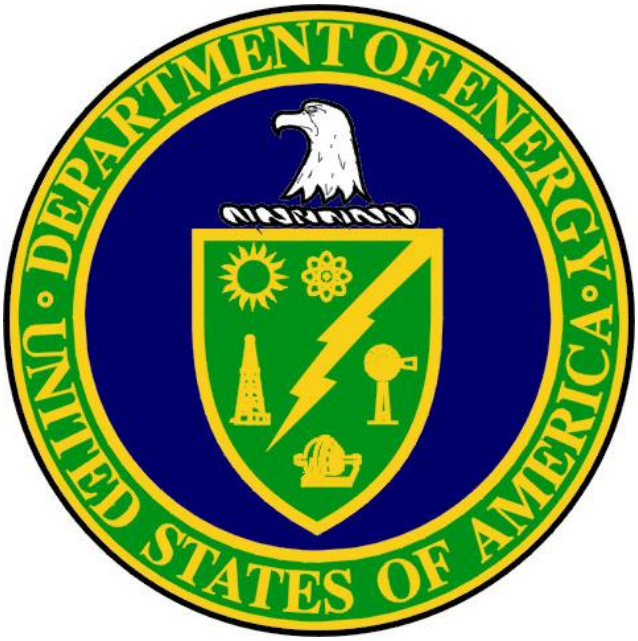
Office of Enterprise Assessments
Review of the Hanford Site
Waste Treatment and Immobilization Plant
Construction Quality



June 2015

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

Table of Contents

Acronyms

ASME	American Society of Mechanical Engineers
BNI	Bechtel National, Inc.
BOF	Balance of Facilities
CCTV	Closed Circuit Television
CDR	Construction Deficiency Report
CFR	Code of Federal Regulations
CM	Commercial Grade
CRAD	Criteria, Review and Approach Document
DOE	U.S. Department of Energy
EA	Office of Enterprise Assessments
HLW	High Level Waste
HVAC	Heating, Ventilation, and Air Conditioning
Intermech	Intermech, Inc.
LAB	Analytical Laboratory
LAW	Low Activity Waste
MCC	Motor Control Center
MSOW	Management Suspension of Work
NCR	Nonconformance Report
NEC	National Electric Code
NQA	Nuclear Quality Assurance
OFI	Opportunity for Improvement
ORP	Office of River Protection
PDSA	Preliminary Documented Safety Analysis
PICA	Post Installed Concrete Anchor
PIER	Project Issues Evaluation Report
psi	Pounds per Square Inch
PTF	Pretreatment Facility
PTJ	Process and Mechanical Handling CCTV System
Q	Quality Related
QA	Quality Assurance
QAM	Quality Assurance Manual
QC	Quality Control
SSC	Structure, System, and Component
WCD	WTP Construction Oversight and Assurance Division
WED	WTP Engineering Division
WTP	Waste Treatment and Immobilization Plant
VAC	Volts Alternating Current

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

EXECUTIVE SUMMARY

The U.S. Department of Energy Office of Enterprise Assessments (EA) conducted a review of construction quality at the Hanford Site Waste Treatment and Immobilization Plant (WTP) from December 15 to 18, 2014. This EA review was performed in the broader context of an ongoing program of quarterly reviews of construction quality at the WTP construction site.

For the scope of this review, EA observed ongoing work activities, reviewed the Bechtel National, Inc. (BNI) program for control nonconforming conditions, examined implementation of selected requirements in the BNI quality assurance program, and followed up on issues identified during previous reviews.

Overall, the construction quality (including pressure testing of piping, electrical cable pulling, and leak testing of heating, ventilation, and air conditioning ducts) at WTP is satisfactory in the reviewed areas. BNI has also developed appropriate corrective actions to resolve specific deficiencies for closed nonconformance reports and construction deficiency reports that EA reviewed.

