Office of Enterprise Assessments Review of the Hanford Site Waste Treatment and Immobilization Plant Hazards Analysis Report for the Low-Activity Waste Facility Reagent Systems

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Acronyms

AMR	Ammonia Reagent System
BLEVE	Boiling-Liquid, Expanding-Vapor Explosion
BNI	Bechtel National, Inc.
BOF	Balance of Facilities
CDG	Carbon Dioxide System
CFR	Code of Federal Regulations
CRAD	Criteria, Review, and Approach Document
DBA	Design Basis Accident
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
HAR	Hazards Analysis Report
HAZOP	Hazards and Operability Analysis
HLW	High-Level Waste
LAB	Analytical Laboratory
LAW	Low-Activity Waste
LBL	Low-Activity Waste, Balance of Facilities, and Analytical Laboratory
MAR	Material at Risk
OFI	Opportunity for Improvement
ORP	Office of River Protection
PDSA	Preliminary Documented Safety Analysis
PST	Pacific Standard Time
PTF	Pre-Treatment Facility
SBRT	Safety Basis Review Team
SHR	Sodium Hydroxide System
SSC	Structures, Systems, and Components
USE	Unmitigated System Effect
WTP	Waste Treatment and Immobilization Plant

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) performs targeted oversight activities for select high-hazard nuclear facility design/construction projects. One of the targeted oversight activities is the DOE Office of River Protection Waste Treatment and Immobilization Plant, managed by Bechtel National, Inc. Currently, EA is evaluating the development of the documented safety analysis for the Low-Activity Waste facility. EA examined the development of the hazards analysis for the Ammonia Reagent and Carbon Dioxide systems because their operations pose significant hazards to co-located workers and adjacent nuclear facilities. EA observed the hazards analysis team's activities associated with these systems and reviewed the *Hazards Analysis Report for the Low-Activity Waste Facility, Volume 7, Ammonia Reagent System, Carbon Dioxide System, and Sodium Hydroxide System*, which was approved in December 2014.

The Bechtel National, Inc. hazards analysis team used a thorough hazard identification process to identify the hazards requiring analysis. Overall, the hazards analysis team analyzed event types appropriate to the systems and developed a comprehensive set of events. This hazards analysis report focuses on completing unmitigated event analyses and, for the most part, includes conservative estimates of the material at risk and unmitigated consequences. The identified candidate controls, along with the specified safety functions and attributes, provide a mostly complete set to support control selection.

However, the EA review identified a significant weakness in that the hazards analysis report does not adequately describe the relationship between the candidate design basis accidents and the underlying bounded hazard events for these systems. Candidate design basis accidents are intended to represent underlying bounded events; sharing substantially in the event causes and bounding the consequences of these underlying events. Candidate design basis accidents are analyzed to select a set of hazard controls and may be included in the documented safety analysis (DSA) accident analysis. Although the hazard event analysis is mostly thorough, some candidate design basis accidents were chosen based on common generic causes (e.g., operator error, mechanical error, or impact) without sufficient regard for whether the chosen event was fully representative of the underlying bounded events. Thus, the hazards analysis report lists many preventive candidate controls that are not applicable to the candidate design basis accident under which they are listed and does not provide a basis for control selection strategy. Consequently, the candidate design basis accidents do not provide a fully representative set in preparation for control selection and a number of preventive engineering controls are unlikely to be selected to the hazard control set.

The review also identified some weaknesses in the areas of hazard identification, hazards analysis, and candidate hazard control documentation. In some cases the hazards analysis team did not fully describe the hazard event sequence, and the team did not address the physical consequences to the co-located worker resulting from explosion events. In addition, the candidate control sets for large release and explosion events lack balance between engineered controls that prevent accidents and those that mitigate the consequences. Finally, in a few cases, the characterization of the safety function of some candidate controls as either preventive or mitigative was incorrect.

EA will continue to follow the progress of the safety analysis for the Ammonia Reagent and Carbon Dioxide systems, including the site's completion of the hazards analysis updates, control selection, and accident analysis, in accordance with the EA plan for reviewing the development of the Low-Activity Waste facility's documented safety analysis.

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1.0 PURPOSE

As part of the U.S. Department of Energy's (DOE's) self-regulatory framework for safety and security, DOE Order 227.1, *Independent Oversight Program*, assigns the Office of Enterprise Assessments (EA) the responsibility for implementing an independent oversight program and requires EA to conduct independent evaluations of safety and security. To fulfill these responsibilities, EA performs targeted oversight activities for select high-hazard nuclear facility projects during the design and construction phase. The DOE Office of River Protection (ORP) Waste Treatment and Immobilization Plant (WTP), managed by Bechtel National Inc. (BNI), is one of the projects identified for targeted oversight activities.

