are located in separate rooms behind the elevators (L-B012 and L-B014). An operator working at these panels will not be able to visually monitor the equipment being operated. The panels provide neither position encoder readouts nor camera views of the equipment.	The location of these panels will expose the maintenance person operating these controls to unhealthy conditions without any benefit from being co-located with the equipment being operated.	Consider moving the Local Control Panels LPH-PNL-0001/4/7/10 to LCB-004 either in the corridor, or across the wall from the current position.
LPH-IC-2-V002	A PIER regarding the pinching of the Monorail Hoist Festoon was closed by changing the operator message described on the logic diagrams 24590-LAW-J3-LPH-02016002/02017002/02018002/02019002, Sequential Function Chart LAW Container Pour Handling (LPH) System Trolley Maintenance (Sheet 2 of 2) LPH-HST-00001, 0002, 0003, and 0004. These changes were not made.	PIER Number 24590-WTP-PIER-MGT-13-0458-C, LAW Pour Cave Monorail Hoists-Door Interlock Inadequate to Prevent Pinching Festoon, identifies an issue with pinching the Monorail Hoist Festoon. The PIER recommended adding to the warning message telling the operator to check hoist and the festoon. The Verification Statement says, "The action has been satisfactorily completed. The sequential logic diagrams were updated to resolve the issue with the maintenance shield doors pinching the monorail hoist festoon. The revised sequence logic was performed by C&I and reviewed by Mechanical Handling, Ops and Start-up. Refer to 24590-LAW-EDR-J-12-0120". The PIER was closed on 08/16/2013. The J3s in question were revised to Rev 3 on 02/02/2013, including a note	If the operator signals the Automatic sequence that the Monorail Hoist is clear of the Maintenance Door without checking the Festoon, the sequence could allow the door to close and damage the Festoon. This would render the Hoist inoperable.	Investigate why the correction suggested by the PIER and reviewed, does not appear on the logic diagram. There appears to be a disconnect between the direction to correct a document and its implementation.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		that said, "Clarify Step Descriptions". They were revised again to Rev 4 on 1/28/2014, the operator messages say, "Verify Hoist Clear of MAIN Door". There is still no mention of the Festoon as recommended by the PIER. The EDR referred to in the PIER does not show or specify the changes that were made. There is nothing available for review that shows what was done to close the PIER and the concern is still extant on the current revision of the J3 drawing.		
LPH-HST-1-V002	LAW Pour Cave Hoist Capacity Inadequacy	The current 10 ton hoist capacity limits the items that can be handled by the LPH hoists. The basis for this value is not defined therefore it is unclear if a 10 ton hoist can meet all the lifting requirements of the system. There is a case where the load can exceed 10 tons; specifically an overfilled/non-spec container utilizing the lower overpack and recovery lifting frame (LPH-RCVY-00003).	• Inconsistent design basis • Inadequate design margin • Potential for Operational Impacts and Risks to Commissioning Phase	• Provide a detailed analysis of the lifting requirements of the pour cave hoists. • Establish the bounding scenario that provides the basis for hoist capacity and make changes where appropriate (re-rate the hoists to lift more than 10 tons). • This may also require a specific weight limit be placed in the design of the Container Recovery Lifting Frame LPH-RCVY-00003.
LPH-HST-1-V004	LAW Pour Cave Hoist Design Temperature Inconsistencies	The basis for temperatures within the areas of operation of the pour cave hoists (LPH-HST-00001/2/3/4) is not consistently applied to design documents. 24590-LAW-M0D-LPH-00053, 00054, 00055, 00056, Mechanical Handling Data Sheets - LPH-HST-00001, 00002, 00003, and 00004 Pour Cave Monorail Hoists, do not accurately reflect the correct environmental conditions as documented in the CFD analysis (24590-LAW-M4C-C5V-00001, CFD Analysis of LAW Pour Caves [with Additional Cooling] and Finishing Lines). The elevated temperatures the hoists will be subjected to may lead to premature failure of equipment.	• Inconsistent design basis • Inadequate design margin • Potential for equipment failure • Potential for production impacts	• Provide a detailed analysis of the environmental requirements of the pour cave hoists. • Establish the bounding scenario that provides the basis for temperature values within the pour caves and transfer corridor. Update data sheets and verify with vendor if changes are required to meet the environment. Make changes where necessary (different lubricants, localized cooling, higher inspection frequencies, etc.). . • Review with HVAC if hoist requirements affect HVAC design.
LPH-HST-1-V005	Hoist Specification Requirement Deficiencies	Features and concepts of the pour cave hoists must meet the functional requirements specified in the Engineering Specification for Process Monorail Hoists (24590-WTP-3PS-MJKH-T0002). Validation of these features/concepts is either done through acceptance of vendor deliverables (drawings, calculations, data sheets, etc.) or through physical proof testing. It is assumed that Factory Acceptance Tests (FAT) done by the equipment supplier or Test Acceptance Criteria performed during	• Inconsistent design execution • Inadequate design margin • Potential for undersized equipment • Potential for Operational Impacts and Risks to Commissioning Phase	• Establish the actual requirements of the engineering specification and validate the hoist supplier has met the requirements. • Provide documentation to validate the requirement was met.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		commissioning will meet all the requirements that are not validated through the vendor submittal process. There are several requirements of the specification that were not tested during FAT and are not covered by a test requirement in the LPH System Description. The items/functions not tested can impact commissioning or future production when called on to perform.		
LPH-HST-1-V006	LAW Pour Cave Trolley Recovery Design Inadequacies	Based on the LPH Pour Cave hoist engineering specification (24590-WTP-3PS-MJKH-T0002), trolley recovery shall be accomplished through pullback means to the hoist maintenance area. Pullback design is required with safe working load. The lack of vendor calculation to justify the recovery cable sizing prompted a PIER (24590-WTP-PIER-MGT-13-0268-C, LAW Pour Cave Monorail Hoists - Remote Recovery Capabilities Inadequate or Unverified [RVP]). Cable sizing was deemed appropriate by CCN 258131, but the analysis does not include bearing friction forces and the design may not meet the recommended design factor.	• Inconsistent design execution • Inadequate design margin • Potential for undersized equipment • Potential for Operational Impacts and Risks to Commissioning Phase	Reassess recovery scenarios and provide a detailed analysis/calculation for cable sizing. Undertake a proof test to ensure cable and swivel ring design can recover a loaded hoist within the curved section of the monorail beam.
LPH-HST-1-V007	LAW Pour Cave Hoist Recovery Design Inadequacies	Based on the LPH Pour Cave hoist engineering specification (24590-WTP-3PS-MJKH-T0002, Rev. 3), in the event of a hoist drum brake, seizure recovery shall be accomplished by utilizing the hoist motor (sized large enough to overcome the brake force) to drive through the brake and be able to lower the load. Although brake failure is covered in the specification, motor failure is not. Recovery method for a grappled load and a hoist motor failure can only be accomplished through cable cutting. This issue was identified in PIER (24590-WTP-PIER-MGT-13-1090) and is still an open issue.	• Inadequate design execution • Inadequate consideration for maintenance tasks • Risk transfer to operating contractor	• Assess the impacts of load recovery and assess if additional design features should be implemented. If the impact is great enough, it may be necessary to add a secondary motor on the LPH hoists. • Undertake a proof test to ensure the redesign can adequately recover from a seized motor with a full load through remote recovery operations.
LPH-HST-1-V008	LAW Pour Cave Hoist FAT Test Deficiencies	Factory acceptance testing does not fully test the items as specified in the engineering specification for LPH pour cave hoists (24590-WTP-3PS-MJKH-T0002). Of the items tested, the FAT does not validate the performance requirements adequately. Several features are not fully tested to simulate the bounding conditions and the acceptance of the FAT report places a false sense of security on the adequacy of design.	• Inadequate design execution • Inadequate consideration for maintenance tasks • Risk transfer to operating contractor	• Establish an adequate FAT test plan that meets the requirements of the engineering specification. • Undertake a proof test to ensure the existing hoists can adequately meet all the tests required in the plan and document the results.
LPH-HST-1-V009	Monorail Hoist Maintenance Platform Inadequacies	The fixed handrails of the platforms (LPB023A/B) located in the monorail hoist maintenance rooms (L-B023A/B) interfere with the ability to move the hoist trolley over the platforms. The hoist festoon system hangs 42" below the handrail elevation and this will block the trolley from moving over the platform. In addition, the platform is designed with removable grating sections	• Inadequate design execution • Inadequate consideration for maintenance tasks • Risk transfer to operating contractor	• Modify the fixed handrail section to include a spring loaded gate that can swing open and allow for the festoon to pass through. • Modify the removable grating area and provide an opening directly below the

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		to allow for equipment to pass through the opening to the floor below, but the opening does not allow for use of the existing monorail beam or hoist; they are not in the vertical path of the monorail beam.		monorail beam to allow for items to pass through utilizing the monorail beam. Another option is to add permanent lifting devices directly above the removable grating sections to aid in maintenance tasks.
LPH-BFSTR-1-V001	Insufficient shield door design basis.	The transfer corridor North and South shield doors, 24590-LAW-AD-LPH-DOOR-00024 and 00026, are required to be 4 inches thick and provide adequate shielding dose rate to R3 (2.5 mrem/hr) radiation levels. 24590-LAW-Z0C-W13T-00002, LAW Facility Shielding Confirmation Calculation, is identified as the basis for the shield door design conformation. However, section 7.2.6 identified as steel walls/doors performs an analysis with a single point source term and this is not the conditions expected in the container buffer storage area.	Potential employee exposure due to unanalyzed source configuration.	The LAW Facility Shielding Confirmation Calculation, 24590-LAW-Z0C-W13T-00002, should be revised to include the shield door design verification. The verification should include the actual buffer storage container configuration and source term to identify if the current door design will perform the expected shielding effect. The verification calculation should drive design modifications, if necessary, to ensure maintenance activities can be performed as intended and safely
LPH-BFSTR-1-V003	Additional cameras needed in container export area.	The container export area, located at East end of transfer corridor, does not have sufficient camera coverage for export operations to the LFH system. According to camera location drawing, 24590-LAW-J0-PTJ-00001, System PTJ Supplemental Instr. Diagram CCTV Equipment Plan @ EL -21'-0", there is one camera located in the North wall covering the buffer storage room, L-B025C, and the South wall covering the rework area, L-B025D, both camera views are partially obstructed when trying to view the transfer corridor export location.	Operators will have a difficult time engaging and dis-engaging the container grapple with no elevation view of the export location, in the transfer corridor. This could result in a high risk of improperly engaging or dis-engaging a container and result in container, equipment, or facility damage.	Install two additional cameras, located in the container transfer corridor, to provide an elevation view of the container export position.
LPH-BFSTR-1-V004	Incorrect buffer storage and finishing line container import temperature.	Described in 24590-LAW-M4C-C5V-00003, CFD Analysis of LAW Buffer Storage and Finishing Line calculation, the intended operation is to transfer the container directly from the pour cave into the finishing line, after 59.27 hours, in an alternating pour mode. There is no direct container temperature results identified in the analysis, so the Reviewer will assume the container temperature is identical to container temperature profile for the maximum container temperature for alternate pour schedule. That would mean the finish line import temperature is 460°F. In the single pour mode the container is required to be removed from the pour cave at 29.63 hours and using the container temperature for a single pour schedule the container temperature would be 630°F. However, the container cannot be lifted with the current grapple design until it cools to 600°F. Assuming	Using the incorrect model input data could either under or overestimate the effects on the facility or production. The project cannot use obviously incorrect container temperatures and expect that the facility insulation design basis is accurate. Re-performing the analysis with the correct input temperatures may verify an increase in safety factors and improve operations ability to manage container throughput.	Clearly define the container temperature profile, for all operating modes, prior to containers entering temporary storage and re-run the CFD models for long term transient analysis. The model outputs should be used to refine operating limitations, insulation configurations, and HVAC cooling air profiles.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		the cooling rate is approximately linear, after 20 hours, the container will not be able to leave the pour cave until hour 34-36. This single pour schedule would result in approximately 18 percent melter throughput reduction.		
LPH-BFSTR-1-V005	Insufficient Buffer Storage CFD analysis.	The CFD Analysis of LAW Buffer Storage and Finishing Lines, 24590-LAW-M4C-C5V-00003, includes the container rework area, L-B025D, and does not analyze the larger buffer storage area, L-B025C. There is an attempt, in section 6.2.4.4, to justify the modeling choices by saying that although the area to the north has more canisters, the model has the six hottest canisters in the south area, and the air temperature in the north will be less in this situation than the air temperature in the south. This is not a justification for not analyzing the larger buffer storage area, because it has less air flow for convective cooling, twice the potential heat loading, higher temperature effects on concrete structure and worker occupied areas.	The HVAC system may be undersized to handle the total cooling load. The area insulation may be insufficient to protect the facility structure. The storage area may not be large enough to allow operations to achieve the required facility glass production. The correct CFD analysis could validate the current facility design and operations, but without a reasonable analysis of the facility intended operations the basis of design cannot be relied upon.	• Clearly define the container temperature profile, for all operating modes, prior to containers entering temporary storage. Update CFD model to accurately analyze all storage geometries, cooling air patterns, and operating conditions. Then re-run the CFD models for long term transient analysis to identify the true maximum temperature locations and the frequency at which they occur. • The model out puts should be used to refine operating limitations, insulation configurations, and HVAC cooling air profiles.
LPH-BFSTR-1-V006	Excessive buffer crane operating temperature.	24590-LAW-M0D-LPH-00003, Mechanical Handling Data Sheet - Top Running, Double Girder, and Buffer Storage Crane 24590-LAW-MJ-LPH-CRN-00002, indicates the operating environment as 59-113°F and a special temperature condition of 130°F max. The CFD analysis of the LAW buffer storage and finishing lines indicate the walls and ceiling temperature maximum well in excess of 130°F, for a single pour schedule. If the buffer storage area, L-B025C, is analyzed the inner wall and ceiling temperatures will be as bad or worse all of which exceed the cranes operating conditions.	The crane will prematurely fail and require increased maintenance and repair. The increased maintenance and repair downtime will affect the facility overall throughput requirements.	Execute the above OFI, for the CFD analysis, and use the output model data to identify the true operating environment and procedures for which the crane will perform. If temperatures are above the cranes design operating conditions then modify the crane to meet the new operating conditions or use the container re-work area as a cold container storage location that could also be designated as the crane park position. Parking the crane in the rework area, between container moves, would ensure the crane is located within its design basis operating environment and only periodically enter elevated temperature zones.
LPH-BFSTR-1-V007	Insufficient Buffer Storage Capacity.	Drawing number 24590-LAW-J3-LPH-02011, sequential function chart, indicate the storage position shall be selected by the ICN using the sequence order identified in note 5. This sequence will fill 11 storage positions located in both the buffer store and container rework areas. This sequence requires the center row, B row, to be kept empty to allow automated crane movements. This operating sequence will reduce the storage capacity from 18 positions to 11, which is a nearly 39 percent reduction. The crane can be operated manually and the	The insufficient buffer storage capacity will limit operations ability to manage container throughput and the facilities different operating modes. This will result in reduction in facility overall throughput requirements.	• Expand the container buffer storage area by one of the following: • Increase buffer storage by facility design modifications to expand area designated for container storage both long and short term. • Increase container cooling capability to reduce the storage time for the container to be reduced to target

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		additional storage locations be filled with containers, however doing so would require all crane movements to be done manually and with the limited maneuvering area the risk of container collisions would be greatly increased.		temperature for the finish line import. This would increase flexibility and overall throughput using the current container buffer storage area. • Modify operating procedures to allow more efficient management to current container buffer store to achieve facility throughput and validate these operating procedures through model validations.
LPH-BSMF-1-V001	Container Recovery Lifting Frame issues.	A workable Container Recovery Lifting Frame has not been designed and will not be procured until it is needed. Delaying the final design and procurement of the frame could adversely impact container throughput. Drawings indicate the frame is stored in the Buffer Store Maintenance Area but the conceptual design of the frame is too tall to be moved through the door separating the maintenance area and the Buffer Store Area.	Significant adverse impact on throughput while the lifting frame is being designed fabricated and tested.	Identify an alternate storage location for the Container Recovery Lifting Frame that will allow the current conceptual design to be utilized. Redesign the lifting frame so it can be transferred through the Buffer Store Maintenance Facility door.
LPH-BSMF-1-V002	Transfer of ILAW container and Lower Overpack from the Container Transfer Corridor to LFH issue.	CCN 227163, LPH-CRN-00002 Energy Chain Modifications Required to Remove Container/Overpack through LFH-DOOR-00010 Openings, provides recommended modifications to the LPH-CRN-00002 energy chain trough and support beam that will be necessary to transfer a container and overpack from LPH to LFH through LFH-DOOR-00010. The steps include parking LPH-CRN-00002 in the Buffer Store Crane Maintenance area, removing insulation batts, cutting the energy chain trough and supports before the container and overpack can be moved through LFH-DOOR-00010. This appears to be a lengthy and complex operation that will significantly impact throughput. An alternate method of moving a container and lower overpack through LFH-DOOR-00010 should be considered when the recovery lifting frame is redesigned, or relocate the energy chain trough.	System throughput may significantly impact mission duration. Overly optimistic assumptions result in operational decisions based on inaccurate information.	Prepare a design change to modify the energy chain trough so the modifications can be completed prior commissioning of the facility. The modification needs to ensure minimal work will be required in a contamination area to transfer the ILAW container and lower overpack.
LPH-OR-1-V001	CCN 068381, LAW Facility LPH System - RAM Assessment and Basis, recovery logic inconsistent with equipment operability.	The RAM assessment and basis report for the LPH system contains recovery logic for a failed turntable which is inconsistent the operability and capabilities of the pour cave hoist. The positioning lasers, which are not redundant, and utilized to accurately and safely position the crane are not included in the OR model.	System throughput may significantly impact mission duration.	• Revise the recovery logic for a failed pour cave turntable motor and update the OR Model. • Add the Buffer Store Crane positioning lasers to the OR Model.
LPH-OR-1-V002	24590-CM-POA-MJKG-00003-15-01, Failure Mode, Effects, Reliability, Maintainability, and Criticality Analysis, inconsistencies.	The Failure Mode, Effects, Reliability, Maintainability, and Criticality Analysis prepared by the Buffer Store Crane vendor contain inconsistent values for the operational availability of the crane. The analysis utilized	Erroneous input data in OR Model results in overly optimistic predictions of system and facility availability.	• Revise the FEMCA for the Buffer Store Crane to include “non-normal” environmental conditions due to the high environmental temperature.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		a "normal" environmental factor which is not consistent with the high temperature environment of the Buffer Store Area. Based on a throughput of 5 ILAW containers per day, the duty cycle (crane movements) and time of use per day are underestimated.		• Revise the duty cycle and operation time of the Buffer Store Crane to align with the current container handling and sequencing methods
LPH-CPS-1-V001	Potentially insufficient design margin for working load capacity of Container Park/Export Stands.	If not frequent, there are conditions where the Park/Export Stands will support a weight higher than the design working load. It may result in gradual deformations of the top ring that directly supports the bottom of the containers, which may later become a problem if repair/replacement is needed.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	• Perform confirming structural calculation using the redefined working load calculated for the maximum anticipated weight and a 25% design margin. • Re-run the functional test conducted by the Vendor using a 20,000-lbs simulated Container bottom for the possible higher working load.
LPH-CPS-1-V005	The truncated Container Export Stands will provide an insufficient thermal protection of the concrete floor below.	The truncated sides of the Export Stands will allow radiant heat to shine on the concrete floor below that will result in a risk that a hot Container overheats the floor above the 150°F maximum allowable temperature.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Develop a detailed calculation to verify the temperature conditions of the floor at the east end of the Transfer Corridor and define need for additional localized thermal insulation.
LPH-CTB-1-V001	Bogie thermal shield design differences between the Design Proposal Drawing and the fabricated Bogies are not documented.	There is no justification available that documents the WTP Project's acceptance of the Manufacturer's deviation from the initial design that called for the heat barrier to cover the entire top surface of the Container Transport Bogies.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Re-run the Manufacturer's thermal analysis of the Container Transport Bogies for the expected higher ambient temperature range, and verify that the temperatures of the Bogie most fragile components including the motor and junction boxes remain acceptable.
LPH-CTB-1-V002	No I&C Component prevents a Bogie from colliding with a filled Container standing on an Export Stand.	During normal operations in automatic mode, the Bogie positioning is obtained from a laser-positioning device. There is no way for the system to identify that a filled Container is present on the Export Stands. There is a risk that a bogie will collide with the Container and damage it or move it off-center the top ring of the stand.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Equip the two Export Stands with a Container Presence Detection Instrument signaling to the ICN and the Operator (Manual mode) the presence of a Container on an Export Stand.
LPH-CTB-1-V003	Wall of the Corridor at Column Line 12.5 in not protected from radiant heat dissipated by a filled Container on a Bogie parked at Position 15.	There is a risk that a hot Container parked at Position 15 overheats the non-insulated north and south concrete wall surfaces around Column Line 12.5 above the 150°F maximum allowable temperature for reinforced concrete structures.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Conduct a thermal analysis, verify the surface temperature level of the north and south corridor wall at and near Position 15, and define the needs for adding insulation material and stainless steel liner in this area during the construction phase prior to commissioning (similar to the wall configuration at the east end of the Corridor near the Export Stands).

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-CTB-1-V004	Non-finished surfaces of the Corridor walls will trap volatile contamination migrating from Pour Caves resulting in challenging cleanup work.	During operations a natural circulation thermal plume exits each Pour Cave into the upper part of the Container Transport Corridor. These thermal plumes may spread contamination from the Caves to the Corridor in a direction opposite of the C5V cascade airstream. Several elements present in the ILAW glass are volatile and may rapidly condense as a stream of molecular sized particulate contamination exiting the Caves. After a period of operation, this contamination dispersed everywhere in the Corridor will accumulate firstly on the upper surfaces of the Corridor which, as they are not protected by any coating, will greatly complicate access and maintenance.	• Inconsistent/inadequate design • Maintenance concerns	• Conduct a detailed thermal analysis of the Container Transport Corridor focused to the identification of the natural circulation thermal plumes and air temperatures. • Evaluate the needs for applying epoxy coating to the unfinished upper surfaces of the Corridor.
LPH-CTB-1-V006	Maximum temperature requirement for Conductor Bar design is significantly lower than anticipated temperatures near filled Container.	There are conditions where the conductor bars may see ambient temperatures over the maximum specified operating environment of 113°F.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Verify the acceptable temperature range for the cover material of the installed conductor bars, resume contacts with the Manufacturer, and evaluate the option of replacing the conductor bars by a product with an alternative cover material resistant to higher temperatures if the durability of the installed material cannot be demonstrated in the expected temperature conditions.
LPH-BMA-1-V001	Bogie Maintenance Hoist not adequate to lift the Container Transport Bogies to access the underside of the Bogies.	The capacity of the Bogie Maintenance Hoist is not sufficient to lift a Bogie from the rails as a whole assembly so that operators can access the underside for repair/maintenance.	• Inconsistent/inadequate design • Maintenance concerns	Develop detailed maintenance/repair procedures for the Container Transport Bogies that minimize the need for a lengthy disassembly of bogie parts prior to lifting the failed bogie from the rails
LPH-BMA-1-V003	Use of Bogie Recovery Systems will pull contamination inside the Bogie Maintenance Area.	The wire ropes of the Bogie Recovery Systems sit between the rails between column lines 2 and 14, with a long length (approx. 208 ft - between column lines 3 and 14) located in the potentially contaminated Container Transport Corridor.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Develop maintenance procedures to wipe-out the contamination from the wire ropes before it is dispersed inside the components of the Bogie Recovery Systems located in the Bogie Maintenance Area
LPH-PC-1-V001	High ambient air temperatures in the pour cave affect pour cave equipment and cause a natural convection air plume out of the top of the open pour cave/bogie tunnel door.	The CFD engineering analysis performed to analyze pour cave temperatures only modeled one pour cave and did not consider ventilation interactions with the bogie tunnel. The Mechanical Systems cooling panel heat exchanger analysis allowed a cooling water temperature rise above 10°F to preclude excessive cooling water flows through the cooling panels and this cooling water temperature rise will cause higher pour cave ambient air temperatures. At molten glass temperatures, Technetium oxides are a volatile gas which will be off-gassed into the natural convection thermal plume. The magnitude of the	High ambient air temperatures in the pour cave will affect equipment, container cooling times, and promote the spread of contamination.	• Perform a CFD of the HVAC interaction of the bogie corridor (L-B025B) and all four pour caves at full LAW facility throughput. Install additional cooling in the LAW Facility and modify the LAW Facility HVAC C5V system as required to preclude excessive temperatures based on the CFD analysis. • Convert all the “delay time” requirements in the canister handling

