Office of Enterprise Assessments
Assessment of the Hanford Site
Waste Treatment and Immobilization Plant
Construction Quality

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Acronyms

AHJ	Authority Having Jurisdiction
ASME	American Society of Mechanical Engineers
BNI	Bechtel National, Inc.
BOF	Balance of Facilities
CDR	Construction Deficiency Report
CFR	Code of Federal Regulations
CM	Commercial Grade
CR	Condition Report
CRAD	Criteria and Review Approach Document
DOE	U.S. Department of Energy
EA	Office of Enterprise Assessments
EMF	Effluent Management Facility
HLW	High-Level Waste Facility
LAB	Analytical Laboratory
LAW	Low-Activity Waste Facility
NCR	Nonconformance Report
NEC	National Electrical Code
NQA	Nuclear Quality Assurance
ORP	Office of River Protection
psi	Pounds per square inch
PTF	Pretreatment Facility
Q	Quality Related
QA	Quality Assurance
QAM	Quality Assurance Manual
QC	Quality Control
SSCs	Structures, Systems, and Components
TIRB	Technical Issues Resolution Board
UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply
WCD	ORP WTP Construction Oversight and Assurance Division
WTCC	Waste Treatment Completion Company
WTP	Waste Treatment and Immobilization Plant

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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 construction quality and the implementation of the quality assurance program at the Hanford Site Waste Treatment and Immobilization Plant (WTP) from June 5 to 8, 2017. EA performed this assessment in the broader context of an ongoing program of quarterly assessments of construction quality at the WTP construction site.

The scope of this EA assessment included observing ongoing work activities, reviewing the program for controlling nonconforming conditions, examining the implementation of certain requirements in the Bechtel National, Inc. (BNI) quality assurance program, and following up on issues identified during previous assessments.

Overall, construction quality is satisfactory in the areas of pressure testing of piping, concrete placements, welding, electrical cable pulling, equipment installation, and corrective action program activities related to nonconformance reports.

The Technical Issues Resolution Board (TIRB) is used by BNI and Office of River Protection (ORP) to address and resolve significant technical issues to ensure successful completion of the WTP. In April 2017, the TIRB reviewed and approved a resolution to the EA and ORP longstanding issue regarding the method BNI has used for transitioning electrical cables from cable trays to cabinets or equipment. The TIRB accepted BNI's method based primarily on a report prepared by Underwriter's Laboratory (UL) as a subcontractor to BNI, and therefore existing electrical cable to cabinets and equipment installations are approved.

EA noted as a deficiency that the BNI electrical Authority Having Jurisdiction ruling that approved a cable tray that exceeded the allowable cable fill criteria was not approved by DOE before acceptance by BNI design engineering.

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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 construction quality at the Hanford Site Waste Treatment and Immobilization Plant (WTP). The onsite portion of this assessment was conducted from June 5 to 8, 2017. This EA assessment was performed within the broader context of an ongoing program of assessments of construction quality at DOE major construction projects. Because of the safety significance of WTP facilities, EA plans to continue these ongoing quarterly assessments at the WTP construction site to ensure that construction contractors meet the requirements of 10 CFR 830, Subpart A, *Quality Assurance Requirements*.

2.0 SCOPE

This quarterly assessment evaluated construction quality by observing ongoing work activities; reviewing the Bechtel National, Inc. (BNI) program for controlling nonconforming conditions; and, examining the implementation of certain requirements in the BNI quality assurance (QA) program and the BNI corrective action program. Design and procurement programs were not included in this assessment.

3.0 BACKGROUND

The DOE Office of River Protection (ORP), among its other duties, manages the 56 million gallons of liquid or semi-solid radioactive and chemical waste stored in 177 underground tanks at the Hanford Site and the WTP. The WTP, an industrial complex for separating and vitrifying the radioactive and chemical waste in the underground tanks, is in the design and construction phase. The QA program requirements for design and construction of the WTP referenced in the preliminary documented safety analysis and cited in the BNI contract are American Society of Mechanical Engineers (ASME) Nuclear QA (NQA)-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications*, and DOE Order 414.1C, *Quality Assurance*. BNI Document 24590-WTP-QAM-QA-06-001, *Quality Assurance Manual*, provides a detailed description of the application of the 18 NQA-1-2000 requirements to the WTP. The WTP QA Manual (QAM) establishes a management system of planned and systematic actions necessary to ensure that structures, systems, and components (SSCs) perform satisfactorily in service.