A focus area of EA oversight activities for the WTP is to provide independent oversight of the development of the documented safety analysis (DSA) for the Low-Activity Waste (LAW) facility. Oversight activities are focused on the extent to which nuclear safety is integrated into the design of the LAW facility in accordance with DOE Order 420.1B, *Facility Safety*, and DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*. This review focuses on selected high-hazard aspects of the initial phase of the LAW DSA development to verify that the hazards associated with the facility's work scope have been accurately identified and analyzed, candidate hazard controls have been identified, and an acceptable set of candidate design basis accidents (DBAs) has been identified for further analysis.

This report documents EA's review of the *Hazards Analysis Report for the Low-Activity Waste Facility, Volume 7, Ammonia Reagent System, Carbon Dioxide System, and Sodium Hydroxide System*. For the LAW facility, the hazards analysis report (HAR) volumes document the system-specific hazards analyses and identify candidate hazard controls to support development of the DSA. Since autumn 2012, EA has conducted periodic independent oversight reviews at the WTP and observed the conduct of BNI hazards analysis team meetings, reviewed hazard event tables, and interviewed key members of the hazards analysis team. EA observed hazards analysis team activities for the systems covered by this HAR volume during an onsite review from June 2 to 19, 2014. BNI approved this HAR volume on December 22, 2014, and subsequently made it available for ORP and EA review.

2.0 SCOPE

In accordance with EA's *Plan for the Independent Oversight Review of the Hanford Site Waste Treatment Plant Low Activity Waste Facility Documented Safety Analysis Development*, April 2013, EA reviews focus on safety analysis of selected structures, systems, and components (SSCs) involving the most hazardous and complex operations. The Ammonia Reagent system (AMR) and Carbon Dioxide Gas system (CDG) are being reviewed because of the potentially high consequences from accidents involving those systems. The associated HAR also addresses the Sodium Hydroxide System (SHR), but its low-consequence hazards to co-located workers do not warrant the same level of review. For simplicity, this report will refer to these systems collectively as the "reagent systems."

To maximize the effectiveness of these oversight activities and minimize the impact on WTP project organizations, EA conducts its reviews concurrently with the ORP Safety Basis Review Team (SBRT) reviews and oversight activities. However, EA provided its comments and observations to BNI separately, and received BNI's responses independent of the SBRT review process.

3.0 BACKGROUND

The LAW facility is part of the WTP, which is being designed and constructed by BNI at the Hanford Site, with DOE field management and oversight from ORP. The mission of the WTP is to process and immobilize the Hanford Site high-level tank waste into a stable glass form suitable for permanent disposal. The LAW facility is designed to convert liquid low-activity waste into immobilized low-activity waste glass, which are slated to be disposed at the Hanford Site Integrated Disposal Facility. Currently, LAW facility construction is more than 70% complete.

The LAW facility, the Balance of Facilities (BOF), and the Analytical Laboratory (LAB) facility of the WTP are collectively known as LBL facilities. The present safety basis for these facilities is a collection of preliminary documented safety analyses (PDSAs) for each of the three facilities. These PDSAs were not prepared using a "safe-harbor" methodology, such as that described in DOE-STD-3009-94, to comply with the Nuclear Safety Management rule (10 CFR 830, subpart B). Thus, the WTP project is developing a set of rule-compliant DSAs for submittal to ORP for review and approval. The LAW DSA submittal is currently scheduled for January 2017.

To support DSA development and ultimately the commissioning and operation of the LAW facility, BNI initiated a series of system-by-system hazards analyses. These system hazards analyses, which are being consolidated into a multi-volume HAR, constitute an intermediate step toward preparing the LAW DSA Chapter 3, Hazard and Accident Analyses. The system HAR volumes and subsequent draft chapters of the LAW DSA are being made available to the SBRT for review and comment. Although DOE approval of the HAR volumes is not required, the HAR form an integral part of DSA development by identifying and evaluating hazards and potential hazard controls. HAR results also feed into the accident analysis process and provide input to control evaluation and selection; therefore, an understanding of the LAW HAR is critical to reviewing the adequacy of LAW DSA Chapters 3 and 4.

In December 2011, ORP provided direction to BNI for implementation of 10 CFR 830 and DOE-STD-3009-94 in DSA development (reference: ORP letter 11-WTP-470). Thereafter, BNI implemented DOE-STD-3009-94 methodologies in procedures and guidance documents and trained its technical staff in DOE-STD-3009-94 requirements. As part of the DOE-STD-3009-94 implementation, BNI started performing new hazards analyses for LAW and LAB facility systems, based on current design, in the fall of 2012 (reference: 24590-WTP-PL-ENS-11-0001, Rev. 0). The PDSAs and development of the draft LAW DSA are supported by the WTP basis of design documents, design descriptions, process and instrumentation diagrams, SSC failure modes and effects analyses, accident analyses, consequence studies, and various other design and analysis documents.

