# Office of Enterprise Assessments
# Assessment of the
# Hanford Site Waste Treatment and Immobilization Plant
# Low-Activity Waste Facility
# Documented Safety Analysis, Technical Safety Requirements, and Safety Evaluation Report

**August 2018**

**Office of Nuclear Safety and Environmental Assessments**
**Office of Environment, Safety and Health Assessments**
**Office of Enterprise Assessments**
**U.S. Department of Energy**

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## Acronyms

| | |
|---|---|
| BDBA | Beyond Design Basis Accident |
| BNI | Bechtel National, Inc. |
| CFR | Code of Federal Regulations |
| CLW | Co-Located Worker |
| $CO_2$ | Carbon Dioxide |
| COA | Condition of Approval |
| DBA | Design Basis Accident |
| DID | Defense-in-Depth |
| DOE | U.S. Department of Energy |
| DSA | Documented Safety Analysis |
| EA | Office of Enterprise Assessments |
| FHA | Fire Hazards Analysis |
| FW | Facility Worker |
| HC | Hazard Category |
| HID | Hazard Identification |
| LAW | Low-Activity Waste |
| LCO | Limiting Condition for Operation |
| MAR | Material at Risk |
| ORP | Office of River Protection |
| PAC | Protective Action Criteria |
| PPJ | Programmable Protection System |
| PrHA | Process Hazards Analysis |
| SAC | Specific Administrative Control |
| SBRT | Safety Basis Review Team |
| SER | Safety Evaluation Report |
| SIL | Safety Integrity Level |
| SMP | Safety Management Program |
| SR | Surveillance Requirement |
| SS | Safety Significant |
| SSC | Structure, System, and Component |
| TSR | Technical Safety Requirements Document |
| TSRs | Technical Safety Requirements |

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## EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Office of Nuclear Safety and Environmental Assessments, within the independent Office of Enterprise Assessments (EA), conducted an assessment of the documented safety analysis (DSA), technical safety requirements document (TSR), and safety evaluation report (SER) for the Low-Activity Waste (LAW) facility at the Hanford Site Waste Treatment and Immobilization Plant. This assessment is part of a series of targeted safety basis assessments of nuclear facility design and construction projects at selected DOE sites.

The assessment evaluated the conformance of the LAW facility DSA, TSR, and SER to the requirements of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Change Notice 3, and DOE-STD-1104-2014, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*, for the development, review, and approval of safety basis documents. The review encompassed selected aspects of the DSA, TSR, supporting hazard analysis, and supporting engineering documents. EA examined the summary of the hazard analysis in the DSA, as well as key documents, including the process hazards analysis and the fire hazards analysis. EA also examined the safety functions, functional classifications, functional requirements, performance criteria, and TSR controls for selected safety structures, systems, and components (SSCs) and specific administrative controls.

The DSA conforms to the requirements of DOE-STD-3009-94 and adequately supports the future operations of the LAW facility. The comprehensive site and general information, hazard identification and screening, and process descriptions support a thorough hazard evaluation. The hazard evaluation includes an appropriately detailed, conservative set of events and provides a sound basis for control selection and functional classification of safety significant SSCs. The radiological consequences do not challenge consequence thresholds; furthermore, for chemical hazards the DSA appropriately identifies safety significant controls for protection of the workers and public. The selected hazard controls adequately address the identified hazards. The safety functions and functional requirements for the controls are generally appropriate and adequately evaluated. The TSR is sufficient to ensure that SSCs and specific administrative controls meet their safety functions and functional requirements.

During the assessment, EA provided comments on the final draft of the DSA and TSR. The Bechtel National, Inc. LAW project team reviewed and responded to the comments, and all EA comments were satisfactorily resolved in the initial Bechtel National, Inc. transmittal of the DSA and TSR, or by committed actions for revision 1 of the DSA. EA provided several additional comments on the submitted DSA and TSR. Those comments were similarly resolved by the final transmittal of the DSA and TSR, or will be resolved in response to the DOE Office of River Protection-directed actions described in the SER.

The DOE Office of River Protection Safety Basis Review Team, which included appropriate subject matter experts, documented their review of the DSA and TSR in an SER. The SER addresses the DOE-STD-1104-2014 approval bases, and appropriately concludes that there is reasonable assurance of adequate protection of workers, the public, and the environment from adverse consequences, taking into account the work to be performed and the associated hazards.

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## 1.0 PURPOSE

The U.S. Department of Energy (DOE) Office of Nuclear Safety and Environmental Assessments, within the independent Office of Enterprise Assessments (EA), conducted an assessment of the documented safety analysis (DSA), technical safety requirements document (TSR), and safety evaluation report (SER) for the Low-Activity Waste (LAW) facility at the Hanford Site Waste Treatment and Immobilization Plant. The assessment evaluated selected aspects of the LAW facility DSA and TSR, including supporting documentation. This assessment, conducted from November 2017 through May 2018, is part of a series of targeted safety basis assessments of nuclear facility design and construction projects at selected DOE sites.