However, progress continues to be slow in addressing identified deficiencies in two areas. First, although BNI's approach to determining the extent of condition was adequate for errors in installation of certain important structural components (i.e., post installed concrete anchors); corrective actions have not been timely to resolve these errors. Because of BNI's delay in developing installation criteria for these components, a large number of components had to be re-inspected and re-evaluated after having been previously inspected and found to be acceptable. BNI expects to complete remaining corrective actions for the post installed concrete anchors by December 2015. Second, questions regarding certain aspects of electrical construction such as inconsistencies in labeling of some electrical cabinets, possible incorrect sizing of breakers, and the adequacy of cable support between the cable trays and cabinets remain unresolved.

EA also identified one opportunity for improvement in the area of electrical cable termination work. Deficiencies in design drawings and work planning and inadequate review of some aspects of electrical work by field engineers resulted in potential errors in termination of electrical cables. Fortunately, during field observations, the electrical craft personnel identified the errors as they prepared to perform the work. Also,

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

1.0 PURPOSE

The U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA) conducted a review of construction quality at the Hanford Site Waste Treatment and Immobilization Plant (WTP). EA's Office of Environment, Safety and Health Assessments conducted the review from December 15 to 18, 2014. EA performed this review in the broader context of an ongoing program of quarterly reviews of construction quality at the WTP construction site. Because of the safety significance of WTP facilities, EA will continue to conduct quarterly reviews to assess the quality of ongoing construction.

2.0 SCOPE

The scope of this quarterly review of construction quality included observations of ongoing work activities, review of the Bechtel National, Inc. (BNI) program for control of nonconforming conditions, examination of implementation of selected requirements in the BNI quality assurance (QA) program, and follow-up on issues identified during previous assessments. Design and procurement programs were not included in the scope of this review.

EA conducted several construction site walkthroughs concurrently with the DOE Office of River Protection (ORP) WTP Construction Oversight and Assurance Division (WCD) staff to determine whether work activities were completed in accordance with the appropriate design drawings, specifications, and installation procedures. EA observed two pneumatic pressure tests; a heating, ventilation, and air conditioning (HVAC) duct leak test; inspection of welds; and installation and termination of electrical cables. EA examined nonconformance reports (NCRs) and construction deficiency reports (CDRs) identified by BNI under its corrective action program, as well as ongoing corrective actions to address deficiencies identified in the installation of post installed concrete anchors (PICAs). EA also reviewed construction quality records documenting the results of quality control (QC) tests performed on samples of concrete placed in the High Level Waste (HLW) Facility, the self-assessment program, and QC surveillance reports.

3.0 BACKGROUND

ORP 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, an industrial complex for separating and vitrifying the radioactive and chemical waste in the underground tanks. The WTP is in the design and construction phase.

BNI manages design and construction activities at WTP under contract to ORP. The QA program requirements for design and construction of the WTP, referenced in the preliminary documented safety analysis (PDSA) 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*.

The WTP complex consists of five major components: the Pretreatment Facility (PTF) for separating the waste into low activity and high activity waste, the HLW Facility where high level waste will be

immobilized in glass, the Low Activity Waste (LAW) Facility where the low level waste will be immobilized in glass, the Analytical Laboratory (LAB) for sample testing, and the balance of facilities (BOF) that will house support functions. Construction work is essentially complete for the LAB and for most BOF buildings. ORP staff, primarily the WCD staff, provides oversight of construction activities at the WTP.

The LAW Facility is expected to be essentially complete by the end of CY 2017. 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. Construction is slowed in the HLW Facility pending resolution of technical issues of the waste treatment process. In a September 2014 letter, DOE authorized BNI to proceed with design engineering work on the HLW Facility since BNI has made considerable progress in resolving the HLW technical issues.

4.0 METHODOLOGY

EA conducted this review of WTP construction quality processes in accordance with the *Plan for the Office of Enterprise Assessments Review of the Hanford Site Waste Treatment and Immobilization Plant Construction Quality*, dated December 2014. EA reviewed procedures, specifications, drawings, and records, interviewed key personnel responsible for construction and inspection work activities, and conducted site walk downs to observe work activities and inspect WTP components. This review considered the requirements of 10 CFR 830, Subpart A, *Quality Assurance Requirement*, and DOE Order 414.1C, *Quality Assurance*. Title 10 CFR 830 and DOE Order 414.1C require the contractor to use appropriate national consensus standards to implement DOE QA requirements. The PDSA references ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications*, as the national consensus standard for BNI to follow as the basis for the WTP QA program. BNI Document 245909-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 QA Manual (QAM) establishes the planned and systematic actions necessary to ensure that structures, systems, and components (SSCs) perform satisfactorily in service. The WTP QAM incorporates the basic and amplified requirements of the supplemental criteria of NQA-1.