BNI manages design and construction activities at WTP under contract to ORP. ORP staff members, primarily WTP Construction Oversight and Assurance Division (WCD) staff, provide oversight of construction activities at the WTP. In March 2017, a joint venture was formed between BNI and AECOM, the contractor responsible for maintenance and commissioning systems after turnover from BNI. The new organization, the Waste Treatment Completion Company (WTCC), is a subcontractor to BNI. WTCC is contracted to complete construction, conduct startup, and commission the WTP in accordance with the BNI QAM. BNI construction personnel, including craft, field engineers, quality control (QC) inspectors, administrative personnel, and managers became employees of WTCC on March 31, 2017. Administrative changes have been implemented to transition BNI construction procedures into WTCC construction procedures for control of site work activities.

The WTP complex consists of the Pretreatment Facility (PTF) for separating the waste into low-activity waste and high-activity waste; the High-Level Waste Facility (HLW), where the high-level waste will be immobilized in glass; the Low-Activity Waste Facility (LAW), where the low-activity waste will be immobilized in glass; the Analytical Laboratory (LAB) for sample testing; and, the balance of facilities (BOF), which will house support functions.

Construction work is essentially complete for the LAB and most BOF buildings. The BOF Electrical Distribution Building was turned over from BNI Construction to AECOM in 2016. When additional buildings are completed, the turnover process will be internal within WTCC, from the Construction group to the Operations group.

Construction work activities are deferred in the PTF pending satisfactory resolution of technical questions regarding separation and processing of the waste and the design life of PTF equipment. After construction was slowed in the HLW pending resolution of technical issues involving the waste treatment process, DOE decided to curtail construction of the HLW in late 2016 and concentrate on completing the LAW and the Effluent Management Facility (EMF) in order to begin processing low-activity waste in 2022 using direct feed from the tank farms.

The EMF is being constructed to process the effluent remaining after the low-activity waste is processed in the LAW. Effluent from the LAW will be transferred via buried piping to the EMF, where it will be processed to separate non-radioactive liquids (water) from radioactive or chemical byproducts. Radioactive and chemical byproducts will be transferred from the EMF via a designated piping system back to the LAW for vitrification or return to the tank farm. Construction of the EMF began in 2016.

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" as defined in DOE Order 227.1A. In accordance with DOE Order 227.1A, DOE line management and/or contractor organizations must develop and implement corrective action plans for the deficiencies identified as findings. Other important deficiencies not meeting the criteria for a finding are also highlighted in the report and summarized in Appendix C. These deficiencies should be addressed consistent with site-specific issues management procedures.

EA conducted this assessment of WTP construction quality processes in accordance with the *Plan for the Office of Enterprise Assessments Assessment of the Hanford Site Waste Treatment and Immobilization Plant Construction Quality*, June 2017. This assessment considered the requirements of 10 CFR 830, Subpart A, and DOE Order 414.1C, which specify that the contractor must use appropriate national consensus standards to implement DOE QA requirements.

EA used the following criteria and review approach documents (CRADs):

- CRAD-45-52, *Construction – Piping and Pipe Supports*
- CRAD-45-53, *Construction – Mechanical Equipment Installation*
- CRAD-64-15, *Construction – Structural Concrete*
- CRAD-64-16, *Construction – Structural Steel*

- CRAD 64-20, *Feedback and Continuous Improvement Inspection Criteria and Approach – Contractor*.

EA is developing additional CRADS for installation of electrical cables and equipment, as well as instrumentation. In the interim, assessment of electrical construction and quality requirements are based on the approved BNI design criteria and specifications and national standards included in the contract.

EA reviewed procedures, specifications, drawings, and records; interviewed key personnel responsible for construction and inspection work activities; and, conducted site walkdowns to observe work activities and inspect WTP components. EA conducted several walkdowns at the WTP construction site with WTCC personnel and the WCD staff to determine whether work activities were completed in accordance with the appropriate design drawings, specifications, and procedures. EA observed three piping pressure tests; observed concrete placements in two EMF walls; and, inspected structural and piping welds and electrical equipment in the LAW. EA reviewed nonconformance reports (NCRs) that either BNI or WTCC identified under the BNI corrective action program, selected condition reports (CRs), and the system turnover process. EA also reviewed an Authority Having Jurisdiction (AHJ) ruling regarding cable tray fill that BNI completed in accordance with its assigned AHJ role and the decision of the Technical Issues Resolution Board (TIRB) regarding the method to transition electrical cables from cable trays to cabinets and equipment.

The members of the EA assessment team, the Quality Review Board, and EA management responsible for this assessment are listed in Appendix A. A list of the documents reviewed, personnel interviewed, and observations made during this assessment, relevant to the findings and conclusions of this report, is provided in Appendix B.