## 2.0 SCOPE

This assessment covered the development and approval of the LAW facility safety basis, which includes the DSA and TSR, and was performed in accordance with review plan DOE/Headquarters EA-31, *Plan for the Office of Enterprise Assessments Assessment of the Waste Treatment and Immobilization Plant Low-Activity Waste Facility Safety Basis at the Hanford Site, May 2016 – February 2018*. The assessment encompassed review of supporting documents, including the process hazards analysis (PrHA), fire hazards analysis (FHA), engineering calculations, reports, studies, and drawings. The assessment concentrated on safety controls required to prevent (or reduce the frequency of) or mitigate the consequences of the higher-risk postulated events. The assessment also included review of the SER, which documents the approval of the DSA and TSR by the DOE Office of River Protection (ORP).

## 3.0 BACKGROUND

Bechtel National, Inc. (BNI), the prime contractor for the Waste Treatment and Immobilization Plant design and construction, developed the safety basis documents for the LAW facility to support a scheduled start-up in late calendar year 2021. Construction of the main portions of the LAW vitrification building is nearing completion, although several of the support facilities, such as the Effluent Management Facility, are still in early construction phases. When operational, the LAW facility will vitrify the low-activity liquid waste currently stored in the Hanford Tank Farms. ORP is implementing a sequenced approach (direct feed LAW) that will treat Hanford Tank Farm low-level radioactive waste prior to final development of the high-level radioactive waste treatment capabilities. The waste feed into the LAW facility will be pretreated by the Tank Farms LAW pretreatment system, and its constituents will be verified before receipt. The LAW facility has two melters for vitrification and a system for processing the offgas prior to discharge from the facility. Major chemical constituents removed by the offgas system include mercury and nitrogen oxides. The molten glass mixture will be poured into 626-gallon stainless steel containers. The LAW vitrified glass containers will be transferred to the Hanford integrated disposal facility.

The BNI Nuclear Safety Engineering Manager is responsible for the development of the safety basis documents. ORP performs independent review and approval of the safety basis. The ORP Deputy Manager is the Safety Basis Approval Authority. The BNI LAW project team is implementing the

requirements and processes established in DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Change Notice 3, for the development, review, and approval of the facility's safety basis. The DSA, TSR, and SER collectively comprise the LAW facility safety basis.

## 4.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A, *Independent Oversight Program*. EA implements the independent oversight program through a comprehensive set of internal protocols, operating practices, assessment guides, and process guides. Organizations and programs within DOE use varying terms to document specific assessment results. In this report, EA uses the terms "deficiencies," "findings," and "opportunities for improvement" consistent with DOE Order 227.1A. In accordance with this order, DOE line management and/or contractor organizations must develop and implement corrective action plans for deficiencies identified as findings. In this report, open issues that have an adequate commitment for closure are defined as "discrepancies."

As identified in the approved EA plan, this assessment considered requirements for the LAW facility safety basis documents from Title 10 CFR Part 830, *Nuclear Safety Management*; DOE-STD-3009-94; and DOE-STD-1104-2014, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*. For the DSA, TSR and SER review, EA selected objectives and criteria from EA Criteria and Review Approach Document 31-07, *New Nuclear Facility Documented Safety Analysis and Technical Safety Requirements Criteria Review and Approach Document*, Rev. 0, to guide the assessment.

EA independent oversight assessments focus strategically on aspects of nuclear safety essential to ensuring effective protection of workers and the public. By performing a vertical slice sampling review of selected aspects of the DSA, TSR, and supporting hazard analysis, the assessment indirectly addressed the line management preparation, review, and approval processes. EA examined key supporting documents, such as the PrHA, the FHA, accident analysis calculations, criticality safety evaluation reports, design calculations, piping and instrumentation diagrams, analytical limit calculations, and the safety integrity level (SIL) determination engineering study and verification calculations. EA also conducted meetings with key BNI and safety basis review team (SBRT) personnel responsible for developing and reviewing the safety basis documents. Appendix A lists the members of the EA assessment team, the Quality Review Board, and EA management responsible for this assessment. Appendix B provides a list of the primary documents reviewed and personnel interviewed during this assessment. Attachment 1 provides a summary of discrepancies pending closure.

EA uses a comment and response process to address issues identified during its review. EA provided comments on the DSA, TSR, and SER to ORP at various points during the document development process, and received written responses. When necessary, follow-on discussions between EA, ORP, and BNI were conducted to resolve issues. Comments were resolved by either adequate comment responses or by changes incorporated into the DSA, TSR, SER, and supporting documents.

## 5.0 RESULTS

This section presents the results of the review of the LAW facility DSA, TSR, and SER.