This EA review focused on installation and terminations of electrical cables as well as certain portions of the following criteria, review and approach documents (CRADs):

- CRAD 64-15, *Construction – Structural Concrete.*
- CRAD 45-52, *Construction – Piping and Pipe Supports.*
- CRAD 64-20, *Feedback and Continuous Improvement Inspection Criteria and Approach – Contractor.*

Supplemental information, including the members of the EA team, the Quality Review Board, and EA management, is provided in Appendix A. Key documents reviewed, interviews conducted, and work activities observed are listed in Appendix B.

5.0 RESULTS

This section includes a brief description of the activities that EA evaluated during the review and the results of that review. Conclusions are summarized in Section 6, opportunities for improvement (OFIs) are included in Section 7, and items for follow-up are discussed in Section 8.

5.1 Corrective Action Program

Criteria: 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-16.1 of the WTP QAM; and DOE Order 414.1C)

BNI Procedure 24590-WTP-GPP-MGT-044, *Nonconformance Reporting and Control*, defines the requirements for identifying, documenting, reporting, controlling, and dispositioning nonconforming conditions at the WTP associated with quality related (Q) and commercial grade (CM) SSCs. NCRs are issued to document and disposition Q nonconforming conditions, while CDRs are used to document and disposition CM nonconforming conditions. According to 24590-WTP-GPP-MGT-044, SSCs designated as Q (previously classified as Quality-List or QL) in the design documents must be constructed or manufactured in accordance with the WTP QA program and the ASME NQA-1 standard. Additionally, 24590-WTP-GPP-MGT-044 requires SSCs designated in the design documents as non-Q (i.e., CM) to be 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 60 NCRs issued by BNI issued between September 15 and December 15, 2014, and the 61 CDRs issued by BNI in October 2014 to evaluate the types of nonconforming issues that were identified, their apparent causes, and subsequent corrective actions. The NCR categories were 12 NCRs related to construction or installation errors, including damage to installed components resulting from construction activities; 42 NCRs for procurement and supplier deficiencies; 4 NCRs for engineering issues; and 2 for materials handling issues. The 61 CDRs that EA reviewed included 28 for construction deficiencies; 17 CDRs for procurement and supplier deficiencies; 4 CDRs for engineering errors; and 12 CDRs for materials identified with expired shelf life.

The BNI engineering organizations have developed appropriate corrective actions to disposition the specific problems identified in the completed NCRs and CDRs that EA reviewed. The corrective action program and implementation is adequate to address and resolve specific construction quality deficiencies.

5.2 Deficiencies in Installation of PICAs

Criteria: A process shall be established to identify, control, document, evaluate, and correct conditions adverse to quality. Management shall determine the extent of the adverse condition and complete corrective action, including assigning responsibilities and establishing milestones to ensure timely completion of corrective actions. 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-16.1 of the WTP QAM; and DOE Order 414.1C)

PICAs are installed in the concrete structure after the concrete has hardened and attained its design strength to provide anchorage for equipment in locations where embedded plates and cast in-place anchor bolts are unavailable. The types of hardware and components that PICAs support include structural steel platforms, pipe supports, instrument racks, transformers, electrical components, and conduit and instrument supports. During a review of CM pipe support installation records in September 2011, ORP WCD personnel identified incorrect or missing data in the documentation of installation of CM PICAs. BNI issued Project Issues Evaluation Report (PIER) 24590-WTP-PIER-MGT-11-0918-C to follow up on concerns that WCD identified. The action items for this PIER required review of the PICA records for all anchors installed between July 19, 2010, and May 2012. Upon completing the documentation review, BNI Construction Field Engineering determined that the PICA installations should be physically inspected. BNI issued PIER 24590-WTP-PIER-MGT-12-1246-B to re-inspect all CM PICAs installed on

the WTP project. BNI issued a management suspension of work (MSOW) to control installation of new PICAs. Under the MSOW, installers and field engineers received additional instructions to ensure that new PICA installations complied with design criteria. PICAs used in Q applications were not included in the re-inspection program because the location and anchor type (diameter and length) are shown on the design drawings and QC inspectors perform independent inspections of all Q PICAs to verify the location, correct anchor type, and appropriate installation method. Field engineers perform the final acceptance inspections for CM PICAs.