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		problem will not be discovered until full production throughput is obtained on a hot summer day with a buffer storage area full of cooling containers.		scenarios to actual canister temperatures requirements.
LPH-PC-1-V002	Pour Cave shielded windows are overheated.	By WTP engineering calculations, the shielded windows in the pour caves are overheated by a hot container in the cooling position of the pour cave turntable.	Overheating the windows will cause thermally induced cracks limiting visibility through the window.	Design a thermal barrier to prevent radiant heating of the pour cave windows by hot containers in the turntable cooling position.
LPH-PC-1-V003	Filled containers which cannot be promptly exported from the pour cave will require LAW Facility production to be reduced.	WTP engineering calculations impose time delays on export of filled containers from the pour cave to both the buffer storage area and finishing line to preclude overheating. If the downstream container line is choked with non-conforming containers or thermally hot, filled containers, pour cave operations will have to be suspended.	The LAW Facility Production rate will be reduced.	Install temperature instruments to base filled container movements based on temperature of the containers rather than time since the initial glass pour and allow containers which happen to be cool enough to be immediately processed out of the area.
LPH-PC-1-V004	If the Seal head cameras overheat and fail, pour operations through the respective melter spout must be stopped until the camera is replaced.	Electronic devices such as cameras have ambient temperature limits. By WTP calculations, the seal head heat exchangers are overloaded for a period of ½ hour after the fourth pour into a container. This heat exchanger overload period will cause the temperature in seal head to increase and may cause installed cameras to fail.	If the Seal head cameras fail, the pours through the respective melter spout must stop until the instruments are replaced.	Increase the cooling to the Seal head camera areas.
LPH-PC-1-V005	Failure of the Seal head cooling water piping will require shutdown of the Seal head and respective melter pour spout. Leaks will mobilize contamination and increase the risk of the spread of contamination.	Piping is stress analyzed to give some assurance the piping will not fail due to excessive piping stresses. A leak in the small diameter seal head cooling water piping would allow cooling water to leak into the seal head area and drip into the pour cave below. The pour cave is expected to be contaminated to C5 levels and dripping/flowing water will mobilize this contamination. There is no collection sump in the LAW pour caves.	A leak in a Seal head cooling water line would require the shutdown of the respective melter pour spout to isolate the cooling water leak. A leak from the Seal head piping would drip/run into the pour cave below. The LAW Facility is not permitted by the State of Washington to have contaminated / radioactive water running over the floor.	Perform a B31.3 piping stress analysis on the Seal head cooling water pipe.
LPH-PC-1-V006	• Air temperatures of up to 650°F on loss of pour cave cooling water will cause severe equipment problems. • Inadequate pipe sizing may cause cooling water supply problems.	• Calculation 24590-LAW-M4C-C5V-00001, CFD Analysis of LAW Pour Caves (with additional cooling) and Finishing Lines, Conclusion 8.10.2, 7th bullet, page 186 reports the air temperature in the pour cave are approximately 650°F upon loss of cooling water. • Rule-of-Thumb pipeline sizing has been successfully used for many years in a large variety of industries. Undersized piping will make itself evident during startup operations with high pipeline velocities. Oversized piping will have low pipeline velocities and accumulate sediment.	• A loss of cooling water may expose pour cave equipment to excessive temperatures. • Improperly sized piping will be discovered during flow balancing and startup operations delaying the correction of pipeline problems to startup and commissioning phases.	• Install backup cooling systems as required to mitigate a loss of pour cave cooling water. • Perform an Engineering calculation to verify the Rule-of-Thumb sizing method chose the correct piping sizes, or accept the risk and wait until startup and fix any incorrectly sized piping then.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-PC-1-V009	• High container temperatures due to inadequate container cooling directly impact LAW Facility throughput. • Excessive yielding of the container flange may preclude sealing of the container with a lid which must be inserted into a round hole and create non-conforming ILAW packages.	Calculation 24590-LAW-M4C-C5V-00001, Figure 49 Sheet 117, plots a graph of the temperature of a filled LAW container flange area versus time. At hour 20, calculation 24590-LAW-M4C-C5V-00001 estimates the maximum temperature of the flange area on the filled container will be just under 1,000°F. This temperature is well above the 600°F temperature required to perform a safe lift of the container with the pour cave hoist/grapple without deforming the container flange.	Lifting a container by its flange before the stainless steel has cooled sufficiently will deform the upper flange. It may well lead to the situation where the container lid cannot be inserted into the flange.	Increase cooling to the filled container flange area to reduce the time it takes for the container flange to cool and regain its strength. Install an instrument to measure the temperature of the filled container in the cooling position on the Turntable
LPH-PC-1-V010	While the container grapples are reliable, failure of the grapple to release a container will shut down operations in the respective pour cave and could require extensive recovery efforts.	The LAW Container grapple can be manually released from the container with an emergency release operated by an MSM as is stated in the system description. However, the MSMs are not procured and not installed. The ability of the MSM to reach the release pins on the grapple will be problematic. Pulling the release pins on the grapple will probably require a manned entry with personnel working off of a ladder to reach the release pins on the grapple stuck on top of the can fifteen feet above the floor.	Pour operations in the affected cave will be stopped until the grapple is removed from the container and a new, operable grapple is installed on the pour cave hoist.	Design and procure a Grapple that can be remotely disengaged.
LPH-PC-1-V011	After cutting the pour cave hoist cable, recovery of the pour cave will involve a manned entry with containers in the pour cave.	While the pour cave hoist cable can be cut remotely if the pour cave hoist fails when attached to a container in the pour cave, it will require a manned entry into a pour cave with filled containers to secure the load prior to cutting the cable and further manned entries to recover the grapple fouled with the cut cable. Recovery of the grapple will be elevated work from ladders.	Pour Cave operations in the affected cave will be stopped until the wire-rope- fouled grapple is removed and the filled container is recovered. Dropping a full container in the Pour Cave may damage equipment.	Install a hoist with redundant drives for the trolley wheels, and hoist to allow independent recovery without cutting the hoist cable.
LPH-PC-1-V012	The contamination levels in the pour caves will be a mystery until a sample is taken or an entry is made.	While the System Description describes a Continuous Air Monitoring (CAM) system installed in the Pour Cave to allow retrospective analyses to be done. However, no CAMs are permanently installed and connections are only provided for portable CAMs. Contamination off-gassed by the hot containers will be distributed throughout the pour cave by the thermally driven natural circulation air plume.	Contamination levels in Pour Caves will be unknown and no retrospective analysis of contamination levels can be done. When personnel enter the pour cave, contamination on the floor and equipment they mobilize will not be known.	Install the CAM system described in the System Description to allow retrospective analyses to be done for the pour caves.
LPH-PC-1-V013	• Overpacks, and containers within overpacks, will not be able to be remotely handled, limiting LAW Facility throughput if manual handling must be done. • Use of conventional lifting & rigging gear will increase the quantity of potentially contaminated items which must be handled and controlled.	There is currently no equipment supplied to remove a container from the turntable if either the flange is distorted or a buildup of glass interferes with the engagement of the grapple, or if a glass overflow "glues" the container/overpack to the Turntable. A manned entry will have to be made into the pour cave to recover the Pour Cave.	The inability to lift a container from the Turntable will stop operations in that pour cave until the container is cleared and force the opposite spout of the melter into single pour operations. Manual handling will require Pour Cave entries with filled containers present. The amount of contaminated lifting equipment will be increased.	Design and procure a lightweight, high strength, remotely handled, lifting frame to handle overpacks, and containers in overpacks, when lifting them to/from the Pour Cave Turntable is required.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-PC-1-V014	The natural circulation hole in the Container Lower Overpack will increase radiant heating of the Turntable and Turntable base.	The original design of the Container Lower Overpack was a closed bottom overpack with 1" of thermal insulation to prevent overheating the Pour Cave Turntable. The Lower Overpack was modified to promote natural air circulation past the container and allow heat to be transferred via thermal radiation out the bottom of the container. This radiant energy will now heat up the lower Turntable area.	The impact of higher temperatures due to radiant heating must be determined for the Turntable seismic analysis, the turntable bearing, the Turntable heat exchanger, and the concrete below the Turntable.	• Perform a CFD thermal analysis of the pour cave turntable with radiant heating from the modified overpack. Re-perform the turntable seismic analysis if the temperature increase exceeds the bounds of the existing seismic analysis. Install heat shields and thermal insulation on the turntable as required. It is suspected that Pour Cave L-B013C will have the highest temperatures during normal operation. • A new thermal analysis of the Turntable should be done, and if the Turntable metal temperatures increase above the Turntable's seismic analysis temperature assumptions/limits, a new seismic analysis should be done.
LPH-PC-1-V017	Potential equipment damage to Pour Cave Turntable locking actuator.	The Elevator/Turntable Vendor Manual 24590-CM-POA-MJW0-00001-11-00001 page 454 of 989 cautions that jamming the actuator by driving the actuator against an immovable object and thus overloading the actuator severely can damage the actuator. The end of the Turntable locking pin is tapered to engage the turntable, slightly move the turntable if required to precisely position the turntable, and then precisely lock it in position (24590-CM-POA-MJW0-00001-03-87, Supplier's Submittal - Turntable Drive Cassette Assembly). Driving the high reduction pinion gear drive backwards will require significant force.	A slight misalignment or Turntable binding may jam the actuator and damage it.	Ensure a timer in the control system is monitoring the run time of the Turntable locking actuator motor. If the actuator motor exceeds a run time setpoint, the control system stops pour cave equipment operations until Operating/Maintenance personnel have investigated and corrected the failure of the Turntable locking pin actuator to lock the turntable in position.
LPH-PC-1-V018	Overheating the Turntable bevel gear drive oil, will reduce the life of the bevel gear drive.	The Turntable Vendor recommends Hub City Lubricant GL-90 for ambient temperatures of 15°F to 125°F and for ambient temperatures above 125°F to consult the factory. With the removal of the bottom of the Container Lower Overpack to promote natural convection cooling, the Turntable bevel gear drive (24590-CM-POA-MJW0-00001-03-84, Supplier's Submittal - Elevator Assembly) will be exposed directly to the bottom of hot containers in the cooling position. This will heat up the bevel gear.	Overheating the Turntable bevel gear lubricant will reduce the operating life of the bevel gear. Failure of the bevel gear drive will stop Pour Cave operations.	Use a synthetic oil with a higher rated operating temperature and install a heat shield to protect the Turntable bevel gear drive from the hot container sitting in the Lower Overpack.
LPH-PC-1-V019	Overfill of container will impact facility throughput, require immediate maintenance actions, result in a large contamination cleanup effort, and impose unplanned costs on the facility.	Duratek Vendor Submittal 24590-QL-HC4-W000-00011-03-00256 Section 5.2.1 page 46, discusses the ramifications of container overfill and suggests two methods of recovery. The first method is to lower the container and spill the excess molten glass into the pour cave below. The second is to let the glass cool and	• Allowing the glass to solidify in the melter bellows before lowering the container to the Pour Cave Turntable would cause damage to the melter pour spout and Seal head assemblies.	Install an overfill spout to direct the molten glass to a safe area. A system similar to the WTP HLW melter installation could be used. The WTP HLW melter has a spill port closed by a disk secured with an aluminum bolt that

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		solidify and then through mechanical means separate the bellows with the column of glass in it from the melter and lower it into the pour cave and then replace the pour spout components. Both of the suggested Duratek methods of recovery could have very serious operational concerns. In Section 5.2.1.1.1 Duratek states that spilling molten glass has been done on several occasions at the LAW pilot melter and reduced the time required to recover from a container overfill. LPH System Description, Section 7.3.10, page 46, discusses recovery of an over-filled container says an over-filled container is lowered to the turntable and rotated to the cooling position. However, the System Description does not say if the overfilled container will be lowered with the glass still liquid, or if delay is imposed to allow the glass to solidify.	• Spilling the molten glass to the Pour Cave below would coat the Elevator, container, and Turntable with hot glass. • Both paths forward will require extensive repair efforts to recover the melter pour spout and Pour Cave.	will melt when exposed to molten glass and spill the molten glass to a safe area in the cave below the canister.
LPH-PC-1-V020	Failure to detect glass build-up in a Melter spout bellows can lead to blockage of the bellows and render the respective Melter pour spout inoperable.	Theoretically, the tip of the melter pour spout is aligned with the container flange hole below the spout so that the glass falls from the melter spout into the container. When Duratek performed the LAW container prototypical pours per 24590-101-TSA-W000-0009-101-00007, RPP Pilot Melter Prototypic LAW Container and HLW Canister Glass Fill Test Results Report, Duratek had a pour spout streams that deposited glass on upper surfaces of test containers LT002 and LT003. This indicates the prototypical pour stream has a variation greater than the radius of the prototype container flange hole. The prototype containers had the same nominal 16" container flange hole diameter as the LAW facility production containers will have. However, at the LAW Facility, any wavering glass will not hit the flange of the container. It will hit the bellows piece 4 on detail drawing 24590-QL-HC4-W000-00011-03-00244, Supplier's Submittal – Canister Seal Ring Details. The bellows piece 4 has a 13" diameter hole. Duratek submittal 24590-QL-HC4-W000-00011-03-00256, LAW Glass pour spout final design resolution, sections 5.2.1.2 and 5.2.1.3, pages 47 through 49, discuss the impact of a wavering glass stream and the resulting glass build-up.	• If the glass builds up in the bellows, it can block the pour stream and render that Melter pour spout inoperable. • If the pour is continued through the blocked pour spout, a glass spill will occur. • Failure of the container to fill cannot be detected by the infrared camera when the level is low in the container since the camera cannot see the lower portion of the container. • Observation of the weight increase indicated by the Elevator load cell will be problematic since the bellows diameter/area is much smaller than the container diameter/area.	Install a camera in the Pour Cave to look upward into the bellows when the container is lowered to the Turntable to allow the Operator to determine if any glass is building up on the Melter pour spout bellows.
LPH-PC-1-V021	If the replacement melter Vendor uses original design drawings rather than "as-built" drawings to determine allowable Melter pour spout installation tolerance, the replacement melter may not be able to pour glass into a container.	The WTP Project appears to have used just about all of the available installation tolerances for the melter / turntable / elevator / canister installations to allow a +/- 1" centerline installation tolerance over the original design installation tolerance of +/- 5/16". The computation for the tolerance stack up is done in Field Change Request 24590-WTP-FC-M-12-0350, LAW -	If all the tolerances for installation of equipment are used by the WTP Project during the initial installation, then the follow on vendors / installers will have to work to tighter installation tolerances.	Create a Melter replacement document that captures all the special places the Melter replacement Vendor must fabricate the replacement Melter with tight dimensions and tolerances which are Not-To-Be-Exceeded in any case.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		LMP-MLTR-00001 & 2 Melter Centerline and not done in an Engineering Calculation.		
LPH-PC-1-V022	Installation of an Elevator weigh instrument with a very small or no temperature margin can cause operational and maintenance problems.	• The insulation on the Container Elevator steel is on the outside of Elevators in room L-B012 & L-B-014 and not on the Pour Cave side of the Elevator steel inside the Pour Caves. The load cell is installed below the horizontal shaft bearings in the load path between the Elevator bearings and the LAW Facility embeds. The lower shaft is inside the elevator insulation. Calculation 24590-LAW-M4C-C5V-00001, Figure 36, sheet 107 calculates an Elevator steel temperature of 180°F to 300°F depending on where in the pour cycle the process is and an average temperature at the steel / insulation interface of about 105°F. Per figure 39, sheet 110, when the Serapid chain and elevator lifting arm are supporting the container in the pour position, the Serapid chain and container lifting arm near the top of the pour cave should go to near the calculated steel temperatures and this temperature could be 300°F to 500°F. • When the full container is lowered to the Turntable, the Serapid chain is withdrawn into the chain canister in rooms L-B012 & L-B014 and the lifting arm is near the bottom of the Elevator. The hottest portion of the chain and lifting arm will heat up to the lower elevator metal. The load cell is installed in this area of the elevator (The load cell is tagged with note 12 on drawing 24590-CM-POA-MJW0-00001-03-49, Supplier's Submittal - Elevator Lift Table Weldment, section BB). If the Elevator steel starts at a temperature of 105°F the hot lifting arm and Serapid chain will increase this temperature until an empty container is raised to the pour position. The temperature of the load cell will probably be over 95°F since it will be inside the insulation and in contact with the Elevator steel.	The Elevator load cell should fail safe and the load cell failure will stop the pour from the respective Melter spout until the load cell is replaced. This will force the LAW facility into a single pour mode of operation with the Melter's opposite spout. Single pour operations cause higher Pour Cave temperatures and higher container temperatures, which may lead to the early failure of the second load cell monitoring the single pour operation. If the load cell does not stop a pour on high container glass weight, overfill of container will impact facility throughput, require immediate maintenance actions, result in a large contamination cleanup effort, and impose unplanned costs on the facility.	Install an Elevator load cell that is rated for the temperature of the installation area.
LPH-PC-1-V026	Indeterminate specification of mode of operation for the Model 60 series Container Elevator load cells may cause problems if an improper mode is used.	The Elevator Vendor Manual 24590-CM-POA-MJW0-00001-11-00001, chapters 4, 5, and 6, beginning on page 319, details the various operating modes the Model 60 series load cell controller can perform: Counting Mode, Known Container Weight, Accumulation Mode, Truck-in/Truck-out, and several other operating modes detailed in the vendor manual; it is a versatile instrument. At first glance, the Accumulation Mode given on page 323	If the "Accumulation Mode" is selected, then a continuous pour will cause continuous motion and when the control system requests an accumulation, a "Mot'n Delay" prompt is displayed until motion ceases.	Specify a proper instrument mode of operation to preclude overfill of a container

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		appears to be the mode to choose. However, the LAW containers will be continuously filled for a one hour period with a constant stream from the pour nozzle and the Vendor Manual page 323 says if motion is occurring when an accumulation is requested, then a "Mot'n Delay" prompt is displayed until motion ceases. This may make weighing the container problematic when the weight is continually increasing during the pour.		
LPH-PC-1-V028	It appears the control system will allow a full container to be raised to the pour position. This will increase the risk of overfilling a container.	LPH System Description, Section 7.2.1, page 36, says that each Elevator has a set of load cells to determine the state of the container prior to pouring: whether the container is full, partially full, or empty. The intent is not to raise a full container to the pour position and initiate another pour because it may overfill a container. 24590-LAW-J3-LPH-01014, LAW Container Pour Handling System LPH Elevator Weight LPH-ELEV-00001, 00002, 00003, and 00004, pass signals to drawings 24590-LAW-J3-LMP-00008, LAW Melter 1 Discharge Airlift Instrument Air Valves, and 24590-LAW-J3-LMP-00010, LAW Melter 2 Discharge Airlift Instrument Air Valves, to indicate a full container is present and to override close the respective melter airlift valve.	The J3 drawing 24590-LAW-J3-LPH-01014 does not follow the intent of 24590-LAW-3YD-LPH-00001, System Description for the LAW Container Pour Handling System (LPH), and a partially full or completely full container could be raised to the pour position.	Update the LPH system Description to reflect how the control system will control the system. If the control system will not perform/provide an acceptable control scenario to meet System Description requirements, revise the control system.
LPH-PC-1-V029	During shift turnovers, if a partially filled container is placed on the Turntable for the next shift to complete the filling process, the oncoming Operator may not know a partially filled container is present if turnover is not proper. If the weight of the "empty" container is tared upon lifting it with the elevator, the container may be overfilled.	• 24590-LAW-M1-LPH-00001, Mechanical Sequence Diagram (MSD) For LAW Vitrification System LPH, page 36 of 37, step 3.1 has the Operator determining that the pour cycle is complete and that an Empty Container is staged in Import/Export position of Turntable. Determining an empty container is staged in the Import/Export position of the Turntable may be difficult. The operator must do it by reviewing shift or turnover logs. The container is sitting on the Turntable in the Pour Cave with its 16" diameter opening in the top flange of the container about 12 feet in the air. There is no camera in the Pour Cave that can look down through the 16" diameter opening in the top of the container and see the bottom of the container. There will probably not be enough light inside the container for the operator to see anything if a camera was available. It is unclear how the Operator determines the container is empty other than written logs. • Further, during the life of the facility, there is the possibility that a container will be partially filled and the pour will be interrupted due to a problem in the	A container can be overfilled if the Conduct of Operations is not strictly adhered to.	Strictly control the topping off of a previously poured container with an Operating Procedure. Install instrumentation (cameras) and lighting to allow the operator to inspect the container internals after moving the container to the Pour Cave Turntable.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		facility. This will result in the situation where a partially full container must be raised to the pour position and filled to 90%. A container that has had glass poured into it undergoes thermal oxidation as a result of the glass pour; a new container is bright stainless steel, and the poured container is discolored. So if a container is 30% or more full, the operator should be able to see it in the camera. However, the container overpack is 29 inches tall; a container could have 20 inches of glass poured in it and the resulting container discoloration that will be hidden by the overpack. The infrared camera will not detect a glass level in a cold container. Overfilling this container may be problematic if the load cell is tared.		
LPH-PC-1-V030	Non-installation of Pour Cave MSMs transfers items to the LAW Facility Operations Contractor. Insufficient equipment complicates recovery operations and increases the risk of the spread of contamination; may impose operational delays.	While the Pour Cave windows have penetrations for MSMs above the windows, no MSMs are called out on the drawings. They are shown on drawings 24590-LAW-P1-P23T-00005, Equipment Location Plan EL. (-) 21'-0"/ Area 4, Note 8, and 24590-LAW-P1-P23T-00006, Note 7, as being shown for space allocation only. LPH System Description, Section, page 32 states the MSMs will be installed or removed as needed. Section 6.2.19, page 32 and 33, describes tasks the MSMs may perform on an as needed basis. The WTP Project has procured spare MSMs and is holding them in the spares inventory for use as needed. The WTP Project is not providing any MSM tools for use in the pour caves and they will have to be developed / designed / imported on an as needed basis.	Pour Cave recovery efforts may be complicated and delayed if the Operators have to move MSMs from another location and work around the inability to easily import MSM tools into the pour caves.	Provide MSMs or other equipment capable of performing Pour Cave recovery operations.
LPH-PC-1-V031	Cracking of the Pour Cave viewing windows may limit viewing.	The Pour Caves viewing windows are overheated by the close proximity of a filled LAW container sitting at the cooling position on the Turntable. 24590-LAW-M4C-C5V-00001, CFD Analysis of LAW Pour Caves (with Additional Cooling) and Finishing Lines, Section 8 and calculation 24590-LAW-M4C-C5V-00005, Conclusions Section 8.3, sheet 29, conclude the Pour Cave viewing window limit of a 2°F per hour heat-up rate is exceeded for the various configurations and thermal shields analyzed. It is unclear what the WTP Project path forward is to prevent overheating the Pour cave shield windows with a cooling container in the turntable cooling position.	Pour Cave recovery efforts may be complicated and delayed if the Operators have to work around cracked viewing windows.	Remove the Pour Cave windows, install video monitors at the Pour Caves, and install more replaceable cameras in Pour Cave to replace the viewing window functionality.
LPH-PC-1-V032	• Contamination on the surface of the Container Lower Overpacks may be physically pressed and imbedded in the lower surface of the container at	Calculation 24590-LAW-M4C-C5V-00001, Figure 47, sheet 116, reports that during glass pour number 1 the maximum container surface temperature will be on the order of 2,100 °F. Calculation figure 46, page 116, says	• Contamination will be pressed into the container due to the differential expansion of the container relative to the Lower Overpack. Further the	• Remove the Lower Overpack ribs as recommended by the analysis in Vendor submittal 24590-QL-HC4-W000-00085-T07-02-00001.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	8 locations. The indentations will increase complexity of the decontamination process since "indentations" are being decontaminated rather than a smooth cylinder. • Thermal distortion of the Lower Overpack may cause binding of the container and Overpack.	the peak average container temperature is 1,413 °F. However, during the first pour, the molten glass fills the lower ¼ of the container and thus the bottom of the container will be closer to glass temperature than the container average temperature. The projected mean coefficient of thermal expansion for 304 stainless steel will be on the order of 12.94 x 10-6 in/in °F in a temperature range of 32°F to 2,100°F. The container diameter will thermally expand and increase from 48" to about 49.26". The relatively cool Lower Overpack has eight, ½" thick, 4 ¼" tall, alignment ribs in the bottom of the Overpack with an inside diameter of 48.600 +/- 0.10". Per Engineering Calculation Change Notice 24590-LAW-M4E-C5V-5, the container overpack will heat up to 450°F to 638°F 2.5 hours after the pour starts. Vendor submittal 24590-CM-POA-MJW0-00001-02-07 shows high temperature vertical stripes on the Overpack where it appears the container is hitting the interior ribs and transferring heat due to direct conduction. Vendor submittal 24590-QL-HC4-W000-00085-T07-02-00001, Structural & Thermal analysis of pour cave elevator/overpack, shows the temperature of the overpack one hour after the pour starts. This thermal analysis also has high temperature vertical stripes in the vicinity of the overpack ribs. The LAW Container will heat up and expand much faster than the Lower Overpack. There appears to be nothing that prevents the container from expanding around the ribs and yielding to form 8 indentations (1/2" wide, 4 ¼" tall", & 1/3" deep) around the lower circumference of the container. These indentations may affect the ability of the LFH System to decontaminate the container and the LFH swabbing system to swab the container. Given the above, the overpack will also cool and thermally contract faster than the filled container. Uneven heating / cooling cycles can cause distortion in metal parts. 24590-QL-HC4-W000-00085-T07-02-00001 recommended changes to the Lower Overpack such as cutting notches in the overpack support rings and removing the increase in thickness in the lower overpack alignment webs. These recommended changes were not done by the WTP Project per the rationale given in CCN 226706 WTP Rationale to close LAW Overpack/Elevator Technical issue 2009-000. Without the notches in the	container will be indented by the Lower Overpack ribs and make decontamination and swabbing more problematic. • Not slotting the upper rim flanges as recommended by the Vendor performing a thermal analysis of the overpack, may lead to thermal distortion of the Lower Overpack rim flanges after repeated thermal cycles to 600+°F over several years of operation. • If a container becomes stuck inside a Lower Overpack, there does not seem to be a way to remotely un-stick the container.	• Cut slots in the Overpack upper rim flanges recommended by the analysis in Vendor submittal 24590-QL-HC4-W000-00085-T07-02-00001.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		overpack support rings, they are susceptible to thermal distortion which will occur every time a container is poured and will build up over years of operation. If the overpack contracts faster than the filled container, the alignment webs can contact the container. It is unclear how an Overpack stuck to a container is removed from the container		
LPH-PC-1-V034	A review of Maintenance, Operating, Emergency, and Abnormal Operating Procedures for Pour Caves could not be done to verify no vulnerabilities exist.	At the present time maintenance, operating, emergency, and abnormal operating procedures have not been completed by the WTP Project. These items could not be reviewed for the Pour Cave Operational Vulnerabilities. Review of the procedures for adequacy and correctness must wait until the procedures are written, validated, and issued by the Project.	There is a delay in determining if operating vulnerabilities exist for the Pour Cave equipment.	Expedite the creation of the maintenance, operating, emergency, and abnormal operating procedures so they can be reviewed for Operational Vulnerabilities.
LPH-IC-1-V003	ICN Screens don't use equipment noun names.	The LPH System Description, the Mechanical Handling Diagrams, the Mechanical Sequence Diagrams and the Computer Software Logic Diagrams all refer to 24590-LAW-MQ-LPH-TRLY-00001/00002/00005/00006 as the Container Transport Bogie. However, in the System Design Document for LAW Container Pour Handling (LPH) System (24590-LAW-PISW-J-08-0023-01), the ICN screens, "Transport Carts", "Transport Carts - Recovery", "Buffer Store Crane - Bridge and Trolley", "Buffer Store Crane - Recovery" and " LAW Container Pour Handling - Maintenance" all refer to the Bogies as Carts.	The inconsistent use of noun names will encourage confusion among different disciplines. A maintenance person trained on Engineering and Operations documents will be confused by the screens. Screen Captures made for reports or troubleshooting or for the Traveler verifying the Waste Acceptance Criteria will not be consistent with other facility documentation. This is not proper from a Conduct of Operations perspective.	Revise the ICN screens to use labels that are consistent with facility documentation. .
LPH-HST-1-V001	LAW Pour Cave Hoist Data Sheet Inconsistencies	LAW Pour Cave Hoist data sheets (24590-LAW-M0D-LPH-00053/54/55/56) do not provide a clear basis for the design. The hoist calculation that is referenced is cancelled, the specification that is inaccurately referenced, and there is no documented basis for the operating requirements (number of lifts per day, moves per day, and operating envelope).	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment	Provide a detailed analysis of the requirements of the pour cave hoists. Establish a bounding design and document the basis in a formalized document that provides the specific inputs used in the design (provide details for hoist sizing, operating envelope, number of movements, travel speeds, etc.). Review this information against what is procured and define what requirements need to change or what items already procured need to be modified to meet the requirements. This analysis needs to be documented as well.
LPH-HST-1-V003	LAW Pour Cave Hoist High Hook Limit Related to Preliminary Container Recovery Frame Design	The high hook limit of the Pour Cave hoists (LPH-HST-00001/2/3/4) is adequate for container handling into/out of the turntable as well as lifting the proposed container recovery lifting frame during off-normal events. The	• Inconsistent design basis • Inadequate design margin	Establish a bounding design envelope for the container recovery lifting frame and complete the design for it. Provide a design that is consistent with the