On November 6, 2012, BNI paused its initial processes for the hazards analysis based on ORP, EA, and Defense Nuclear Facilities Safety Board staff observations and feedback that identified weaknesses in the hazards analysis process, such as failure to perform unmitigated analysis (i.e. evaluation of event sequences assuming that all available controls fail) of events (reference: CCN 249553). In early March 2013, BNI revised its process and resumed hazards analysis activities. Although the revised process emphasizes the use of hazard and operability (HAZOP) studies to accomplish the hazards analyses, the hazards analysis for the reagent systems was conducted using a "what-if?" analysis approach because of the relative simplicity of the systems. BNI issued the HAR for the reagent systems in December 2014.

4.0 METHODOLOGY

EA's reviews focus on BNI's development of select HAR volumes associated with the highest-hazard systems, such as the LAW melter processing system, the primary off-gas processing system, the

secondary off-gas/vessel vent process system, and associated supporting/interfacing systems. Review activities include sampling information from the safety basis and supporting documents in the following broad areas:

- Hazard identification
- Hazard evaluation using "what-if" methodology
- Identification of hazard controls, including safety SSCs and administrative controls.

During the onsite review periods, EA observed the BNI hazards analysis team activities for hazards analysis and hazard control identification for various systems. EA observed the team's activities for the reagent systems in June 2014. For AMR and CDG, EA reviewed the hazard event documentation generated from the hazards analysis and control identification activities (as of June 12, 2014), submitted technical review comments to BNI, and met with BNI personnel to clarify the comment responses. EA documented this activity in Operational Awareness Record EA-WTP-LAW-2014-06-02, *Observation of Waste Treatment and Immobilization Plant Low Activity Waste Facility Reagent Systems Hazard Analysis Activities*.

Following issuance of the reagent systems HAR, EA reviewed the HAR and related supporting documentation using the review criteria and guidance in Criteria, Review, and Approach Document (CRAD) 45-58, *Review of Documented Safety Analysis Development for the Hanford Site Waste Treatment and Immobilization Plant (LBL Facilities)*. The results of this EA review are discussed in Section 5, which is divided into four subsections: hazard identification, hazards analysis, candidate hazard controls and accident selection. The specific criteria used are included in italicized text at the beginning of each subsection.

Section 6 of this report summarizes EA's conclusions, and Sections 7 and 8 list EA's findings and opportunities for improvement (OFIs), respectively. Items for EA follow-up are identified in Section 9. Supplemental information about the team responsible for this review is provided in Appendix A, and the list of documents, interviews, and observations is provided in Appendix B. References are listed in Appendix C.

5.0 RESULTS

As part of its multi-phased review of the development of the LAW HARs, EA reviewed the *Hazards Analysis Report for the Low-Activity Waste Facility, Volume 7, Ammonia Reagent System, Carbon Dioxide System, and Sodium Hydroxide System*, Revision 0, which was approved on December 22, 2014. EA focused on the AMR and CDG because they represent the highest hazards and potential consequences (reference: 24590-WTP-Z0C-W14C-00029 - Rev. A, and 24590-WTP-Z0C-W14T-00023 - Rev. B).

EA provided 49 comments on the HAR to BNI for written response. After reviewing BNI's written responses, EA met with BNI personnel to clarify the comment responses. BNI subsequently revised its responses in the comment table and provided it to EA (reference: e-mail from Stan Hill to James Low, February 10, 2015). In its final responses, BNI identified a number of follow-on actions to resolve EA's comments. These included:

- Clarifying some hazardous event sequence descriptions
- Addressing high physical consequences to co-located workers in some events
- Developing and documenting a candidate control selection strategy
- Adding or revising some candidate controls or correcting the characterization of a few candidate controls

- Clarifying the basis for selecting the candidate DBAs
- Including an Open Item to specifically track the resolution of unmitigated system effects (USEs) from boiling-liquid, expanding-vapor explosion (BLEVE) events to the adjacent LAW, Pre-Treatment Facility (PTF), and High-Level Waste (HLW) facility.

5.1 Hazard Identification

The documented safety analysis for a hazard category 1, 2, or 3 DOE nuclear facility must, as appropriate for the complexities and hazards associated with the facility, provide a systematic identification of both natural and man-made hazards associated with the facility. (10 CFR 830.204.b.2)

The BNI hazards analysis team conducted the hazard identification process using an extensive checklist that included not only the hazardous materials present in the system but also the energy sources that may contribute to the release of hazardous material. To identify the hazardous chemicals requiring further analysis, the team screened the hazards using appropriate criteria for standard industrial hazards and chemical screening. The team then identified the limited number of hazardous materials associated with operation of AMR and CDG (Table 3-3).