5.0 RESULTS

5.1 BNI Corrective Action Program

Criterion:

A process shall be established to identify, control, document, evaluate, and correct conditions adverse to quality. Records shall be maintained documenting the corrective action program, including documentation of objective evidence of satisfactory implementation of corrective actions. (NQA-1, Requirement 16; Policy Q-15.1, Policy Q-16.1, and Appendix A Policy Q-15.1 of the WTP QAM; and DOE Order 414.1C)

BNI Procedure 24590-WTP-GPP-MGT-044, *Nonconformance Reporting and Control*, adequately defines the requirements for identifying, documenting, reporting, controlling, and dispositioning nonconforming conditions associated with Q (previously classified as Quality-List or QL) and commercial grade (CM) SSCs at the WTP. This procedure requires NCRs to be issued to document and disposition nonconforming conditions associated with Q SSCs, while construction deficiency reports (CDRs) are required to document and disposition nonconforming conditions associated with CM SSCs.

The process for determining quality levels is specified in BNI Procedure 24590-WTP-3DP-G04T-00905, *Determination of Quality Levels*. This procedure references other supporting, interfacing project documents regarding identification of items/services subject to the QA program and procurement requirements. SSCs designated as Q in the design documents must be constructed or manufactured in accordance with the WTP QA program and the ASME NQA-1 standard. SSCs designated in the design

documents as non-Q (i.e., CM) are constructed in accordance with CM standards, such as the Uniform Building Code, or purchased as CM items from vendors who are qualified CM suppliers.

EA reviewed the 74 NCRs that BNI issued between March 9 and June 6, 2017, to ascertain the types of nonconforming issues and their apparent causes. The NCRs included four related to construction or installation errors; five for failure of procurement engineering to properly review or document evaluation of commercial grade dedication for Q components; four for materials handling issues, such as expired shelf life, damage to material in storage, or inadequate performance of receipt inspections; 13 for issues involving subcontractors; and, 48 for procurement/supplier deficiencies.

All but one of the subcontractor NCRs were issued to disposition nonconforming conditions identified by the heating ventilation and air-conditioning subcontractor, Intermech, under its QA program. The resolution proposed by Intermech of the nonconforming conditions identified in the 12 NCRs was either "use-as-is" or required a design change, both of which required review and approval by BNI design engineering.

Records for the 10 closed NCRs that EA reviewed document the completed corrective actions and provide evidence that corrective actions were satisfactorily implemented. However, the remaining 64 NCRs were still open and require an evaluation by BNI Design Engineering. Closure of the NCRs initiated to document procurement/supplier and/or inadequate commercial grade dedication evaluations continues to challenge the BNI Design Engineering organization. CDRs were not reviewed during this assessment.

5.2 Concrete Placement Activities

Criterion:

Work, such as concrete construction shall be performed in accordance with approved procedures, design drawings, manufacturer's instructions, and other design basis documents, including applicable codes and standards. The procedures, instructions, and drawings shall include or reference appropriate quantitative or qualitative acceptance criteria for determining that prescribed results have been satisfactorily attained. (NQA-1, Requirement 5; Policy Q-5.1 of the WTP QAM; and DOE Order 414.1C)

Records shall furnish documentary evidence that items or activities meet specified quality requirements. (NQA-1, Requirement 17; Policy Q-17.1 of the WTP QAM; and DOE Order 414.1C)

EA observed portions of two CM concrete placements for exterior walls in the EMF, placement numbers EMF 12103 and 12109. Specification No. 24590-WTP-3PS-DB01-T0001, *Engineering Specification for Furnishing and Delivering Ready-Mix Concrete*, and Specification No. 24590-WTP-3PS-D000-T0001, *Engineering Specification for Concrete Work*, cite the requirements for concrete quality and concrete work activities at WTP. The EMF wall design criteria specify a concrete mix with air entrainment and an unconfined compressive strength of 5,000 psi at 28 days after placement. Because the walls will be exposed to weather, the concrete is required to be air entrained to resist the effects of freeze/thaw conditions. Since this type of concrete mix had not been used previously on the WTP project, it was necessary for the WTP project concrete supplier, Central Premix, to develop a new air entrained 5,000 psi mix for the EMF walls.

EA reviewed QC surveillance report 24590-WTP-SV-QC-17-044, *CPM Certification Testing for Mix Number 358129*. Mix number 358129 was developed to meet the concrete properties specified in the EMF wall design criteria. The report documents the surveillance that WTCC QC inspectors performed to

witness batching and testing of the concrete mix to verify that the properties of the mix complied with the EMF wall design criteria.

EA observed several activities related to concrete placement, including acceptance testing of the fresh concrete for slump, temperature, entrained air content, and unit weight by the materials testing subcontractor; review of concrete batch tickets and acceptance test results by the WTCC QC inspectors; placement of the concrete in the forms; and, consolidation of the concrete. Because the EMF walls are classified as CM, WTCC field engineers inspected concrete placement and consolidation activities.