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		design of the recovery lifting frame (LPH-RCVY-00003) is preliminary and based on the proposed 24590-LAW-M0-LPH-00024, Rev. 0, Design Proposal Drawing - Container Recovery Lifting Frame, the lifting flange is inadequate to support the load. Any future changes to the lifting frame design must remain within the bounds of the hoist high hook envelope. The current recovery lifting frame DPD does not reference the hoist operating envelope limitation or bound the frame to any specific dimension.	• Potential for Operational Impacts and Risks to Commissioning Phase	requirements for off-normal events (load limit, flange design that can be grappled, flange design that can support the load limit, etc.).
LPH-BFSTR-1-V002	Additional interlocks needed for transfer corridor shield doors.	24590-LAW-M0D-LPH-00030, Mechanical Handling Data Sheet Shield Door, Transfer Corridor, North, and 24590-LAW-M0D-LPH-00031, Mechanical Handling Data Sheet Shield Door, Transfer Corridor, South and design proposal drawings 24590-LAW-M0-LPH-00012001, Transfer Corridor Shield Door (South), and 24590-LAW-M0-LPH-00013001, Transfer Corridor Shield Door (North), requires a door closed and door open position sensor. These door position sensors are utilized as sequence specific interlocks, per 24590-LAW-M1-LPH-00001 Mechanical sequence diagram for system LPH, to ensure the buffer store bridge crane is prevented from colliding with shield doors during the transition from the buffer storage area to the store maintenance area. However, no such interlocks exist for the buffer store crane bridge device specific interlocks, per 24590-LAW-M1-LPH-00001 Mechanical sequence diagram for system LPH.	Additional risk of a collision between the crane or load with a closed maintenance shield door. This door could be left closed after a maintenance event and the operator will have to totally rely on visual methods to ensure the path is clear.	Add the shield door position sensor inputs as an added interlock for all crane bridge movements. This will lower the risk of a collision due to human error.
LPH-TOOL-1-V001	Inadequate design basis documentation.	Failure to provide accurate design requirements in data sheets, drawings, and test documentation.	Maintenance and operations will spend time researching and establishing the design basis for equipment.	Revise design and fabrication documentation to ensure accurate and as-built information.
LPH-TOOL-2-V001	Inconsistent grapple load rating.	Mechanical Handling Data Sheets - LPH-LAW Product Container Grapples Pour Cave 24590-LAW-M0D-LPH-00009, 24590-LAW-M0D-LPH-00010, 24590-LAW-M0D-LPH-00011, 24590-LAW-M0D-LPH-00012, 24590-LAW-M0D-LPH-00013, 24590-LAW-M0D-LPH-00014, and 24590-LAW-M0D-LPH-00015 LPH-LAW Product Container Grapple Buffer Store, all require the grapple load capacity to be 10 ton (20,000 lbs.). However, 24590-WTP-3PS-MQL0-T0003, Engineering Specification for Special Grapples and Lifting Devices, section 3.8.2.1 requires a safe working load of 16,500 lbs. The 24590-WTP-ICD-MG-010015 (ICD 15), Interface Control Document for Immobilized Low Activity Waste,	Confusion with basis of design.	Increase the grapples safe working load design to 25,000 lbs. to handle all container conditions.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		allows the mass of each package to not exceed 10,000 kilograms (22,046 lbs.).		
LPH-TOOL-2-V002	LAW production container volume, weight, and center of gravity calculation, 24590-LAW-M0C-LRH-00004, does not include an Overpack condition.	An abnormal condition could occur if the container cannot be decontaminated and over packing is required to be added to the container.	Special container handling devices will be required to handle off-normal conditions	Revise calculation to include the addition of over packing material to the outside of the container. This will provide a basis for future non-conforming container handling designs.
LPH-TOOL-2-V003	Grapple temperature limitations.	24590-QL-POA-FH00-00001-08-00001, Supplier's Submittal - LAW Container Grapple Stress Analysis, indicates that the reserve factor is barley met with a load of 16,500 lbs. and a flange temperature of 600°F. The CFD Analysis of LAW Pour Caves and Finishing Lines, 24590-LAW-M4C-C5V-00001, indicates the surface temperature of the pour container neck and flange vs. time will be much higher than 600°F. The analysis, shown in figure 49, stops after 20 hours but the trend is to be well above 800°F after 28 hours. This temperature range would prevent the container movement under the single pour operating conditions. The alternating pour operating conditions may or may not be an issue based on this data, so the analysis should be redone to include additional time and cooling conditions.	Since the grapple is a common design the temperature limitation is as important as the safe working load limitations. These conditions could lead to unsafe lifting conditions and/or prevent the melter single pour operating condition.	Add grapple markings to clearly identify temperature limitations the same way safe working loads are identified. Consider adding instrumentation to directly measure the container flange temperature, in the pour cave, prior to using the grapple.
LPH-TOOL-2-V004	Grapple excessive load testing.	24590-WTP-3PS-M000-T0002, General Specification for Remote and Mechanical Handling Equipment Design and Manufacture, Section 3.4.3.10, indicate that lifting attachments shall be factory load tested at 125% of rated load in accordance with ASME B30.20-2010, Below - The-Hook Lifting Devices, Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, jacks, and Slings. The ASME B30.20, Below the hook lifting devices, section 20-1.3.8.2 indicate that test loads shall not be more than 125% of the rated load unless otherwise recommended by the manufacturer. The testing requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.6.c requires the grapple static load test to be performed at 150% of the SWL and held for 15 minutes.	Confusion with basis of design.	Revise BNI procurement process to ensure vendors test equipment according to contractual documentation and that all requirements are consistent between documents.
LPH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	The design requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.8.2.3 requires the grapple's three fingers to have a combined minimum total contact area of 15 in^2. This requirement was not validated in 24590-QL-POA-FH00-00001-13-00003, Factory Acceptance Test Plan for MR36 LAW Grapples and Grapple Stands, and should have been measured as a critical characteristic of the	Failure to document design requirements.	The requirement should be validated during start-up testing to ensure these critical characteristic are met.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		grapple assembly. This requirement is carried into the LAW Production Container Stress Analyses, 24590-LAW-M0C-LRH-00003, which indicates that at hour 20 the container flange temperature is 457°F and can be safely moved without the container flange reaching yield stress limit. However, this analysis container flange temperature does not agree with the CFD analysis, the grapple contact area is less than half the actual grapple contact area, and the container load is assumed to be 16,000 not 16,500 lbs.		
LPH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	• Specification requirements in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.7.g indicate the grapple will be tested to ensure it is capable of maintaining its engagement even if the load is laid on its side and the tension on the bail is relieved; the grapple shall then be capable of lifting the load when the hook is raised, all as part of the 20 complete cycles simulating actual operating conditions. The simulated operating conditions test consisting of 20 completed cycles is performed in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test plan for MR36 LAW grapples and grapple stands section 3.A.4, but this step is omitted. • 24590-LAW-3YD-LRH-00002, System Description for the LAW Container Receipt Handling System (LRH), section 4.1.2.1.2, indicates the grapple, in the disengaged position, shall be capable of being inserted into and withdrawn in a vertical direction from a right-circular, cylindrical cavity with a diameter equal to that of the container. This requirement would qualify as a critical dimension and should have been verified during the factory acceptance testing performed and documented in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test plan for MR36 LAW grapples and grapple stands. • The specification for special grapples and lifting devices, 24590-WTP-3PS-MQL0-T0003, section 3.2.2.3 requires the grapple to be capable of being remotely engaged and disengaged from a container that is standing on its base, with the container's centerline within five degrees of vertical. This requirement was not tested or verified in the factory acceptance test plan for MR36 LAW grapples and grapple stands, 24590-QL-POA-FH00-00001-13-00003.	Failure to test and document that the design requirements are met.	All required performance design requirement should be performed as part of an additional FAT or demonstrated through analysis.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-BSMF-1-V003	Buffer Store Maintenance Facility Crane (LPH-CRN-00001) issues.	The basis document for the rated capacity of the Buffer Store Maintenance Facility Crane has been cancelled, and the Mechanical Data Sheet has become the "controlling source of the crane capacities". Some dimensional inconsistencies exist between the Mechanical Data Sheet and general arrangement drawings.	Adversely affects ability to confirm design meets requirements and operational envelope	Prepare a document that evaluates potential loads to be lifted by the maintenance crane.
LPH-OR-1-V003	Inconsistencies in the MTBF data for the Buffer Store Crane.	24590-CM-POA-MJKG-00003-15-01, Failure Mode, Effects, Reliability, Maintainability, and Criticality Analysis, which was prepared by the crane manufacturer, states the MTBF is 3,300 hours. However, the MTBF for the crane is listed as 35,040 hours on page 1 of Attachment 9 of CCN068381. The CCN references 24590-CM-POA-MJKG-00003-06-03, Spare Parts List and Cost, LAW Buffer Store Crane, as the basis the 35,040 hours. There is no information in 24590-CM-POA-MJKG-00003-06-03 that justifies the significant increase in the MTBF. To further confuse the issue, Table 75 of 24590-WTP-MDD-PR-01-001, Operations Research (WITNESS) Model Design Document, indicates an MTBF of 730 hours for the Buffer Store Crane. A rationale for which value is the most appropriate could not be located.	Results of the OR Model may be inaccurate because the input data may be inappropriate.	Develop and document a robust logic for the Buffer Store Crane MTBF value to be used in the OR Model and update the OR Model accordingly.
LPH-OR-1-V004	24590-WTP-MDD-PR-01-001, Operations Research (WITNESS) Model Design Document, inconsistencies.	Section 6.6 and Table 71, of 24590-WTP-MDD-PR-01-001, Operations Research (WITNESS) Model Design Document, indicates the number of ILAW containers in the model has been reduced from 18 to 12 storage spaces due to height constraint in the buffer storage area. However, Note 5 of 24590-LAW-J3-LPH-02011001, Sequential Function Chart LPH Filled Container To and From Buffer Storage LPH-CRN-00002, provides the sequencing of how the ILAW containers will be stored in the Buffer Store and Rework Areas and lists 11 storage locations.	Results of the OR Model may be inaccurate because the input data may be inappropriate.	Revise the OR Model to be consistent with the current sequencing and handling strategy.
LPH-CPS-1-V002	Durability of Park/Export Stand thermal insulation material over a 40-year operating life is not documented.	The Vendor's submittal does not provide evidence that the selected insulation material will maintain its insulating properties and protect the floor for over 40 years in the conditions of its application inside the Transfer Corridor L-B025B.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Resume contacts with Pittsburgh Corning Corp and obtain documented evidence of the durability of the selected insulation material over 40 years at 460°F. Modify the existing Park/Export Stands prior to commissioning to provide a way to facilitate the replacement of the insulation material blocks.
LPH-CPS-1-V003	Design of the manufactured Container Park/Export Stands may result in unnecessarily complex maintenance.	Welded retention plates will not make the replacement of the insulation blocks possible (see Note 2) without lengthy hands-on work inside the Transfer Corridor L-B025B.	• Inconsistent/inadequate design • Maintenance concerns • ALARA concerns	Modify the existing Park/Export Stands prior to commissioning to provide a way to facilitate the replacement of the insulation material blocks.

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-CPS-1-V004	Thermal conductivity of the selected thermal insulating material for the Container Park/Export Stands doesn't meet the WTP thermal conductivity requirement.	Thermal conductivity of the selected insulation material is higher than the thermal conductivity requirement for the material which provides insulation to concrete floor from filled Containers. This material offers less protection than defined by the design requirement.	• Inconsistent/inadequate design • Maintenance concerns	Update calculation 24590-LAW-M4C-C5V-00003 using the actual physical properties of the thermal insulation material and verifies that the 4"-thick blocks are sufficient to meet the 150°F maximum allowable temperature for the concrete floor.
LPH-CPS-1-V006	FAT Test of the Container Park/Export Stands was not conducted in a representative temperature configuration.	The temperatures recorded in the FAT Test Report lead to think that the tests were performed by the Vendor at a much lower "ambient" temperature than the expected average temperature in the Transfer Corridor, and don't actually demonstrate that the concrete floor temperature will remain under the 150°F limit when the Corridor temperature will be 113°F (or higher).	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Re-run the heat tests for the Park and Export Stands) in a more representative temperature environment to verify that the concrete floor is not overheated.
LPH-CPS-1-V007	Lack of calculations to support the design and validate the performance of the fabricated Container Park/Export Stands.	There is no documentation (primarily calculations) available that supports the revision of the design of the Stands and validates that the revised final design actually meets the expected performance of preventing damage to the concrete floor from the heat dissipated by the Containers.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Develop documentation (primarily calculations) to validate that the revised final design of the Park/Export Stands actually meets the expected performance of preventing damage to the concrete floor from the heat dissipated by the Containers.
LPH-CTB-1-V005	Performance of IR Transmitters measuring Container surface temperature before export to System LFH is not demonstrated.	Two IR transmitters are used to verify the temperature of the container prior to export to the LFH System. There is no documentation available which describes key features of the transmitters and no evidence that the selected transmitters meet the functional requirements for this essential temperature measurement.	• Inconsistent/inadequate design • Operations concerns	Perform tests of the selected IR Transmitters in a representative environment to demonstrate the performance of these essential Container surface temperature measurement components prior to commissioning.
LPH-CTB-1-V007	Engineering Specification for Transport Bogie design defines a temperature environment not representative of anticipated higher ambient temperatures in the Transfer Corridor.	There are operating conditions and large areas of the Transfer Corridor where the Container Transport Bogies may see ambient temperatures over the maximum specified operating environment of 113°F.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Re-run the Manufacturer's thermal analysis of the Container Transport Bogies for the expected higher ambient temperature range, and verify that the temperatures of the Bogie's most fragile components including the motor and junction boxes remain acceptable.
LPH-CTB-1-V008	Value of the maximum Container weight shown on DPD and in Engineering Specification for Container Transport Bogie is misleading.	DPD and Engineering Specification for the Container Transport Bogie mention a maximum weight of the container at 22,046 lbs. when the maximum filled container mass without lid is 14,902.28 lbs. with a glass density at 2.6 MT/m3 (and 15,422.28 lbs. for the approximate density of glass at 2.7 MT/m3).	Inconsistent design	Revise Note 4 on 24590-LAW-M0-LPH-00026, Design Proposal Drawing Container Transport Bogie, and Section 5.6.2.1.2 of, 24590-WTP-3PS-MQR0-T0003, Engineering Specification for LAW and PTF Bogies, with correct value of product container weight.
LPH-CTB-1-V009	Maximum payload of the Bogie is defined for a service that the Bogie may never be providing during the Facility operating life.	Maximum payload (25,000 lbs.) is defined for the transport of test weights for the overhead hoists located in the Corridor when these test weights should be delivered through a totally different path.	Inconsistent design	Update Engineering Specification 24590-WTP-3PS-MQR0-T0003 and System Description to reflect alternative approach

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				for transporting test weights for the overhead hoists within the Corridor.
LPH-BMA-1-V002	Discrepancy in location of Bogie Maintenance Hoist between Vendor's calculation and Structural Steel Drawing.	There is no evidence that the building steel is adequate to allow the Bogie Maintenance Hoist to be used, which may lead to operational administrative controls to limit live floor loads and to increased maintenance efforts.	• Inconsistent/inadequate design • Operations concerns	Re-run 24590-LAW-SSC-S15T-00015, Calculation - Bogie Maintenance Monorail, with the correct location of the monorail and hoist so that the structural resistance of the structural steel in the Bogie Maintenance Area is verified.
LPH-PC-1-V007	Cold commissioning will demonstrate adequacy of container bottom within a modified overpack. This will allow an adequate container to be procured if required.	Informal computations showed the hydrostatic head of the molten glass was sufficient to challenge the proposed LAW container at elevated temperatures and the lower container overpack was modified to promote natural convection cooling and heat transfer radiated from the container. Pours into the container during cold commissioning will demonstrate the falling glass will not heat up a spot on the container bottom and punch a hole in the weakened metal.	If the container will not resist the impact of falling glass on a hot spot, then a glass spill to the pour cave floor will occur. This would require a slightly more robust container to be procured (perhaps with a splash plate on the bottom of the container).	Perform a prototypical pour of the LAW glass, or accept the risk and test the container during cold commissioning. It any case, this item should be resolved prior to hot operations with radioactive materials.
LPH-PC-1-V008	Increased maintenance entries to restore pour cave lighting.	The electrical lighting calculation selected light fixtures reported on Architectural Drawings. The Architectural Drawings were revised to remove the temperature information. A HVAC calculation predicts a varying temperature of between 126°F to 140°F at the light fixture installation location over a 20 hour period as container pour/cooling cycles are performed in the pour cave. It is unknown if the ballasts in the lights are suitable for these temperatures.	Failure of the light fixtures will require maintenance entries into the Pour Cave.	Evaluate the suitability of the electric light fixtures in the pour caves. This item should be done after pour cave temperatures are re-evaluated.
LPH-PC-1-V015	• A motor with an operating surface temperature of 239°F is a personnel hazard. • The Pour Cave Elevator motors are supplied with a 105°C (189°F) temperature rise creating a personnel hazard greater than 140°F. .	• The Vendor supplied Turntable rotation motor has an 80°C (144°F) temperature rise. • Per data sheet 24590-CM-POA-MJW0-00001-06-05, Supplier's Submittal - Turntable Rotary Lock Assembly, the Elevator motor has a 105°C (189°F) temperature rise. If the ambient temperature in the rooms is 95°F, the motor could be at 284°F.	• Operating and Maintenance Personnel in the room could be exposed to high temperature surfaces. • This is a personnel hazard for people working in the immediate area along the Pour Cave walls in rooms L-B012 & L-B014.	Install a removable, expanded metal heat shield around the motor to prevent personnel from contacting the hot surfaces and still enable maintenance to be done.
LPH-PC-1-V016	Missing Vendor documentation needed to support maintenance.	The Elevator/Turntable Vendor Manual 24590-CM-POA-MJW0-00001-11-00001 page 351 of 989 appears to be incorrectly scanned into the file and separated from the remainder of the Vendor information.	If Vendor information is not available when maintenance needs to be done, maintenance will be delayed until the information is obtained.	• Correct the Vendor Manual 24590-CM-POA-MJW0-00001-11-00001. • Perform an extent of conditions review of the WTP PIER data base and determine if this is a unique occurrence. If the review shows there are enough occurrences of lost vendor documents in PADC, take corrective actions as required.
LPH-PC-1-V023	If maintenance must be performed on the modified Pour Cave Elevator Lift	The Pour Cave Elevator Lift Table per 24590-CM-POA-MJW0-00001-03-36 Rev 00D Supplier's Submittal––	If a lift of the Elevator lifting arm is done using the center-of-gravity located on the	Update the 24590-CM-POA-MJW0-00001-03-36 Rev 00D with a VDCN to

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	Table and it must be lifted from the Elevator, the lift must be planned due the R5/C5 Pour Cave area.	Container Overpack Weldment, was modified per Vendor Drawing Change Notice (VDCN) 24590-LAW-VDCN-MH-11-00009, - Modifications to Turntable/Elevator Overpack and WTP Modifications to Elevator Lift Table, to allow natural convection airflow past the container during melter pours. The VDCN removed a 24"x24"x1 ½" piece of material from Piece #4, removed a 24"x66"x1" piece of material from Piece #1, removed a 24"x66"x1 1/2" piece of material from Piece #3, and added a 5.5"x30"x(unspecified thickness) End Plate. Simplistically, the total volume of steel removed from the elevator pour lift table is about 4,701 cubic inches (2.7 cubic feet) and this much steel will weigh about 1,360 pounds. 24590-CM-POA-MJW0-00001-03-36 Rev 00D Note 5 gives the elevator lift table a calculated weight of 2,770 pounds and the drawing gives the XYZ dimensions for the center of gravity for the elevator pour lift table.	drawings, the center-of-gravity will be off and the load will swing upon lift.	show the correct weight and center-of-gravity.
LPH-PC-1-V024	The sides of the Pour Cave Elevators in rooms L-B012 & L-B014 around the location of the door hinges, handles, and lubrication ports may be over 140°F.	While drawing 24590-LAW-DD-S13T-00029, LAW Vitrification Building Main Building Enlarged Pour Cave Plan SS Liner Plate & Insulation @ EL (-) 21'-0", is showing the back of the Elevators insulated with 6" of insulation, nothing appears to be insulating the sides of the Elevator. Per calculation 24590-LAW-M4C-C5V-00001, Figure 36, sheet 107, the Elevator metal temperatures will be a minimum of 150°F.	This is a personnel hazard for people working in the immediate area along the pour cave walls in rooms L-B012 & L-B014.	Provide removable expanded metal barriers to protect personnel from high temperature surfaces.
LPH-PC-1-V025	If improper oil is used in the Container Elevator, the heat will degrade the oil and cause Elevator gear drive problems. If the oils in the gear reducers degrade at the same rate, all four Elevators will experience problems at approximately the same time.	The elevator gear reducers are shipped without oil. The elevator Vendor Manual 24590-CM-POA-MJW0-00001-11-00001 page 278 of 989 gives a table of suitable lubricants versus ambient air temperature. However, the oil selected is not specified.	The Elevator gear reducers will have a shorter service life. If the oils in the gear reducers degrade at the same rate, all four elevators will experience problems at approximately the same time.	Use Elevator gear reducer oil suitable for the temperature service.
LPH-PC-1-V027	LPH System Descriptions which is to be used to document the system should reflect the as-built system and the reason for the design.	System Description 24590-LAW-3YD-LPH-00001, Section 6.2.10, page 25 does not describe the changes done to the Container Lower Overpack to promote natural convection cooling of the container. Figure 6-8, page 27 does not reflect the changes to the Container Elevator done by 24590-LAW-VDCN-MH-11-00009 on 11/15/2011 to promote natural convection cooling of the container. Facility documents such as the System Description which are to be used to document the system should reflect the as-built system and the reason for the design.	Inadequate description of the reason for the system design may cause problems as items are lost due to the failure of tribal knowledge degrading over the years.	Update the LPH System Description to reflect design changes.
LPH-PC-1-V033	• Improper specification of equipment operating in high temperature	• Vendor Submittal 24590-CM-POA-ADDH-00005-02-15 is the Operating Manuals / Instructions for Pour	• The Pour Cave Shield Doors will fail early in the service life requiring	• Analyze the Pour Cave Shield Door ambient temperatures and supplied

Table B-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	environments will lead to premature failure of the Pour Cave Shield Doors. • Inadequate specification of the setpoint of thermal switches & motor temperature rises can cause motors to trip out when exposed to high ambient temperatures.	Cave Shield Doors LPH-DOOR-00009/00010/00016/00017. The Vendor Manual says that for a proper installation the drive installation site (motors & brake motors) ambient temperatures should be below 104°F. It also says the drive installation site (for gear motors & gear reducers) should be selected to ensure the ambient temperatures are below 104°F. Mechanical Data Sheets - Shield Doors, Pour Cave, 24590-LAW-M0D-LPH-00016/00017/00018/00019 state the maximum operating temperature of the Pour Cave Shield Doors is 175°F. It is unclear whether WTP engineering analysis determined the installation of the Pour Cave Doors was satisfactory from an operating temperature point of view. It is unclear if higher operating temperature greases and oils were specified to replace the vendor supplied greases and oils. • In addition, the Operating Manuals show the motor wiring diagrams for the Pour Cave Shield Doors. In zone B2 for the motor wiring diagrams there appears to be a thermal switch (TS) on terminal #5 with no setpoint indicated.	manned entries into the Container Transfer Corridor and manual recovery of the doors with come-alongs or winches. • The Shield Doors will not operate upon command in high ambient temperature conditions requiring a manned entry to open/close them.	door motor/brake/gear motor/ gear reducers and determine if the installation must be upgraded. • Specify and procure replacement motors for the high ambient temperature conditions as required.

Table B-9. Vulnerabilities Identified for Melter Handling System (LMH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LMH-F-12-V-01	The current design of the LAW facility will not support the operation of a 3rd melter without significant facility design revision to accommodate the addition of necessary support equipment such as the UPS system, pour cave heat removal system, LVP and LOP systems, and the buffer storage heat removal system. In addition, the BOF cooling water supply capacity is not sufficient to support 3rd melter operation. There is not sufficient space in the existing	The basis for this vulnerability is the facility description, the results of this (2014) operational review and existing identified issues. Specifically, the UPS system is undersized, the preliminary results from heat removal capability for the pour cave and canister storage is not sufficient to support the additional heat load from operation of a 3rd melter. In addition, the BOF cannot support the loads associated with operation of a 3rd melter.	The current design of the LAW facility does not support the addition of a third melter without design changes	• Redesign necessary equipment to support operation of a 3rd melter. The following systems are identified as needing redesign but 3rd melter support is not limited to the systems noted below: - UPS - LVP - LOP - Heat removal in canister store - Heat removal in pour cave - BOF • Consider adding an installed spare melter into the 3rd melter position and keep it isolated from the LAW facility until it is needed to replace a spent or failed melter.

Table B-9. Vulnerabilities Identified for Melter Handling System (LMH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	LAW facility to accommodate the necessary equipment to support operation of a 3rd melter.			
LMH-S-10-01	The facets of location, human resources, transportation, and parts availability need to be resolved to support fabrication of replacement melters.	Based on a need for replacement melters by 2023 the project needs to start planning for location, parts availability, expertise, and transport for these long lead time components.	Lack of replacement melters available when needed may have significant production ramifications.	Determine a schedule of need, a location for melter assembly, parts availability, and a method of transport for replacement melters. This scope lies with DOE.
LMH-F-15-V-01	• It has not been demonstrated that the 0.1g new melter acceleration limit is adequate to protect the melter systems (refractory). • It has not been demonstrated that the melter winch and rail system will operate within the 0.1g acceleration limit. • It should be established what the correct maximum melter acceleration is and that value should be defined as the criteria for every new melter.	• The torque setting required may be changed by the operator based upon melter condition, ambient temp., age, etc. The basis for these torque settings is not defined. • The Load Limiting feature when activated will slow the winch to a stop based on programmed ramp settings. The basis for these ramps is not defined. • The melter rails are covered with formed metal sheeting to protect the rails from obstructions or minor damage. Requirements for inspection and monitoring are not defined. • No preservation maintenance program has been established for the wheels/rollers and rails or other rotating LMH component to ensure that false brinelling does not occur. • Critical attributes have not been defined and the associated requirements established. • The documented FAT neglected to address numerous critical functions of the winch, pulleys and cable. • No SME was identified that could address the design basis for the items above. • It has not been determined whether the accelerations imparted to the melter when moved should be monitored only during commissioning or for every melter import.	Melter damage could occur and reduced glass production could result from; • Failure to correctly establish and consistently apply acceleration limits requirements for new melters. • Failure to adequately control winch acceleration rate requirements. • Failure to monitor and maintain melter rail conditions. • Failure to test critical winch and rail components against critical attributes and requirements. • Inadequate functional requirements definition may result in negative impacts to new melter operation and throughput.	• Develop and document the basis for the test torque setting ranges and the Load Limiting feature programmed ramp settings including the activities necessary to maintain them. Off-normal conditions should also be considered. • Establish a periodic inspection program and monitor melter rail conditions regularly. Melter rails and wheels/rollers should be inspected and refurbished before each new melter movement. • Definitively establish the acceleration and deceleration limits for new melters and document the basis. Monitor all new melters against the established acceleration criteria. • Develop long term plans that address melter equipment obsolescence, warranties, and replacement or refurbishment for all equipment procured. • Identify and document all critical attributes of equipment and components associated with the winch. Thoroughly test all those components accordingly and document these test. • Identify a Subject Matter Expert that can assume responsibility for the basis of the design criteria used in the winch and rail design.
LMH-F-05-V-01	The detailed process for containment of the spent/failed LAW melters has not been defined.	• Since this process has not been defined: • A timeline of melter decontamination and removal from the facility is undefined. • All equipment is unspecified, not designed and cannot be purchased.	If the melter containment process is left undefined the removal of the melter will impede the new melter moving into operating position causing a delay in production.	Develop a detailed process definition that will allow for procurement of needed equipment and account for allocation of funds during operations.

Table B-9. Vulnerabilities Identified for Melter Handling System (LMH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Resources and funds for the task have not been allocated.		
LMH-S-11-V-01	Alternate vendors for refractory should be identified and plans/schedules for future replacement melter materials defined.	The existing refractory vendor has ceased production. Refractory production for a new melter will require 1 ½ years lead time plus waiting-list time once a new vendor has been selected.	Construction of a replacement melter will be a critical path activity. Failure to adequately plan, procure and execute all of the required activities for replacement melter fabrication will have a negative impact on process throughput and glass production .	Alternate vendors for refractory should be identified and plans/schedules for future replacement melter materials defined.
LMH-S-11-V-02	A consistent philosophy regarding manual and/or remote operations and maintenance should be determined, and the plant design should then be adjusted accordingly.	• System descriptions are inconsistent regarding manual versus remote O&M activities. • This is a configuration management issue.	Inconsistent expectations across systems could lead to incompatible system interactions.	Develop a consistent philosophy regarding manual and/or remote operations and maintenance should be determined, and the plant design should then be adjusted accordingly.
LMH-W-07-V-02	Inadequate melter decontamination approach.	Decontamination of the bottom of the melter is required by SIPD to be performed prior to moving the melter to L-0113; WTP plans to decontaminate bottom of melter in L-0113.	Extended production outage due to delay in melter export to effect alternate method of decontaminating bottom of melter.	Provide systems for decontamination of melter exterior, including the bottom, prior to commissioning to ensure capability to decontaminate is adequate.
LMH-S-16-V-01	There are gaps in the LAW process of designating components to owning systems.	The glass pour seal head, preparation for disposal of the melter, list of components in LMH description and placing the melter on and off of a transporter are examples of the system designator gaps immediate to LMH.	Equipment that is not "owned" by a system will cause inefficiencies when operating and maintaining equipment.	Designate each component to a system to ensure there are no gaps in the operations and maintenance of the equipment.
LMH-F-01-V-01	Melter and facility dimensions should be carefully tracked and controlled to ensure melter ingress/egress access to the LAW facility. Careful consideration should be given to the installation of any and all additional components in this area, or any modifications to the melter design that could impact the nominal clearances available.	• When the melter was moved into place through the rollup door it had the lid and sides installed. The limiting clearance was from the top of the melter lid to the underside of the facility structural beam; which was approximately 3/8 inch. While this 3/8 inch clearance is nominally acceptable, it is dependent upon numerous critical dimensions that must be tracked closely during melter fabrication, (i.e.. melter lid warping). • Since the time when the melter frame was moved into place, numerous cable trays, utilities and other equipment have been installed between the melter and the roll-up doors that would impede melter ingress and egress. While the existing equipment could be	• Melter may not fit into LAW facility. • Melter ingress and egress could be complicated/precluded by the installation of utilities and equipment.	Melter, utility and equipment dimension stack-up should be carefully tracked to ensure melter ingress/egress access to the LAW facility is maintained and not impeded.