Using the hazard identification table, the hazards analysis team conducted brainstorming sessions to complete a "what-if" analysis (Appendix D, Tables D-3 for CDG and D-4 for AMR) and identify events to include in the hazards analysis. Each analyzed event is represented in a hazard evaluation table (Appendix D, Table D-1) that includes the location(s) of the upset condition and a conservative estimate of the involved material at risk (MAR).

EA did not identify any hazardous materials or energy sources that the hazards analysis team had not already addressed.

A number of events associated with AMR failures could result in unanalyzed hazards with significant consequences for the LAW, HLW, and PTF facilities due to gas releases and BLEVEs (i.e., USEs). However, the HAR includes no summary discussion of the risks related to these USEs. Further, while HAR Section 4.4.3, Unmitigated System Effects, indicates that Open Items will track USEs, EA's review of Open Items in the action tracking system indicates that the effect of a BLEVE on other WTP facilities is not being tracked (reference: 24590-WTP-ATS-MGT-14-0343, -0344, -0345, - 0354). With the possibility that failure of an AMR System could adversely affect safety at other WTP nuclear facilities, the safety functions and functional classifications of some AMR candidate engineered controls could change (see **OFI-LAW-AMR-1**).

5.2 Hazards Analysis

The documented safety analysis for a hazard category 1, 2, or 3 DOE nuclear facility must, as appropriate for the complexities and hazards associated with the facility, evaluate normal, abnormal, and accident conditions, including consideration of natural and man-made external events, identification of energy sources or processes that might contribute to the generation or uncontrolled release of radioactive and other hazardous materials, and consideration of the need for analysis of accidents which may be beyond the design basis of the facility. (10 CFR 830.204.b.3)

The scope of the AMR portion of the HAR includes ammonia vessel filling operations, liquid ammonia storage, and transfer of gaseous ammonia to the LAW facility. This HAR does not address ammonia system operations within the LAW facility or onsite transportation accidents, which are the subject of separate LAW HAR volumes or the transportation HAR. The CDG portion of the HAR includes CO_2

receipt, storage, and delivery to the LAW pelletizer system for use in LAW container decontamination (as CO_2 pellets).

The hazards analysis team analyzed a total of 77 AMR and 78 CDG events, including fires, explosions, loss of confinement, external hazards, and natural phenomena hazards. Analyzed fire events included fires starting at the delivery truck and fires in the vicinity of the ammonia storage vessels. The analysis of loss-of-confinement events (50 for AMR and 48 for CDG) included equipment, control system, and operator failures; impacts or drops; as well as, overfill and overpressure events. Analyses of natural phenomena events addressed wind-driven missiles, lightning strikes, earthquakes, and ambient high temperature. Many of the unmitigated events progress to a BLEVE, the consequences of which were determined to adversely affect LAW and other WTP nuclear facilities. Overall, the analyzed event types are appropriate to the systems and constitute a comprehensive set.

Although the set of analyzed AMR events is mostly complete, the analysis of external events includes only two events, both of which involve the underground ammonia transfer line (from the AMR vessels to the LAW facility). The HAR does not address wildland fires, another external event that would be appropriate for this facility given its proximity to the WTP site boundary. External events for the cumulative LAW facility systems, such as aircraft crashes and natural phenomena events, are included in the scope of the LAW facility-wide HAR Volume 10, but the current draft of the facility-wide HAR (reference: 24590-LAW-HAR-NS-13-0001-10) does not include the effects of wildland fires on the reagent systems (see **OFI-LAW-AMR-2**).

To complete the hazards analysis, the hazards analysis team used a computer-based tool, INSIGHT (reference: 24590-WTP-GPG-RANS-NS-0005, Rev 1B), to document the evaluation for each event. The event descriptions, release mechanisms, and causes are included in the hazard evaluation tables. Event descriptions generally include the mechanisms by which material is released. The unmitigated portion of event analysis assumed that all available controls (non-safety and safety) fail. Consequently, event descriptions do not always address the full sequence of the event (process system and control failures) that led to the release. For example, the analysis of valve closures during ammonia vessel-filling (hazard event #AMR-3-007e, which is also identified as a candidate DBA for AMR loss of confinement based on operator error) does not specify which fill valve is closed, although the sequence of events will differ depending on the specific valve failure. Failure to identify and analyze the sequence of events may result in the omission of appropriate candidate controls (see **OFI-LAW-AMR-3**).