BNI Specification 24590-WTP-3PS-FA02-T0004, *Engineering Specification for Installation and Testing of Post Installed Concrete Anchors and Drilling/Coring of Concrete*, establishes the technical requirements for installing, inspecting, and testing PICAs. On April 29, 2014, BNI issued Revision 7 to the Engineering Specification that included more conservative installation criteria for PICAs. Before this revision, re-inspections had been completed for CM PICAs documented in 1954 records for closure of PIER 24590-WTP-PIER-MGT-12-1246-B. The number of PICAs represented by each record varies, typically between 4 and 10. The PICAs documented in 1176 records complied with the criteria in the Engineering Specification, while installation errors were identified for one or more PICAs documented on the remaining 778 records. CDRs were initiated to document the errors. BNI Design Engineering evaluated the CDRs and concluded that in most cases the installed PICAs could support the applied loads. Those PICAs that BNI Design Engineering determined did not comply with the design criteria were repaired.

BNI engineers concluded it was necessary to re-inspect the PICAs documented on the 1176 records that complied with the pre April 29, 2014 installation criteria, in addition to those installed under the MSOW, to determine whether these PICA installations complied with the more conservative installation criteria in Revision 7 of the Engineering Specification. These re-inspections are ongoing. The revised PICA installation criteria also require re-inspection of Q PICAs (maxi-bolts). EA noted that 5 NCRs were initiated since the September 2014 EA construction quality review to document Q maxi-bolt installations that do not comply with the installation criteria in Revision 7 of the Engineering Specification.

BNI's approach to determine the extent of condition and the corrective actions necessary to correct the PICA installation deficiencies was adequate. However, corrective actions have not been timely. Because of BNI's delays in developing PICA installation criteria, BNI had to perform significant rework to re-inspect and re-evaluate CM PICAs that had had been previously inspected and found acceptable. BNI expects that corrective actions for the PICAs will be completed by December 2015.

5.3 Pressure Testing of Piping

Criteria: 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 two pneumatic pressure tests performed on CM instrument tubing, one in the LAB and another in a BOF building. The WTP site work process for conducting leak testing is specified in Construction Procedure 24590-WTP-GPP-CON-3504, *Pressure Testing of Piping, Tubing and Components*. The requirements for pneumatic pressure testing 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 walked down the piping system and examined the valve lineup and pressure test tags attached to the valves. EA witnessed the pressurization sequence and verified that the system tested was pressurized to the designated test pressure and held for a minimum of 10 minutes before initiating the system walk down to inspect the piping for leakage. EA observed the walk downs and inspections that BNI Field Engineering personnel performed. No leaks were identified, and BNI Field Engineering personnel declared the pressure tests successful. The implementation of the pressure testing program was satisfactory for the sample that EA reviewed.

5.4 WCD Welding Inspection Program

Criteria: 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)

The WCD staff performs independent inspections of one or more inspection attributes on approximately five percent 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 examine are Q, but the WCD staff also includes some CM welds in their independent sample.

EA observed a WCD site inspector perform an independent final visual inspection of a completed structural steel Q column to baseplate weld in the HLW and a fit-up inspection on a CM pipe weld spool. Acceptance criteria for visual examination of support and structural steel welds are specified in *Bechtel Nondestructive Examination Standard, Visual Examination VT-AWS D1.1* and in *Bechtel Nondestructive Examination Standard, Visual Examination VT-ASME* for visual examination of piping welds. The WCD site inspector also reviewed the field welding checklists, weld wire draw slips, and drawings associated with the welds. The implementation of the WCD welding inspection program was satisfactory for the sample that EA reviewed.