Table B-9. Vulnerabilities Identified for Melter Handling System (LMH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		temporarily relocated to facilitate removal of a spent melter, it could complicate spent melter egress and new melter ingress.		
LMH-F-14-V-01	System LMH does not address the 0.1g acceleration limit for a transport vehicle.(i.e.. sub compartment transporter)	24590-WTP-ICD-MG-01-003 (ICD-03), Interface Control Document for Radioactive Solid Waste, Table 1, item 6 states the WTP contractor shall load RSW onto TOC transport vehicles and provide documentation as requested by TOC to support RSW transportation.	Left unresolved, this issue may reduce throughput of the LAW facility. If a melter is loaded with refractory at a nearby location, then it will have to be transported to the LAW facility. During transport the melter and/or transport vehicle is limited to an acceleration of 0.1g. If the limit is exceeded an inspection may be necessary. This may cause a delay in startup.	Consider use of submarine compartment transport vehicle in use at Hanford to transport melters including 0.1g acceleration instrumentation.
LMH-CO-13-V-01	The current LMH system excludes the work scope of transferring a melter between the melter rails and a melter transport vehicle.	Current design and exclusions noted in the LMH system excludes the work scope of moving a melter to or from the melter rails	This issue could result in a reduced throughput if left unresolved	Identify a method, system or equipment to transfer a melter from the melter rail system to a transport vehicle.
LMH-W-07-V-01	Inability to drain free liquids from cooling panels in spent melters	In preparation for waste disposal the melter needs to be drained of all free liquids. No plan or process has been identified to remove free liquids (water) from the cooling panels of a spent melter.	Inability to dispose of the spent melter.	Determine a method to drain all free liquids from a spent melter in preparation for waste disposal. Determination should be made prior to loss of access to the cooling panels during fabrication.
LMH-CO-13-V-02	The current LMH system does not include disposal of a spent/failed melter	Current design and exclusions noted in the LMH system description.	This issue could result in a reduced throughput if left unresolved	Identify the final disposal criteria and prepare procedures and align equipment to implement disposal plan.
LMH-S-11-V-03	Section 3.5 of 24590-LAW-3YD-LMP-00001 should be revised to use the correct reference.	Section 3.5 of 24590-LAW-3YD-LMP-00001 references deleted sections and no valid alternate reference has been provided.	No valid alternate reference has been provided.	Section 3.5 of 24590-LAW-3YD-LMP-00001 should be revised to use the correct reference.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-LID-1-V001	LAW container lid ANSI N14.5-1997 Radioactive Materials – Leakage Tests on Packages for Shipment requirements do not match in the System Description as stated in the ILAW Product Compliance Plan.	24590-LAW-3YD-LFH-00001, System Description for the LAW Container Finishing Handling System (LFH), requires ANSI N14.5 leak tightness and testing but this requirement does not match 24590-WTP-PL-RT-03-001, ILAW Product Compliance Plan, closure and sealing sections. ANSI N14.5 requirements are included in Section 4.4 of the System Description but the ILAW Product Compliance Plan has been revised (Sections 3.2.2.2 and 4.1.12.1) to eliminate the ANSI requirement.	• Confusion in design requirements can lead to inadequate seal design and may require a redesign in the future. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase	• Define correct package type and seal requirement and update relevant documents. • Establish the correct test method/methodology and update relevant documents.
LFH-LID-1-V002	LAW container leak testing was not implemented correctly.	Leak tests performed by the lidding manufacturer, was not performed to the correct methodology. Leak rates in the tests do not match the specification limits and 1 of 6 lids failed the test. In addition, gasket/seal design may not be adequate to meet the LAW facility "remote" environment and can cause future seal failures.	• Inadequate testing and non-robust seal design and may require a redesign in the future. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase	• Establish the correct leak rate limit and update all relevant documents. • Establish the correct test method/methodology and update relevant documents. • Execute valid leak test. • Assess if seal design requires modification (seal/gasket type, threaded vs. welded, etc.).
LFH-LID-1-V003	Lid seal design and method of lid deployment increases chances of seal damage.	The LAW container lid seal is vulnerable to damage as observed in DOE 09-WTP-077 Contract No. De-AC2701RV14136 – the U.S. Department of Energy, Office of River Protection (ORP) Surveillance of the Low-Activity Waste Facility (LAW) Container Lidding Seal Leak Testing S-0-WED-RPPWTP-006. Not only is this type of seal suspect to damage, the seal is pre-attached to the underside of the lid and stacked within a lid holder without any additional protection. The stacking of lids and pre-compression of this type of seal, prior to use, can cause it to be ineffective.	• Inadequate design will lead to ineffective seal • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase Inconsistent design basis • Inadequate Consideration for Conduct of Operations	• Revise lid gasket/seal type that is more robust and not suspect to damage. • Revise underside of lid to provide protection of seal when stacked in lid holder (i.e., standoff integrated into the lid that keeps the seal surface from contacting the next lid it is stacked on).
LFH-LID-1-V007	Lidding Jib Crane FAT Test Deficiencies.	There several requirements of the lidding jib crane specification (24590-WTP-3PS-MJKJ-T0003) that were not tested during FAT and are not covered by a test acceptance criteria in the LFH System Description (24590-LAW-3YD-LFH-00001). The items/functions not tested can impact commissioning or future production when called on to perform. Of the items tested, the FAT does not validate the performance requirements adequately.	• Several features are not fully tested to simulate the bounding conditions and the acceptance of the FAT report places a false sense of security on the adequacy of design. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration for Maintenance and Waste Requirements • Inadequate Consideration for Conduct of Operations	• Establish an adequate FAT test plan that meets the requirements of the engineering specification. • Undertake a proof test to ensure the existing jib cranes can adequately meet all the tests required in the plan and document the results.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-LID-1-V008	Finish Line MSMs design temperature conflicts with CFD analysis of finishing line equipment.	Calculation 24590-LAW-M4C-C5V-00003 provides radiant heat data for finishing line equipment. The maximum temperature imparted on the MSMs is calculated at 233°F, while the data sheets for the same equipment only show a maximum temperature of 175°F. MSM data sheets (24590-LAW-M0D-LFH-00120/121/122/123, North Finishing Line [LFH-Manip-00025/ 00026/ 00027/00028]) do not accurately reflect the correct environmental conditions in which the MSMs will be subjected to and this can lead to premature failure of equipment.	• Incorrect values used to design the equipment may lead to premature failures. • Inadequate Discipline in Design Execution and Control • Throughput not Adequately Underpinned • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration for Maintenance and Waste Requirements • Inadequate Consideration for Conduct of Operations	• Provide a detailed analysis of the environmental requirements of the MSMs. • Establish the bounding scenario that provides the basis for temperature values within the finishing line. • Update data sheets and verify with vendor if changes are required to meet the environment. • Make changes where necessary (different lubricants, localized cooling, higher inspection frequencies, etc.). Review with HVAC if hoist cooling requirements affect HVAC design.
LFH-LID-1-V009	Lid holder decontamination and refilling process has not been determined.	The LFH lid magazine stores lids in a vertical stack. As lids are used by the lid press, the removable lid holder must be moved to Room L-0217C for decontamination and Room L-0217A for refilling. Lids must be manually loaded in the lid holder. The lid holder holds 35 lid-and-seal assemblies, with each lid weighing 45 lbs. The means to load magazines has yet to be determined and is an open issue as documented in Section 6.2.3.2 of the LFH System Description (24590-LAW-3YD-LFH-00001, Rev 2 issued in 2010).	• No current design to execute a safe way to decontaminate and refill lids. • Inadequate Discipline in Design Execution and Control • Throughput not Adequately Underpinned • Inadequate Implementation of ALARA Principles • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration for Industrial Safety • Inadequate Consideration for Conduct of Ops •	• Provide an effective method to safely decontaminate lid holder in L-0217C. • Install fixed lid magazine stand in L-0217A to safely refill lid holder. • Install jib crane with lid lifter dedicated for lid refilling. • Purchase 2 spare lid holders (one for each lidding line) to minimize downtime and keep lids refilled at all times.
LFH-LID-1-V010	Lid Press Tool and Lid Recovery Tool design temperature issues.	The lid press tool and lid recovery tool are specified to engage on a 175°F container flange (Table 3-4 of 24590-LAW-3PS-HCTH-T0001). CFD analysis (Figures 142 and 145 of 24590-LAW-M4C-C5V-00001) shows the flange temperature will range between a low of 335°F to a maximum of 475°F. Pneumatic tubing used in the fabrication of the lidding/rework equipment is not compatible at this temperature and will fail prematurely. The polypropylene tubing manufacturer has a suggested operating limit of 200°F.	• Incorrect values used to design the equipment may lead to premature failures. • Inadequate Discipline in Design Execution and Control • Throughput not Adequately Underpinned • Transfer of Scope and Risk to the Commissioning Phase	• Provide a detailed analysis of the environmental requirements of the tools. • Establish the bounding scenario that provides the basis for temperature values within the finishing line. • Update data sheets and verify with vendor if changes are required to meet the environment. • Make changes where necessary (stainless tubing, additional insulation).

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-LID-1-V011	Lid recovery tool operation deficiencies.	• The recovery tool design has not been tested to recover an improperly installed lid. Testing does not validate that the recovery tool is effective for "tilted" lids. • Failed recovery tools that cannot be disengaged from a container, requires MSM use to remotely disengage the recovery tool. The MSM is not designed to remove nuts to release the recovery tool. • Lids that have been removed by the recovery tool are placed on a park stand, prior to disposal. The location of this stand cannot be reached by the MSM in order to remove the lid and place in a disposal bin. MSM may not be able to grasp lid while lid is on park stand. MSM fingers may not be able to hold lid in vertical orientation when attempting to place in disposal bin.	• Several features and operational requirements are not fully developed or tested to validate a functional design. • Inadequate Discipline in Design Execution and Control • Throughput not Adequately Underpinned • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration of Maintenance and Waste Management Requirements • Inadequate Consideration for Conduct of Ops	• Provide a proof of principle test to validate the current design can remove a "tilted" lid, place on park stand, remove lid from stand via MSM and place in disposal bin. • If this cannot be done, revise design to allow for a valid method of lid removal and disposal (this may require new equipment be utilized instead of modifying existing designs). • Undertake a new proof of principle test to validate new/revised equipment can effectively meet the functions required in "lid recovery" operations.
LFH-LID-1-V012	Lid disposal bin handling deficiencies	The LFH lid disposal bin (LFH-LID-00033/34) weighs 44 lbs. empty and is significantly heavier when full of lids. The bin is mounted against the finish line wall and is located approximately 10 feet above finished floor elevation. The bin is too heavy to be lifted by MSMs (LFH-MANIP-00026/28) and is out of the reach of the jib cranes (LFH-CRN-00003/4/6/7). With the bins located 10 feet above the floor elevation, it will be extremely difficult to handle manually.	• Several features and operational requirements are not fully developed or tested to validate a functional design. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration of Maintenance and Waste Management Requirements • Inadequate Consideration for Industrial Safety • Inadequate Consideration for Conduct of Ops	• Provide a proof of principle test to validate the current design can hold lids without buckling, be removed "manually" in a safe manner. • If this cannot be done, revise design to allow for a valid method of lid disposal (this may require new bin design and new location for remote handling with jib cranes be utilized instead of modifying existing designs). • Undertake a new proof of principle test to validate new/revised equipment can effectively meet the functions required in "lid disposal" operations.
LFH-IC-1-V001	• The design for the LFH system is not in compliance with the requirements flow down as described in the Technical Baseline. • It is not clear how requirements flow from the Mechanical Sequence Diagram or the Mechanical Handling Diagrams (MHD) to the J3 Logic Diagrams, Function	• 24590-WTP-ENG-01-001 Technical Baseline Description, Appendix A shows the WTP Design Document Hierarchy. Requirements flow down from upper level document through lower level documents and into the design. • However, it is not possible to know where a higher level MSD or MHD requirement has flowed down to the design or what criteria will be used to test it. For example, an interlock to keep a door from closing on a bogie is device specific; it will always be in effect when the door is asked to close. On the other hand, an interlock to keep the bogie from running into the door	Independent verification that upper level requirements properly flow down to lower level design documents or the implementation will be very difficult. As a result testing will be ineffective.	• Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	Diagrams and Sequential Function Diagrams. • There is no way to verify that interlocks have been passed down to the J3 Logic Diagrams and no way to verify that they are implemented correctly.	if it is already closed is a sequence interlock that will not be in effect when the bogie is run manually and may not be in effect if the sequence is modified or if another sequence is added.		• Scrub the logic diagrams to correct the labels and ensure consistency among the off-sheet connectors. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V002	Interlocks on the Lidding Bogie listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001 are not sufficient to protect the equipment from damage.	• There are no device specific interlocks to prevent collisions with: - The Decon Shield Door - The Shard Tray - Load on the Lidding Monorail Hoist - Lidding Bogie Lift - Lidding Jib Crane Arm - Sealing Jib Crane Arm • Device specific interlocks should be complete enough to keep the equipment from damaging itself or other systems, structures or components regardless of whether they are operated locally or remotely; manually or automatically.	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V003	Interlocks on the Lidding Jib Crane listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001 are not sufficient to protect the equipment from damage.	The Lidding Jib Crane (LFH-CRN-00003 / 00006) should be interlocked with the Sealing Jib Crane (LFH-CRN-00004 / 00007) to allow movement of the Lidding Crane only if it will not collide with the Sealing Crane. Device specific interlocks should be complete enough to keep the equipment from damaging itself or other systems, structures or components regardless of whether they are operated locally or remotely; manually or automatically.	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V004	Interlocks on the Sealing Jib Crane listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001, are not sufficient to prevent the equipment from damage.	• The Sealing Jib Crane (LFH-CRN-00004 / 00007) should be interlocked with the Lidding Jib Crane (LFH-CRN-00003 / 00006) to allow movement of the Sealing Crane only if it will not collide with the Lidding Crane. (Either Lidding Crane NOT at P1; or Lidding Crane at P4 – parking Stand). • Device specific interlocks should be complete enough to keep the equipment from damaging itself or other systems, structures or components regardless of whether they are operated locally or remotely; manually or automatically.	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V005	Interlocks on the Decon Shield Door listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001 are not sufficient to protect against HVAC flow disruptions or the spread of contamination.	• The Decon Shield Door (LFH-DOOR-00019 / 00015) should be interlocked to prevent it from opening when the Lidding Trap Door (LFH-DOOR-00010 / 00009) is open. • Device specific interlocks should be complete regardless of whether they are operated locally or remotely; manually or automatically.	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could disrupt air flow and spread contamination.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-IC-1-V006	Interlocks on the Decontamination Power Manipulators and the Decontamination Turntable listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001, are not sufficient to prevent the equipment from damage.	• Since a canister hanging from the crane could collide with any of these components; the Upper Decontamination Power Manipulator (LFH-MANIP-00008 / 00001), the Lower Decontamination Power Manipulator (LFH-MANIP-00012) and the Decontamination Turntable (LFH-TTBL-00002 / 00001) should be interlocked to both the hoist and the trolley of the Decontamination Dual-Rail Hoist(s) (LFH-HST-00005 / 00010). • Also the North Lower Decontamination Power Manipulator (LFH-MANIP-00011) has no interlocks listed. • Device specific interlocks should be complete enough to keep the equipment from damaging itself or other systems, structures or components regardless of whether they are operated locally or remotely; manually or automatically.	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V007	Interlocks on the Swabbing Bogie (LFH-TRLY-00015 / 00005) listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001, are not sufficient to prevent the equipment from damage.	• The Swabbing Bogie (LFH-TRLY-00015 / 00005) should be interlocked with the Swabbing Power Manipulator (LFH-MANIP-00009 / 00002) and the Swab Turntable (LFH-TTBL-00006 / 00005) to ensure the Swabbing Bogie doesn't move during Swabbing operations. • Device specific interlocks should be complete enough to keep the equipment from damaging itself or other systems, structures or components regardless of whether they are operated locally or remotely; manually or automatically.	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V008	• There is no clear flow down of requirements from higher level documents to the Logic Diagrams.	• According to the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001, the Line Transfer Crane Hoist (LFH-HST-00001) is interlocked to prevent it from lowering when the North (LFH-Door-000014) and South (LFH-Door-00011) Line Transfer Trap	• This means that the software cannot be tested against the Mechanical Sequence Diagrams, or the Mechanical Handling Diagrams or the System Descriptions.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	• The J3 logic Diagrams attempt to correct this, but that puts them in violation of an upper-level requirement.	Doors are not open. However, it should be interlocked when the Crane trolley is at {P2 AND the South Door is NOT open} and when the trolley is at {P3 AND the North Door is NOT open}. • As written both the North and South Line Transfer Trap Doors must be closed before the hoist can be lowered making transfer into either Decon Room impossible. • If the requirement is wrong (it is) then the MSD should be corrected The point is not that the logic won't work; the point is that there is no clear flow down of requirements from higher level documents to the J3 Diagrams.	• An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin. • .
LFH-IC-2-V001	The way the carbon dioxide pelletizers, CDG-BLWR-00001/00002/00003/00004 are mounted orients the control panels between the Blasters and the Pelletizers. This provides no room for an operator or maintenance personnel to access the panels.	An operator viewing or working the controls on this piece of equipment will have to reach in from the sides which are partially blocked by the side panels.	Access to E-stop button on the control panel is obstructed. Stretching and reaching to operate controls is poor ergonomics. The operator will have a poor view of his indications. It will make reaching for and operating a control error-prone and will increase the chance of slips and falls.	The carbon dioxide pelletizers, CDG-PLT-00001/00002 must be re-installed with a different orientation that allows proper access.
LFH-IC-2-V002	The bogies (i.e.. LFH-TRLY-00006/00007) are variously referred to as Trolleys in the equipment name, Bogies in the System Description; Carriages on the label of the Control Panels LFH-PNL-00002/00011, and as Carts on the HMI Screens.	This is poor engineering practice as it will cause confusion between control room operators and field operators as well as between operations and maintenance.	Every procedure and every work package will have to deal with this inconsistency. If a procedure tells an operator to move a bogie to a position, the operator cannot use a control marked as a cart to accomplish this unless the procedure specifically tells him that the bogie and the cart are the same equipment. Likewise a maintenance technician cannot perform a work package on a trolley by operating a control panel labeled to operate a carriage unless the work package explicitly tells him to. The operator or maintenance technician has no way of knowing whether the procedure is referring to the piece of equipment at hand, or some other piece of equipment elsewhere in the facility. It is a vital part of conduct of	Align the design of the facility so that each piece of equipment has one and only one name.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			operations to verify that one is operating the piece of equipment directed by the procedure. No worker should perform a procedure step on a piece of equipment labeled differently than that called for in the procedure .	
LFH-IC-3-V001	The design provides no method of verifying compliance with Waste Affecting Criteria regarding temperature before the container is exported for transport to the disposal facility.	• The ILAW Product Compliance Plan 24590-WTP-PL-RT-03-001 Section 4.1.13 states, "… This temperature constraint shall assume a shaded, still air environment at an ambient temperature of 38 C…." • Section 4.1.13.1 says the compliance Strategy for the temperature requirement is to hold the filled ILAW containers for sufficient time to cool. "The external temperature of the filled ILAW container will be measured to confirm that the temperature is below the maximum temperature before the ILAW product is picked up for transport to the disposal facility." • However there is no means provided in the design for a still air environment or temperature transmitters to accomplish this. The design provides the only measurement of the container temperature in the Transfer Tunnel. The temperature in the Transfer Tunnel is assumed to be 113°F or 45°C. The assumed air flow in the Transfer Tunnel will be over 5000 scfm. This temperature and air flow make the Transfer Tunnel an unacceptable location to measure the temperature to meet the requirement.	ICD 15 – Interface control Document for Immobilized Low Activity Waste, Section 1.7 Acceptance Criteria points out that the requirement… "for the PRC to develop waste acceptance criteria for the Integrated Disposal Facility (IDF) may result in exceeding the criteria contained in the WTP contract for the production of ILAW…Also, there are no provisions within the WTP contract or its facility permits to retain the ILAW or to accept its return from the TOC once transferred. Consequently, the potential exists that an interface incompatibility may be created wherein the produced ILAW must be transferred from the WTP but the TOC or PRC is unable to accept it."	Redundant temperature transmitters similar to the ones provided at the end for the Pour Tunnel should be provided at the Monitoring/Export area. These instruments should have an appropriate quality level with pre and post calibrations to verify their operation and accuracy.
LFH-TRLY-1-V001	Bogie thermal shield design differences between the Design Proposal Drawings and the fabricated Lidding and Decontamination Bogies are not documented	No justification is available that documents the WTP Project's acceptance of the Manufacturer's deviation from the initial design that called for the heat barrier to cover the entire top surface of the Lidding Bogie Elevating Tables and Decontamination Bogie Assemblies.	• Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration of Maintenance Requirements	Re-run the Manufacturer's thermal analyses of the Lidding and Decontamination Bogies for the expected higher ambient temperature range, and verify that the temperatures of the Bogie most fragile components including the motor, junction boxes, and cable carrier remain acceptable.
LFH-TRLY-1-V003	Absence of container centering guides on the bogie-mounted Swabbing Turntables may result in challenging container lifting operations and container dropping accidents	The top of the swabbing turntable is a flat circular metal plate. Its edge is only 2.5" wider than the container radius, assuming the container is perfectly centered on the plate. The decontaminated container is lowered onto the swabbing turntable by the Swabbing Dual-Rail Hoist.	• Inadequate Discipline in Design Execution and Control • Inadequate Consideration for Conduct of Ops	Add bolted containers centering wedge assemblies around the top plate of the Swabbing Turntables (similar to the wedges installed on the Decontamination Turntables).
LFH-TRLY-1-V005	Material of flexible electrical conduits to Bogie stand-mounted	Temperature at the side of the ILAW product container may be up to 615°F at the lidding station. Flexible	• Inadequate Discipline in Design Execution and Control	Design and add local insulation for the electrical conduits connected to the Bogie Power Junction Boxes

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	Power Junction Boxes may not be adequate for temperature conditions in the immediate vicinity of LFH Bogies	electrical conduits connected to stand-mounted Lidding Bogie power junction boxes have working temperatures of -22°F to 174°F.	• Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration of Maintenance Requirements	(and to any other junction box in the Finishing Lines located in the immediate vicinity of a side of a product container).
LFH-TRLY-1-V009	Configuration of the recessed rails in the Finishing Line will promote the accumulation of contamination	The rails and rail clips at EL 3'-0" are embedded into an 8" thick concrete infill covering the entire floor of the 2 Finishing Lines.	• Inadequate Discipline in Design Execution and Control • ALARA concerns	Develop procedures for frequent periodic decontamination work activities to prevent contamination buildup along the bogie tracks.
LFH-TRLY-1-V010	Maintenance on Bogies in Swabbing and Export Rooms may be problematic due to contamination potentially pulled from Container Lidding Areas	The bogies are all recovered by the Recovery Systems located in the Monitoring/Export Areas. Use of the recovery systems will pull contamination along with the wire rope onto the recovery winch cable drum.	• Inadequate Discipline in Design Execution and Control • ALARA concerns • Inadequate Consideration of Maintenance Requirements	Develop procedures to minimize the spread of contamination into rooms that should stay clean while performing maintenance on the LFH Bogies.
LFH-TRLY-1-V011	Absence of Finishing Line Bogie maintenance hoist may result in problematic bogie maintenance	The Swabbing Hoists or Export Cranes are the only installed lifting options to gain access to the bottom of the bogies.	• Inadequate Discipline in Design Execution and Control • ALARA concerns • Inadequate Consideration of Maintenance Requirements	Develop maintenance procedures for LFH Bogies that minimize impact to the installed process lifting equipment.
LFH-TRLY-1-V012	Lidding and Decontamination Bogies need to be disconnected from Power Cables and Carrier prior to maintenance which makes their transfer back to their respective process area problematic	Movements of the Lidding Bogies east of Position 4 and movements of Decontamination Bogies eastward to about Column 19 to the maintenance areas are not possible unless energy chains are disconnected.	• Inadequate Discipline in Design Execution and Control • ALARA concerns • Inadequate Consideration of Maintenance Requirements	Define the maintenance areas actually available for maintaining the Lidding and Decontamination Bogies and develop procedures accordingly.
LFH-TRLY-1-V013	Mechanical Handling Data Sheets and Thermal Analysis for the Swabbing Bogie-Mounted Turntables Define Incorrect Container Bottom and Side Temperatures	There are many discrepancies between engineering documents that define the Bogie-mounted Swabbing Turntables with regard to design temperatures which are definitely a critical process parameter for the design of these components of the LFH System.	Inadequate Discipline in Design Execution and Control	Correct the discrepancies in engineering and Vendor's documentation package for the two Bogie-mounted Swabbing Turntables.
LFH-TRLY-1-V014	High Probability of Damaging the Container Present Sensor of Bogie-Mounted Swabbing Turntables When Lowering Container Lower Overpack on Top Plate	The vertical part of the bracket supporting the Container Present Sensor protrudes over the edge of the circular top table and is located at less than 2" from the edge of the 48" diameter table.	• Inadequate Discipline in Design Execution and Control • Inadequate Consideration of Maintenance Requirements	Re-locate the bracket and Container Present Sensor further away from the edge of the top plate after checking that the laser sensor can detect the presence of an object on the turntable from its modified location.
LFH-DS-1-V001	Retrieval of Bogie Doors in Decontamination Rooms L-0109C/-0115C not yet possible.	Retrieval of Bogie Doors in Decontamination Rooms L-0109C/-0115C not yet possible.	If the doors in the decontamination rooms L-0109C or L-0115C are stuck in the open position, a manned entry must be done to recover the stuck door with a come-along	Develop an easy method of door retrieval to minimize the impact of an occurrence of a door fail-to-move situation.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-DS-1-V002	Container decontamination and recovery of a contaminated container may be problematic.	In, DOE 07-WTP-061 Technology Readiness Assessment for the Waste Treatment and Immobilization Plant (WTP) Analytical Laboratory, Balance of Facilities and LAW Waste Vitrification Facilities, the DOE determined on page 2-19 that the LAW Decontamination system was at a Technology Readiness Level of TRL 4.A CO2 decontamination system has not been demonstrated or proven to be effective. The method to deal with a contaminated container has not been established.	Accumulation of non-conforming ILAW containers will fill up the buffer storage area and stop production in the LAW Facility.	• Demonstrate the capability of a CO2 system to decontaminate an ILAW Container. • Develop a method to export a non-conforming ILAW container.
LFH-DS-1-V003	C5 Duct pressurization over C3 room & C2 Corridor pressure	By design, the pressure in the C5V ducting in the CO2 exhaust ducting from the discharge of the C5V-FAN-00009/-00010 fans is positive compared to the C3 room / C2 corridor the ducting is in.	If a leak develops in the C5 fan discharge ducting, contamination can be spread to a C3 area. A leak may be a CO2 gas personnel hazard	• Install a CO2 gas monitor instrument in Room L-217B to detect rising CO2 levels. • Invoke a periodic maintenance surveillance to inspect the CO2 exhaust ducting from the discharge of the C5V-FAN-00009/-00010 fans through the C3 rooms / C2 corridors to the tie-in point on the main C5V duct.
LFH-DS-1-V004	Operation of the Carbon Dioxide (CO2) pelletizer and C5V vacuum pickup system may be problematic.	Operation of the Carbon Dioxide (CO2) pelletizer and C5V vacuum pickup system may be problematic. The shrouds and operation of the upper and lower decontamination power manipulators may be problematic (24590-LAW-MJ-LFH-MANIP-00001 / -00008 / -00011 / -00012). The power manipulators, CO2 pelletizer/blaster, C5V vacuum pickup system, and the LAW Facility Integrated Control Network (ICN) have never been tested as an integrated system. The ability of the robot to dodge the alignment lugs on the decontamination turntable and the fingers/alignment arms on the container lifting grapple has not been demonstrated. The lifting grapple contamination capture target box has not been designed or demonstrated to work. Decontamination of the bottom of the grapple will blow air & ice pellets into the cam area of the grapple through the hole in the bottom plate of the grapple. Switching between the upper and lower decontamination power manipulators and between the various power manipulator end effectors will cause the flow through the contamination pickup system to vary. The CO2 C5 FAN-00009/-00010 flow is monitored by a flow instrument and the ICN uses the flow signal to vary the fan speed to attempt to maintain a constant flow through the system. As the decontamination robot cycles through its program, the C5 FAN-00009/-00010 fan speeds will vary to maintain a constant flow through the system. There has been no demonstration of adequate contamination capture velocities and of the ability of the fan speed control system to keep up with the decontamination robot	ILAW Containers may not be able to be decontaminated by the installed CO2 ice pellet system. If a CO2 blaster shroud cannot decontaminate an ILAW container area on the first attempt, repeated attempts using the same shroud system should not be expected to have success a second or a third time.	• Testing of the CO2 system to optimize container decontamination efficacy should be done before startup. • It would be best to start the testing and development of the integrated CO2 system as soon as possible to minimize the impact of the possible failure of the CO2 system to decontaminate an ILAW container on the LAW Facility commissioning.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		swapping out end effectors and switching between the upper and lower manipulators. The Vendor is recommending that no spare parts be provided for the pelletizer to support startup and commissioning. The actual flow of CO2 ice pellets is not monitored and if the bottom of the blaster feed hopper is frozen, no ice pellets will be fed into the blasting air creating the possibility of attempting to decontaminate the container by just blowing air on it. Old, rotten, CO2 ice pellets can be removed from the CO2 blasting hopper by letting them sublimate over a period of hours, or manually scooping them out. This may be a problem when one finishing line is down for maintenance and all five containers are processed through one line giving the system a 4.8 hour cycle time rather than a 9.6 hour cycle time.		
LFH-DS-1-V005	Decontamination system obsolescence and Vendor support.	The WTP has a 40 year operating mission. There is a danger that the Motoman® decontamination robot, and PLC control system will go obsolete before the 40 year life of the WTP project is over. Further, KTECH, the robot vendor may go out of business or get bought out by another company. In any case, if Vendor support for repair parts, software support, or training is lost, the decontamination robot may become inoperable.	ILAW containers may not be able to be decontaminated by the Motoman® decontamination robot and another system must be procured, tested, installed, and commissioned to resume LAW Facility ILAW Container filling operations.	DOE should begin the process to qualify another decontamination robot or other system, to replace the CO2 decontamination robots. In light of the time it has taken to develop the current Motoman® decontamination system, DOE should start the hunt for a replacement system immediately.
LFH-DS-1-V006	Daily hoist inspections required by the Vendor with a "SHALL" in the maintenance manual will mean daily personnel entries into a C5 area. Decontamination rooms L-0109C and L-0115C overhead container hoist maintenance, operation, and spare parts may be problematic.	ASME Code, OSHA and Vendor required daily "SHALL" inspections for cranes and hoists may be difficult. Decontamination rooms L-0109C and L-0115C overhead container hoist maintenance, operation, and spare parts may be problematic.	ASME Code, OSHA, and Vendor requirements appear to require daily manned entries into contaminated areas to perform daily crane/hoist inspections given a "SHALL" by the Vendor.	• Apply to the DOE for relief from the ASME 29 CFR 1910.178, "Occupational Safety and Health Administration Standards" Code of Federal Regulations, Subpart "Powered Industrial Trucks", and Vendor Manual requirements in DOE/RL-92-36 Rev 1, Release 73, Hanford Site Hoisting and Rigging Manual, Chapters 12 & 13. • Tailor the ASME B30 Series Code requirements, OSHA 1920.178, and DOE/RL-92-36 Rev 1, Release 73, Hanford Site Hoisting and Rigging Manual Chapters 12 & 13 requirements in the SRD.
LFH-SWAB-1-V003	24590-CM-POA-HDYR-00002-04-00002, Bolted Pedestal and Frame Structures Structural Design Analysis and Calcs, loss of configuration control.	The calculation was changed after it was stamped by a professional engineer with no evidence the professional engineer reviewed the changes, and there are several pages with no evidence the mathematical calculations were reviewed and checked.	Component failure due to over stress or seismic event due to unreviewed changes made in the analysis.	The calculation needs to be completely reviewed and checked by a registered professional engineer and implement any design changes that result.
LFH-SWAB-1-V005	24590-CM-POA-HDYR-00002-21-00002, Swabbing Manipulator	The analysis indicates air moving over the robot arm to the gripper to create convective cooling is required to maintain temperature sensitive instruments below critical	Contamination spread and release of contaminated ILAW container to LEH.	Analyze air velocity at surface of the container and redesign cooling system to ensure temperature sensitive