The hazard evaluation tables also include the likelihood of the events and consequences (chemical, radiological, and physical), which are conservatively estimated for the facility worker, the co-located worker, the public, and the environment. In a number of AMR events, the consequences of chemical releases to the worker and the public are estimated to be high due to the quantity of ammonia (the inventory of both storage vessels and the delivery truck) that may be involved. Consequences from radiological releases (from the PTF and the HLW facilities) are estimated to be moderate to the public and high to the workers for an event based on the loss of all power to both the PTF and the HLW facilities following an ammonia release and BLEVE. The ammonia release and BLEVE also are estimated to result in high physical consequences to the facility worker, but the HAR did not address physical consequences to the co-located worker. Depending on the hazard event conditions, shock waves and vessel fragments from a BLEVE can impact co-located workers (see **OFI-LAW-AMR-4**).

5.3 Candidate Hazard Controls

The documented safety analysis for a hazard category 1, 2, or 3 DOE nuclear facility must, as appropriate for the complexities and hazards associated with the facility, derive the hazard controls necessary to ensure adequate protection of workers, the public, and the environment, demonstrate the adequacy of these controls to eliminate, limit, or mitigate identified hazards, and define the process for maintaining the hazard controls current at all times and controlling their use. (10 CFR 830.204.b.4)

The hazard evaluation table includes candidate preventive and mitigative controls, both engineered and administrative, for further evaluation during control selection, which is a separate, sequential process following the hazards analysis. The EA review focused on evaluating whether the candidate controls included in the candidate DBAs are complete to the extent that the control selection process can arrive at an adequate set of hazard controls. The review also examined whether the candidate controls reflect DOE's preferred hierarchy of controls as input to the control selection process. DOE's hierarchy of controls emphasizes engineered controls over administrative controls, preventive controls over mitigative controls, and passive controls over active controls.

The HAR includes lists of candidate preventive and mitigative engineered and administrative controls in the table of candidate bounding events (Table 4-3) and the subsequent discussion of candidate control strategies (Section 4.3.4). These lists are built from the individual event entries in the hazard evaluation tables. Additionally, Appendix E of this HAR provides a table of candidate controls that includes the control title, attribute, function, and type, and each control has a list of the related hazard events. The lists of candidate controls, along with the specified safety functions and attributes, provide a mostly complete set of candidate controls to support control selection; however, many candidate controls for bounded events are not applicable to the candidate DBAs (see Section 5.4, below). Candidate DBAs should be representative of the underlying bounded events, sharing the same event causes and subsequent candidate controls.

BLEVE events provide little reaction time and result in high consequences to the co-located worker and, therefore, preventive controls are desired over mitigative controls (consistent with the DOE-preferred hierarchy of controls). In general, the candidate hazard control sets for AMR large release/BLEVE events are biased toward mitigative controls. For example, 11 preventive controls that can directly apply to preventing a BLEVE are identified by an asterisk as not applicable to the candidate DBA. Further, candidate DBA AMR-3-007e, "*AMR System Operator Error*," contains roughly three times as many candidate mitigative engineered controls as preventive engineered controls, and candidate DBA AMR-3-002a, "*Mechanical Failure of Ammonia Piping, Vessel or Vaporizer*," contains roughly twice as many candidate mitigative engineered controls as preventive engineered controls. Further, of the bounded events, approximately one-third have zero or one preventive engineered control, and of 38 BLEVE events, 7 have only one preventive engineered control. The HAR does not clearly justify the apparent bias of these candidate hazard control sets toward mitigative controls (see **OFI-LAW-AMR-5**).

Some events had missing, inappropriate, or misclassified candidate hazard controls, which could lead to selection of an inadequate set of hazard controls. For example:

- Candidate DBA AMR-1-001 is missing the presence of the onsite fire department monitoring and response during ammonia tank filling operations as a potential control.
- Hazard event AMR-3-013 is missing the (existing) pressure relief valves as potential passive engineered controls.
- Pipe routing is incorrectly included as a preventive control for receipt of wrong material (hazard event AMR-3-013).

- Ammonia vessel excess flow check valves are incorrectly listed as mitigative features for a seismic event that causes the ammonia vessel's pressure boundary to fail.
- The fire suppression system (not in the current design) is misclassified as a potential mitigative (rather than preventive) engineered control in responding to a delivery truck fire, when fire suppression would reduce the probability of an ammonia release or a BLEVE event (hazard event AMR-1-001).

Inappropriate or incomplete candidate control sets could adversely impact the ability to select controls that prevent the candidate DBA (see **OFI-LAW-AMR-6**).