5.5 Concrete Placement Records

Criteria: Work, such as concrete construction, shall be performed in accordance with approved procedures, design drawings, 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, Criterion 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 reviewed the results of QC tests performed on concrete samples from the four Q concrete placements completed between October 1 and November 19, 2014. The concrete placements were in the HLW Facility, three walls and one in an interior floor slab. The tests included slump, temperature, and unit weight testing performed on the freshly mixed concrete and unconfined compression tests performed on concrete cylinders cured for 28 days in the concrete laboratory to verify the concrete quality and demonstrate that the concrete met the design strength requirements. The methods for sampling the concrete, casting and curing the cylinders, and performing the unconfined compression tests are specified in American Society for Testing and Materials International standards.

The unconfined compression tests performed on 11 sets of concrete cylinders from the 4 HLW Facility pours showed that the concrete strength at 28 days old in these placements varied in the range of 5470 and

7490 pounds per square inch (psi). The average strength for the 11 sets of test cylinders, 6410 psi exceeds the required (design) strength of 5000 psi indicating that the quality of concrete in the HLW Facility was satisfactory. The results of the unconfined compression strength of the concrete at 28 days continues to exceed the specified design strength by at least 1000 psi for all classes of structural concrete at WTP.

5.6 Leak Testing of HVAC Ducts

Criteria: Construction and pre-operational tests, such as leak testing of the HVAC 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) The procurement of purchased items and services shall be controlled to assure conformance with specified requirements. (NQA-1, Requirement 7; Policy Q- 7.1 of the WTP QAM; and DOE Order 414.1C)

The task for design, fabrication, installation, and testing of the HVAC system for the WTP was subcontracted by BNI to Intermech, Inc. (Intermech). Construction craft employed by Intermech install the HVAC system, using Intermech installation procedures. Intermech is responsible for performing QC inspections of the work performed by its construction workers and for maintaining a QA program that complies with NQA-1 requirements. BNI QA and QC personnel perform surveillances of Intermech work activities to confirm that Intermech complies with the contract requirements and their QA program.

EA observed a leak rate test performed on a section of ductwork in the LAW Facility under Work Data Package 362173C. The test method was specified in Intermech Procedure W\IP-WTP 11.30, *HVAC Housing/Duct Structural Capability and Leak Testing*. EA verified that the instruments used in the test had calibration stickers that identified the instruments and were current. The leak test met the test acceptance criteria and was performed in accordance with the test procedure.

5.7 Installation and Termination of Electrical Cables

Criteria: 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)

EA observed cable pulling and cable termination activities in the LAW Facility to verify that the work was performed in accordance with design documents (i.e., specifications and drawings). EA's observations are discussed in more detail below.

Cable Pulling

Most cable pulling activities are performed on the night shift to reduce interference with other craft personnel. EA and the WCD site electrical inspector discussed cable pulling operations with the supervisors and electrical craft and observed electricians hand-pulling cables between two cabinets within the same room on the 28' level of the LAW Facility during the night shift. The electricians performed the work efficiently and in a good workmanlike manner, observing all safety precautions.

Cable Terminations

BNI uses a database called SETROUTE to organize information for all of the electrical cables, raceways, and terminations. SETROUTE cards are generated for each cable to detail the routing of the cables and the terminations.

EA and the WCD site electrical inspector accompanied an electrician to observe him complete the termination of three power conductors (cables) in panel UPE-PNL-20046 located on Elevation -21 in the LAW Facility. The SETROUTE card the electrician used to perform the work showed that cable EMJ-JB-00004 was to be terminated on circuit breaker 1. However, another cable, RPJ-JY-2102, was already terminated on this breaker. Upon noting that an existing cable was terminated on circuit breaker 1, the electrician stopped work and notified his foreman. BNI's investigation of this issue disclosed the following discrepancies:

- Drawing number 24590-LAW-E6X-UPE-20046 on page 2 shows that cable EMJ-JB-00004S01, a black conductor, was to be terminated on circuit breaker 1. However, page 6 of the drawing shows that cable RPJ-RY-2102S01, a black conductor phased to red, was also to be terminated on circuit breaker 1.