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	Thermal Calculation, cooling air issues.	temperatures. The velocity of the air at the surface of the container was not analyzed to determine the potential for spreading contamination and adversely affecting the quality of the swabs. Temperature of the compressed air lines has not been adequately analyzed to determine if the aluminum wrap is effective at maintaining the compressed air lines below critical temperatures.	Failure of compressed air line results in failure of robot to operate.	proximity sensors and compressed air tubing below critical temperatures.
LFH-SWAB-1-V006	24590-CM-POA-HDYR-00002-14-00005, Swabbing System Operating Guide for Decontamination and Swabbing Project, missing instructions	The robot is programmed to swab the curved bottom, vertical sides, and tops of the ILAW containers, but no provisions (i.e., alternate swabbing patterns and programs) have been developed to swab a lower container over pack. The inability of the swabbing robot to handle a lower container over pack could cause significant production delays.	ILAW container and over pack will probably need to be returned to the Buffer Storage Area until the swabbing robot can be reprogrammed and tested.	Create and test swabbing programs for the lower container over packs prior to commissioning activities.
LFH-SIFH-1-V003	No adequate container temperature design basis.	Mechanical handling data sheets 24590-LAW-M0D-LFH-00011, MDS North Inert Fill Hopper, and 24590-LAW-M0D-LFH-00070, 24590-LAW-MJ-LFH-Manip-00017 – Tool Tray used to Hold Effluent Shrouds and Other Tools for Decontamination Power Manipulator, indicate the operating environment is 59-113 °F with a container temperature maximum of the bottom=400 °F, sides=700 °F, and top=350 °F. Document reviews have been unable to establish this container temperature profile as the correct basis for the equipment design requirements. The BNI system matter expert was asked to provide the design basis for the container entering the LFH system and no response has been issued. Described in the CFD Analysis of LAW Buffer Storage and Finishing Line calculation, 24590-LAW-M4C-C5V-00003, the intended operation is to transfer the container directly from the pour cave into the finishing line, after 59.27 hours, in an alternating pour mode. There is no direct container temperature results identified in the analysis, so I will assume the container temperature is identical to container temperature profile for the maximum container temperature for alternate pour schedule, figure 25.b. That would mean the finish line import temperature is 460 °F. In the single pour mode the container is required to be removed from the pour cave at 29.63 hours and using the container temperature for a single pour schedule, figure 25.a, the container temperature would be 630 °F. However, the container cannot be lifted with the current grapple design until it cools to 600 °F. A CCN 051255 LAW Container Skin	This could severely restrict operational throughput for the finishing line.	Perform CFD thermal analysis to establish an actual container cooling temperature profile that the finish line equipment can be evaluated for potential impacts (good or bad). Until a believable container temperature design basis is established the finish line systems cannot be evaluated for maximum throughput.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		Temp Calculation, was developed to calculate the container skin temperature as it moves from the LAW pour cave through the transfer tunnel and the finishing line to the airlock for export. In section 6.0, results and conclusion, the process describes the container, at hour 28.33, moving to the lidding station. According to figure 3 the maximum container surface temperature is above 600 °F. None of the above mentioned CFD container thermal analysis can be used to support the equipment design environmental conditions listed in the mechanical handling data sheets.		
LFH-SIFH-1-V005	Incorrect isolation valve in day tank.	• The day tank upper isolation valve is identified as a Posi-flate butterfly valve series 485. This type of valve will not be able to displace the inert material in order to close the valve. If the inert material is flowing through the rotary feeder and moving past the isolation valve the valve will be able to be closed, but once the rotary feeder is stopped the spool piece and isolation valve will become packed solid with inert material. Once this happens the butterfly valve will not be able to rotate and displace enough material to fully close. This isolation valve should be a slide gate type. The lower isolation valve is acceptable and will be able to perform as designed. • The vendors factory acceptance testing, section 7.4, indicates that functional testing was not required and that BNI did not specify any functional testing be performed.	The system isolation valves will not operate as designed.	The day tank upper butterfly valve should be replaced with a slide gate valve that can operate with a full pipe of dense inert fill material. Full functional testing should be performed during commissioning.
LFH-SSS-1-V002	Limited glass sample capability.	The shard pickup assembly is intended to be maneuvered by the assembly MSM handle located approximately 18 inches from the tip. This means the shard pickup assembly can only be inserted approximately 16 inches below the container flange surface. That would mean that any container with less than 90 percent fill volume would not be capable of taking a glass sample. This does not meet the requirement to be able to take a glass sample as required. The most likely need to take a glass sample would occur if something unexpected occurred during the glass process and/or the pouring schedule is interrupted. If for any reason the container glass level is not within 16 inches of the flange surface a glass sample cannot be taken with provided equipment.	Glass samples will not be able to be taken from all product containers as required.	Redesign the glass shard pickup assembly to meet the glass sample requirement regardless of the glass height in the product container. I believe this is required to meet the contract requirement.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-SSS-1-V003	Insufficient shard pickup design.	• The shard pickup tool is designed to use the MSM to bang the tool against the glass surface to create shards for collection. This is not an acceptable design task for an MSM to perform on a regular basis • A spring reel used to support the shard pickup assembly will increase the resistance force the more the cable is extended. This will make it difficult for the MSM to control the assembly with the cable reel pulling back with a 30 pound force let alone trying to hammer something.	Premature MSM failures will cause increased maintenance costs and decrease equipment overall effectiveness. Containers requiring samples to be taken will have to be stored until repairs are made thus decreasing the facilities ability to manage the container throughput.	Retest the shard pickup assembly using a proto-typical MSM and prove the tool design can be controlled and glass shards can be generated for sample pickup. These tests should be performed on actual solid glass samples not on glass frit to ensure the tool can be used to generate glass shards for pickup.
LFH-SSS-1-V004	The shard table does not prevent material from dropping into the container during MSM operations.	The Specification for shard Sampling System, 24590-LAW-3PS-M000-T0006, section 3.2.3 requires the equipment shall not introduce any foreign substance into the product container. Normally this would be accomplished by providing a catch pan below activities or components that may introduce foreign materials. The current design, for the shard tray, presented in the drawing series for the shard tray assembly beginning with 24590-CM-POA-M000-00006-06-00082, North Shard Pickup Assembly, has no tray or means to prevent foreign material from dropping into the product container. The foreign material would be the sample bottles and lids that are handled by the MSMs. If during the sample bottle handling either the bottle or lid is dropped it is likely to end up in the product container. Procedures could prevent the handling of all glass sample bottles while the product container is present, however that would not satisfy the specification design requirement.	Foreign material dropping into the product container is prohibited and will require additional operations and/or processes to remove the material to allow the product container to be exported from the facility.	Redesign the shard sampling tray to prevent material from dropping into the product container.
LFH-LID-1-V004	Lid seal identification on DPD is incorrect.	24590-LAW-M0-LRH-00004001, LAW Vitrification System LRH Product Container Assembly, identifies the seal as a Garlock Helicoflex with part number E-800164 instead of a Technetics E-Flex type. The part number is actually a Technetics drawing number.	• The misidentification of the seal may cause confusion in the fabrication of the container and lid • Inadequate Discipline in Design Execution and Control	Provide correct seal manufacturer/type/part number on applicable drawings.
LFH-LID-1-V005	Lidding jib crane capacities do not have a documented basis.	The current 3 ton capacity of the LFH Lidding Jib Cranes (LFH-CRN-00003 and 00006) and Sealing/Lid Recovery Jib Cranes (LFH-CRN-00004 and 00007) are not based on any supporting calculation. Data sheets for these cranes (24590-LAW-M0D-LFH-00096 through 00099) do not have an issued calculation to support the 3 ton hoist rating.	• The lack of a documented basis limits the items that can be handled by the LPH hoists and it is unclear if a 3 ton hoist can meet any future lifting requirements of the system. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase	• Define all the requirements/scenarios (including any off normal events) of the jib cranes. • Document the lifting requirements and provide an established margin for sizing the hoist. Documentation should be in the form of an approved calculation.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-LID-1-V006	Lidding jib crane design temperature conflicts with CFD analysis of finishing line equipment.	The design temperature of the LFH Lidding Jib Cranes (LFH-CRN-00003 and 00006) and Sealing/Lid Recovery Jib Cranes (LFH-CRN-00004 and 00007) are not based on any supporting calculation. Data sheets for these cranes (24590-LAW-M0D-LFH-00096 through 00099, LFH Lidding and Sealing Jib Cranes, North and South Lines) show a max design temperature of 160°F while CFD analysis show co-located MSMs will reach 233°F.	• Incorrect values used to design the equipment may lead to premature failures. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration for Conduct of Operations	• Provide a detailed analysis of the environmental requirements of the cranes. • Establish the bounding scenario that provides the basis for temperature values within the finishing line. • Update data sheets and verify with vendor if changes are required to meet the environment. • Make changes where necessary (different lubricants, localized cooling, higher inspection frequencies, etc.). Review with HVAC if hoist cooling requirements affect HVAC design.
LFH-TRLY-1-V002	The ICN does not prevent collision between the Lidding and Decontamination and Bogies when present at and moving to Position P4 in rooms L-0109C and L-0115C	No interlock prevents the operator from driving the Decontamination Bogie into the Lidding Bogie parked at Position P4 "Decon Station", or conversely, from moving the Lidding Bogie forward and colliding with the Decontamination Bogie parked at Position P4.	• Inadequate Discipline in Design Execution and Control • Inadequate Control System Design Requirements • Inadequate Consideration for Conduct of Ops	Update ICN to include interlocks preventing Bogie collisions in the Finishing Line.
LFH-TRLY-1-V004	Potentially insufficient maximum load capacity of bogie-mounted Swabbing Turntables	Engineering Specification and Vendor's Turntable Instruction Manual state that" in no case should the weight on the turntable exceed 20,000 pounds", when there are conditions where the Bogie-mounted Swabbing Turntables will support a weight (20,533 lbs.) higher than the design working load.	• Inadequate Discipline in Design Execution and Control • Inadequate Consideration of Maintenance Requirements • Inadequate Consideration for Conduct of Ops	Verify the acceptable load range for the Bogie-mounted Swabbing Turntables, resume contacts with the Manufacturer, and run a structural analysis of the turntable for the anticipated higher loads.
LFH-TRLY-1-V006	Vendor's calculation for bogie bumper selection is based on incorrect gross weight and bogie speeds	Calculation of the energy acting on one bumper during collision with rigid structure uses the incorrect 6,500 lbs. gross weight value for the bogie when it should use the bounding weight of 10,500lbs which corresponds to the total weight of the swabbing bogie and the bogie-mounted turntable. In addition, the operating speeds used in the calculation are incorrect and not consistent with the values specified in the other engineering documents for the LFH Bogies.	• Inadequate Discipline in Design Execution and Control	Re-run the LFH Bogie Bumper Selection Calculation for the corrected weights and operating speeds to verify that the bumpers mounted on the fabricated and installed bogies are adequate prior to commissioning.
LFH-TRLY-1-V007	Vendor's calculations for bogie container supports and bogie frame analysis are based on an incorrect maximum loading	Bounding payload does not correspond to the weight of the test weights for overhead hoists, and does not include the weight of the lifting table or the swabbing turntable.	Inadequate Discipline in Design Execution and Control	Re-run the structural calculations for the Lidding and Decontamination Bogies using the revised bounding payload to verify the structural resistance of the guides and chassis are adequate prior to commissioning.
LFH-TRLY-1-V008	Length and travel of Container Present Sensor of Lidding and Decontamination Bogies may not be adequate for detecting presence of an Overpack	No evidence is provided that the radial position, length, and travel of the Container Present Sensor mounted on the fabricated/installed Lidding and Decontamination Bogies allows it to actually make contact with the bottom surface of the Overpack and signal the presence of the Overpack to the ICN.	• Inadequate Discipline in Design Execution and Control • Inadequate Control System Design	Verify radial position, length, and travel of the Container Present Sensor mounted on the fabricated/installed Lidding and Decontamination Bogies against the most current design of the Container Lower Overpack.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-DS-1-V007	Maintenance on the LFH-HST-00001 monorail hoist will be difficult.	Per drawing 24590-LAW-P1-P23T-00046 Rev 3, LAW Vitrification Building Equipment Location Plan EL. 28'-0"/Area 9, the ladder to access maintenance platform LP0217A at elevation 37'-6 ¼"is to the east of the LFH-HST-00001 monorail beam on the north wall of Room L-0217. When the LFH-HST-00001, per 24590-CM-POA-MJKH-00001-05-00001 Rev 00D, Drawing - 10 Ton Monorail Electric Wire Rope Hoist General Arrangement, is not present, there is about 6' of clearance between the bottom of the hoist beam and the platform deck. When the LFH-HST-00001 is present, there is about 3' of clearance between the bottom of the hook and the platform deck. Access to the western side of the platform along the southern side of the hoist is blocked by the hoist's power/control festoon. Access to the western side of the platform along the northern side of the hoist is blocked by a 19' fall to the floor below. To gain access to the western side of the crane, the maintenance worker will have to crawl on his belly under the crane along the platform floor and standup on the west side. It will be very difficult to perform some maintenance activities such as replacing the recovery hoist motor.	Worker contamination due to sliding across the floor to gain access to the western side of the LFH-HST-00001.	Install a second access ladder to the LP0217A platform.
LFH-OR-1-V001	24590-LAW-RPT-PO-05-0001, LAW Reliability, Availability, and Maintainability Data Development Report, errors.	The RAM data development report contains errors in the MTTR hours for the Mechanical Handling System, and it erroneously states the Decon Turntables are mounted on bogies.	Results of the OR Model may be inaccurate because the input data may be inappropriate.	Revise the RAM data development report and incorporated into the OR model and other documents.
LFH-OR-1-V002	24590-WTP-MDD-PR-01-001, Operations Research (WITNESS) Model Design Document, errors and inconsistencies.	The OR Model design document erroneously states temporary lids are installed on ILAW containers, contains process steps for the LFH system that is not consistent with 24590-LAW-M1-LFH-00001, Mechanical Sequence Diagram (MSD) for LAW Vitrification System LFH, and contains process time, MTBF, and MTTR information that is not consistent with 24590-WTP-RPT-PT-02-005, Flowsheet Bases, Assumptions, and Requirements.	Erroneous input data in OR Model results in overly optimistic predictions of system and facility availability.	Compare information in the OR model, mechanical sequence diagrams, and the flowsheet, basis, assumptions, and requirements document and revise the documents as necessary for consistency. Rerun the OR model after all of the process steps and correct MTBF and MTTR data have been updated.
LFH-OR-1-V003	24590-WTP-RPT-PET-07-003, Waste Treatment Plant Reliability Availability Maintainability (RAM) Basis Report, error.	LFH-WELD-00001/00002 are identified on page B-8 as being "In OR Model" with an MTBF of 43,800 hours and an MTTR of 46 hours based on CCN 068376, LAW - Ram Data Collection for OR Model – LFH. However, CCN 068376 states on page 5 of Attachment 1 that the welders have been deleted due to design change. Furthermore, page 8 of Attachment 2 of the CCN states, "Do not include in OR Model Run 2004. The welding equipment has been deleted through 24590-LAW-DCA-M-03-011, Rev 0."	Erroneous input data in OR Model results in overly optimistic predictions of system and facility availability.	Revise the RAM basis report to remove LFH-WELD-00001/00002 and verify the weld equipment has been removed from the OR model.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-SWAB-1-V001	24590-LAW-3YD-LFH-00001, System Description for the LAW Container Finishing Handling System (LFH), issues and inconsistencies.	Section 3.6 states that surface contamination is determined by swabbing "random container patch areas" using an automated power manipulator. However, Sections 6.2.5.1 and 7.2.4 state swabbing will be performed over "pre-programmed" areas or "patches" of the container surface. The document needs to be revised to resolve the internal inconsistency.	Internal inconsistencies could result in operational confusion.	Revise the document to correct internal inconsistencies.
LFH-SWAB-1-V002	24590-LAW-M0D-LFH-00066, Mechanical Handling Data Sheet: North Swabbing Power Manipulator, inconsistencies.	The maximum cycle time is listed as 120 minutes which conflicts with the 210 minute cycle time for the swabbing bogie mounted turntable as indication on 24590-LAW-M0D-LFH-00087, Mechanical Handling Data Sheet - North (South) Swabbing Bogie-mounted Turntable.	Inconsistencies could result in operational confusion.	Revise the documents to correct inconsistencies.
LFH-SWAB-1-V004	24590-CM-POA-HDYR-00002-10-00001, Swabbing Factory Acceptance Test Plan, issue.	The completed data sheets of the test plan are dated prior to the issuance and approval of the work plan and the duration of the endurance tests failed to meet specification requirements.	Functionality of the system not verified prior to installation and commissioning	Complete full endurance test during commissioning activities.
LFH-SIFH-1-V001	Insufficient rotary valve isolation for maintenance.	According to the inert fill hopper general assembly drawings there is no isolation valve between the rotary airlock valve and the inert fill hopper. Installation, operation and maintenance manual indicates that to perform a seal strip replacement the valve should be removed from the installation or gain access to the top and bottom of the feeder. If the rotary valve fails while the hopper is full of material it will be difficult for maintenance repair to be performed without manually draining the hopper contents out through the valve body.	This will not prevent the repair but will significantly increase the maintenance interval and housekeeping afterwards. The day tank directly above the inert fill hopper has the same rotary valve but does incorporate isolation valves both above and below the rotary valve.	Modify the inert fill hopper design to incorporate a manual slide gate for isolation directly above the rotary airlock valve.
LFH-SIFH-1-V002	Failure to record requirements during factory acceptance testing.	24590-LAW-3PS-HCHH-T0002, Engineering Specification for Special Inert Fill Hoppers – Low Activity Waste Vitrification Facility, section 6.3.14.1, requires tests to be conducted using environmental conditions specified in the associated MDSs. The associated MDSs environmental conditions require a temperature range of 59-113 °F and a relative humidity range of 5-85 percent. The performed factory acceptance testing failed to record any environmental conditions at the time of the tests, so this specification requirement cannot be confirmed.	This is a minor omission of specification requirements, however it was thought to be important enough to specifically identify that testing be perform under specific conditions. This also indicates a programmatic failure to verify all identified design and testing requirements identified in equipment procurement.	This testing requirement should be added to commissioning test documentation.
LFH-SIFH-1-V004	Performance requirements not fully met.	The special inert fill hoppers specification 24590-LAW-3PS-HCHH-T0002, section 3.2.1, requires the equipment to be designed to incorporate features to enable remote maintenance. There are no design provisions for remote maintenance and the 24590-CM-POA-HCHH-00001-03-00004 Vendor Low Activity Waste Facility North Inert	Increased manned entries, for preventive maintenance, will increase personnel risk of contamination exposure and reduce the system availability.	The design requirement for remote maintenance features cannot be readily corrected, nor should they. The frequency for equipment maintenance should be handled during routine maintenance for all equipment in the same area.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		Fill Hopper Assembly- Installation, Operation and Maintenance Manual, requires chain lubrication and gearbox oil replacement approximately every 6 months. This maintenance frequency would seem to suggest that the design provisions for remote maintenance would be required.		
LFH-SSS-1-V001	Inadequate materials of construction.	The coil airline, connecting the shard pickup assembly to the facility air, is not high temperature material. The hose material cannot be operated reliably at temperatures above 180-200 °F. The air supply hose will only see high temperatures when the shard pickup assembly is at its lowered position and the air supply is turned off. However, this condition will occur often enough to cause premature airline failures.	Premature material failures will cause increased maintenance costs and decrease equipment overall effectiveness.	The coil air supply line should be covered with high temperature sheathing to reduce any high temperature effects.
LFH-SSS-1-V005	The shard pickup assembly cannot be remotely disassembled for cleaning between samples.	Specification for the Shard Sampling System, 24590-LAW-3PS-M000-T0006, section 3.1.4.9 indicates the shard pickup assembly shall be able to be remotely cleaned to minimize cross contamination between samples, by disassembly of pickup and filter parts for change out. The filter assembly is designed for MSM remote replacement, but the pickup assembly is not designed for remote maintenance. The shard pickup tip assembly does have the ability to provide pneumatic back pressure to reverse flow and blow the pickup tip clean. This may meet the intended philosophy for remotely cleaning between glass samples, however it does not meet the specification functional requirement.	If this is required to prevent cross contamination between samples the activity will need to be performed by a manned entry. This additional maintenance activity will increase maintenance costs and decrease the equipment's overall efficiency.	Redesign the shard pickup tip assembly for remote disassembly for cleaning between samples. Demonstrate the remote disassembly capability using a proto-typical MSM.
LFH-TOOL-1-V001	Inadequate design basis documentation	Failure to provide accurate design requirements in data sheets, drawings, and test documentation.	Maintenance and operations will spend time researching and establishing the design basis for equipment.	Revise design and fabrication documentation to ensure accurate and as-built information.
LFH-TOOL-2-V001	Inconsistent grapple load rating	Mechanical Handling Data Sheets all require the grapple load capacity to be 10 ton (20,000 lbs). However, specification for special grapples and lifting devices, 24590-WTP-3PS-MQL0-T0003, section 3.8.2.1 requires a safe working load of 16,500 lbs. The ICD 15, Interface Control Document for Immobilized Low Activity Waste, allows the mass of each package to not exceed 10,000 kilograms (22,046 lbs.).	Confusion with basis of design	Increase the grapples safe working load design to 25,000 lbs. to handle all container conditions.
LFH-TOOL-2-V002	Law Production Container Volume, Weight, And Center Of Gravity Calculation, 24590-LAW-M0C-LRH-00004, does not include an over pack condition.	An abnormal condition could occur if the container cannot be decontaminated and over packing is required to be added to the container.	Special container handling devices will be required to handle off-normal conditions	Revise calculation to include the addition of over packing material to the outside of the container. This will provide a basis for future non-conforming container handling designs.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-TOOL-2-V003	Grapple temperature limitations.	24590-QL-POA-FH00-00001-08-00001, Supplier's Submittal - LAW Container Grapple Stress Analysis, indicates that the reserve factor is barley met with a load of 16,500 lbs and a flange temperature of 600 °F. The CFD Analysis of LAW Pour Caves and Finishing Lines, 24590-LAW-M4C-C5V-00001, indicate the surface temperature of the pour container neck and flange vs. time will be much higher than 600 °F. The analysis, shown in figure 49, stops after 20 hours but the trend is to be well above 800 °F after 28 hours. This temperature range would prevent the container movement under the single pour operating conditions. The alternating pour operating conditions may or may not be an issue based on this data, so the analysis should be redone to include additional time and cooling conditions.	Since the grapple is a common design the temperature limitation is as important as the safe working load limitations. These conditions could lead to unsafe lifting conditions and/or prevent the melter single pour operating condition.	Add grapple markings to clearly identify temperature limitations the same way safe working loads are identified. Consider adding instrumentation to directly measure the container flange temperature, in the pour cave, prior to using the grapple.
LFH-TOOL-2-V004	Grapple excessive load testing.	General specification for remote and mechanical handling equipment design and manufacture, 24590-WTP-3PS-M000-T0002, section 3.4.3.10, indicate that lifting attachments shall be factory load tested at 125% of rated load in accordance with ASME B30.20 (Below the hook lifting devices). The ASME B30.20, Below the hook lifting devices, section 20-1.3.8.2 indicate that test loads shall not be more than 125% of the rated load unless otherwise recommended by the manufacturer. The testing requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.6.c requires the grapple static load test to be performed at 150% of the SWL and held for 15 minutes.	Confusion with basis of design	Revise BNI procurement process to ensure vendors test equipment according to contractual documentation and that all requirements are consistent between documents.
LFH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	The design requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.8.2.3 requires the grapple's three fingers to have a combined minimum total contact area of 15 in2. This requirement was not validated in the factory acceptance test, 24590-QL-POA-FH00-00001-13-00003, and should have been measured as a critical characteristic of the grapple assembly. This requirement is carried into the LAW Production Container Stress Analyses, 24590-LAW-M0C-LRH-00003, which indicates that at hour 20 the container flange temperature is 457 °F and can be safely moved without the container flange reaching yield stress limit. However, this analysis container flange temperature does not agree with the CFD analysis, the grapple contact area is less than half the actual grapple contact area, and the container load is assumed to be 16,000 not 16,500 lbs.	Failure to document design requirements.	The requirement should be validated during start-up testing to ensure these critical characteristic are met.

Table B-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	• Specification requirements in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.7.g indicate the grapple will be tested to ensure it is capable of maintaining its engagement even if the load is laid on its side and the tension on the bail is relieved; the grapple shall then be capable of lifting the load when the hook is raised, all as part of the 20 complete cycles simulating actual operating conditions. The simulated operating conditions test consisting of 20 completed cycles is performed in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test plan for MR36 LAW grapples and grapple stands section 3.A.4, but this step is omitted. • The system description for the LRH, 24590-LAW-3YD-LRH-00002 section 4.1.2.1.2, indicate the grapple, in the disengaged position, shall be capable of being inserted into and withdrawn in a vertical direction from a right-circular, cylindrical cavity with a diameter equal to that of the container. This requirement would qualify as a critical dimension and should have been verified during the factory acceptance testing performed and documented in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test	Failure to test and document the design requirements are met.	All required performance design requirement should be performed as part of an additional FAT or demonstrated through analysis.

Table B-11. Vulnerabilities Identified for Radioactive Solid Waste Handling (RWH). (4 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRWH-F-06-V-01	Incomplete design of equipment and systems to implement waste handling and storage functions.	LAW system RWH only provides cranes; the following are not adequately addressed: • Lifting and handling equipment for handling the various waste containers and movement through the facility. • Waste transfer paths within LAW, export location, and waste storage locations not defined. • Size reduction capability required but not provided for caustic scrubber bed and mist eliminator candles. • The expected dose rate and chemical hazard from the waste and the need for shielding/protection is not defined. • The decontamination effectiveness to meet WIR requirements is not defined.	• Increased risks in delaying completion of commissioning and operations interruptions: • Equipment currently not provided. Delaying definition and procurement of equipment may delay commissioning • Lack of defined path and export point may result in interface issues; lack of permitted storage may result in production delays • Size reduction equipment/facilities not provided;	• Define, design, and provide lifting and handling equipment for each identified packaging. • Define waste export paths from each point of generation, define export location with consideration of interfacing systems or competing uses, and define and permit waste storage suitable for radioactive and chemical hazards with consideration of waste flow patterns and waste transport schedule.

Table B-11. Vulnerabilities Identified for Radioactive Solid Waste Handling (RWH). (4 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			adequate packaging without size reduction not identified • Increased dose to workers if adequate shielding during packaging, handling, or storage not provided; delay in production if adequate packaging not available. • If WIR requires higher level of decontamination than provided by dry wipe down methods; aggressive decon methods and facilities will need to be designed into LAW facility; delaying start of production	• Define, design, and provide waste size reduction equipment and facilities for caustic scrubber bed and mist eliminator as required to package in designated packaging. • Define radioactive and chemical hazard expected for the various waste streams and define and provide shielding, protective packaging, as required. • Obtain the WIR determination and evaluate ability to decontaminate to WIR requirements using dry wipe decon methods; define, design, and provide additional aggressive decontamination equipment and facilities as required. •
LRWH-F-07-V-01	The RWH process crane does not have an indexing system that defines its safe operating envelope(s).	• The similar LSH process and CCB handler cranes were manufactured and delivered by the same supplier and have utilized laser positioning for convenience but this technology was not utilized for the RWH crane even though the lifts and lift paths would be repetitive and programmable. • Also, there is offgas piping in the room that can be programmed to avoid if engineering controls were in place. •	• Repetitive and frequent jogging of the crane decreases the life of the electrical components and can cause serious wear to the mechanical components of the crane. • Impact with the offgas piping can completely stop production and puts an operator in a dangerous position.	• Utilize laser positioning and develop indexing or auto-indexing features for the RWH process crane. • Program engineering controls into the crane to avoid travel over the offgas piping.
LRWH-M-02-V-01	Sufficient priority, resources and funding have not been allocated to LRWH maintenance work planning to ensure successful plant commissioning, startup and operations.	• Detailed work plans have not been developed for maintenance/repair activities that utilize the LRWH System to ensure adequate space, time and crane availability. • The current WTP OR model is based upon assumed times and rates, even though no detailed work breakdown evaluation has been conducted to support these assumptions. • Failure to conduct adequate work planning and OR modelling so that conflicts can be resolved in the plant design, will negatively impact plant commissioning, startup and production.	• Waiting until plant commissioning and startup to determine how maintenance will be conducted is too late to influence gaps in plant design. • Failure of the LRWH System to support critical path activities for other systems on schedule during commissioning, startup and operation resulting in a failure to support glass production estimates and to meet throughput expectations.	Detail, model and evaluate all critical LRWH System activities and spaces. Factor the results of these evaluations back into the plant and system designs.

Table B-11. Vulnerabilities Identified for Radioactive Solid Waste Handling (RWH). (4 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRWH-M-02-V-03	• WTP is not following the DOE Hoisting and Rigging program, and no WTP specific hoisting and rigging program and/or critical lift program for the LRWH System have been defined nor is currently under development. • It is unclear how a WTP LAW hoisting and rigging program or critical lift program will adequately protect critical at-risk Safety equipment.	• Operations will be constrained to the DOE Hoisting and Rigging program, but this is not considered in the current construction contract or plant design. • It is unclear how any hoisting and rigging programs will adequately prevent damage to Safety system piping.	Due to the crane and LRWH area configuration, damage can occur to critical Safety system offgas piping.	Restrictive crane envelopes, and more extensive physical and procedural barriers, should be added to protect critical Safety systems. The specific hoisting and rigging program and/or critical lift program for the LRWH must comply with the DOE Hoisting and Rigging Manual.
LRWH-F-06-V-02	HEPA filters may develop too high a radioactive loading before pressure differential monitoring indicates a heavy particulate loading.	HEPA filters are bagged out using a hands-on method and this change-out is currently assumed to be scheduled before the filters have accumulated excessive radioactive loading; however, how this will be achieved is not defined as most particulate is not expected to be radioactive.	• Inadequate consideration of ALARA principles: • Increased dose to workers, • Ad-hoc procedures and packaging necessary after assumed survey prior to filter extraction, • Disruption of normal activities as off-normal container is conveyed though corridors and freight elevator.	Identify available ports on the HEPA filter assemblies and specify a method to monitor radioactive loading buildup during normal inspections (i.e.. rounds).
LRWH-S-09-V-01	Experience performing startup and commissioning the LAW System RWH Process Area Bridge Crane for turnover to construction indicates that not performing these activities as soon as possible will delay all startup and commissioning activities as problems are uncovered late in the schedule when the project will be on the critical path for startup and commissioning.	• Commissioning major pieces of equipment is a difficult and usually lengthy effort. LAW Facility Systems are often complex, with many interacting components. Installed plant equipment that has not been through the commissioning process or otherwise turned over to operations will very likely require rework, delaying the completion of the Facility System startup and commissioning. • Current startup and commissioning plans begin after construction is complete, which will place all component rework on the critical path to startup/commissioning.	Startup and commissioning will be delayed as rework on component equipment and assemblies will occur on the system startup and commissioning critical path. This will delay facility startup and commissioning, which will have mission impact of six months or more.	• Follow a "bottom up" startup and commissioning strategy to reduce upsets on the critical path during plant startup and commissioning: • Isolate an area from construction activities containing installed components, • Bring in plant services or equivalent temporary services, • Startup / commission all components in the isolated area, • As the area can be extended, startup and commission interacting components and assemblies, • When a Facility System is entirely in an isolated area, begin startup and commissioning activities.