5.4 Accident Selection

The documented safety analysis for a hazard category 1, 2, or 3 DOE nuclear facility must, as appropriate for the complexities and hazards associated with the facility, evaluate normal, abnormal, and accident conditions, including consideration of natural and man-made external events, identification of energy sources or processes that might contribute to the generation or uncontrolled release of radioactive and other hazardous materials, and consideration of the need for analysis of accidents which may be beyond the design basis of the facility. (10 CFR 830.204.b.3)

The process of selecting candidate DBAs is based on identifying unique and representative accidents that may be included in the accident analysis. As discussed in DOE-STD-3009, unique accidents are those hazard events with sufficiently high-risk estimates to justify individual examination to support control functional classification and evaluation. Representative accidents bound a number of similar accidents of lesser risk and are expected to have similar control sets; they are also further examined to verify that they do not contain unique accidents. At least one representative DBA from each of the major types determined from the hazards analysis (e.g., fire, explosion, spill) should be selected unless the DBA consequences are "low." The functional classification of controls and evaluation of the control set leads to development of technical safety requirements.

EA evaluated whether the HAR contained unique and representative candidate DBAs for AMR and CDG. Section 4.3 of the HAR includes a set of candidate DBAs for fires, operational upsets, and natural phenomena hazard events. Individual subsections describe the underlying event scenarios, describe the candidate DBAs, and list the candidate controls. In many cases, events from CDG and SHR are combined with the AMR events in the candidate DBA. As described in the HAR, candidate DBAs often share similar causes with the underlying events (e.g., equipment failure, operator error, and system impacts or load drops).

The discussion of candidate DBA selection focuses primarily on whether the consequences of each candidate DBA bound those of the underlying events. However, this HAR does not explain the parameters that the analysts used to establish and evaluate whether the candidate DBAs are representative. Some candidate DBAs were selected on the basis of similar cause (e.g., equipment failure, system impacts) rather than on the system's operating mode (e.g., AMR unloading, storage/normal operation). In addition, some candidate DBAs include underlying bounded events from all three reagent systems, even though the systems' hazardous materials, operations, and locations are different. Consequently, the HAR does not adequately describe the relationship between the candidate DBAs and the underlying bounded hazard to justify the selection of candidate DBAs as representative. For example:

- Candidate DBA AMR-3-002a, which has as a cause mechanical failure of piping, vessel, or vaporizer, includes underlying bounded event causes of computer control system failure but does not explain how the mechanical failures are intended to be representative of control system failures.

- Candidate DBA AMR-3-007e, which covers events resulting from operator error during AMR loading operations, also includes normal storage/transfer operations but does not explain how the candidate DBA is representative of these dissimilar operations.
- Seismic and high ambient temperature events are discussed separately in HAR Section 4.3.2.1, but the events are combined in the candidate seismic DBA (AMR-7-003), with no explanation of how the candidate seismic DBA is representative of a high ambient temperature/stuck open pressure relief valve hazard event.

Further, the candidate control strategies in this HAR contain a number of controls that are identified, by an asterisk, as not applicable to the candidate DBA but as applying to one (or more) of the underlying bounded events. For example:

- Eighteen preventive controls used in bounded events were not applicable to any of the candidate DBAs.
- Approximately one-third of the preventive controls in the underlying bounded events were not applicable to the specific candidate DBA.
- In some candidate DBAs, non-applicable controls exceeded the number of applicable candidate controls (e.g., AMR-3-007e includes 42 non-applicable controls but only 20 applicable controls).
- A small percentage of the mitigative controls in the underlying events are not applicable to the specific candidate DBA.

The candidate controls are included in the HAR in list form, but the strategies and process for applying the controls to the candidate DBA or for analyzing the asterisked controls (i.e., those applicable to underlying events but not to the candidate DBA) are not addressed. The HAR does not address how the asterisked controls are to be considered in the control selection process. In response to EA comments, BNI stated that "*Section 6.0 of the Control Selection Process Handbook is a description of the 'DBA' confirmation task. The handbook requires that each event be evaluated and 'If the result of the DBA confirmation is identification of an event needed to be presented to the CST [Control Selection Team] for additional control selection, the control selection process is repeated for this event'*" (reference: 24590-WTP-GPG-RANS-NS-0004). This method of resolving the asterisked candidate controls would require BNI to rework the candidate DBA sets to determine whether additional accidents must be considered in order to capture the asterisked controls. Furthermore, this method does not address the requirement in the Control Selection Process Handbook to verify that the proposed DBA scenario is representative of the bounded events before controls are selected. In response to EA's comments on the HAR, BNI committed to documenting a control selection strategy and process (see **Finding F-LAW-AMR-1, OFI-LAW-AMR-7** and **OFI-LAW-AMR-8**).

6.0 CONCLUSIONS

The BNI hazards analysis team used a thorough hazard identification process to identify the hazards requiring analysis. Overall, the hazards analysis team analyzed event types appropriate to the systems and developed a comprehensive set of events, including fires, explosions, loss of confinement, external hazards, and natural phenomena hazards. The HAR focuses on completing unmitigated event analyses and, for the most part, includes conservative estimates of MAR and unmitigated consequences. The candidate controls, along with the specified safety functions and attributes, provide a mostly complete set of candidate controls to support control selection.