EA reviewed the concrete pour cards and verified that they were signed to document that all required construction work and inspections were completed before the start of concrete placement. Review of the concrete batch tickets indicated that the proper concrete was being delivered. Testing of the concrete was performed in accordance with the ASTM International standards specified in the project procedures. Test results showed that the delivered concrete met project requirements for slump, entrained air content, and temperature. Concrete samples were obtained from the end of the pump line as required by the project specifications for concrete with entrained air. Concrete was sampled for molding of cylinders for unconfined compression testing.

Concrete forms were secured and cleaned (debris removed) prior to concrete placement, the equipment used for delivering the concrete to the forms was suitable, and enough vibrators were used to consolidate the concrete. Vibrator operators, other construction craftsmen, and WTCC field engineers had sufficient access to the placement. Concrete drop distances were within specifications, vibrators were properly used, and excess water did not accumulate in the forms during placement and consolidation.

EA reviewed the results of tests performed on the fresh concrete placed in EMF wall numbers EMF 12110 and 12104 on May 24, 2017, to measure slump, entrained air content, unit weight, and temperature, and also reviewed the unconfined compression tests performed on concrete cylinders moist cured in the concrete laboratory for seven days.

The test results showed that the freshly placed concrete complied with the criteria specified in BNI Specification No. 24590-WTP-3PS-DB01-T0001. Unconfined compression tests are used to demonstrate that the concrete strength meets the specified design strength. The tests performed on cylinders moist cured for seven days provide an early indication of the 28-day concrete strength. Typically, the seven-day unconfined compression strength is approximately 80 percent of the 28-day unconfined compression strength. The unconfined compression tests performed on two test cylinders from EMF wall number EMF 12110 and 12104 that were seven days old indicated an average unconfined compressive strength of 3,940 psi, which is approximately 80 percent of the design strength.

5.3 Pressure Testing Program

Criterion:

Construction and pre-operational tests, such as pressure testing operations for piping systems, shall be conducted in accordance with methods approved by the design organization. Test procedures shall include test requirements, acceptance criteria, test prerequisites, inspection hold points, and instructions for recording data. Testing shall be observed by qualified inspection personnel. Test results shall be recorded and evaluated by qualified personnel. (NQA-1, Requirement 11; Policy Q-11.1 of the WTP QAM; and DOE Order 414.1C)

EA observed one hydrostatic pressure test and two pneumatic pressure tests. WTCC Construction Procedure 24590-WTP-GPP-CON-3504, *Pressure Testing of Piping, Tubing and Components*, specifies

the generic work process and quality requirements for pressure testing, including the test requirements, test prerequisites, hold points, inspection requirements, test sequence, instructions for recording and evaluating data, and acceptance criteria. This procedure references the appropriate codes and documents approved by BNI design engineering for conducting pressure testing. The procedure was adequate.

EA observed the following tests:

- Pneumatic pressure test performed on LAW primary offgas process system Q instrument air tubing, recorded on document numbers 24590-LAW-PPTR-CON-16-0091, -0093, and -0099. Code requirements are specified in ASME Code B31.3, Paragraph 345.5, *Pneumatic Testing*.

- Hydrostatic pressure test performed on CM plant cooling water system piping in BOF chiller compressor plant, recorded on document number 24590-BOF-PPTR-CON-17-0026. Code requirements are specified in ASME Code B31.3, Paragraph 345.4, *Hydrostatic Testing*.

- Pneumatic pressure test performed on LAW primary offgas process system Q instrument air tubing, recorded on document number 24590-LAW-PPTR-CON-17-0062. Code requirements are specified in ASME Code B31.3, Paragraph 345.5, *Pneumatic Testing*.

EA attended the pre-test briefings, reviewed drawings and test data sheets, examined the testing apparatus, and verified that the calibration stickers on the test pressure gauges were current and that whip restraints were installed on pressure hoses. Before the pressure tests, EA examined the piping system and the valve lineup and pressure test tags attached to the valves. EA witnessed the test pressurization sequence during each pressure test and verified that the piping systems were pressurized to the designated test pressures and that the required test pressures were maintained for the required hold time (10 minutes) before the WTCC field engineers initiated the system walkdown to inspect the piping/tubing for leakage and to ensure that pressure was maintained during the walkdowns. WTCC QC inspectors also performed walkdowns to inspect the Q instrument tubing for leakage.

EA observed the walkdowns and inspections that WTCC Field Engineers and QC inspectors performed. No leaks were identified during the pressure tests on the plant cooling water system piping or on the primary offgas system instrument air tubing, and these tests were declared successful by the WTCC test engineers. The pressure testing program was satisfactory for the sample that EA reviewed.