## 5.1 Documented Safety Analysis

***Criterion:***

*In establishing the safety basis for a hazard category 1, 2, or 3 DOE nuclear facility, the contractor responsible for the facility must: (1) Define the scope of the work to be performed; (2) Identify and analyze the hazards associated with the work; (3) Categorize the facility consistent with DOE–STD–1027–92; (4) Prepare a documented safety analysis (DSA) for the facility; and (5) Establish the hazard controls upon which the contractor will rely to ensure adequate protection of workers, the public, and the environment. (10 CFR 830 Section 830.202.b)*

### 5.1.1 Hazard and Accident Analyses (Chapter 3)

EA reviewed Chapter 3 of the LAW facility DSA and supporting documents to evaluate the hazard analysis and the identification of hazard controls. Although the final hazard category (HC) of the LAW facility is HC-3 (potential for only significant localized radiological consequences), all the potentially significant identified hazards are attributed to hazardous chemicals. The review included events related to fires, explosions, loss of confinement, direct radiation exposure, criticality, external hazards, and natural phenomena hazards. No radiological consequences exceed the offsite Evaluation Guideline for the public or thresholds for consideration of safety significant (SS) controls for the co-located worker (CLW). Direct radiation exposure was determined to result in low exposures to the facility worker (FW). The criticality safety evaluation reports demonstrate that the facility processes will remain subcritical for normal and credible abnormal conditions. EA determined that the LAW facility hazard categorization is appropriate per DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*.

#### 5.1.1.1 Hazard Identification

The hazard identification (HID) methodology for the LAW facility DSA uses an HID checklist that includes both hazardous materials and energy sources. The HID process also includes a review of historical events at similar facilities. HID was comprehensive, and hazards for all processes are systematically evaluated. Waste and hazardous chemicals are appropriately described in quantity, form, and location. Material at risk (MAR) estimates are conservative. The DSA adequately identifies and categorizes the hazards associated with the LAW facility processes.

#### 5.1.1.2 Hazard Evaluation

EA reviewed the hazard analysis to determine whether it appropriately evaluated the LAW facility and processes under normal, abnormal, and upset conditions. EA examined the analyzed hazard scenarios and potential effects of postulated events to verify that the estimated unmitigated consequences for workers and the public are appropriately conservative.

The LAW facility hazard analysis is divided into a series of nodes to allow for a systematic approach to developing accident scenarios, identifying boundaries and interfaces, and establishing the applicable MAR. More complex systems are subdivided into multiple nodes. The PrHA engineering study includes an appendix for each node containing the applicable PrHA tables. The hazard evaluation analyzes normal operations and maintenance processes, as well as abnormal and accident conditions. The evaluation includes natural phenomena hazards (i.e., seismic, lightning, wind, and ashfall) and man-made external events (e.g., aircraft crash, external fires, vehicle fires). The hazard analysis team primarily used the "what-if" methodology to identify and evaluate the hazard events.

The hazard evaluation process described in the LAW facility DSA includes hazard screening, hazard evaluation, unmitigated and mitigated consequence/frequency estimation, risk bin assignments, and control selection. For each hazard event, qualitative estimates are assigned for initiating event frequencies and consequences. Radiological consequences do not exceed or challenge the Evaluation Guideline for the public or safety thresholds for the CLW. Maximum radiological doses to the public and CLW are "low" based on the source term of the low-level radioactive waste stream, which is protected by the waste acceptance criteria specific administrative control (SAC). High chemical consequence thresholds are based on DOE Protective Action Criteria (PAC)-2 (public) and PAC-3 (CLW) values. Calculations are produced in specific cases to determine chemical consequences to the public and CLW. The methodology for evaluating chemical hazards is conservative and complete. Likelihood estimates are consistent with the frequency bins identified in DOE-STD-3009-94; assigned initiating event frequencies are sufficiently conservative. Consequences are properly estimated and, in conjunction with assigned frequencies, are appropriately applied to the functional classification of hazard controls.

EA reviewed the analyzed fire scenarios, including earthquake-induced fires and the potential effects of fire events leading to explosions. In general, the fire hazards analyses and controls are adequately documented in the DSA, supporting FHA, and fire scenario development documents; furthermore, DSA Section 3.3.2.3.2, *Planned Design and Operational Safety Improvements*, commits to a number of changes to the FHA and supporting calculations to better align the DSA and the FHA. The proposed primary fire control strategy consists of the separation of fire areas (through the use of credited fire barriers) and suppression (using non-credited automatic sprinklers). The FHA identifies appropriate fire safety requirements; is consistent with the requirements of DOE Order 420.1B, *Facility Safety*; and provides for a sufficient level of protection to prevent the loss of SS structures, systems, and components (SSCs) due to thermal effects from fire.