- The panel schedule drawing, number 24590-LAW-E8-UPE-00006, shows that cable EMJ-JB-00004 is connected to circuit breaker 1 and that cable RPJ-JY-2102 should be phased red and connected to circuit breaker 21. Three-phase low-voltage panels are arranged to have a standard color code for each phase, black for Phase A, red for Phase B, and blue for Phase C. If the conductors are not the proper colors, BNI Specification 24590-WTP-3PS-E00X-0005, *Engineering Specification for Electrical Raceway and Cable Identification*, directs the electricians to use colored tape to re-label the conductors. Cable RPJ-JY-2102 was not re-labeled with red tape to indicate it was Phase B (red).

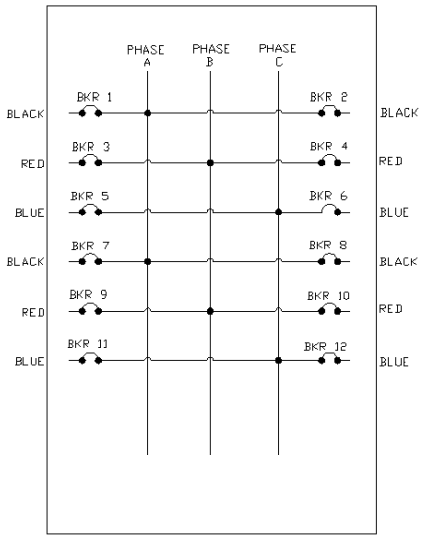
- BNI Field Engineering accepted cable RPJ-JY-2102, even though it was incorrectly terminated and incorrectly color coded.

- Drawing 24590-LAW-E8-UPE-00006 was not referenced on the SETROUTE card.

- The SETROUTE card was improperly verified against the design drawings, and the electrician did not have copies of the design drawings in the field to reference when performing the work.

The field engineer appropriately initiated CDR 24590-WTP-CDR-CON-14-0716 to document that the field engineer accepted an incorrectly phased conductor that was terminated on the incorrect circuit breaker in Panel UPE-PNL-20046. EA will review this CDR during a later review.

As mentioned above, the WTP site has a standard electrical color code of black for Phase A, red for Phase B, and blue for Phase C for low-voltage 3-phase panels. A typical panel is shown below:



TYPICAL 3 PHASE 120/208 PANEL

EA and the WCD site electrical inspector also observed a deficiency in cable termination work on Panel LVE-PNL-20032, located on Elevation -21 in the LAW Facility. When the electrician inspected the panel to begin work, he noticed that the colors of the conductors were not consistent with the standard color code as shown in the diagram above. The SETROUTE card instructed him to terminate a blue conductor (Phase C) on circuit breaker 9; however it should have been a Phase B conductor (red). The electrician stopped work pending resolution of the discrepancy. As EA, WCD, and Field Engineering reviewed the design drawings it was apparent that the SETROUTE card was incorrect and the Phase C conductor was actually to be terminated on circuit breaker 6. The field engineer had not identified and corrected the error on the SETROUTE card in the pre-work planning stage.

Electricians identified both of the errors discussed above, which involved CM work activities, when they attempted to perform the work. The errors were not identified and corrected earlier in the work planning and control process. These errors may have been self-revealing and corrected during the startup testing process. However, these types of errors could damage equipment or result in personnel injuries. More significant is the lack of independent review of CM work activities on the complex WTP project. Because of the process used for CM work at WTP, the same field engineer usually performs the pre-work planning, orders materials, provides technical assistance to the craft personnel to resolve questions, and then performs the acceptance inspections of the completed work activity. QC does not inspect CM work, although occasionally CM work may be inspected by an independent field engineer not involved in the earlier planning and work implementation activities.

Process and Mechanical Handling CCTV System

The Process and Mechanical Handling Close Circuit Television (CCTV) System (PTJ) is a vendor supplied CM CCTV and camera system. BNI installed junction boxes for the interface between the vendor supplied camera equipment and the WTP plant wiring. 67 of these junction boxes are in various stages of completion in the LAW Facility, 21 on the -21 elevation and 46 on the +3 elevation. 35 of these junction boxes have 120 volts alternating current (VAC) wiring and terminals, while the other 32 junction boxes have signal cables only.