5.4 WCD Welding Inspection Program

Criterion:

Special processes that control or verify quality, such as those used in welding, shall be performed by qualified personnel using qualified procedures in accordance with specified requirements. (NQA-1, Requirement 9; Policy Q-9.1 of the WTP QAM; and DOE Order 414.1C)

WCD site inspectors perform independent inspections of one or more inspection attributes on approximately 5% of Q welds they select at random. Welds selected for inspection include structural steel, piping, pipe supports, vessel (tank) welds, and weld repairs. Most welds that WCD examines are Q, but the WCD staff also includes some CM welds in its independent sample. The site inspectors also select for examination some welds that have unique configurations or geometry that differ in some respect from routine site welds.

EA observed a WCD site inspector performing an independent final visual inspection of three piping welds: one pipe to pipe circumferential butt weld on the LAW melter process system and two pipe to

flange circumferential fillet welds on the high pressure steam system. The WCD site inspector had selected these welds as DOE-designated witness points. Acceptance criteria for visual examination of piping welds are specified in Procedure 24590-WTP-MN-CON-01-001-10-09, *Bechtel Nondestructive Examination Standard, Visual Examination VT-ASME*.

The WCD site inspector also performed a final visual inspection of the structural fillet and flare bevel welds on the caustic scrubber hatch doorframe and on a CM plant service air system pipe support. Acceptance criteria for visual examination of the structural welds are specified in Procedure 24590-WTP-MN-CON-01-001-10-10, *Bechtel Nondestructive Examination Standard, Visual Examination VT-AWS D1.1*.

The specific welds examined by the WCD site inspector are listed in Appendix B of this report. EA also examined these welds. All welds met the visual acceptance criteria. EA and the WCD site inspector reviewed the field welding checklists, weld wire draw slips, and drawings associated with the welds that were inspected and verified that the correct filler materials and weld processes were used to complete the welds and that the size and type of welds matched the construction drawings. During previous EA assessments, EA reviewed the welding procedures and a sample of the welder qualification records, which indicated that the welding procedures were pre-qualified and that the welder qualifications complied with ASME Code and/or American Welding Society requirements.

The implementation of the WCD welding inspection program was satisfactory for the sample that EA reviewed.

5.5 Electrical Construction Activities

Criterion:

Electrical equipment that performs a safety function shall be installed in accordance with approved procedures, design drawings, manufacturer's instructions, and other design basis documents, including applicable codes and standards. The procedures, instructions, and drawings shall include or reference appropriate quantitative or qualitative acceptance criteria for determining that prescribed results have been satisfactorily attained. (NQA-1, Requirement 5; Policy Q-5.1 of the WTP QAM; and DOE Order 414.1C)

Technical Issues Resolution Board

During the May 5 to 8, 2014, construction quality assessment, EA identified an issue with the method that BNI design engineers had prescribed in the design documents for transitioning electrical cables between cable trays and electrical equipment or enclosures. The WCD site electrical inspector stated that she had previously identified this concern. The design documents specified that the electrical cables were not required to be routed in cable trays or conduit, but could be unsupported, and therefore unprotected, by dropping in open air between the cable trays and electrical equipment or enclosures.

The BNI Design Engineering organization issued a formal interpretation of the National Electrical Code (NEC), stating that cables can run in free air, up to 6 feet, between cable trays and/or between cable trays and equipment. WCD personnel and ORP electrical engineers continued to discuss this issue with BNI electrical design engineers but did not reach a consensus because of differing interpretations of the NEC, thereby delaying the completion of cable installation and terminations.

Approximately two years after EA had identified the above issue, BNI contracted Underwriters Laboratories (UL) to evaluate whether the method in the BNI design documents for routing electrical

cables between cable trays and electrical cabinets and equipment complied with the NEC. UL determined that the method proposed by BNI for transitioning electrical cables between cable trays and electrical equipment or enclosures was NEC-compliant. However, after reviewing the UL report, ORP electrical engineers and the WCD site inspectors identified several concerns that the ORP electrical engineers and the WCD site inspectors believed were not adequately addressed in the UL report, including: (1) whether the method proposed by BNI for transitioning cables between cable trays and electrical distribution equipment complies with the NEC; (2) why the application of UL Standard 514B, *Conduit, Tubing, and Cable Fittings*, was not addressed in the report; and, (3) why the use of conduit hubs, nipples, and bushings was acceptable when not expressly permitted in NEC section 318 for cable tray installations.

In March 2017, ORP management requested the TIRB to review the issue. The TIRB process was established in 2013 to provide a way for BNI and ORP senior management to address and resolve significant technical and project challenges to ensure successful completion of the WTP. A TIRB panel composed of seven ORP and BNI senior technical managers met on April 13, 2017, and electrical design engineers from ORP and BNI explained their differing positions regarding the appropriate method of transitioning cables from cable trays into electrical equipment. The TIRB panel ruled 6 to 1 in favor of the method proposed by BNI.