The DSA summary tables include the estimated risk bins for both unmitigated and mitigated hazard events. The tables identify controls that provide preventive or mitigative functions for specific hazard events. The frequency and consequence estimates are used to assign a risk bin to each analyzed accident scenario for the public and the CLW. Risk ranking is provided for both unmitigated and mitigated scenarios. The DSA provides a summary of the risk ranking for accident scenarios by node and type of hazard event (e.g., fires, loss of confinement), including their unmitigated and mitigated frequencies and consequences. Each of the risk ranking tables is followed by a list of the credited controls, safety management program (SMP) key elements, and defense-in-depth (DID) considerations for that node and hazard type. The hazard analysis appropriately identifies safety SSCs and SACs as controls based on the unmitigated frequency and consequences.

The LAW facility DSA includes a single seismic design basis accident (DBA) and two seismic beyond design basis accidents (BDBAs). The seismic DBA assumes the simultaneous release of hazardous material from multiple sources with conservative MAR estimates and consequence modeling. With an unlikely seismic event frequency and appropriately derived controls, the risk for all associated mitigated releases is demonstrated to be in risk bin III or IV for the public (situations of minor or minimal concern). However, several mitigated releases remained in risk bin II for the CLW (situations of concern, but not major concern). The residual risk and control selection rationales are adequately justified for the seismic DBA in the DSA.

The two BDBAs comprise seismic events with an initiating frequency greater than the design basis return period, with and without a carbon dioxide ($CO_2$) vessel explosion. The estimated chemical consequences for the BDBAs are in the moderate to low range for the public and in the high to moderate range for the CLW. The seismic event with a $CO_2$ vessel explosion is postulated to result in severe damage to the LAW facility and melter displacement. The analysis concludes that there is sufficient margin in the design of the $CO_2$ storage vessel to preclude the explosion. No additional controls are identified. EA

considers the BDBA analysis, which demonstrates that there is no "cliff-edge effect" evident in the accident severity level, to be adequate for this HC-3 facility.

BNI used an adequate approach to identify preventive and mitigative safety controls for the hazard events that are postulated to pose unacceptable risk to the public or the CLW. No safety class controls are required because radiological consequences to the public are demonstrated to be low. The identified SS controls provide protection from the chemical hazards. Appropriate controls are assigned to protect the FW based on a qualitative assessment of the consequences. The hazard analysis evaluates an appropriate range of hazardous materials and energy sources and postulates an adequate set of hazard events. EA determined that the control strategies are adequate to reasonably ensure the safety of workers and the public with clear identification of risk.

#### 5.1.1.3 Hazard Controls

EA reviewed the hazard events identified in DSA Chapter 3 to evaluate the derivation and functional classification of hazard controls. Chapter 3 identifies controls for protecting the FW and CLW from process hazards, exclusive of standard industrial hazards. SS controls are identified to prevent or mitigate accidents exceeding the consequence thresholds for chemical hazards (PAC-2 for the public and PAC-3 for CLW), which primarily involve offgas, concentrated mercury, ammonia, and $CO_2$. These controls are properly listed by node and hazard type in tables throughout Chapter 3. The credited controls for offgas releases include interlocks to limit the MAR, primary confinement, interlocks to protect primary confinement, and secondary confinement to an elevated release. Mercury released from carbon bed fires is limited by primary confinement, the combustible control SAC, and interlocks. Control of ammonia and $CO_2$ hazards relies largely on primary confinement. The tables include identification of the safety function, control type, receptor (i.e., public, CLW or FW), and a list of applicable hazard events. No safety class controls are identified because the maximum radiological dose consequence to the public, based on the entire MAR available in the LAW facility, is 7.9E-2 rem (significantly less than 5 rem).

The DSA generally follows the DOE-STD-3009-94 hierarchy of controls philosophy. Deviations from the hierarchy of controls are necessary because much of the LAW facility has been designed, procured or constructed, requiring reliance upon administrative controls rather than engineered controls. The mitigated risk to the CLW is in risk bin III or IV for most events. Approximately 25 events remain in risk bin II after crediting controls; the residual risk for these events was deemed acceptable by ORP primarily based on conservatism in the analysis and available DID controls, as discussed in DSA Section 3.3.2.3.1.9, *Rationale for Adequate Protection of Other Risk Bin II Events*.

The safety functions and functional requirements for the SS SSCs and SACs are sufficiently defined to meet the hazard control requirements derived in the hazard analysis.

#### 5.1.1.4 Defense in Depth

The LAW facility DSA effectively incorporates the principles of DID described in DOE-STD-3009-94. First, SSCs and administrative controls provide preventive or mitigative functions so that multiple barriers are available for protection of workers and the public for postulated events; the barriers include independent credited and non-credited safety controls. Second, there is a commitment to integrated SMPs that will provide detection and notification, response processes, procedures, and training for FWs and the CLW, with key elements of programs clearly described. Key elements of SMPs, identified in the TSR, include specific commitments to support important DID features and protect workers.