Installation and wiring details for the 120 VAC boxes are shown on BNI Drawing number 24590-WTP-J9-50-00064, *Controls and Instrumentation CCTV Junction Box, 120 VAC General Arrangement*. Drawing number 24590-WTP-J9-50-00062, *Controls and Instrumentation CCTV Junction Box General*

Arrangement, shows the wiring details for the junction boxes that contain only the signal cables.

An electrician identified an inconsistency in the way the 120 VAC boxes are wired. Drawing 24590-WTP-J9-50-00064 shows a ground bus inside the box and a terminal block for a ground, a neutral, and a 120 VAC conductor. The wiring in junction box PTJ-JB-00070 that was terminated in November 2014 had the power ground connected to the ground bus, but no connections on the ground terminal (19). According to the NEC, all metallic equipment needs to be bonded to ground by an approved means, this could be by using a jumper, or by connecting directly to the ground bus. The failure to properly ground electrical equipment could result in personnel injuries. The same electrician who worked on junction box PTJ-JB-00070 was assigned to make the wiring terminations in junction box PTJ-PB-00126. After the electrician opened box PTJ-PB-00126, he reviewed the SETROUTE card and questioned why the wiring details shown on the SETROUTE card differed from those for junction box PTJ-JB-00070, i.e., no connections went to the ground bus, only to the ground terminal (19). The electrician showed an excellent inquisitive attitude and stopped work to clarify the proper method of wiring.

As EA and WCD further reviewed the situation to address the electrician's questions they identified a design inconsistency in the way the ground wires are terminated in the 120 VAC junction boxes. Drawing number 24590-LAW-E6X-UPE-20041, *Termination Schedule for 24590-LAW-E6-UPE-20041*, shows the ground wires are to be connected to the ground bus in junction boxes PTJ-JB-00070, -00071, and -00072. However, drawing number 24590-LAW-E6X-UPE-20144, *Termination Schedule for 24590-LAW-E6-UPE-20044*, shows the ground wires in junction boxes PTJ-JB-00124, -00125, -00126, -00127, -00128, -00129, and -00130 are to be connected to terminal 19 and not the ground bus. The drawings also show that some ground wires use the Phase A (black) conductor, some the Phase B (red) conductor, and others the Phase C (blue) conductor for ground wires in the junction boxes. EA noticed that drawing numbers 24590-LAW-E6X-UPE-20041 and 24590-LAW-E6X-UPE-20044 for the two sets of junction boxes were issued by the same designer on the same day. After the December 2014 construction quality review, BNI issued field change numbers 24590-WTP-FC-E-0735 and 24590-WTP-FC-E-0736 to correct the drawing discrepancies.

Routing of Cables between Cable Trays and Electrical Cabinets

During the May 2014 quarterly WTP construction quality review, EA identified a problem with the method of routing electrical cables between cable trays and the top of electrical cabinets such as motor control centers (MCCs). The cables are not routed in conduit or vertical cable trays, but rather drop unprotected in the open air. The WCD site electrical inspector also questioned this practice before the May 2014 review. BNI has issued a formal interpretation of the National Electric Code (NEC), stating that cables can be run in free air, up to 6' between cable trays and/or between cable tray and equipment, and that multiple cables can be bundled together up to 6' in length without derating their ampacity. EA, in a previous review of WTP construction quality, identified an OFI in the area of cable entry into electrical cabinets. The OFI states, "WTP should re-evaluate the adequacy of support of cables between the cable trays and entrance into equipment cabinets, and the effect of bundled cables on the ampacity of the cables." This issue remains unresolved. WCD requested that the ORP WTP Engineering Division (WED) electrical safety system oversight engineer evaluate the BNI Authority Having Jurisdiction ruling. WED is evaluating this ruling.

EA noted that several MCCs in the Glass Former Building, Compressor/Chiller Building, and the Water Treatment Building are examples of preferred methods of transitioning between cable trays and MCC cabinets.