Activities in the LAW

EA, accompanied by the WCD site electrical inspector, observed in-process work activities and inspected installed electrical equipment on each elevation of the LAW. Overall, the installation of the electrical equipment that EA examined was completed in a good, workmanlike manner. Most cable pulling activities are performed during the night shift, when fewer personnel are on site and there is less impact to other work activities. EA and the WCD site electrical inspector observed two cable pulls in the LAW, which were successfully performed in accordance with specification requirements.

During the September 14 to 17, 2015, construction quality assessment, EA and the WCD site electrical inspector identified two uninterruptible power supply (UPS) disconnect switches in the LAW that did not have the proper documentation (i.e., the configuration for these UPS disconnect switches had not been evaluated by UL). Additional evaluation was required to ensure that the installed UPS switches complied with NEC requirements. During the June 2017 walkdown in the LAW, EA observed that WTCC had removed the previously installed UPS disconnect switches and that WTCC electricians were in the process of modifying the UPS switches. The Lead Electrical Field Engineer for the LAW stated that the cabinets will be certified by an independent organization to ensure that the installed configuration for the UPS switches is properly documented and complies with NEC requirements.

System Turnover

After construction is completed on a system, responsibility for maintaining the system is transferred from WTCC construction personnel to WTCC operations. EA reviewed WTCC Procedure 24590-WTP-GPP-CON-1602, *System and Area Completion Turnover*, which specifies the process and steps to be followed for system turnover from construction to operations. The procedure requires performance of a walkdown eight weeks before the planned turnover date to identify and resolve issues that could delay system turnover.

EA and the WCD site electrical inspector attended a pre-job briefing for the eight week walkdown to examine four electrical panels and two disconnect switches in the LAB. EA and the WCD site electrical inspector accompanied WTCC field engineers, electricians, and a WTCC NEC inspector during the walkdown. A few minor issues were identified by WTCC personnel during the walkdown that were

corrected on the spot. The walkdown was adequately performed by WTCC personnel. The procedure requires another walkdown to be completed three weeks before the scheduled system turnover date.

WTCC NEC Inspectors

WTCC has 14 NEC inspectors assigned to different areas in the WTP who perform independent inspections of the electrical installations completed by WTCC electricians and inspected and accepted by WTCC electrical field engineers for CM systems and by QC inspectors for Q electrical installations. EA interviewed several of the NEC inspectors regarding the results of their inspection activities. These discussions disclosed that the NEC inspectors are identifying numerous issues, many of which are repetitive. EA reviewed CR number 24590-WTP-GCA-MGT-17-00698, *Electrical NEC Inspections, Electrical Installations, and Electrical Hazardous Conditions on the Project*, which provides an overview of issues identified by the NEC inspectors. Some of these issues, if not corrected, could result in equipment failure or injury or death to personnel operating or maintaining electrical equipment. A number of these same issues have been previously identified by EA and/or the WCD site electrical inspectors.

The NEC inspectors and the WCD electrical inspectors have started meeting on a bi-weekly basis to discuss issues and concerns regarding electrical work at the WTP site. These meetings provide a forum for sharing ideas, lessons learned, and best practices to correct the electrical work installation issues and reduce the number of repetitive errors.

Review of AHJ Activities

On March 2, 2017, ORP issued a letter to BNI to clarify the role that BNI has as the electrical AHJ. The letter describes different scenarios that require DOE approval for code interpretations, including defining an interpretation as “an explanation of the text in simpler, more concise terms that are [in] agreement with the explicit code test.” The letter also states that AHJ waivers or equivalencies shall be submitted to DOE for approval. BNI has a dedicated electrical AHJ group to review questions concerning compliance with the NEC.

EA reviewed AHJ ruling number 24590-WTP-AHJRA-E-17-00003, which evaluates the allowable cable fill for cable tray numbers 91ETHX1203, -1204, and -1206 in BOF Building 91. The calculations for the SETROUTE electrical cable and conduit database indicated that the three cable trays were overfilled. The NEC provides guidance on calculating the fill for cable trays, stating that the sum of all the cable diameters must be less than the total cable tray width. The BNI AHJ group calculated that the fills for two of the cable trays, 91ETHX1203 and -1204, were less than the cable tray widths and, therefore, acceptable. EA reviewed the calculations and concur with BNI’s conclusion. The BNI AHJ calculation for cable tray 91ETHX1206 indicates that the cable fill slightly exceeds the cable tray width (sum of diameter of cables is 36.2" vs 36" cable tray width); however, BNI declared this to be acceptable even though Section 318 of the NEC does not provide a tolerance or allowance for the cable fill to exceed the cable tray width.

Part of the justification for the BNI AHJ group declaring this to be acceptable is that the cables in this tray are bundled together in a triangular configuration, with two cables on the bottom and one on the top, and free space (gap) between the cable bundles. A picture is included in the calculation that shows the cables bundled in this triangular configuration. The AHJ calculation states that, with the free space between the triangular bundles, it is acceptable for the sum of the cable diameters in the cable tray to exceed the cable tray width. The NEC states that cables should be arranged in a single layer but does include the option to bundle cables if there is a free space of 1.2 times the cable diameter between the bundles. Calculating the cable fill value using this option (cables bundled) results in a cable fill value of greater than 36.2".