### 5.1.2 Safety Structures, Systems, and Components (Chapter 4)

EA reviewed the DSA to verify that the functional classification of select safety SSCs is appropriate and to assess whether the safety functions, functional requirements, and performance criteria are adequate. The DSA clearly identifies the safety functions for credited SSCs and provides the criteria and evaluation to demonstrate that the SSCs can perform the safety functions to prevent or mitigate the identified hazards. Chapter 4 describes attributes of the controls required to support the safety functions identified in the hazard and accident analyses and to support subsequent derivation of the (technical safety requirements) TSRs. The LAW Facility Control Summary Table (Appendix A of the DSA) provides a cross-linkage of safety functions, functional requirements, and performance criteria between the PrHA and the hazard analysis summarized in Chapter 3. The LAW facility control strategy makes use of both passive design features and active SSCs identified as SS for the protection of the FW and CLW. The active safety controls include 44 SS Programmable Protection System (PPJ) interlocks.

The safety functions, functional requirements, and performance criteria are clearly described and support the conclusion that the selected controls effectively prevent or mitigate corresponding hazard events. The functional requirements adequately address the hazards, and the system evaluations adequately assess control performance. The safety functions are consistent with those identified in the hazard analysis. Generally, the functional requirements and system evaluations support a sufficient understanding of how the SSCs meet the safety function; however, EA identified two discrepancies where performance criteria are not adequate to ensure the prescribed safety functions:

- The maximum allowable water flow rate for the Melter Feed Nozzle Cooling Water Needle Valves does not prevent steam generation above the design flow capacity of the offgas system, which does not support the safety function of offgas confinement. Planned improvement #8 in DSA Section 3.3.2.3.2 commits to revising the supporting calculation (24590-LAW-M6C-LOP-00017, *Melter Steam Surge Evaluation*) by the first annual update to the DSA. The committed action should resolve this issue.

- Simple average values are used for calculating the probability of failure on demand for safely instrumented systems without considering the uncertainty and dataset-specific distributions used for SIL determinations in Chapter 4 of the DSA. This issue could result in incorrect SIL determinations, such that interlocks may not meet their reliability requirements. Planned improvement #9 in DSA Section 3.3.2.3.2 commits to revising the supporting calculation (24590-WTP-RPT-ENG-15-041, *Equipment Justification Report*) by the first annual update to the DSA. The committed action should resolve this issue.

The DSA/TSR submitted by BNI on March 23, 2018, did not resolve all of EA's previous comments on the draft DSA/TSR during the document development process. The following three comments were not addressed:

- The performance criteria for interlocks did not meet all of the required criteria from ISA-84.00.01-2004, *Functional Safety: Safety Instrumented Systems for the Process Industry Sector*. In particular, SS interlocks that share final elements with non-safety interlocks were not fully analyzed.

- The performance criteria for the Ammonia High Flow and Ammonia Dilution Air Low Flow interlocks were ineffective to prevent ammonia gas concentration from exceeding the lower flammability limit criterion. A setpoint change was required to ensure the prevention effectiveness of these interlocks.

- One general surveillance requirement (SR) would have allowed operations in an unanalyzed condition. The 25 percent grace period for surveillances was inappropriate for interlock testing based on supporting calculations.

EA subsequently communicated these concerns to ORP and BNI. BNI resolved these comments in a revision of the DSA/TSR (submitted on May 7, 2018) and in updates to a setpoint calculation and engineering study demonstrating compliance with ISA-84.

### 5.1.3 Specific Administrative Controls (Chapter 4)

DSA Chapter 4 identifies 17 SACs for the protection of workers and the public. SACs are identified in four categories: Waste Feed Process, Reagent, Facility Processes, and Support Processes. Examples of SACs include Waste Acceptance Criteria, Ammonia Supply, Access Controls, and Lift Restrictions. For each SAC, the DSA provides its safety function, a description, and functional requirements. The DSA includes an evaluation section that assesses the ability of the SAC to meet the safety functions. The safety functions are consistent with those identified in the hazard and accident analyses. The safety functions, functional requirements, and SAC evaluations sufficiently justify how the SACs meet those requirements.

### 5.1.4 Documented Safety Analysis Conclusion

In summary, the LAW facility DSA meets the requirements of DOE-STD-3009-94. It comprehensively identifies and evaluates the hazards associated with the LAW facility and its processes. The hazard analysis appropriately addresses hazardous materials and energy sources and postulates an adequate set of hazard events. The control strategies are adequate to reasonably ensure the safety of workers and the public, with clear identification of residual risk. The safety functions and functional requirements defined in DSA Chapter 4 for SSCs and SACs are sufficiently defined to meet the hazard control requirements derived in the hazard analysis. The evaluation of the SSCs and SACs identifies sufficient performance criteria to ensure that safety functions will be met.