Table B-11. Vulnerabilities Identified for Radioactive Solid Waste Handling (RWH). (4 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRWH-M-02-V-02	Funding & resources have not been allocated to address: • Equipment no longer under warranty. • Equipment preservation and degradation	• Equip. procured early in the project: - Is now no longer covered under the manufacturer's warranty (e.g., cranes). - Is experiencing degradation such as corrosion and false brinelling (e.g., cranes). • If plant startup is subsequently delayed, additional inspection, refurbishment and equipment procurements may be required	• Existing equipment warranties have expired (e.g., plant cranes) • Increased costs due to additional procurements of equipment to replace degraded items procured early in the project. • Increased cost and schedule delays due to numerous setbacks in WTP plant startup date projections.	Develop long term funding and plans that address expired warranties, replacement and/or refurbishment of equipment.
LRWH-M-02-V-04	Key LAW documents contradict each other regarding LRWH System scope.	• The scope of the LRWH System is not consistent in key LAW documents. • The LAW Facility Description and RWH System Description are inconsistent regarding the discussion of; "bagging, packaging, decontamination, swabbing, etc." • The LRWH System description specifies that crane decon can be accomplished with CO2, pressurized warm water, steam, etc. However no such capability exists within LRWH and the SME states that no decontamination beyond wet wipes will be done. • The LRWH System description states that crane operations are conducted autonomously from the crane's pendant or its radio transmitter which is a contradiction.	• The lack of consistent understanding regarding key LRWH system functions could lead to deficiencies that delay commissioning and startup. • LRWH crane control will not be correctly designed nor adequately protect Safety System components.	The specific activities included in the scope of the LRWH System and equipment, and all interactions with associated systems should be clarified and documented consistently in WTP documentation.
LRWH-S-04-V-01	Many methods of secondary waste disposition and transfer paths within the facility remain undefined.	• Facility personnel conveyed that HEPA filters "may" fit in 55 gallon drums and a location for agitator blade change out remains undetermined. No specific system addresses this scope. • The agitator and pump will not fit in the waste container identified. A special waste container design and certification will be required.	Inability to disposition waste could significantly impact facility production.	Model all waste disposition streams and determine whether necessary equipment and transfer paths within the facility are adequate. Incorporate results into appropriate system descriptions.
LRWH-F-13-V-1	Transitioning an agitator or pump from a vertical position to a horizontal position is not identified in the current design or operation.	A methodology to export a spent agitator or pump has not been identified. No size reduction is planned. Therefore, a spent agitator or pump must be transitioned between vertical and horizontal at least twice on the export pathway from El. 28 ft. to El. 3 ft.	The LAW facility design does not currently facilitate exporting and packaging a spent agitator or pump in a vertical only position. Therefore, the spent components must be transitioned between vertical and horizontal positions.	Develop a methodology to export a spent agitator or pump which may require transitioning the spent equipment between a vertical and horizontal position.
LRWH-F-13-V-2	A method to transport an agitator or pump from: a) the process cell charge floor hatch area to the L-0207 floor hatch; and b) El. 3	A methodology to transport a spent agitator or pump within the LAW facility has not been identified	The LAW facility will be unable to transport a spent or new agitator or pump within the facility.	Develop a methodology to transport a spent agitator or pump.

Table B-11. Vulnerabilities Identified for Radioactive Solid Waste Handling (RWH). (4 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	laydown area to the truck dock has not been identified.			
LRWH-O-03-V-01	Equipment and attachment points are not determined for recovery of the Process Area Bridge Crane to its maintenance position.	The System Description talks to "recovery features" but no specific method or equipment is identified.	In the event of a failure of the Process Area Bridge Crane drive system, a recovery approach and the needed equipment would have to be determined with potential production impacts.	Perform preliminary planning on how the crane would be recovered and what equipment is needed.
LRWH-F-13-V-3	Replacement of 14 components (agitators and pumps) from tanks within the process cell may be completed within the 6 month schedule to replace a melter. However, each replacement activity will compete for a finite man-hour resource.	The estimated outage for agitator and pump replacement activities is 168 days using the OR model. The melter replacement effort will compete with agitator and pump replacement and may create a challenge for the LAW man-hour resource.	The melter outage may not be completed within 6 months as currently planned due to competition with agitator and pump replacement for man-power resources.	Perform a man-power loaded melter outage including RP technicians, operators, and maintenance staff and include a simultaneous outage for replacement of 14 agitators and pumps and determine if throughput is reduced without modification such as staff augmentation.

Table B-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LCP/LFP-01	Potential for GFR component omission to cause premature melter failure	• Waste composition changes to melter feed expected to be gradual over time, but misbatching GFR addition (bounded by a component omission) calculated to cause change to melter inventory composition after one melter feed batch • Some GFR components ensure glass properties are compatible with melter operation • Estimate omission of single GFR for one or two feed batches in succession reduces melter inventory composition by 20 to 50 % relative to goal composition • Unclear if this type of off-normal condition could cause premature melter failure • MFPV sample not designated as hold point, but would be expected to be available to define mitigation under normal conditions • Unclear if laboratory priorities could delay results for samples that are not designated as hold points during time periods where a work flow backup occurs • Could result in processing multiple off-normal feed batches in succession • Waste composition changes to melter feed expected to be gradual over time, but misbatching GFR addition (bounded by a component omission) calculated to cause change to melter inventory composition after one melter feed batch • Some GFR components ensure glass properties are compatible with melter operation • Estimate omission of single GFR for one or two feed batches in succession reduces melter inventory composition by 20 to 50 % relative to goal composition • Unclear if this type of off-normal condition could cause premature melter failure • MFPV sample not designated as hold point, but would be expected to be available to define mitigation under normal conditions • Unclear if laboratory priorities could delay results for samples that are not designated as hold points during time periods where a work flow backup occurs	• Undefined potential for premature melter failure resulting in loss of production • Non-conforming glass canister	• Conduct impact assessment that defines the time period associated with omitting each glass forming component that could result in a premature melter failure • Define receipt of MFPV sample analysis results as hold point for initiating the next (or a fixed number of batches) glass former addition to mitigate potential for multiple misbatch additions in a row based on the omission time periods that could result in premature melter failure • Use control system to identify gross changes in batch to batch glass former component additions as method of warning that a potential input error has occurred (i.e.. use control system to flag large variances in expected inputs such as glass former weights).

Table B-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		Could result in processing multiple off-normal feed batches in succession		
LCP/LFP-03	Design basis temperature of 150°F for CRV, MFPV and MFV vessels may not be adequately conservative under off-normal conditions (extended idle periods).	• Cooling jackets for MFPV and MFV appear adequate under nominal conditions but could exceed temperature design limit if agitation is required over long periods or if temperatures of feed transferred from CRV are elevated. • Appears 150 °F is adequate for CRV under most conditions. However, establishment of vessel design temperature considered agitator operation for 64 hours rather than an equilibrium temperature. Agitation could be required for more than 64 hours. • The current temperature hi-hi alarm is set at 150 °F without margin to design limit.	• Operation of vessels beyond design temperature limits (tanks are built as pressure vessels with code stamp). Vessel appears adequately robust to support increasing the design basis temperature. • If tank temperature limits are exceed then development of recovery action plans and associated vessel analysis could impact throughput.	• Re-evaluate design basis temperature limits for vessels to increase operating margin and operational flexibility. Vessels appears adequately robust to support increasing the design basis temperature to 200°F • Establish operational procedures and protocols to deal with prolonged periods of agitation operation in both CRV and LFP tanks (i.e., add water, temporary termination of agitation, etc.). • Re-analyze LCP/LFP tank equilibrium temperature for the possibility of extended periods for melter idling. Calculate the tank equilibrium temperature using agitator heat input, latent heat of evaporation inside the tank, plant service air flow rate and vessel vent flow rates. • Evaluate the impact that the boric acid exothermic reaction has on the operation of the MFPV tank temperature. • Consider feeding glass formers into the MFPV tank over a longer period of time (5-7 hours) to prevent tank temperature approaching or exceeding the tank design temperature limit.
LCP/LFP-04	Unknown ability of the LAW LFP Feed Prep and Feed Vessels to structurally support the external cooling panel sections.	• Unverified assumptions in the code calculation addendum need to be verified. • Method for attaching the cooling panels to the vessel is different than what was analyzed. • Weight of the panels analyzed was 3,000 lbs. when actual panel weights are 3,556 lbs. with cooling water and hoses. • Actual height of the jackets (unsupported portion) is 7'-11" and the calculation shows 5'-5". • In the WTP calculation, the UBC information utilizes an "R Factor" of 2.2000 and the Vendor calculation utilizes an "R Factor" of 2.9000. The reason for this difference is unclear.	• The LFP vessels may not meet the structural and seismic requirements of ASME Boiler and Pressure Vessel Code. Vessels that do not meet code requirements will result in delays to resolve issues and may not be able to place vessels into service until resolved (e.g., *RCRA* permit concerns related to code requirements) • May require vessel repairs or replacement if structural integrity cannot be confirmed. • There appears to be sufficient margin in the vessel skirt thickness	• Confirm unverified assumptions in analysis • Update analysis and verify adequacy of vessel design.

Table B-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• In the WTP calculation, the UBC "Soil Profile" uses "SD" and the Vendor calculation uses a "Soil Profile" of "SC". The reason for this difference is unclear. • The Vendor calculation and the WTP calculation did not take into account the full equipment weight attached to the vessel (1,631 lbs. vs. 18,450 lbs.) • The cooling jackets have been fabricated and delivered without closing out the unverified assumptions in the calculation.	analysis but cannot confirm acceptability.	
LCP/LFP-05	The 40 year design life of the LFP Vessels is in question due to the lack of credible data to accurately predict the erosion wear for SA-240, 316L material.	• The basis for the assumption that for the LFP Vessels, the velocity inside the vessels with glass formers will be less than ½ the agitator tip speed is derived from the results of a Non-NQA-1 Computational Fluid Dynamic (CFD) software performed by the agitator vendor. With this unverified assumption accepted, all that is currently required for verification is to confirm the agitator shaft RPM and blade dimensions during startup testing and commissioning. • The LFP Vessels have welded features attached to the inside lower head (instrument cluster, pumps and pump alignment pins and agitator bump ring) that have not been modeled in the agitator vendor CFD analysis. These internal appurtenance's will disrupt flows and create eddies such that accelerated erosion pockets can form in the bottom head and shell which could exceed the calculated uniform erosion rate. • The 24590-WTP-RPT-M-12-001, WTP Sensitivity Assessment of Erosion Calculation states "All of the models used by the WTP Project have coefficients and exponents with a large degree of uncertainty since they are primarily derived from test data that was not directly applicable to the waste streams that are expected to be treated at WTP and/or did not use the materials of construction at WTP."	• Premature failure and leaking of LFP vessels in the C5 Wet Cell. • Premature failure of equipment installed in the vessels • Expectation of a 40 year design life without a plan for vessel removal, fabrication and re-installation.	• Conduct additional CFD analysis with appurtenances modeled per vessel configuration to identify potential areas of accelerated erosion. • Based on the CFD analysis, consider remote vessel wall thickness monitoring (e.g., ultrasonic thickness transducers) permanently mounted to lower head and shell. • Conduct additional prototypic testing with relevant simulant to confirm relationship of agitator speed to fluid velocity at vessel head/walls. • Perform post-commissioning vessel inspections to determine evidence of premature erosion. • If still warranted from above, consider thermal spray hard coating of vessels and internals. • If thermal spray is considered, then also consider increasing the vessel design temperature to eliminate the need for the add-on cooling panels.
LCP/LFP-06	The operating envelope has not been defined to ensure the requirement for mixing homogeneity can be met	• The information (e.g., agitator performance) required to prove 2% mixing variance is not directly or immediately available to the operator.	• Non representative sampling leads to incorrect GFC composition/amounts leading to non-compliant LAW glass.	• Define operating envelope and how much deviation can be allowed.

Table B-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	during normal plant operations	• VSL testing indicated that radar level instrumentation may be problematic (affected by vortexes, foaming, splashing, etc.)	• May require additional waste or glass sampling. • May prolong commissioning efforts to determine 'confirmed' operating envelope for mixing.	• Consider alternative level detection such as using existing dip tubes (add transmitter to long leg of specific gravity dip tubes). • Consider adjustable speed drive (ASD) on agitators to allow flexibility to achieve required mixing performance.
LCP/LFP-07	Fixed speed agitators may not provide adequate flexibility to address variations in process conditions or recover after prolonged down time	• Adjustable speed drive was recommended by the vendor. • Testing has shown that variation in feed rheology is not always predictable.	• Increased erosion rates during prolonged melter idling reduce life expectancy of vessel and/or agitator. • Inability to recover from batches that exhibit high viscosity due to 'aging'.	Consider adding ASD to agitators.
LCP/LFP-12	A comprehensive equipment condition monitoring strategy/system is not evident so that process cell entries can be avoided	• Pump and agitator performance parameters (e.g., amperage, earth fault, thermistor) are inherent in the design but not currently identified for display to operators. • Many useful pump performance parameters are available via the ASDs PROFIBUS connection. The ASD design exists for the pumps and could be easily modified to include ASDs on the Agitators to improve flexibility and troubleshooting capabilities • Riser for agitator gear box oil provided but no definition on how to use it. • No means evident to monitor/maintain oil pumps included in agitator gear boxes	• Incomplete information regarding equipment performance may require process cell entries for troubleshooting that could otherwise be avoided • Premature failure of equipment that otherwise could be avoided • Unaccounted production impacts and potential for increased worker exposure to hazards (e.g., to enter process cells).	Develop a formal comprehensive strategy for equipment performance monitoring. Review current design against the strategy and implement design changes as necessary.
LCP/LFP-14	Current approach to ADS pump monitoring/trending may not be adequately indicative of performance	• Monitoring/trending currently considers single point comparisons of time phased pressure drop. This may provide false indication of adequate pump performance if the poppet valve is stuck closed. • Cannot confirm adequacy of ADS pump performance by the visual inspection of the condition of the cold-cap	Inadequate pump performance not identified thereby leading to lack of uniform feed for cold cap which can then lead to melter performance problems such as the creation of hot spots, elevated temperature in the offgas and loss of volatiles normally suppressed by the presence of the cold cap.	Consider using a two or more point comparison of ADS pump air-line pressure as a better indicator of overall performance and as an operator aid, for example the apex of the pump discharge pressure.
LCP/LFP-02	Capability to monitor feed slurry rheology during extended storage in MFPV/MFV is not defined/demonstrated	Test reports indicate that feed slurry apparent viscosity can increase by a factor of 2 due to aging	• Increased apparent viscosity may prevent transfers at desired transfer rate • Inadequate transfer rate may result in line plugging	• Include agitator power trending and/or periodic (or perhaps continuous) pumping of tank contents through MFPV/MFV recirculation lines as part of monitoring scheme when melters placed in idle mode. An ASD is considered to be the best

Table B-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			• No tool available to decide if/when MFPV/MFV contents must be recycled to Pretreatment via RLD system when idling melters for an extended time period (glass former recycle has potential to cause Pretreatment and HLW operating upsets)	method for agitator control and trending parameters/performance. • Periodic sampling during long outages to test for rheology changes
LCP/LFP-08	Cooling jackets for MFPV and MFV tanks do not include pressure relief.	• Jackets are designed for a maximum pressure of 100 psig. • Maximum demineralized water pressure is 145 psig. • Pressure relief is provided for other cooling jackets (e.g., SBS vessel)	Failure of cooling jacket could impact production and challenge the design temperature limit (150°F) of the vessel	• Evaluate the need for pressure relief for the MFPV and MFV cooling jackets. • Add pressure relief on the demineralized water system downstream of the PCV-2101 to control pressure for SBS as well a LFP cooling jackets.
LCP/LFP-09	Lack of comprehensive engineering strategy for removal of hard to remove solids or significant accumulations of solids in piping and vessels.	• Spool pieces are available to connect flush equipment but interfacing equipment not designed • Necessary design features for flush equipment and strategies for removal of significant solids accumulations not yet defined • Flush equipment necessary to support removal of pipe blockages or introduce alternative flush agent chemicals has not been developed. • Not evident that spray nozzles in vessels are sufficient to remove high shear (up to 2300 Pa) solids from vessels as could result from the loss of agitation for an extended period or collection in tank zones with poor agitation over an extended period (e.g., under center of agitator impeller)	Lack of design and testing of interfacing flush equipment could delay recovery from pipe blockages with attendant production impacts May impede pump and agitator replacements Reduction of vessel working volume	• Develop comprehensive strategy for removal of blockages from piping and high shear solids from vessels. • Define features necessary for pipe and vessel flush equipment to implement solids removal strategy • Design, test and demonstrate ability to deploy flush equipment • Evaluate the need for additional spool pieces/cleanout ports to support pipe flushes • Evaluate alternative flush chemicals • Evaluate need for other slurry handling systems based on lessons learned from other facilities • Consider tank farm lessons learned on removal of high shear solids
LCP/LFP-10	The LCP/LFP bulge drain systems do not appear to have adequate drain capacity when spray rings are turned on.	• It appears that the LCP and LFP bulges can either partially fill with water or completely overflow via the HEPA filter if spray water system is left on for extended periods. • The only equipment for control of the spray water is the manual water spray ring valve and the RLD sump level • Drain blockage can be caused by system leaks which dry up and form crystals that blind strainer. Creeping film across the bulge to the drain is also	• Contaminated water (from C5 area) can overflow to the floor of a C3 area. • The bulge HEPA filter will become wet and have to be replaced.	Consider additional controls for the flush water flow to the bulge spray rings such as: • Install level monitoring in the bulge and change manual valve to a control valve which could be shut off automatically whenever the level in the bulge gets too high. • Install smaller capacity spray nozzles. • Install local liquid level gauge for operator to monitor liquid level.

Table B-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		possible. If the bulge drain line strainer is partially blocked or totally blocked then the bulge could overflow into the C3 area in less time than for a free flowing drain.		• Install orifice to reduce flow and pressure to spray nozzles. • Automate water spray system to limit time of flush and/or sequence flushes for short flushes followed by time drainage periods in a series of 2-3 cycles.
LCP/LFP-11	Ability to automate using existing design features appears underutilized	• Valve alignments for fluid transfers and flushes currently rely on operator actions and specific permissives. • Functionality is inherent in the design to fully automate transfer and flush sequences to minimize the potential for misrouting or line blockages due to operator error. • Auto-lubrication system for pumps/agitators includes option for remote control & power which has not included in the design (relies on battery power and in-cell indicator lights monitored by a camera)	• Increased probability of human error leading to misrouting transfers of process solutions or inadequate flushing leading to blockages. • Increased frequency of entries to process cells to monitor/maintain lubrication system with attendant throughput impacts.	• Consider fully automating transfer and flush sequences. • Consider adding equipment performance trending/monitoring parameters for display to operators. • Consider adding ASDs for agitator operation. • Incorporate remote monitoring/power option for auto-lubrication system
LCP/LFP-13	Undemonstrated ability to install/replace pumps/agitators and other internal components that require alignment with the vessel base (such as bubbler tubes and thermowells).	• No testing evident that the approach for alignment of pumps and agitators within the vessels can be effectively performed with the vessel in various operational conditions (e.g., full, partially full, minimum heel, etc.). • Effectiveness of the positioning aids to ensure alignment not apparent or demonstrated with anything other than a completely empty tank.	• Extended duration of agitator/pump replacement. • Installation without verification of adequate alignment could result in premature failure of pump/agitator and damage to vessel.	• Confirm the ability to change a pump/agitator under various vessel operating conditions during commissioning or as a mock-up • Consider the viability of incorporating additional alignment aids such as inverted cone to the base of the flange with the stabilizer guide
LCP/LFP-15	Basis/definition of acceptable gear oil leakage rates and process impacts is not evident	• Seals in gear boxes for agitators are not totally leak free, as per operating manual "If oil level has been exceeded, drywell will be filled with oil and oil leakage down output shaft will occur". Therefore, it appears that gear box oil/grease could leak into process vessels unnoticed. • Gear box holds 9.5 gallons of mineral oil. • Normally small amounts of leakage are probable, but no formal analysis demonstrated to determine process impacts, if any.	• Increased wear on agitator gear boxes from loss of oil/lube • Increased generation of Products of Incomplete Combustion (PICs) in the melter • Increased TCO catalyst usage • Exceed VOC limits in the offgas discharge • Operators have to enter Wet Process Cell to refill lubricant as necessary – requires melter(s) to be idled.	• Perform calculations to quantify acceptable limits for leak rates and/or amounts each vessel can tolerate. • Finalize design features for checking and replacing gearbox oil utilizing existing riser piping at the 28" level.
LCP/LFP-16	Adequate mock-up/testing facilities are not available/planned to support high risk contact maintenance activities (such as	• Lessons learned from nuclear facilities across the DOE complex indicated that the success of high risk maintenance activities depends on the ability to mock-up and practice such activities.	• Increased planning and preparation duration	• Conduct a formal and systematic analysis of maintenance infrastructure needs

Table B-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	pump/agitator replacement) and testing/run-in of mechanical equipment	• No evidence that a mock-up facility or dedicated mock-up area within the facility is planned or available	• Increased potential for errors (in planning and execution) that cause rework. • Increased risk of worker exposure to hazards • Increased impact to throughput due to prolonged outage durations	• Identify and prepare an existing facility for use as a WTP mock-up/testing facility (e.g., 2101M, MASF at FFTF, etc.) or; • Design and build (e.g., pre-fab building) a testing/mockup facility at WTP. • Consider working with the tank farm contractor to establish a shared/consolidated mock-up facility.

Table B-13. Vulnerabilities Identified for Container Export Handling (LEH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LEH-IC-1-V001	Requirement Documents Conflict	• The 24590-CM-POA-MJKG-00003-11-00002 Software Document LEH Export Handling Crane, says that the LEH Export Handling Crane LEH-CRN-00003 uses the North position as its "home position" and that forward motion indicates south travel. The first interlock shown on Mechanical Sequence Diagram (MSD) for Law Vitrification System LEH (24590-LAW-M1-LEH-00001) indicates that forward movement is to the North. This makes interpreting the interlock difficult.	• If the interlock fails to operate as intended the crane, the container or the extended shield wall may be damaged. Crane operations over the Export Office would endanger workers. • Even if the interlock operates as intended, the conflicting documentation will make it difficult to over-ride the interlock for off-normal operations or to change the interlock, if necessary for future software revisions.	• Correct the Export Handling Crane LEH-CRN-00003 software documentation for consistency and to agree with the calibration of the Laser Positioner ZT-0147. Verify that the programming matches the updated documentation. • Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming
LEH-IC-1-V002	Interlock Incorrectly Defined	The interlocks for raising and lowering the Main Hoist on the LEH Export Handling Crane (LEH-CRN-00003) are shown on Mechanical Sequence Diagram (MSD) for Law Vitrification System LEH (24590-LAW-M1-LEH-00001). The state column incorrectly shows the undesirable condition (i.e., Overload instead of Not Overload or Slack Cable instead of Not Slack Cable).	• Reversing the interlocks will cause the crane hoist to not operate. Operation of an overloaded hoist will damage the crane and stop all export operations as there is no redundancy. • The consequence of incorrect documentation is improper programming, and improper programming of software changes.	• Correct the Export Handling Crane LEH-CRN-00003 documentation so the interlock shows the correct state. • Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming
LEH-IC-1-V003	Missing Interlocks	There are no interlocks shown on the Mechanical Sequence Diagram (MSD) for Law Vitrification System LEH (24590-LAW-M1-LEH-00001) that prevent one of the two roll-up doors to the Export Truck Bay (L0127) from being opened while one or both of the Hatches to the Finishing Lines is open. There are no interlocks at all for the LFH Hatches to the Export Truck Bay shown either on the LEH MSD or 24590-LAW-M1-LFH-00001,	Opening one of the hatches and roll-up doors at the same time would expose a R5/R3/C2 area (Rooms L-115E or L-109E) to the Outside.	• Add interlocks to the design to: - Allow only one LFH hatch to be open at a time - Prohibit the opening of a roll-up door when a hatch is open

Table B-13. Vulnerabilities Identified for Container Export Handling (LEH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		Mechanical Sequence Diagram for LAW Vitrification System LFH. Without these interlocks it would be possible to open both hatches at the same time, open a hatch when the roll-up door was already open, or to close the hatches while transporting a container through them.		- Prohibit the opening of a hatch when a door is open. • Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming with special attention to interlocks that interface between LFH and LEH systems.
LEH-CRN-1-V001	Jib Crane Data Sheets and Specification Inconsistencies	Documentation related to the design and procurement of the West and East Maintenance Jib Cranes (LEH-CRN-00005/6) on 24590-LAW-M0D-LEH-00036/0037 Mechanical Handling Data Sheets - LEH West Maintenance Jib Crane / LEH East Maintenance Jib Cranes, are not in agreement with modifications to de-rate the crane. Hoist information is not consistent with de-rating changes. No record of de-rating or embed wall limitations are documented on the data sheet, even when data was required to be submitted by vendor under 24590-WTP-3PS-MJKH-T0001, Engineering Specification for Commercial Quality Monorail Hoists, Jib Cranes, and Under-Running Single Girder Cranes.	• Inconsistent design basis • Unknown design margin • Potential for exceeding design capacity	Revise all issued documents to reflect the de-rated capacity of the maintenance jib cranes (LEH-CRN-00005/00006).
LEH-CRN-1-V002	Structural Analysis of Export Bay Inconsistencies	The FEA Model for the LAW Export Bay (LAW-S0C-S15T-00022, Rev 0, GT Strudl Finite Element Analysis for the LAW Export Bay) and the LAW Export Bay Wall Design calculation (24590-LAW-DBC-S13T-00053, Rev. 0) were both issued in 2005. Both calculations utilized jib crane vendor issued data as input into the analysis, but neither document determined that embeds design and anchorage could not support the vendor reaction forces from the jib crane and 5 ton load.	• Inconsistent design basis • Unknown design margin • Potential for exceeding design capacity	• Provide a full extent of conditions analysis on embeds that support loads on vertical walls of the LAW Export Bay to ensure the embed design meets equipment loads. • This may already be covered under PIER 13-0515, but this

Table B-13. Vulnerabilities Identified for Container Export Handling (LEH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				PIER was not provided by BNI during the review.
LEH-CRN-1-V003	Maintenance Jib Crane De-rating and Analysis of Embeds Inconsistencies	The de-rating of the LEH maintenance jib cranes (LEH-CRN-00005 and 00006) from 5 tons to 1.75 tons was not well documented or provides a level of assurance that the de-rated value is within the embedment structural limit. There is no evidence to support how the de-rated value of 1.75 tons is calculated or what margin exists if the crane embedments are subjected to that de-rated crane load.	• Inconsistent design basis • Unknown design margin • Potential for exceeding design capacity	• Provide a full extent of conditions analysis on embeds that support loads on vertical walls of the LAW Export Bay to ensure the embed design meets equipment loads (This may already be covered under PIER 13-0515, but this PIER was not provided by BNI during the review). • Revise the embed anchorage calculation to provide the limit of the embed design. The results should show the actual load the embeds can support, including resulting crane capacity that produces that load.
LEH-CRN-1-V004	Maintainability of LAW Export Bay Crane and Jib Crane Capacity	The decision to de-rate the jib cranes (LEH-CRN-00005/6) was partly based on the idea that the new 1.75-ton capacity would cover any item requiring removal from the 10-ton Export Bay crane (LEH-CRN-00003). The main area where maintenance is going to occur on the Export Bay Crane will be the trolley and trolley mounted equipment. The trolley is designed to be lifted as a single unit but neither maintenance jib cranes have the capacity to lift the 7.5 ton trolley. This will force work to be done on the crane itself and individual components will need to be removed while working over 30 feet above the Export Bay operating floor.	• Inconsistent design basis • Maintenance requirements not met • Potential for plant throughput impacts	• Investigate the feasibility of a different lifting system (i.e., single underhung or under-running type) to support the maintenance of the LAW Export Bay Crane designed to work within the limits of the facility and lifting capacity requirements. This might require

Table B-13. Vulnerabilities Identified for Container Export Handling (LEH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				additional structural support or utilizing other structural steel already in place. • The new lifting system should have the ability to move over the entire range of the intended work zone.
LEH-CRN-1-V005	Maintainability of LAW Export Bay Crane and Jib Crane Reach	Based on the location of the permanent maintenance platform LP0127 for the 10-ton Export Bay crane (LEH-CRN-0003), the 10-ton crane cannot move underneath the de-rated maintenance jib cranes (that are located above the permanent platform). The permanent platform forces the 10-ton crane to "park" farther away from the jib cranes and results in a significant area where the crane trolley cannot be reached by either jib crane. In addition any item to be lowered over the south end of the crane has only a 12 inch clearance past the crane handrail when using the West Jib Crane (LEH-CRN-00005), there is only a 1 inch clearance when using the East Jib Crane (LEH-CRN-00006).	• Inconsistent design basis • Maintenance requirements not met • Potential for plant throughput impacts	• Investigate the feasibility of a different lifting system (i.e., single underhung or under-running type)) to support the maintenance of the LAW Export Bay Crane designed to work within the limits of the facility and lifting capacity requirements. This might require additional structural support or utilizing other structural steel already in place. • The new lifting system should have the ability to move over the entire range of the intended work zone.
LEH-CNTR-1-V001	Filled ILAW Container export temperature may affect Tank Farm Contractor (TOC) / Integrated Disposal Facility (IDF) operations	The ILAW glass thermal conductivity property, single pour / alternating pour operations, Facility throughput, Buffer Storage area capacity available, and LAW facility ambient temperatures will all affect how quickly the filled ILAW containers cool. The IDF base mat has thermal limitations. At a LAW Facility production rate of 30 MT/day, the Average surface temperature of an ILAW container holding low conductivity glass will be	If the filled ILAW containers are thermally hot, the TOC may have to stage the containers for further cooling prior to internment in the IDF.	Either increase the ILAW container cooling capabilities of WTP LAW facility, or construct ILAW container cooling facilities at either the TOC or IDF facilities.