In an attempt to provide further justification for exceeding cable fill values, the AHJ determination states that "cable diameters fluctuate per Manufacturer info." Although cable diameters do fluctuate, BNI did not measure whether the cable diameter was smaller than the catalog value. The AHJ determination wrongly assumes that the cables may be smaller and, therefore, the cable fill would be less than or equal to the tray width.

Some sections of the NEC permit rounding of decimals following standard mathematical rules (i.e., greater than 0.5 rounds up and less than 0.5 rounds down) when performing calculations. BNI used this approach and rounded the value of 36.2 down to 36.0 and concluded that the cable fill for this tray complied with Code requirements. However, NEC Section 318, which addresses cable tray fill limitations, states the limit for a 36-inch wide tray is 36.0 inches. The use of the tenth place significant digit denotes that this is a threshold not to exceed.

The conclusion in the report for the AHJ ruling states: "The enclosed analysis shows that cable trays 91ETHX1203, 91ETHX1204, and 91ETHX1206 meet the cable fill limitation requirements in NFPA 70 Article 318. None of the designed/installed cable fills exceed the allowable fill per Article NFPA 70 Article 318." However, the analysis does not show that the cable trays meet the cable fill limitation. The report goes on to say that this is a "verbatim interpretation and not a waiver or equivalency." By stating that the interpretation is verbatim and not a waiver or equivalency, BNI removed the requirement to have DOE approval and therefore bypassed a review by DOE. However, according to the requirements in the March 2, 2017 letter from ORP to BNI, this AHJ ruling should have required DOE/ORP review because it permits a defined threshold for allowable cable fill to be exceeded. This AHJ ruling is incorrect because it exceeds a threshold with inadequate technical justification and bypassed the DOE review process. **(Deficiency)**

6.0 FINDINGS

EA identified no findings during this assessment. Deficiencies that did not meet the criteria for a finding are listed in Appendix C of this report.

7.0 OPPORTUNITIES FOR IMPROVEMENT

EA identified no opportunities for improvement during this assessment.

8.0 ITEMS FOR FOLLOW-UP

EA intends to continue to evaluate AHJ rulings.

EA plans to continue to evaluate the effectiveness of the BNI corrective action program and review the resolution of NCRs, CDRs, and CRs. EA plans to continue to review welding inspection activities, as well as activities related to piping and pipe supports, structural steel erection, pressure testing of piping, cable pulling, and installation of electrical and mechanical equipment. EA also intends to perform additional assessments of the construction turnover program and the preservation and maintenance of installed equipment and equipment in long-term storage.

Appendix A
Supplemental Information

Assessment Dates

Onsite visit: June 5–8, 2017

Office of Enterprise Assessments (EA) Management

William A. Eckroade, Acting Director, Office of Enterprise Assessments
Thomas R. Staker, Director, Office of Environment, Safety and Health Assessments
William E. Miller, Deputy Director, Office of Environment, Safety and Health Assessments
C.E. (Gene) Carpenter, Jr., Director, Office of Nuclear Safety and Environmental Assessments
Kevin G. Kilp, Acting Director, Office of Worker Safety and Health Assessments
Gerald M. McAteer, Director, Office of Emergency Management Assessments

Quality Review Board

William A. Eckroade
John S. Boulden III
Thomas R. Staker
William E. Miller
Michael A. Kilpatrick