However, the HAR does not adequately describe the relationship between the candidate DBAs and the underlying bounded hazard events to justify the selection of candidate DBAs as representative. Although the hazard event analysis is mostly thorough, some candidate DBAs were chosen based on similar causes

(e.g., operator error, mechanical error, or impact) and bounding consequences without sufficient regard for whether the chosen event was representative of the underlying bounded events. As a result, many preventive candidate controls identified for bounded events are not applicable to the candidate DBA, and although the HAR lists the candidate controls, it does not address the strategies for applying the controls to the candidate DBA or analyzing the controls that are applicable to the underlying event(s) but not to the candidate DBA. Consequently, the candidate design basis accidents do not provide a fully representative set in preparation for control selection and a number of preventive engineering controls are unlikely to be selected to the hazard control set.

EA identified several areas where the HAR could be improved: hazard identification, hazards analysis, and candidate hazard control documentation. In the hazard identification process, Open Items to track the resolution of BLEVE effects on WTP nuclear facilities have not been fully identified. With respect to hazards analysis, the HAR does not address some relevant external events, and the hazards analysis team did not always fully describe the hazard event sequence. The HAR also did not address physical consequences to the co-located worker from BLEVE events. Finally, in candidate control identification, the candidate control sets for large release/BLEVE events lacked a balance between preventive and mitigative engineered controls, and some candidate controls were not correctly characterized.

7.0 FINDINGS

As defined in DOE Order 227.1, *Independent Oversight Program*, findings are significant deficiencies or safety issues that warrant a high level of management attention. If left uncorrected, findings could adversely affect the DOE mission, the environment, the safety or health of workers and the public, or national security. Findings may identify aspects of a program that do not meet the intent of DOE policy or Federal regulation. DOE line management or contractor organizations must develop and implement corrective action plans for EA review findings. Cognizant DOE managers must use site- and program-specific issues management processes and systems in accordance with DOE Order 227.1 to manage these corrective action plans and track them to completion.

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F-LAW-AMR-1: Some candidate DBAs are not representative of the underlying bounded hazard events. (DOE-STD-3009-94, Section 3.0)

8.0 OPPORTUNITIES FOR IMPROVEMENT

This EA review identified eight OFIs. These potential enhancements are not intended to be prescriptive or mandatory. Rather, they are suggestions that may assist site management in implementing best practices or provide potential solutions to minor issues identified during the EA review. In some cases, OFIs address areas where program or process improvements can be achieved through minimal effort. It is expected that the responsible line management organizations will evaluate these OFIs and accept, reject, or modify them as appropriate in accordance with site-specific program objectives and priorities.

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While evaluating actions to address the weaknesses identified in this report, consider the following actions.

OFI-LAW-AMR-1: Establish Open Items to track the resolution of BLEVE effects on WTP facilities and the potential changes in the functional classification of controls for the reagent systems and components.

OFI-LAW-AMR-2: Add wildland fires to the hazard events analyzed for the AMR system.

OFI-LAW-AMR-3: Review the candidate DBAs and revise the event descriptions as necessary to ensure that the sequence of events is sufficiently described to support identification of the causes and potential controls for the event.

OFI-LAW-AMR-4: Revise the HAR and hazard event tables to address the physical consequences to the co-located worker.

OFI-LAW-AMR-5: To facilitate control selection consistent with the preferred hierarchy of controls, re-evaluate the proposed candidate control sets in a number of candidate DBAs with high consequences to ensure a reasonable balance between candidate preventive and mitigative engineered controls.

OFI-LAW-AMR-6: Add or revise some candidate controls, and correct the classification of some mischaracterized candidate controls.

OFI-LAW-AMR-7: Document a candidate control selection strategy.

OFI-LAW-AMR-8: Revise the event descriptions of the candidate DBAs to ensure that they are more representative of the group of underlying events.

9.0 ITEMS FOR FOLLOW-UP

EA will continue to follow the progress of the safety analyses for reagent systems, including revision of safety analysis processes, completion of the hazards analysis, control selection, accident analysis and integration into LAW DSA chapter development. EA will then review the LAW DSA when it is submitted for approval.