Table B-13. Vulnerabilities Identified for Container Export Handling (LEH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		about 320 °F and the temperature of an ILAW container holding high conductivity glass will be about 250 °F.		
LEH-RCSH-1-V001	Contamination migration when transferring ILAW product container	When transferring the ILAW product container, Operations lowers the grapple into the System LFH monitoring/export area. The ILAW product container is then raised, and is then lowered into an ILAW transport container. Although this task is planned to be remotely conducted, there is no engineered decontamination or downposting verification process identified to ensure none of the contamination has migrated outside of the C5 boundaries (such as on the grapple equipment).	• Contamination migration and permanent increased contamination posting • Increased operational and maintenance costs	Evaluate the currently defined work processes and ensure an engineered or administratively-defined process is adequate for controlling contamination migration when transferring the ILAW Product Container from System LFH to the Transport Trailer and that confirmation is available, such as continuous air monitor, to ensure personnel are not inadvertently exposed to an airborne radioactivity area.
LEH-RCSH-1-V002	LEH system compliance to design and operational safety and health requirements	Within the system description for the LEH are specific OSHA requirements and other standards that pertain to cranes and hoists and fire protection; however, a significant number of requirements and standards were not identified as part of the system such as (to mention a few) Subpart D, Walking-Working Surfaces, Subpart E, Means of Egress, Occupational Health and Environmental Control, Subpart N, Materials Handling and Storage. In particular, under "Hands-On Maintenance" no standards for heat stress were identified, only radiological control considerations. It should also be noted that within 24590-WTP-RPT-OP-001, Rev. 4, Operations Requirements Document, general plant safety requirements are identified; however, minimal operational requirements are not clearly identified.	• Inadequate design and operational procedures • Not meeting regulatory/contractual requirements	Verify and validate that all required codes and standards have been incorporated into the design of the LEH system and, if not within the design, the requirements and standards are within appropriate procedures for both operations and maintenance work evolutions.
LEH-RCSH-1-V003	Thermal Temperatures on ILAW Transport Container Package	Workers are required to physically secure the ILAW transport container package to the transport vehicle; however, this may not be physically possible depending upon the external temperature of the transport container package. Evaluation of	• Inadequate design and operational procedures • Not meeting regulatory/contractual requirements	Define/determine an external temperature (max operational parameter) of the transport container

Table B-13. Vulnerabilities Identified for Container Export Handling (LEH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		calculations by the Review Team found that the predicted external temperature of the transport container is variable depending upon operational throughput and the ability for personnel to be able to physically perform this duty may be significantly impacted, if not physically impossible to be performed with a human being.		package that is expected to be encountered by personnel and then to verify that appropriate mitigation of the hazard has been defined. In addition, per the system description the transport vehicle will contain additional containers; therefore, a cumulative effect of the heat being generated from all shipment containers should be analyzed and determined as to what mitigating factors will be needed to ensure protection of personnel from a heat/thermal hazard
LEH-ICD-1-V001	Shielding of the ILAW product container transporter is not defined	Shielding thickness, height, and configuration (number of containers transported per shipment), etc. are key elements of the design of the ILAW containers transporter, which interfaces daily with the LEH System. They remain undefined, which may have an impact onto the loading operations in Export High Bay L-0127.	• Inconsistent/inadequate design • ALARA design inadequacies • Operations concerns	Provide adequate details in ICD 15 for the requirements of the LEH system in regard to source term and shielding. The details should provide enough information for WTP to complete LEH design activities.
LEH-ICD-1-V002	Essential elements of the authorization process for exporting ILAW containers from the LAW facility and review/approval of the shipping Manifest have not been defined	Lack of definition of the organization/personnel at WTP and TOC who will actually validate for each shipment that the Manifest is acceptable and can be handed out to the transporter driver so that the containers can be exported out of the Export Bay. No definition of the documentation review/approval time. No verification that this time can effectively be compatible with the 5 package/day production rate and the size of the filled containers buffer area.	• Inconsistent/inadequate design • Potential impacts to throughput • Potential impacts to operations or operability	Provide adequate procedures for LEH export activities including ILAW Container shipping inspection and authorization requirements.
LEH-ICD-1-V003	Potential conflict between Contamination limitations in Export High Bay and surface	Lack of plan and/or operations procedure to address the more restrictive limiting factor for loose surface contamination in the Export High Bay required by 10CFR 835, Appendix D against	• Inconsistent/inadequate design • ALARA design inadequacies	Align the design basis of the facility to the design implemented in regard to Contamination

Table B-13. Vulnerabilities Identified for Container Export Handling (LEH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	contamination of ILAW product containers	the surface contamination levels of the ILAW product containers defined by the WTP Contract and the performance of the Carbon Dioxide decontamination process deployed in the LFH System.		limitations in Export High Bay and surface contamination of ILAW product containers.
LEH-ICD-1-V006	Open ICD 15 issues and actions may affect the operations in the LEH System	Appendices A and C to ICD 15 list many issues and actions which remain out of the baselines of the 3 Hanford Projects - WTP, TOC, and PRC – or pending, which may impact the design and operations of the LEH System.]	Inconsistent/inadequate design	Provide adequate details in ICD 15 for the requirements of the LEH system and close open issues that may cause significant impact to the project. The details should provide enough information for WTP to complete LEH design activities.
LEH-OR-1-V001	24590-LAW-RPT-PO-05-0001, Rev 0, LAW Reliability, Availability, and Maintainability Data Development Report, inconsistencies and RAM data issues.	The LAW RAM Data Development Report contains information that is inconsistent with other documents, MTTR data that is over optimistic and MTBF data that appears to be wrong. The document describes a sequence of operations for loading ILAW containers on the transportation trailer which is not consistent with 24590-LAW-3YD-LEH-00001, System Description for the LEH LAW Container Export Handling, Rev. 2. The MTTR data for the cameras on LEH-CRN-00003 is overly optimistic if a camera fails while the crane is transferring an ILAW container. The MTBF data provided for LEH-CRN-00003 appears to be an error because the MTBF hours are less than the MTBM hours.	Overly optimistic MTTR data entered into the OR model results in facility availability estimates that are not accurate.	Correct inconsistencies in LAW Reliability, Availability, and Maintainability Data Development Report, re-evaluate sequence of operations when crane camera fails and either allow suspended loads to be landed or increase MTTR for camera replacement, and correct MTBF for LEH-CRN-00003.
LEH-OR-1-V006	24590-WTP-MDD-PR-01-001, Rev 12, Operations Research (WITNESS) Model Design Document, inconsistency and missing information.	The OR Model Design Document (MDD) and the Flowsheet Bases, Assumptions, and Requirements document do not contain the same process steps and times for the LEH system. The OR MDD does not contain RAM information for the cameras mounted on the LEH-CRN-00003.	Incorrect data input into the OR Model will result in facility availability estimates that are not accurate.	Correct inconsistencies in the Operations Research (WITNESS) Model Design Document, and re-evaluate sequence of operations when a Load-out Bay Crane camera fails and either allow suspended loads to be landed or increase MTTR for camera replacement.

Table B-13. Vulnerabilities Identified for Container Export Handling (LEH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LEH-CRN-2-V001	LEH-CRN-00003 crane capacity may not be sufficient.	If a container cannot be decontaminated then an overpack will have to be added. The added weight of the overpack and lifting device (23,863 lbs) will exceed the 20,000 lbs crane capacity.	LAW container cannot be exported and the facility is at risk of being blocked with non-compliant containers.	Establish method for exporting non-compliant containers and validate LEH-CRN-00003 crane capacity is not exceeded.
LEH-ICD-1-V004	Duration of ILAW product container approval process prior to shipment not defined	Lack of indication of the overall schedule/time necessary to go through the successive steps of the documentation preparation and approval process, and no evidence that the overall process can support shipments of ILAW containers at a production rate of 5 containers a day with a limited buffer capacity in the LFH System.	• Potential impacts to throughput • Potential impacts to operations or operability	Provide adequate procedures for LEH export activities including shipping inspection and authorization requirements.
LEH-ICD-1-V005	Uncertainties in schedule for initial ILAW container production and transport	There is no explanation provided for showing in ICD 15 an over 4-month time period between the planned date to begin hot commissioning of the WTP LAW facility (and initiate the transfer of the first ILAW product) and the planned date for TOC to pick up the first loaded ILAW transporter. Such a long time doesn't match the facility throughput requirements.	• Inconsistent/inadequate design • Potential impacts to operations or operability	Provide adequate details in ICD 15 for the requirements of the LEH system in regard to the schedule for initial ILAW container production and transport. The details should provide enough information for WTP to complete LEH design activities.
LEH-OR-1-V002	24590-WTP-MCR-PET-11-0058, Rev 0, LAW Mechanical Handling System RAM Update, inconsistencies.	The report contains information that is internally inconsistent and inconsistent with other documents. The process steps in the report do not include information on how long it will take to reposition LEH-CRN-00003 to retrieve an ILAW container after discharging an ILAW container on the transportation trailer. The report also contains inconsistencies on MTBF and MTTR data for the LEH coiling doors and process step durations.	Incorrect MTBF and MTTR data will affect the results of the OR model.	Correct the LAW Mechanical Handling System RAM Update, so the data is consistent.
LEH-OR-1-V003	CCN 068365, LAW LEH System – RAMI – OR, lacks bases for MTTR data.	Item 4 indicates the cameras mounted on the load out bay crane (PTJ-XT-2161, PTJ-XT-2162, and PTJ-XT-2163) have a MTTR of 8 hours but no basis for these numbers is provided. As indicated in Note 1.c. above, the repair time will be significantly higher if the failure occurs when an ILAW container is being transferred. The process steps as currently written state that the crane must be stopped upon failure of any one camera. This will require significantly more time to establish and setup safety measures (i.e., shielding) and access	Overly optimistic MTTR data entered into the OR model results in facility availability estimates that are not accurate.	Re-evaluate sequence of operations when a Load-out Bay Crane camera fails and either allow suspended loads to be landed or increase MTTR for camera replacement.

Table B-13. Vulnerabilities Identified for Container Export Handling (LEH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		(i.e., scaffolding or scissor lift) so the failed camera can be replaced. [		
LEH-OR-1-V004	24590-WTP-RPT-PT-02-005, Rev 7, Flowsheet Bases, Assumptions, and Requirements, is inconsistent on the number of ILAW containers to put on the transportation trailer.	The last paragraph of Section 3.7.3 and Figure 3.7-1 imply the trailer in the LEH export bay contains one "flask" to hold one ILAW product container. This is inconsistent with item 28 in Table 3.7-1, page 3.7-11, which states to repeat the transfer of an ILAW product container in to a "cask" on the trailer, and is also inconsistent with other documents that indicate the trailer will be loaded with 5 ILAW product containers.	Incorrect process steps and durations will affect the results of the OR model.	Correct the Flowsheet Bases, Assumptions, and Requirements, so the data is consistent.
LEH-OR-1-V005	24590-WTP-RPT-PET-07-003, Rev 1, Waste Treatment Reliability Availability Maintainability (RAM) Basis Report, redundant information.	The table on page B-5 (rows 23 and 24) appears to be redundant to the information provided in rows 27 and 28. The information in rows 23 and 24 should be deleted.	Incorrect data input into the OR Model will result in facility availability estimates that are not accurate.	Correct the Waste Treatment Reliability Availability Maintainability (RAM) Basis Report, so the data is consistent.
LEH-CRN-2-V002	LEH-CRN-00003 crane maintenance/inspection platform not easily accessible.	The crane platform is located on the South side of the bridge and facility platform is located on the North side. Additionally, the North platform will be under the trolley power rail/cable tray.	Climbing on/over elevated equipment, even with fall protection, is a high risk job.	Establish maintenance/inspection access requirements and make design modifications to ensure safe LEH-CRN-00003 crane access.
LEH-CRN-2-V003	Heavy maintenance strategy not defined for LEH-CRN-00003.	There is less than 3' clearance for the hook lifting device/load spreader and for clearance to lift the item over the crane. Further, when the crane is at the northern travel limit, the South side of the crane handrail will prevent maintenance jib crane access to the floor. The maintenance platform is limited to 100 psf which prevents the platform from being used as a component set-down area.	Heavy maintenance evolutions will be very complicated and will increase the facility downtime during these activities.	Establish heavy maintenance activities and detail step-by-step sequences to establish design requirements for crane LEH-CRN-00003. Make design modifications to perform sequences such as doors or hatches in the maintenance platform.
LEH-TOOL-1-V001	Inadequate design basis documentation for container grapple stands	Failure to provide accurate design requirements in data sheets, drawings, and test documentation.	Maintenance and operations will spend time researching and establishing the design basis for equipment.	Revise design and fabrication documentation for container grapple stands to ensure accurate and as-built information.
LEH-TOOL-2-V001	Inconsistent grapple load rating	24590-LAW-M0D-LEH-00022, Mechanical Handling Data Sheet, Grapple, all requires the grapple load capacity to be 10 ton (20,000 lbs).	Confusion with basis of design	Increase the grapples safe working load to

Table B-13. Vulnerabilities Identified for Container Export Handling (LEH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		However, specification for special grapples and lifting devices, 24590-WTP-3PS-MQL0-T0003, section 3.8.2.1 requires a safe working load of 16,500 lbs. The ICD 15, Interface Control Document for Immobilized Low Activity Waste, allows the mass of each package to not exceed 10,000 kilograms (22,046 lbs).		25,000 lbs to handle all container conditions
LEH-TOOL-2-V002	LAW production container volume, weight, and center of gravity calculation, 24590-LAW-M0C-LRH-00004, does not include overpack condition.	An abnormal condition could occur if the container cannot be decontaminated and overpacking is required to be added to the container.	Special container handling devices will be required to handle off-normal conditions	Revise calculation to include the addition of overpacking material to the outside of the container.
LEH-TOOL-2-V003	Grapple temperature limitations.	The grapple analysis, 24590-QL-POA-FH00-00001-08-00001, indicates that the reserve factor is barley met with a load of 16,500 lbs and a flange temperature of 600°F.	Since the grapple is a common design the temperature limitation is as important as the safe working load limitations. These conditions could lead to unsafe lifting conditions.	Add grapple markings to clearly identify temperature limitations the same way safe working loads are identified.
LEH-TOOL-2-V004	Grapple excessive load testing.	General specification for remote and mechanical handling equipment design and manufacture, 24590-WTP-3PS-M000-T0002, section 3.4.3.10, indicate that lifting attachments shall be factory load tested at 125% of rated load in accordance with ASME B30.20 (Below the hook lifting devices). The ASME B30.20, Below the hook lifting devices, section 20-1.3.8.2 indicate that test loads shall not be more than 125% of the rated load unless otherwise recommended by the manufacturer. The testing requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.6.c requires the grapple static load test to be performed at 150% of the SWL and held for 15 minutes.	Confusion with basis of design	Revise BNI procurement process to ensure vendors test equipment according to contractual documentation and that all requirements are consistent between documents.
LEH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	The design requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.8.2.3 requires the grapple's three fingers to have a combined minimum total contact area of 15 in2.	Failure to document design requirements.	This requirement should be validated during start-up testing to ensure this critical characteristic is met.
LEH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	Specification requirements in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.7.g indicate the grapple will be tested to ensure it is capable of maintaining its engagement	Failure to test and document design requirements are met.	This critical design requirement should be performed as part of an additional FAT or

Table B-13. Vulnerabilities Identified for Container Export Handling (LEH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		even if the load is laid on its side and the tension on the bail is relieved; the grapple shall then be capable of lifting the load when the hook is raised, all as part of the 20 complete cycles simulating actual operating conditions. The simulated operating conditions test consisting of 20 completed cycles is performed in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test plan for MR36 LAW grapples and grapple stands section 3.A.4, but this step is omitted.		demonstrated through analysis.
LEH-TOOL-2-V007	Inconsistent design requirements.	Data sheet 24590-LAW-M0D-LEH-00022 indicates the operating environment temperatures and humidity is 59 – 113 °F and uncontrolled humidity. Specification 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.6.2 indicate ambient temperature range of 50 – 113 °F and humidity range 5 – 100%. Calculation 24590-LAW-M0C-M40T-00001, LAW HVAC Environmental Qualification Conditions Calculation, indicates the building internal unoccupied C3 areas are 59 – 95 °F with 10% relative humidity.	Confusion with basis of design	Revise data sheets, specification, and calculation to indicate a consistent and accurate grapple operating environment.
LEH-TOOL-2-V008	Inaccurate model data for LRH process steps.	The operations research model design document, 24590-WTP-MDD-PR-01-001 table 78, lists the process step for transferring a container from the bogie to the transport trailer. The LAW Vitrification Capacity and Availability Study, 24590-LAW-RPT-ENG-01-001, indicate these same process steps, but the process steps do not match.	Inaccurate model output data.	Engineering should perform a complete OR model input verification prior to model output is considered valid.

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRH-IC-1-V003	No Personal Safety Interlock on the Container Receipt Station.	When a container is inspected and approved, it can be advanced to the P2 position ready to be imported to the Container Receipt Area P3. However when the container at P2 is advanced, a container being inspected at P1 will be advanced at the same time because they are on the same Container Receipt Conveyor.	An operator working on a container at the Container Receipt Station could be injured by a moving Container or the operation of the conveyor.	Add an ICN monitored, hard-wired, lock-out buttons to each of the two Clean Container Receipt Station conveyor lines that will be activated prior to manned operations at that station, and will be deactivated by the receipt inspector before the Container Receipt Conveyor can be operated.
LRH-IC-1-V004	Conveyor Alarm Horns do not sound During Local Operation.	When the conveyors are being operated in Local mode, there will be co-located workers near them. This is when an alarm horn is most needed.	Workers could be injured by the unexpected operation of the conveyors or the moving containers.	Wire the incoming container handling conveyors alarm horn to sound as described in the Software Requirements and Control Logic document in both Local and Remote modes to ensure that everyone in the area knows the conveyors are about to operate.
LRH-IC-1-V005	Retractable Stop is not Required to be Extended to Open the Import Hatch.	Although a hard-wired interlock extends the stop when the Import Hatch is not open, the ICN does not stop the hatch from opening if the stop isn't extended.	If the hard-wired interlock (not shown on the Diagrams) fails, the ICN will allow the hatch to open even though a container at P9 could potentially roll off the Transfer Conveyor into the open hatch.	• Add the interlock requirements to the drawings and program the interlock that allows the Retractable Stop to be retracted when the Clean Container Import Hatch (LRH-HTCH-00001/0002) starts opening but requires it to be extended once the 'Closed' switch indicates the hatch is not closed. • Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming.
LRH-IC-1-V010	The Software Acceptance Procedures do not identify test actions nor provide criteria for acceptance.	The LAW LRH System Software Acceptance Test, 24590-LAW-PISW-J-08-0024-03, section 6.12.3 performs an Input Variable Check. The step provides a table to identify each input, the software parameter name and a record of Pass / Fail. However, there is nothing in the procedure step to identify what the test operator did to test this parameter, nor an indication of what the expected result would be, nor an indication of what result was actually observed. Without this information it is not possible for a reviewer to determine whether the test step correctly tested the parameter, whether the step was performed correctly, or to independently verify that the observed condition did, in fact meet the criteria for passing. [See Section 5 of CNN 089178, the Integrated Control Network Commissioning Strategy White Paper]	It will not be possible to predict whether the software will perform as intended in each case. SAT test documentation is inadequate for replacing field-testing.	Evaluate procedures for preparing Software Acceptance Testing (SAT), evaluate the SAT tests that have been performed and either correct the test procedures and re-perform the SAT tests or, better, perform full field-testing.
LRH-OR-1-V001	24590-LAW-RPT-PO-05-0001, Rev. 0, LAW Reliability, Availability, and Maintainability Data	The LAW RAM Data Development Report documents the basis, methodology and development of RAM data for the LAW facility. However, the report, issued in June 2005 makes some assumptions based on availability	Overly optimistic MTTR data entered into the OR model results in facility availability estimates that are not accurate.	Correct the inconsistencies in the LAW Reliability, Availability, and Maintainability Data Development Report, and work with TOC to develop new MTTR data based on

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	Development Report, inconsistencies and missing information.	of information at that time and the assumed minor design changes to the systems and components in facility. The report appears to assume all spare parts are readily available and sufficient numbers of personnel are readily available to handle maintenance and repair issues. Historically, these have been problems at Hanford and should be incorporated in the MTTR data. Additionally, the MTTR data does not take into account the extra time it takes work to be accomplished in contaminated areas versus uncontaminated areas.		historical availability of spare parts and personnel. Develop detailed list of spare parts to be maintained on site, and parts that are readily available from local vendors.
LRH-OR-1-V002	24590-WTP-RPT-PT-02-005, Rev. 7, Flowsheet Bases, Assumptions, and Requirements, inconsistent data.	The MTBF and MTTR data in the Flowsheet Bases, Assumptions, and Requirements document are not consistent with data provided in the LAW RAM Data Development Report for the LRH conveyors.	Incorrect MTBF and MTTR data will affect the results of the OR model.	Correct the MTBF and MTTR data in the Flowsheet Bases, Assumptions, and Requirements documents so the data is consistent with data provided in the LAW RAM Data Development Report for the LRH conveyors.
LRH-OR-1-V003	24590-WTP-MDD-PR-01-001, Rev 12, Operations Research (WITNESS) Model Design Document, inconsistencies and missing data.	The Operations Research (WITNESS) Model Design Document contains MTBF and MTTR data that is not consistent with the LAW RAM Data Development Report and the Waste Treatment RAM Basis Report. Additionally, document credits the conveyors as being redundant systems; however, the conveyors share a common airlock which will inhibit maintenance activities on one conveyor line when the other is in operation.	Incorrect MTBF, MTTR, and omitted components will affect the results of the OR model.	Correct Operations Research (WITNESS) Model Design Document so the data is consistent with data provided in the LAW RAM Data Development Report and Waste Treatment RAM Basis Report, and update OR model to include conveyors that are not included in the current model. Verify redundant systems are truly redundant based on sequence of operations and sequence of maintenance.
LRH-CRN-1-V001	Empty LAW container deliveries will affect LSH and RWH operations	A delivery of empty LAW containers will block the truck bay / loading dock until all the containers are removed from the truck. Blockage of the truck bay with a container delivery will affect LSH & RWH operations.	Around the clock, multiple shift operations may be required to allow required shipments of empty LAW containers, LSH Melter consumables, and RWH waste shipments into and out of the LAW facility.	• Perform a detailed task analysis of all the over-the-road shipping operations performed in the L-0118 truck bay to support LAW facility operations. Use the task analysis to develop integrated operating procedures across the LRH, LSH, and RWH systems. The integrated procedures should schedule truck bay operations at the facility level. • Provide operator training to quickly improve their proficiency in handling empty LAW containers, removing container shipping hold-down gear, and the removal of container dunnage.
LRH-CRN-1-V002	Empty LAW container handling by the LSH-CRN-00001 crane will have to be done by either	The LSH-CRN-00001 crane does not have enough lift clearance to lift a LAW container over another container on an over-the-road truck. Due to the length of the	The over-the-road truck making a delivery of empty LAW containers will block the L-0118 truck bay until the containers are removed from the truck,	Develop operating procedures and operator aides to facilitate unloading containers from the over-the-road trucks. Provide operator training to quickly improve their proficiency

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	moving the containers around each other or by moving the containers in controlled, sequential order.	procured pendant cable, use of the pendant to control the crane and move canisters from a truck will be difficult.	receipt inspected, and moved into the facility. Double shift operations may be required to clear a shipment of containers.	in handling empty LAW containers with the LSH-CRN-00001 crane.
LRH-CIS-1-V001	Inspection of incoming empty containers required by WTP Contract and ILAW PCP is problematic	There is no inspection procedure available nor description of any toolkit that would be necessary to deal with the detection and removal of any liquid or solid material present inside the 7.5' tall containers: no light, video camera, bore scope, suction and swabbing devices for drainable or adhering liquids, gripping tool for solid debris, etc. have been defined or selected so far.	• Inconsistent/inadequate design • Operations concerns • Secondary waste concerns • Potential safety concerns	A valid inspection procedure and design for removal of foreign material from the incoming container will need to be provided.
LRH-CIS-1-V002	No safe access by personnel to delivery truck trailer	There is no access tool defined that will provide the operators with the safe access to the trailer when they have to untie slings, tie-downs, etc. that may be used to secure the containers during their road transportation to the Import Bay.	• Inconsistent/inadequate design • Secondary waste concerns • Potential safety concerns	A design will need to be provided to give access to transporter trailer from the loading dock. This may require a ramp or platform or redesign of the import bay (increase the size to allow for proper access around the transporter and proper platforming).
LRH-CIS-1-V003	No procedure available for removing container wrapping material and shipping cover	The procedure and tools required for safely removing the shrink wrapped heavy-duty plastic film and steel covers are not defined yet. In addition, no project documentation details the disposition path for the shipping material (wrapping film and steel covers).	• Inconsistent/inadequate design • Secondary waste concerns • Potential safety concerns	A valid inspection procedure and design for removal of wrapping material and shipping cover from the incoming container will need to be provided.
LRH-CIS-1-V004	The angle of view doesn't allow the inspector to see inside the incoming 7.5' tall container	The eyes of the inspector standing on top an inspection stepped platform will be at 130" above the floor of the Load Dock when the top of the container will be at 108" above the same floor. This distance doesn't allow any view of the inside of the container through the 15" diameter container opening.	• Inconsistent/inadequate design • Maintenance concerns	Provide an inspection station that can meet the inspection requirements while the containers are located on the receipt conveyors. This may require a permanent platform over the 3 conveyors and is accessed via ladders.
LRH-CIS-1-V005	The inspection platforms cannot be located as close as possible to the empty container being inspected	The access to the container top opening by the inspector is challenged as the platforms will be located between positions P1 and P2 of the Receipt Conveyors which increases the distance between the inspector and the container vertical axis.	• Inconsistent/inadequate design • Maintenance design inadequacy • Potential safety concerns	Provide an inspection station that can meet the inspection requirements while the containers are located on the receipt conveyors. This may require a permanent platform over the 3 conveyors and is accessed via ladders.
LRH-CIS-1-V008	Problematic communication between Inspector in L-0118 and Operators at LOI in Room L-0117 or in Control Room	There is no operating procedure that defines the role and responsibilities of the Inspector and the operators present at the LOI or in the control room and who makes the decision for transferring an inspected acceptable container from the receipt conveyors to the staging conveyors. Operations may be problematic and even induce an industrial safety risk.	• Operations concerns • Potential safety concerns	It may be necessary to provide a local operator interface (for the receipt conveyors only) at the clean container receipt station, instead of the staging area.
LRH-CIS-1-V010	Proper angular orientation of the	The procedure has not been developed (nor the tool defined to facilitate the safe manual rotation) that defines	• Inconsistent/inadequate design • Operations concerns	A simple solution would be a procedure that requires the container to be in a specific

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	incoming container on the Receipt Conveyors is required but not defined	the proper angular orientation of the painted spot for a container standing at Position P1 on the Receipt Conveyors.		orientation/rotation at the receipt station. Another option would be to provide a new design for container marking/tracking that eliminates the need to provide the proper rotation. This may be as simple as marking the container in each quadrant so it can be viewed at any rotation.
LRH-CNVR-1-V008	Conveyor Impact Loading Calculation Inconsistencies	The 24590-CM-POA-M000-00001-05-00002, Rev. 00A, Vendor Calculation – Conveyor Roller Impact Loading, determines the resulting stress and bearing reactions in the conveyor roller when the conveyor is loaded by the overhead crane. Inputs to the calculation were based on Section 3.3.3 of the conveyor specification and do not account for the grapple weight. When the weight of the grapple is included, the allowable stress in the conveyor design is exceeded.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment	Update the vendor calculation to include the weight of the grapple with the correct weight of the container as the bounding scenario for the clean container handling conveyor roller impact loading calculation. Assess the bounding scenario against the current design to understand the adequacy of the installed equipment. The calculation assumption(s) should be validated against actual loading scenarios (spreading load across several rollers vs. one) to see if it is possible to exceed the stress limits.
LRH-CNVR-1-V011	FAT Test Inconsistencies	The factory acceptance testing of the LRH conveyor system does not seem to meet all the requirements of the conveyor specifications. It is unclear from the test report if the five container requirement for mockup testing was met, if the containers met the required weight limit, and/or if the requirement for 24hr run test meant total run time or continuous run time. It is also unclear if the mockup test container(s) met the bottom requirement	• Inadequate design • Unknown operability • Potential for higher MTTF/operational throughput issues	Reassess FAT test requirements in specification for the LRH conveyor system. Perform a valid startup test to meet the requirements and undertake the test using the accepted requirements.
LRH-CNVR-1-V012	Structural Floor Design	24590-LAW-SSC-S15T-00009, Rev. 0 Steel Framing Calculation (EL +3'–0"), of the LAW facility uses incorrect weight values for conveyor/floor loading. It is indeterminate if the steel design meets shear/moment/deflection limits until new values are calculated using bounding scenarios.	• Potential Inadequate design • Unknown margin for future equipment installation (if heavier) • Potential operational throughput/safety issues	Validate loads defined in 24590-LAW-S0C-S15T-00002, Rev. 2. LAW Floor Loading Calculation. Use this information as input to LAW Steel Framing Calculation 24590-LAW-SSC-S15T-00009 to verify if steel framing design is adequate.
LRH-RCSH-1-V001	Contamination migration at the Container Import/Hatch and Conveyor	The container import to the LPH system consists of lowering the container import hoist and engaging the attached container grapple onto the container that is to be transferred (C3 area). Once the container is engaged the hoist raises the container to a predetermined height and the container import hoist lowers the container to the LPH bogie (C5), disengages the grapple, and returns to the transfer height position and is raised clear of the floor opening into the container import/hatch conveyor area. Although this task is planned to be remotely conducted, there is no engineered contamination/decontamination or downposting verification process identified to ensure	• Contamination migration and permanent increased contamination posting • Increased operational and maintenance costs	Evaluate the currently defined work processes and ensure an engineered or administratively-defined process is adequate for controlling contamination migration at the South and North clean container import hatches and conveyors, and that confirmation is available, such as continuous air monitor, to ensure personnel are not inadvertently exposed to an airborne radioactivity area. In addition, the process for how to decontaminate the clean container conveyor system and needed personnel and method for