## 5.2 Technical Safety Requirements and their Derivation (TSR and DSA Chapter 5)

***Criteria:***

*A contractor responsible for a hazard category 1, 2, or 3 DOE nuclear facility must: (1) develop technical safety requirements that are derived from the documented safety analysis; and (2) obtain DOE approval of technical safety requirements and any change to technical safety requirements. (10 CFR 830, Section 830.205(a)(1)&(2))*

*Technical safety requirements establish limits, controls, and related actions necessary for the safe operation of a nuclear facility. (10 CFR 830, Appendix A, Section G.4)*

EA reviewed selected TSRs and their associated derivation in Chapter 5 of the DSA to verify the accurate translation of the SSC and SAC performance requirements into a set of formal, implementable operational requirements that preserve and maintain the identified safety functions, functional requirements, and performance criteria from Chapters 3 and 4 of the DSA. The sampled TSRs included limiting conditions for operation (LCOs) for SSCs and SACs, directive action SACs, SMP key elements, and design features. EA focused on controls required to prevent or mitigate the consequences associated with the higher risk events. EA also reviewed the general use and application requirements for the LCOs and SRs.

Chapter 5 of the DSA appropriately describes operating modes and derives TSRs for credited controls.

LCOs are appropriately derived for SSCs and SACs. Important attributes of design features are described, including inspection and testing requirements. Minimum staffing levels and key elements of SMPs are identified. Interfaces with TSRs of other facilities (e.g., Tank Farms) are adequately described. Chapter 5 provides sufficient information for TSR development and is consistent with the information in Chapters 3 and 4.

EA reviewed select TSR LCOs, administrative controls, and design features. LCOs and their bases were reviewed for content, operability statements, completion times, SRs and surveillance frequencies, and action statements. In general, the reviewed TSRs accurately reflect their derivation in Chapter 5 of the DSA, and the content conforms to DOE Guide 423.1-1A, *Implementation Guide for Use in Developing Technical Safety Requirements*. The TSRs accurately describe the operating modes derived in Chapter 5, and the LCOs and SRs are sufficient to ensure safe operation of the facility. Key elements of programs are included in a TSR commitment to implement effective SMPs. Design features are adequately described and include inspection and testing requirements. The bases of the reviewed LCOs are accurate and consistent with the DSA.

BNI resolved most EA comments on the March 23, 2018, submittal of the DSA/TSR with the May 7, 2018, final submittal of the documents. The following two discrepancies were not resolved in the final transmittal of the TSR:

- The LCO SRs and bases for the Carbon Bed High-Differential CO Concentration Interlock are not consistent with DSA Chapter 4 and are not sufficient to demonstrate operability (i.e., they do not contain all interlock actuation requirements).

- The LCO required actions for the inoperable Submerged Bed Scrubber High-Level and Low-Level Interlocks are not sufficient to prevent submerged bed scrubber flooding and melter pressurization.

Directed Action 2 of ORP's SER directs specific page changes to incorporate these, and other listed changes, into the DSA and TSR.

### 5.3 Safety Evaluation Report

***Criteria:***

*DOE will review each documented safety analysis to determine whether the rigor and detail of the documented safety analysis are appropriate for the complexity and hazards expected at the nuclear facility. In particular, DOE will evaluate the documented safety analysis by considering the extent to which the documented safety analysis (1) satisfies the provisions of the methodology used to prepare the documented safety analysis and (2) adequately addresses the criteria set forth in 10 CFR 830.204(b). DOE will prepare a Safety Evaluation Report to document the results of its review of the documented safety analysis. A documented safety analysis must contain any conditions or changes required by DOE. (10 CFR 830, Appendix A, Section F.3)*

*DOE will examine and approve the technical safety requirements as part of preparing the safety evaluation report and reviewing updates to the safety basis. (10 CFR 830, Appendix A, Section G.5)*

EA reviewed the SER to determine its adequacy as the approval basis for the DSA, as required by DOE-STD-1104-2014.

The ORP SBRT included members with appropriate subject matter expertise in nuclear safety, criticality safety, fire protection, systems engineering, and operations. The SBRT concluded that the safety basis

has been developed in a manner that provides reasonable assurance of adequate protection of workers, the public, and the environment from adverse consequences, taking into account the work to be performed and the associated hazards; the DSA meets the format and content requirements of DOE-STD-3009-94; and the final submittal of the DSA, in conjunction with the conditions of approval (COAs) and directed actions in the SER, acceptably resolves EA and SBRT comments. Based on its review, the SBRT recommended approval of the LAW facility DSA/TSR.