Appendix A

Supplemental Information

Dates of Review

Onsite Review: June 2-19, 2014
Document Review: December 22, 2014, to February 12, 2015

Office of Enterprise Assessments

Glenn S. Podonsky, Director, Office of Enterprise Assessments
William A. Eckroade, Deputy Director, Office of Enterprise Assessments
Thomas R. Staker, Director, Office of Environment, Safety and Health Assessments
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William A. Eckroade
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Michael A. Kilpatrick

EA Site Lead for Office of River Protection

Robert Farrell

EA Reviewers

James Low – Lead
Kevin Bartling
Roy Hedtke
Mary Miller
David Odland
Daniel Schwendenman

Appendix B

Key Documents Reviewed, Interviews/Discussions, and Observations

Documents Reviewed

- 24590-BOF-S0C-S15T-00006, *Determination of Pressures on Q-Level Structures due to BLEVEs,* Rev. A
- 24590-ENS-DI-RANS-NS-0003, Hazards Analysis Report Format and Contents Desk Instruction, Rev. 0, June 13, 2013
- 24590-HLW-Z0C-W14T-00023, *Severity Level Calculations for the HLW Facility Based on Updated MAR,* Rev. A
- 24590-LAW-HAR-NS-13-0001-07, Rev 0, *Hazards Analysis Report for the Low-Activity Waste Facility, Volume 7, Ammonia Reagent System, Carbon Dioxide System, and Sodium Hydroxide System,* December 22, 2014
- 24590-LAW-Z0C-LOP-00001, *LAW Melter Offgas Release,* Rev. E
- 24590-LAW-Z0C-W14T-00008, *Severity Level Assessment for the LAW Facility,* Rev. B
- 24590-LAW-Z0C-W14T-00014, *Liquid Carbon Dioxide Storage Vessel BLEVE,* Rev. A
- 24590-PTF-Z0C-W14T-00036, *Severity Level Calculations for the Pretreatment Facility Based on Updated MAR,* Rev. B
- 24590-RANS-F00012-I, Instructions for Completing the WTP HID Checklist, Rev. 0, 12/17/12
- 24590-WTP-GPG-RANS-NS-0002, *Hazard Analysis Handbook,* Rev. 2, July 12, 2013
- 24590-WTP-GPP-RANS-NS-0005, *Hazard Analysis Procedure*, Rev. 1, June 13, 2013
- 24590-WTP-GPG-RANS-NS-0005, Rev 1B, WTP Insight User's Guide for Supporting Hazards Analysis, July 10, 2014
- 24590-WTP-Z0C-W14C-00029, *Ammonia Tank BLEVE at the Hanford Waste Treatment Plant,* Rev. A
- 24590-WTP-Z0C-W14T-00023, *Main Control Room Concentrations of Chemicals due to Releases from Transportation, Process, and Storage Accidents,* Rev. B
- E-mail: Stan Hill to James Low, Subject: *Final EA-31 Comment Resolution,* August 27, 2014 9:26 AM (PST) - with attachment.
- E-Mail from Stan Hill to James Low, Subject: *EA-31 DOE Comments Revision 1,* February 10, 2015 – with attachment
- 24590-WTP-ATS-MGT-14-0343, *BOF USEs and HA Actions*, March 30, 2015
- 24590-WTP-ATS-MGT-14-0344, *LAW USEs and other HA Actions*, March 30, 2015
- 24590-WTP-ATS-MGT-14-0345, *Unmitigated System Effects (USEs) to PTF*, March 30, 2015
- 24590-WTP-ATS-MGT-14-0354, *LAW Unmitigated System Effects Impacting HLW*, March 30, 2015
- 24590-LAW-HAR-NS-13-0001-10, *Hazard Analysis Report for Low-Activity Waste Facility, Volume 10, Facility Wide, Rev. 0 (Draft for Review*), January 12, 2015

Interviews/Discussions

- LAW Nuclear Safety Manager
- Hazards Analysis Team Leads
- Hazards Analysis Team Members
- Subject Matter Experts

Observations

- LAW Reagent Systems Hazards Analysis Team Daily Meetings

Appendix C

References

- ORP Letter 11-WTP-470, R. Dawson to F. Russo, Subject: Proposed Changes to the WTP Regulatory Construct to Support Project Transition to Commissioning and Operations, December 22, 2011
- 24590-WTP-PL-ENS-11-0001, Rev. 0, *Safety Basis Development Project Execution Plan for the Analytical Laboratory, Low-Activity Waste and Balance of Facilities*, January 2, 2012
- DOE-STD-3009-1994, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Document Safety Analyses*, Change Notice 3, March 2006
- Operational Awareness Record EA-WTP-LAW-2014-06-02, *Observation of Waste Treatment and Immobilization Plant Low Activity Waste Facility Reagent Systems Hazard Analysis Activities*, December 2014
- CRAD 45-58, *Review of Documented Safety Analysis Development for the Hanford Site Waste Treatment and Immobilization Plant (LBL Facilities),* April 2013
- CCN 249553, *Documentation of Meeting with Safety Design Integration Teams and Hazard Analysis Leads and Scribes Regarding Hazard Analysis Operational Pause*, November 13, 2012
- 24590-WTP-GPG-RANS-NS-0004, *Control Selection Process Handbook*, Rev. 1A, June 2, 2014