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		none of the contamination has migrated outside of the C5 boundaries (such as on the grapple equipment).		performance should be evaluated to determine feasibility given the location and intricacies of the system itself (and the impact to facility operations given the existing radiological design of the system).
LRH-RCSH-1-V002	LRH System compliance to design and operational safety and health requirements	Within the system description for the LRH are specific OSHA requirements and other standards the system conveyors and monorails were constructed against. However, what is not flowed down through the system design/description are the other OSHA and 10 CFR 851 standards that are required to be met when constructing the container receipt handling system in its entirety.	• Inadequate design and operational procedures • Not meeting regulatory/contractual requirements	Verify and validate that all required codes and standards have been incorporated into the design of the LRH system and, if not within the design, the requirements and standards are within appropriate procedures for both operations and maintenance work evolutions. Examples include installation of a dock ladder to provide route worker access to the truck bay, maintenance of ventilation components, potential heat stress within the LRH, emergency egress areas, etc.
LRH-IC-1-V001	Inadequate Interlocks at LRH Roll Up Doors	Obstruction detection devices stop and reverse the door once it has contacted an object. However they can't prevent a collision before it occurs.	Rolling Door Impact with a moving canister could derail or damage the door before it could retract. This would forbid opening of any other rolling door stopping the import of canisters on both lines.	• The addition of a photo-electric sensor with interlock would allow the detection of an obstruction before a collision has occurred and could interlock the roll-up door associated with an LRH conveyor to keep it from closing. • The rolling doors should be interlocked with the associated conveyors to keep the door from closing while the rollers are operating.
LRH-IC-1-V002	Requirement documents are incomplete.	Several interlocks are not shown on the MSD (24590-LAW-M1-LRH-00001) and the sensors for some interlocks are not shown on the MHDs (24590-LAW-M7-LRH-00001001 through -00001004).	Unexpected operations due to unknown interlocks. Overrides or plant modifications that expose the equipment and personnel to hazards that the interlocks were designed to prevent.	• All interlock sensors/devices should be shown on a Mechanical Handling Diagram (MHD). All interlocks should be identified on the Mechanical Sequence Diagrams (MSD). All interlocks should be described in a text-based document with enough information to allow operations or maintenance to determine when or whether the interlock could be over-ridden or modified. • Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming.
LRH-IC-1-V006	The Maintenance Control Panels are not described in the System Description.	The conveyors can be controlled by the ICN in Remote mode, by the Local Operator Interface (LOI) in Local mode and by the Main Control Panel (MCP) panel in maintenance mode. However, the System Description	This will result in an incomplete and conflicting understanding of how the plant operates. New operators or maintenance people may not even be	The Control Logic document (24590-CM-POA-M000-00001-01-00001, Software Requirements Document and Control Logic Information WTP LAW Container Receipt

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		(24590-LAW-3YD-LRH-00002) makes no mention of the Main Control Panel.	aware that the MCP exists or be confused between the MCP and LOI.	Conveyors) should be amended to clarify the difference between the LRH conveyors Main Control Panel (MCP) door controls, and the Local Operator Interface (LOI). The MCP should be added to Section 6 of the System Description to describe the equipment and in Section 7 to discuss when and how these controls will be or not be used.
LRH-IC-1-V007	The Configuration Tool Box items for the LRH Hoists and Receipt Conveyors depend on obsolete hardware and software.	Equipment needed to configure the ELDP Laser Distance Meter is obsolete and will be harder to come by as time goes on. Also, it is questionable whether the software required to configure the ASD drives will run on current operating systems or that it will continue to do so as PC operating systems are updated and replaced.	• As newer operating systems and communications networks are developed, the older systems are eventually abandoned. Even if the software is available, it may not run on newer operating systems. • It may be difficult 40 years from now to configure a new device to match the parameters in the existing software. Maintenance will be difficult if cable adapters are not available.	Configuration toolkits for the LRH hoists and conveyors should be reviewed and updated or instruments replace, if necessary, prior to the beginning of commissioning.
LRH-IC-1-V008	No Link between Interlocks and Requirements	It will be difficult to verify whether the interlocks meet their intended function without understanding the functional requirement. Likewise, it will be difficult for operations to know when an interlock can be over-ridden or for engineering / maintenance to know whether an interlock could be modified or removed without a clear understanding of its purpose or why it was created.	Recovery plans and plant modifications will be slower and less certain as Operations, Maintenance and Engineering try to determine the consequences of over-riding or changing interlocks.	• A requirements matrix would identify the source of the interlock requirements. A description of the interlocks in a higher level document such as the System Design Document would allow the interlock function and purpose to be clearly understood by Operations, Maintenance and Engineering. • Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming
LRH-IC-1-V009	Start-Stop control station in the LRH Clean Canister Receipt Area is not labeled.	During the Walk-down Q&A of the LAW Systems LRH and LEH, a Start/Stop control station was noticed on the North Wall. The station was not labeled and it was not clear from its location what equipment it controlled. Upon questioning it was determined that the station controlled room environmental equipment	Someone will need to control the equipment and not be able to readily locate the control station.	Label all control stations in the LRH Clean Canister Receipt Area. Review equipment with stand-alone controls to verify that the controls are easily associated with the proper equipment and that the controls are properly labeled.
LRH-OR-1-V004	24590-WTP-RPT-PE-12-002, Rev 0, 2012 WTP Operations Research Assessment, data omission.	Table D-2, page D-32, does not contain downtime information for the container grapple that is used in the Import High Bay area. This should be added because it is a non-redundant component.	Omitted data for non-redundant component will affect availability of the facility.	Update OR model to include container grapple that is used in the Import High Bay area.

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRH-CRN-1-V003	LSH-CRN-00001 Crane usage for the LRH system	From a load lifting perspective, the LSH-CRN-00001 appears to be over-specified as a Class D (Heavy Service) crane for empty container handling. However, from a motor jog/start stop perspective, the crane may require a Class D rating. Excessive numbers of starts, stops, and motion reversals is hard duty for motors, motor starter contacts, and motor brakes and may lead to early failure of the motors, starters, and brakes. Maintenance on the motors and motor brakes will require a scissor lift to be rented and delivered to the site. If the repairs cannot be completed in two or three days, the LAW facility will have to be shut down due to a lack of empty LAW containers.	Premature failure of the LSH-CRN-00001 crane motors, motor starters, and motor brakes will increase maintenance activities and may lead to a facility shutdown if repairs cannot be completed quickly.	Provide operator training to quickly improve their proficiency in handling empty LAW containers with the LSH-CRN-00001 crane to minimize crane bumps/creeps. Procure, or lease, a scissor lift and have it staged on the WTP site for rapid response to an LSH-CRN-00001 crane maintenance need. (Note: this scissor lift may be used to service other overhead cranes such as the HRH crane in the HLW facility. There are several cranes on the WTP project where crane maintenance platforms were not installed since the overhead crane maintenance could be done from a scissor lift).
LRH-CIS-1-V006	Time required to unload the container delivery trailer may negatively impact the throughput of the LSH System	There is no operational procedure that defines how fast the containers will be unloaded from the trailer and transferred to the North and South Receipt Conveyors for inspection. The trailer may be parked for a long time in the Import Bay, which may be problematic as this bay is also used by the LSH System for the delivery/export of components and consumables to the LAW Facility.	• Inconsistent/inadequate design • Throughput concerns • Maintenance design inadequacy	A study of the functional requirements of LRH and LSH processes as they relate to the import bay should be developed. Competing LSH activities may determine that the throughput is affected by the single crane and ineffective layout of the import bay, which may result in a redesign of the area.
LRH-CIS-1-V007	Limited staging area for non-acceptable containers	There is no indication of the location and size of the area available on the Load Dock for staging non-acceptable containers, which may be a challenge in this busy area.	• Inconsistent/inadequate design • Operations concerns	A study of the functional requirements of LRH and LSH processes as they relate to the import bay should be developed. Competing LSH activities may determine that the throughput is affected by the single crane and ineffective layout of the import bay, which may result in a redesign of the area.
LRH-CIS-1-V009	Risk exists that proscribed material enters an inspected container in the Staging Area (Room L-0117)	There is a risk that liquids, tools, or various debris fall accidentally into an open container standing on the conveyors in Room L-0117 (and may remain unnoticed).	• Inconsistent/inadequate design • Operations concerns • Secondary waste concerns	It may be necessary to provide a cover/shield over the staging conveyor area to eliminate the chances of material falling into containers that have already been inspected.
LRH-CNVR-1-V001	Container Weight Inconsistencies	LAW container weight data does not seem to be bounded by any specific document. There are several individual documents that define anticipated weight(s) for the container, but none provide a specific bounding design. Weights range from 920 lbs. to 1,600 lbs.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment	Provide a bounding weight for equipment design. This may be as simple as revising the LAW container weight calculation (24590-LAW-M0C-LRH-00004, Rev. 0) by adding a margin to the 1,321 lbs estimated weight. Use the results of the revised calculation as the input for all other equipment (where the container weight is the bounding input source). This includes the container DPD.
LRH-CNVR-1-V002	Receipt Conveyor Design Inconsistencies	Input data used for design/procurement of the South and North Receipt Conveyors (LRH-CNVR-00001/7) is	• Inconsistent design basis	A set of bounding inputs for design and procurement should be established and used

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		inconsistent. Information (equipment load capacity, equipment floor loading, bounding size/dimension allowed, conveyor weight limit) contained within issued project documents conflict with each other. Vendor submittal data conflict with project limits. In addition, the weight of the grapple was not adequately included in the design.	• Inadequate design margin • Potential for undersized equipment • Potential for exceeding floor loading limit	for consistency. The South and North clean container receipt conveyor design and procurement documents should be revised to include all scenarios of conveyor loading; including the weight of the grapple. Vendor submittals will need to be assessed for impacts to current design limits.
LRH-CNVR-1-V003	Staging Conveyor Design Inconsistencies	Input data used for design/procurement of the South and North Receipt Conveyors (LRH-CNVR-00002/8) is inconsistent. Information (equipment load capacity, equipment floor loading, bounding size/dimension allowed, conveyor weight limit) contained within issued project documents conflict with each other. Vendor submittal data conflict with project limits.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment • Potential for exceeding floor loading limit	A set of bounding inputs for design and procurement should be established and used for consistency. Vendor submittals will need to be assessed for impacts to current design limits for the South and North clean container staging conveyors.
LRH-CNVR-1-V004	Airlock Conveyor Design Inconsistencies	Input data used for design/procurement of the South and North Airlock Conveyors (LRH-CNVR-00003/5) is inconsistent. Information (equipment load capacity, dimensional/size limits, equipment floor loading) contained within issued project documents conflict with each other. Vendor submittal data conflict with project limits.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment • Potential for exceeding floor loading limit	A set of bounding inputs for design and procurement should be established and used for consistency. Vendor submittals will need to be assessed for impacts to current design limits for the South and North clean container airlock conveyors.
LRH-CNVR-1-V005	Transfer Conveyor Design Inconsistencies	Input data used for design/procurement of the South and North Transfer Conveyors (LRH-CNVR-00004/6) is inconsistent. Information (equipment load capacity, dimensional/size limits, equipment floor loading) contained within issued project documents conflict with each other. Vendor submittal data conflict with project limits.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment • Potential for exceeding floor loading limit	A set of bounding inputs for design and procurement should be established and used for consistency. Vendor submittals will need to be assessed for impacts to current design limits for the South and North clean container transfer conveyors.
LRH-CNVR-1-V006	Import/Hatch Conveyor Design Inconsistencies	Input data used for design/procurement of the South and North Import/Hatch Conveyors (LRH-HTCH-00001/2) is inconsistent. Information (equipment load capacity, equipment floor loading, bounding size/dimension allowed, conveyor weight limit) contained within issued project documents conflict with each other. Vendor submittal data conflict with project limits. In addition, the weight of the grapple was not adequately included in the design.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment • Potential for exceeding floor loading limit	A set of bounding inputs for design and procurement should be established and used for consistency. The South and North import/hatch conveyor design and procurement documents should be revised to include all scenarios of conveyor loading; including the weight of the grapple. Vendor submittals will need to be assessed for impacts to current design limits.

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRH-CNVR-1-V007	Conveyor Specification Inconsistencies	24590-LAW-3PS-M000-T0004, Rev. 1, Engineering Specification for LAW Container Receipt Conveyors, has no reference to the ten data sheets issued for the conveyors. The data sheets have not been cancelled/superseded and were issued for procurement in 2002. There are other inconsistencies in the specification including inadequate load capacity parameters and container weight.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment	A set of bounding inputs for design and procurement should be established and used for consistency. The South and North clean container handling conveyor specification should be revised to include accurate requirements, notably the information contained in Sections 1 (Scope), 2 (Applicable Documents) and 3 (Design requirements). Vendor submittals and documents will need to be assessed for impacts to current design limits.
LRH-CNVR-1-V009	Conveyor Drive Motor Sizing Inconsistencies	The 24590-CM-POA-M000-00001-05-00003, Rev. 00B, Vendor Calculation Conveyor Drive Motor Sizing, uses inconsistent BNI specified input to determine the adequacy of the motor and gearbox selection. Although the results show the anticipated factor of safety of design, there is no requirement to meet.	• Inconsistent design basis • Unknown design margin • Potential for undersized equipment	Update the vendor clean container handling conveyor drive motor sizing calculation to include the bounding weight scenario. Assess the bounding scenario against the current design to understand the adequacy of the installed equipment. Provide a project approved factor of safety for design of equipment.
LRH-CNVR-1-V010	Conveyor Stress Analysis Inconsistencies	The 24590-CM-POA-M000-00001-05-00004, Rev. 00A, Vendor Calculation – Conveyor Frame Stress Analysis, uses incorrect assumptions as the worst loading condition and bounding case. The information and assumptions used are not accurate. Preliminary analysis with assumed bounding data show the design stress is within allowable limits, but the calculation needs to be revised formally.	• Inconsistent design basis • Unknown design margin • Potential for undersized equipment	Update the vendor clean container conveyor frame stress analysis calculation to include the bounding weight scenario. Assess the bounding scenario against the current design to understand the adequacy of the installed equipment.
LRH-TOOL-1-V001	Inadequate design basis documentation for container grapple stand	Failure to provide accurate design requirements in data sheets, drawings, and test documentation.	Maintenance and operations will spend time researching and establishing the design basis for equipment.	Revise design and fabrication documentation for container grapple stand to ensure accurate and as-built information.
LRH-TOOL-2-V001	Inconsistent grapple load rating	Mechanical Handling Data Sheets 24590-LAW-M0D-LRH-00004 and 24590-LAW-M0D-LRH-00005 all require the grapple load capacity to be 10 ton (20,000 lbs). However, specification for special grapples and lifting devices, 24590-WTP-3PS-MQL0-T0003, section 3.8.2.1 requires a safe working load of 16,500 lbs. The ICD 15, Interface Control Document for Immobilized Low Activity Waste, allows the mass of each package to not exceed 10,000 kilograms (22,046 lbs).	Confusion with basis of design	Increase the grapples safe working load design to 25,000 lbs to handle all container conditions.
LRH-TOOL-2-V002	LAW production container volume, weight, and center of gravity calculation,	An abnormal condition could occur if the container cannot be decontaminated and over packing is required to be added to the container.	Special container handling devices will be required to handle off-normal conditions	Revise calculation to include the addition of over packing material to the outside of the container.

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	24590-LAW-M0C-LRH-00004, does not include over pack condition.			
LRH-TOOL-2-V003	Grapple temperature limitations.	The grapple analysis, 24590-QL-POA-FH00-00001-08-00001, indicates that the reserve factor is barley met with a load of 16,500 lbs and a flange temperature of 600 °F.	Since the grapple is a common design the temperature limitation is as important as the safe working load limitations. These conditions could lead to unsafe lifting conditions.	Add grapple markings to clearly identify temperature limitations the same way safe working loads are identified.
LRH-TOOL-2-V004	Grapple excessive load testing.	General specification for remote and mechanical handling equipment design and manufacture, 24590-WTP-3PS-M000-T0002, section 3.4.3.10, indicate that lifting attachments shall be factory load tested at 125% of rated load in accordance with ASME B30.20 (Below the hook lifting devices). The ASME B30.20, Below the hook lifting devices, section 20-1.3.8.2 indicate that test loads shall not be more than 125% of the rated load unless otherwise recommended by the manufacturer. The testing requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.6.c requires the grapple static load test to be performed at 150% of the SWL and held for 15 minutes.	Confusion with basis of design	Revise BNI procurement process to ensure vendors test equipment according to contractual documentation and that all requirements are consistent between documents.
LRH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	The design requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.8.2.3 requires the grapple's three fingers to have a combined minimum total contact area of 15 in2.	Failure to document design requirements.	This requirement should be validated during start-up testing to ensure this critical characteristic is met.
LRH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	Specification requirements in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.7.g indicate the grapple will be tested to ensure it is capable of maintaining its engagement even if the load is laid on its side and the tension on the bail is relieved; the grapple shall then be capable of lifting the load when the hook is raised, all as part of the 20 complete cycles simulating actual operating conditions. The simulated operating conditions test consisting of 20 completed cycles is performed in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test plan for MR36 LAW grapples and grapple stands section 3.A.4, but this step is omitted.	Failure to test and document design requirements are met.	This critical design requirement should be performed as part of an additional FAT or demonstrated through analysis.
LRH-TOOL-2-V007	Inconsistent design requirements.	Data sheets 24590-LAW-M0D-LRH-00004 and 24590-LAW-M0D-LRH-00005 indicate the operating environment temperatures and humidity is 59 – 113 °F and uncontrolled humidity. Specification 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.6.2 indicate ambient temperature range of 50 – 113 °F and humidity range 5 – 100%. Calculation	Confusion with basis of design	Revise data sheets, specification, and calculation to indicate a consistent and accurate grapple operating environment.

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		number 24590-LAW-M0C-M40T-00001 indicates the building internal unoccupied C3 areas are 59 – 95 °F with 10% relative humidity.		
LRH-TOOL-2-V008	Inaccurate model data for LRH process steps.	The operations research model design document, 24590-WTP-MDD-PR-01-001 table 72, lists the process step for conveyors to move the container into the facility as 20 minutes. The time includes moving the container into the facility, opening/closing container airlocks, lowering the container import hoist, attaching the container grapple to the container, and opening the container import/hatch conveyor. The LAW Vitrification Capacity and Availability Study, 24590-LAW-RPT-ENG-01-001, indicate these same process steps require 41 minutes to perform.	Inaccurate model output data.	Engineering should perform a complete OR model input verification prior to model output is considered valid.
LRH-HST-1-V001	Inconsistent operating environment requirements.	The data sheets 24590-LAW-M0D-LRH-HST-00016 and 24592-LAW-M0D-LRH-00017 indicate the operating environment temperature to be 59-95 °F and the relative humidity to be 30-100 percent. The calculation for LAW HVAC Environmental Qualification Conditions Calculation, 24590-LAW-M0C-M40T-00001, section 2.3.1 indicates the inside design conditions for temperature and relative humidity of internal unoccupied C3 areas to be 59-95°F and 10%.	Confusion with basis of design	Revise design basis documentation to be consistent and perform impact analysis to ensure no impact to equipment life span or performance
LRH-HST-1-V002	Incorrect factory testing requirements.	The data sheets 24590-LAW-M0D-LRH-HST-00016 and 24592-LAW-M0D-LRH-00017 indicate the main hoist maximum operating speed to be 12 ft/min. The factory acceptance test procedure, 24590-CM-POA-MJKH-00001-09-00006, indicates the hoist speed testing was performed and verified to 10 fpm +/- 10%, which would be 9-11 fpm. The testing requirements do not match the specification requirements.	Failure to document design requirements.	Perform an impact analysis for facility overall throughput capacity and verify the OR model assumptions for this hoist activities and process steps. Update all design basis documentation for the current maximum hoist speed.
LRH-HST-1-V003	Failure to perform all required factory acceptance tests.	The process monorail hoists specification, 24590-WTP-3PS-MJKH-T0002, section 6.3.8 indicate the factory acceptance test shall include but are not limited to recovery of the trolley drives and hoist units and a bumper test. According to the factory acceptance test procedure, 24590-CM-POA-MJKH-00001-09-00006, these tests were not performed.	Failure to test and document design requirements are met.	Perform testing requirements during the facility startup.
LRH-HST-1-V004	Limited maintenance allowed from maintenance platforms.	The hoists LRH-HST-00001/2 are serviced from platforms per 24590-LAW-S1-S15T-00090. The structural design criteria, section 4.4.1, requires crane and other heavy maintenance area live floor loads to be 250 psf, the platforms are only designed with a loading	Heavy maintenance evolutions will be very complicated and will increase the facility downtime during these activities.	Perform a maintenance requirements analysis for the hoists and available space to perform all material handling and maintenance activities.

Table B-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		of 100 psf, per calculation 24590-WTP-S0C-S15T-00012 sections 2.4.1 & 2 and drawings 24590-WTP-S0-S15T-00015 and 24590-WTP-S0-S15T-00050.		

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APPENDIX C

PATH FORWARD TO CORRECT PROGRAMMATIC DEFICIENCIES

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APPENDIX C
PATH FORWARD TO CORRECT PROGRAMMATIC DEFICIENCIES

Table C-1. Path Forward To Correct Programmatic Deficiencies (3 pages)

Action
Inadequate Discipline in Design and Execution Control
Conduct reviews to ensure that the primary documents relied upon to establish design functions and requirements are accurate and complete. A key objective is to ensure that specific/quantifiable requirements are established.
Reintroduce and institutionalize multidisciplinary design reviews and monitor their effectiveness.
Conduct multi-discipline reviews of the individual system designs and associated documentation for compliance with the functions and requirements established in the primary documents. Confirm that any procured items, those in procurement, or presently installed meet the functions and requirements.
Implement sizing standards/guides for equipment to provide a standardized documented basis for design. These should include typical design margins to ensure a conservative design is achieved.
Provide project-approved design input for procurement documents; replace or supplement datasheet level information with technical bases.
Inadequate and Incomplete Control System Design Specification and Execution
Consistently define the ICN boundaries and interfaces commensurate with the functions attributed to the ICN.
Evaluate (or reevaluate) the hazards, risk, safety, and permitting compliance controlled or affected by the ICN and its subsystems.
Define (or redefine) the WTP specific functions requirements performed and controlled by the ICN and the PPJ, carefully tracking the flow down of requirements from upper-tier documents. Use these requirements to provide the detailed test criteria when functionality is confirmed during software development or for vendor acceptance criteria.
Use industry standard documentation sets (e.g., IEEE SE series) for the control system and the functional requirements, making it practical for review without recourse to the designer or maintainer
Eliminate the use of commingled design and requirements documents, and the use of logic diagrams as the sole means of defining functional requirements.
Develop software modification procedures and processes and ensure changes can be effectively isolated and verified with minimal regression testing required.
Conservatively evaluate the effect of manual controlled operations and the impacts on facility performance. Identify and implement increased automation for those areas where it is assessed that maximum benefit will be achieved.
Consider implementing current industry best practice in development of facility human machine interfaces.
Inadequate Analysis or Understanding of Production Capability
Realistic throughput for the facility.
Reconsider the bases and requirements for each system associated with facility performance. Confirm that inter-system interfaces and transitions are considered and integrated.
Develop detailed work plans for a representative set of critical maintenance and operations activities based upon fully-validated design input data that has been analyzed and accepted through a multi-discipline review process. Use this information to develop and validate an OR Model that incorporates a consistent process methodology across all plant systems.

Table C-1. Path Forward To Correct Programmatic Deficiencies (3 pages)

Action
Model all plant operations and maintenance activities in detail using the updated OR Model, scale simulations and mockups to validate throughput, space availability, remotability, accessibility, and availability of interfacing systems and organizations such that the production rate and margin can be accurately estimated at the facility and systems level.
Establish a formal and systematic design approach to identify and disposition issues that may adversely affect plant operations, maintenance and throughput. Address any redesign effort that may be required to minimize operational work-arounds, and unanalyzed production impacts.
Include reasonable and justifiable assumptions to predict performance and quality losses in the model basis and assumptions.
Maintain and utilize models, simulations, and mockups as primary operator training tools.
Consider incorporating lessons learned and operational feedback from the nuclear industry best practices that includes a specific structured approach to examine system operability and maintainability, using data based on years of operations.
Inadequate Implementation of ALARA Principles
Model and evaluate work tasks for each process system, identify potential areas where contamination may migrate, and document any additional engineering (i.e. remotely operated HEPA vacuum cleaners) or administrative controls (i.e. procedures) that will be needed to ensure personnel are appropriately protected.
Evaluate and document predicted possible airborne radioactivity work locations, given maintenance and operations tasks to be performed, and determine whether existing engineering controls will be effective in mitigating the airborne hazard.
Apply epoxy coating to the unprotected walls in the facility where radiological contamination could be present and operations or maintenance activities will be performed.
Accelerate the identification and definition of operation, maintenance, and waste management tasks and then revise dose assessment reports to accurately reflect anticipated dose.
Establish a mockup facility/area to evaluate and practice implementation of approaches to control worker dose and work area contamination prior to in-field execution of tasks expected to be high risk or have high radiological consequences.
Transfer of Scope and Risk to the Commissioning Phase
Identify all systems and components that require testing or functional demonstration as part of commissioning. Where feasible, identify off-line testing, modeling, simulations or mockups that may be used to minimize the risk of deferring these testing and functional demonstrations to commissioning
Develop a system for tracking all testing and functional demonstration activities being deferred to commissioning. Use the tracking system to support the planning and manage the risk of these activities.
Inadequate Implementation of Design Requirements for Waste Management
Reassess the adequacy of the functional requirements associated with secondary radioactive waste management to confirm that the full range of wastes anticipated over the life of the LAW Facility is addressed.
Reassess current secondary waste volumes and waste classifications to derive conservative estimates for design. Provide waste handling process design features to accommodate the forecasted waste volumes and classifications.
Update the OR Model to fully incorporate the waste management processes required to handle the estimated volumes of radioactive wastes generated over the life of the LAW Facility. Develop a range of anticipated scenarios and use the OR Model to assess the impacts of waste management activities on overall production. Assess areas that require design changes to ensure that LAW glass production is not impacted to the extent that mission objectives are jeopardized.

Table C-1. Path Forward To Correct Programmatic Deficiencies (3 pages)

Action
Evaluate the ICD-03 to ensure all roles, responsibilities and impacts to the involved contractors are understood and agreed so that operational control of WTP waste handling operations is established and maintained.
The DOE must ensure a facility to satisfy the secondary waste size reduction and repackaging requirements of the LAW facility is available prior to operation.
Inadequate Consideration of Industrial Safety and Industrial Hygiene Requirements
Define and document the chemical source term coming into the LAW Facility. The evaluation should consider historical information previously generated for the Hanford Tank Farms, and should also recommend routine area monitoring that may be warranted to ensure workers are appropriately protected. In addition, identify and incorporate into the design additional area monitoring that may be needed throughout the facility to ensure worker protection (other than areas associated with the offgas system).
Develop a formal process that ensures safety and health requirements and Industrial Safety and Health personnel are involved in the design process. The process should also list the hierarchy of controls and require a basis to be documented that describes how each control was addressed.
Verify and validate (i.e. walk down) those systems where design is substantially complete and identify equipment that will need to be retrofitted (engineered solutions) to ensure compliance to 10 CFR 851 requirements during commissioning activities. For those activities whereby an engineered or administrative means cannot be achieved to perform the task, develop a technical basis process to seek a waiver from the requirement (i.e. daily crane inspections in the finishing line).
Revise exposure assessments to accurately reflect chemical and environmental hazards anticipated during the design phase of the project.
Inadequate Consideration for Success of Operations/Maintenance Activities
Complete the hazards analysis for each (or a representative set of) anticipated manual operation or maintenance activity, including consumable replacement (e.g., bubbler, agitator, and pump) and consider mitigating the hazards through engineered methods.
Accelerate the development of detailed task analyses for a representative set of critical maintenance and operations activities based upon currently available designs using a multi-disciplinary review process.
Develop training simulations and mockups to include hands-on operations and maintenance activities.

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