The SER addresses the approval bases identified in DOE-STD-1104-2014, including base information, hazard and accident analyses, DID, SSCs, SACs, derivation of TSRs, and SMPs. For each approval basis, the SER provides adequate justification to recommend approval of the DSA. Two COAs and two directed actions are identified in the SER. The directed actions require BNI to upgrade the differential pressure instrumentation across the offgas system high-efficiency particulate air filters to SS, and to make a number of specific changes to DSA and TSR pages, including those identified in Section 5.2 of this report. The first COA directs BNI to complete the commitments in DSA Section 3.3.2.3.2 no later than the second annual update to the DSA. The second COA states "BNI shall develop and implement a plan concurred on by ORP for the facility safety software (PPJ) and the integrated control network (ICN), which ensures the safety-significant and other Defense in Depth (DID) software requirements [are met]." The plan must be submitted to ORP for concurrence within 90 days. The time frames are appropriate based on the implementation plan for the DSA, which extends approximately four years to "hot" commissioning. The SER provides closure for all legacy COAs on the preliminary documented safety analysis.

The SER documents a defensible review and appropriately concludes that upon closure of the COAs and directed changes, the DSA/TSR provides a suitable safety basis to advance startup and support safe operation of the LAW facility.

## 6.0 FINDINGS

EA did not identify any findings during this assessment.

## 7.0 OPPORTUNITIES FOR IMPROVEMENT

EA did not identify any opportunities for improvement during this assessment.

## 8.0 ITEMS FOR FOLLOW-UP

EA will review revision 1 of the DSA, updated FHA, revision 4 of the PrHA, and supporting calculations as necessary to verify closure of the noted discrepancies.

## Appendix A
## Supplemental Information

**Dates of Assessment**

Offsite Assessment: November 2017 – May 2018
Onsite Assessment: January 29 – February 8, 2018, April 1-6, 2018

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Jeffrey L. Robinson

## Appendix B
## Key Documents Reviewed and Interviews

### Documents Reviewed

- 18-NSD-009, *Contract No. DE-AC27-01RV14136 – Approval of 24590-LAW-DSA-NS-18-0001 "Documented Safety Analysis for the Low-Activity Waste Facility," and 24590-LAW-TSR-NS-18-0001, "Low-Activity Waste Facility Technical Safety Requirements"* May 17, 2018
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- 24590-LAW-E1-UPE-00003, *LAW Vitrification Building SS UPS UPE-UPS 20304 Single Line Diagram*, Rev. 5, 2/7/17
- 24590-LAW-E1-UPE-00004, *LAW Vitrification Building SS UPS UPE-UPS 20305 Single Line Diagram*, Rev. 5, 2/7/17
- 24590-LAW-E1-UPE-00005, *LAW Vitrification Building SS UPS UPE-UPS 20306 Single Line Diagram* Rev. 5, 2/7/17
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- 24590-LAW-J3C-PPJ-00001, *Setpoint Calculation for Melter Plenum and Annulus High Pressure Interlocks*, Rev. A, 01/31/18
- 24590-LAW-J3C-PPJ-00002, *Setpoint Calculation for WESP High Level Interlocks*, Rev. B, 01/29/18
- 24590-LAW-J3C-PPJ-00003, *Setpoint Calculation for SBS High and Low Level Interlocks*, Rev. A, 01/19/18
- 24590-LAW-J3C-PPJ-00004, *Setpoint Calculation for Caustic Scrubber Interlocks*, Rev. A, 2/21/2018
- 24590-LAW-J3C-PPJ-00005, *Setpoint Calculation for LAW LVP SCO/SCR Temperature, Ammonia Flow, & Air Flow Interlocks*, Rev. A, 02/01/18

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- 24590-LAW-J3C-PPJ-00007, *Setpoint Calculation for HEPA Preheater Outlet High Temperature*, Rev. A, 2/14/18
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- 24590-LAW-J3C-PPJ-00021, *Setpoint Calculation for LAW Melter Lid Cooling Water Interlocks*, Rev. A, 01/26/18
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- 24590-LAW-J3-LOP-01009, *Functional Diagram: Melter 1 SBS & WESP Level Instruments*, Rev. 1, 09/08/11
- 24590-LAW-J3-LOP-90001, *Logic Diagram: LAW-T02F01C01, Melter 1 WESP High Level Interlock*, Rev. 3, 8/20/17
- 24590-LAW-J3-LOP-90003, *Logic Diagram: LAW-T03F01C01, Melter 1 SBS High Level Interlock*, Rev. 2, 08/20/17
- 24590-LAW-J3-LOP-90005, *Logic Diagram: LAW-T03F02C01, Melter 1 SBS Low Level Interlock*, Rev. 2, 08/20/17
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- 24590-LAW-JLD-LOP-00003, *Instrument Data Sheet: Radar Level Xmtr/Switch*, Rev. 3, 01/26/17
- 24590-LAW-JVD-LOP-10610, *Instrument Data Sheet: Actuated On/Off Valve*, Rev. 3, 05/23/2016
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- 24590-LAW-M6C-LMP-00024, *Analytical Limits for Law Melter 1 & 2 Annulus High Pressure Safety Interlocks*, Rev. A, 12/23/17
- 24590-LAW-M6C-LOP-00012, *Analytical Limit for the WESP High Liquid Level Interlock*, Rev. B, 09/28/17
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- 24590-LAW-M6C-LOP-00015, *Analytical Limit for LOP Primary and Standby Film Cooler Low Flow Interlocks*, Rev. B, 12/19/17
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- 24590-LAW-M6C-LVP-00014, *Analytical Limits for LAW Selective Catalytic Oxidizer/Reducer Temperature Interlocks*, Rev. B, 12/08/17
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- 24590-LAW-M6C-LVP-00022, *Analytical Limits for the LAW Caustic Scrubber Interlock*, Rev. B, 12/23/17