EA Site Lead for Hanford Site

Ronald G. Bostic

EA Team Composition

Ronald G. Bostic – Team Lead
James M. Boyd
Joseph J. Lenahan

Appendix B
Documents Reviewed, Interviews, and Observations

Documents Reviewed

- Construction Procedure 24590-WTP-GPP-CON-3504, Rev. 16, Pressure Testing of Piping, Tubing and Components, April 5, 2017
- Construction Procedure 24590-WTP-GPP-CON-3509, Rev. 4, Pipe Support Installation, March 15, 2017
- Specification No. 24590-WTP-3PS-DB01-T0001, Rev. 8, Engineering Specification for Furnishing and Delivering Ready Mixed Concrete, March 30, 2007
- Specification No. 24590-WTP-3PS-D000-T0001, Rev. 8, Engineering Specification for Concrete Work, September 20, 2012
- Specification No. 24590-WTP-3PS-C000-T0001, Rev. 6, Engineering Specification for Material Testing Services, January 11, 2011
- Construction Procedure 24590-WTP-GPP-CON-3503, Rev. 8, Above Ground Piping Installation, May 24, 2017
- Specification No. 24590-WTP-3PS-PS02-T0003, Rev. 10, Engineering Specification for Field Fabrication and Installation of Piping, November 25, 2013
- Specification No. 24590-WTP-3PS-PH01-T0002, Rev. 6, Engineering Specification for Installation of Pipe Supports, July 13, 2011
- Document number 24590-WTP-MN-CON-01-001-01-01, Rev 16, Welding Control Manual, June 18, 2014
- Document number 24590-WTP-MN-CON-01-001-10-09, Rev 8, Bechtel Nondestructive Examination Standard Visual Examination VT-ASME, August 8, 2013
- Document number 24590-WTP-MN-CON-01-001-10-10, Rev 6, Bechtel Nondestructive Examination Standard Visual Examination VT-AWS D1.1, July 12, 2006
- Procedure 24590-WTP-GPP-MGT-044, Rev. 9, Nonconformance Reporting and Control, March 10, 2017
- Document number 24590-WTP-3DP-G04T-00905, Rev 14, Determination of Quality Levels, February 24, 2016
- Document number 24590-WTP-QAM-QA-06-001, Rev. 17, Quality Assurance Manual, August 22, 2016
- QC Surveillance Report 24590-WTP-SV-QC-17-044, CPM Certification Testing for Mix Number 358129
- Nonconformance Report numbers 24590-WTP-NCR-CON-17-0024 through -0097
- Construction Procedure 24590-WTP-GPP-CON-7101, Rev 13 Construction Quality Control Program, March 9, 2017
- National Electrical Code – National Fire Protection Association 70-1999
- Specification No. 24590-WTP-3PS-E00X-T0004, Engineering Specification for Installation of Cables
- Document Number 24590-WTP-AHJRA-E-17-00003, Rev. 0, BOF Cable Trays Indicating Overfill per SETROUTE
- Contract No. DE-AC27-01RV14136 – Final Report from the Waste Treatment and Immobilization Plant Technical Issue Resolution Board for Electrical Installation Methods Held on April 13, 2017
- Condition Report, 24590-WTP-GCA-MGT-17-00698, Electrical NEC Inspections, Electrical Installations, and Electrical Hazardous Conditions on the Project
- Procedure 24590-WTP-GPP-CON-1602, Rev. 6, System and Area Completion Turnover

Interviews

- WTCC subcontract representative for concrete operations
- WTCC pipe fitters
- WTCC civil and mechanical field engineers
- WTCC NEC electrical inspectors
- WTCC electrical Field Engineers
- WTCC Quality Control Inspectors
- WTCC Electricians and Foremen
- WCD Site Inspectors and Facility Representatives
- ORP Design Electrical Engineers

Observations

- Observed electricians pulling cables in the LAW.
- Observed a walkdown performed in preparation for turnover from operations to construction for four electrical panels and two disconnect switches in the LAB.
- Performed walkdowns in the LAW and EMF.
- Observed performance of a hydrostatic pressure test performed on a CM piping section in the plant cooling water system, recorded on document number 24590-BOF-PPTR-CON-17-0026.
- Observed performance of two pneumatic pressure tests performed on Q sections of instrument tubing in the LAW primary offgas process system, recorded on document numbers 24590-BOF-PPTR-CON-17-0062, -0091, -0093, and -0099.
- Observed a WCD site inspector performing final visual inspections of three DOE designated piping welds: weld number GB001 on FWCL 24590-LAW-FWCL-CON-17-00395 on the LAW melter process system and weld numbers FW009 on FWCL 24590-BOF-FWCL-CON-17-02192, and FW010 on FWCL 24590-BOF-FWCL-CON-17-02193 on the high pressure steam system.
- Observed a WCD site inspector performing final visual inspections of seven DOE designated structural steel welds: weld numbers FW-01, FW-02 and FW-03 on FWCL 24590-LAW-FWCL-CON-16-01537 for the caustic scrubber hatch door frame and weld numbers FW-01, FW-02, FW-03, and FW-04 on FWCL 24590-BOF-FWCL-CON-17-01496 for pipe support BOF-PSE-H00349 on the plant service air system.
- Observed concrete placements in two wall sections in the EMF.

Appendix C
Deficiencies

Deficiencies that did not meet the criteria for a finding are listed below, with the expectation from DOE Order 227.1A for site managers to apply local issues management processes for resolution.

- The cable fill for cable tray number 91ETHX1206 in BOF Building 91 exceeds the allowable cable fill established by Section 318 of the NEC. AHJ ruling number 24590-WTP-AHJRA-E-17-00003 erroneously concludes that the allowable cable fill for cable tray number 91ETHX1206 is in verbatim compliance with Section 318 of the NEC and that further DOE review required by the March 2, 2017, ORP letter to BNI clarifying the role that BNI has as the electrical AHJ was unnecessary.