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- 24590-LAW-U3C-PPJ-00003, *PFD for LAW SBS High and Low Level Interlocks*, Rev. A, 01/18/18
- 24590-LAW-U3C-PPJ-00004, *PFD for LAW Caustic Scrubber Safety Interlocks*, Rev. A, 01/18/18
- 24590-LAW-U3C-PPJ-00005, *PFD Calculation for LAW TCO Heater/Skid High Temperature and Ammonia High/Dilution Air Low Flow Interlocks*, Rev. A, 12/21/17
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- 24590-LAW-U3C-PPJ-00020, *PFD Calculation for LAW Offgas Exhausters Shaft Seal Air Supply/Seal Low Pressure Interlocks*, Rev. A, 01/17/18
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- 24590-LAW-U3C-PPJ-00022, *PFD Calculation for LAW Analyzer Room High Temperature Interlock*, Rev. A, 1/17/2018
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- 24590-WTP-3PS-JD03-T0002, *Engineering Specification for Programmable Protection System*, Rev. 6, 11/21/17
- 24590-WTP-3ZD-PPJ-00001, *WTP Programmable Protection (PPJ) System Design Description*, Rev. 1, 08/03/16
- 24590-WTP-GPG-ENG-0153, *Design Guide: Safety Instrumentation - Independent Protection Layer Identification*, Rev. 0, 08/24/12
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- 24590-WTP-RPT-ENG-15-041, *Equipment Justification Report*, Rev. 1, 11/29/17
- 24590-WTP-SRDCN-ENG-16-00021, *SRD Tailoring to adopt DOE-STD-1195 (2011) Including TEC 61511 , Hardware Fault Tolerance Requirements*, 08/21/17
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- 24590-LAW-M4C-V11T-00003, *Calculation of Hydrogen Generation Rates for LAW Melter Feed Process Vessels*, Rev. 0, 7/13/17
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- 24590-LAW-Z0C-LOP-00001, *LAW Melter Offgas Release Accident Analysis Calculations*, Rev. 0, 9/28/17
- 24590-LAW-Z0C-W14T-00008, *Severity Level Assessment for the LAW Fac*ility, Rev. B, 1/15/14
- 24590-LAW-Z0C-W14T-00013, *LAW Vessel Hydrogen Explosion*, Rev. A, 7/17/15
- 24590-LAW-Z0C-W14T-00006, *Design Basis Event – LAW Facility Seismic*, Rev. C, 5/17/17
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- 24590-WTP-Z0C-W14T-00014, *Carbon Dioxide Storage Vessel BLEVE*, Rev. A, 11/3/14
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- CCN 303588, *Contract NO. DE-AC27-01RV14136 – Regulatory Deliverable 9.1- Submittal of the Updated Low-Activity Waste Facility Documented Safety Analysis and Technical Safety Requirements for ORP Approval*, May 7, 2018

**Meetings/Interviews**

**BNI**

- Nuclear Safety Manager
- Deputy Nuclear Safety Manager
- LAW Hazard Analysis Supervisor
- Nuclear Safety Engineers (9)
- Design Authority
- Design Engineers (3)
- Plant Engineers (3)
- Fire Protection Engineer

- Design Engineering Manager
- Plant Operations Managers (2)

**ORP**

- Nuclear Safety Division Director
- Safety Basis Review Team Members (8)
- Federal Project Director for LAW
- ORP Deputy Assistant Manager for Technical and Regulatory Support
- ORP Deputy Manager

**Attachment 1**
**Summary of Discrepancies Pending Closure**

1. The maximum allowable water flow rate for the Melter Feed Nozzle Cooling Water Needle Valves does not prevent steam generation above the design flow capacity of the offgas system, which does not support the safety function of offgas confinement.

2. Simple average values are used for calculating the probability of failure on demand for safely instrumented systems without considering the uncertainty and dataset-specific distributions used for SIL determinations in Chapter 4 of the DSA.

3. The LCO SRs and bases for the Carbon Bed High-Differential CO Concentration Interlock are not consistent with DSA Chapter 4 and are not sufficient to demonstrate operability.

4. The LCO required actions for inoperable Submerged Bed Scrubber High-Level and Low-Level Interlocks are not sufficient to prevent submerged bed scrubber flooding and melter pressurization.