Finally, electricians have been pulling the cables and leaving them coiled above the cabinets and at a later date coming back to install the cables into the cabinets and make the terminations, which is inefficient and delaying completion of cable installations. During this review EA identified techniques which if applied

to the cable terminating work, should improve efficiency, OFI-WTP-1:

5.8 Self-Assessment Program

Criteria: Line and support organizations shall perform self-assessments of their performance and the adequacy of their processes. Self-assessments shall be used to evaluate performance at all levels periodically and to determine the effectiveness of policies, requirements, and standards and implementation status. Self-assessment results must be documented in sufficient detail to identify the activity covered, identify the individuals performing the surveillance, and document results and any necessary corrective actions. (Policy Q-02.2 of the WTP QAM; DOE Order 226.1A; DOE Order 226.1B; and DOE Order 414.1C) Note: DOE Order 226.1A was superseded by DOE Order 2261B by Contract Modification 310, dated January 28, 2014.

EA reviewed two reports that document performance based self-assessments that the BNI Field Engineering organization performed. These reports were SAR-CON-14-014, *Survey Field Book*, dated September 30, 2014, and SAR-Con-14-0013, *Rotating Equipment Alignment, Performance Assessment and Opportunities for Improvement*, dated October 15, 2014. The self-assessments were satisfactory. Because of the small self-assessment sample size available, EA will continue to evaluate implementation of the self-assessment program by the BNI Field Engineering organization in subsequent quarterly construction quality reviews.

5.9 Quality Assurance Surveillance Activities

Criteria: Quality Assurance surveillances shall be performed by knowledgeable personnel and shall be scheduled in a manner to provide coverage, consistency and co-ordination of ongoing work. Surveillance results shall be documented in sufficient detail to identify the activity covered, identify the individuals performing the surveillance, and document results and any necessary corrective actions. (NQA-1 Criterion 18; Policy Q-02.3 of the WTP QAM; and DOE Order 414.1C) The procurement of purchased items and services shall be controlled to assure conformance with specified requirements. (NQA-1, Requirement 7; Policy Q- 7.1 of the WTP QAM; and DOE Order 414.1C)

BNI Procedure 24590-WTP-GPP-QA-601, *Quality Assurance Surveillance*, describes the process used to plan, conduct, and document surveillances of work activities at WTP. The surveillances focus on observations of work activities to determine whether procedures are followed and to provide feedback to management on organizational performance. The onsite QA and QC staffs perform these surveillances, which supplement QA audits that are conducted by the offsite QA staff. Surveillances performed by the QA staff are titled QA Surveillances, while those performed by the QC staff are titled QC Surveillances.

EA reviewed 12 QC surveillances listed in Appendix B that were completed in October through December 2014 to evaluate performance of the subcontractor supplying concrete and the performance of the subcontractor installing the HVAC system. These surveillances covered observations of work activities and reviews of implementation of the QA programs for the HVAC and concrete supplier subcontractors. The reviewed BNI QC surveillances met the requirements of BNI Procedure 24590-WTP-GPP-QA-60.

6.0 CONCLUSIONS

The construction quality at WTP is adequate in the reviewed areas. BNI has developed appropriate corrective actions to resolve specific deficiencies for closed construction quality NCRs and CDRs that EA reviewed. BNI continues to implement corrective actions that are necessary to address errors in the

installation of PICAs. BNI's approach to determining the extent of condition was adequate, but corrective actions have not been timely to resolve the PICA installation errors that were identified in September 2011. Delays by BNI Design Engineering to evaluate and re-issue PICA installation criteria required re-inspection of CM PICAs that had previously been determined to comply with the installation criteria. Several Q PICAS (maxi-bolts) were also identified that did not comply with the revised PICA installation criteria. Corrective actions are expected to be completed by December 2015.

Electrical cable pulling was satisfactory. However, deficiencies in design drawings and work planning and inadequate review of some aspects of electrical work by field engineers resulted in errors in termination of electrical cables. The errors were identified by electrical craft personnel as they were preparing to perform the work. Issues identified in previous inspections regarding inconsistent labeling of some MCCs in the LAB, incorrect labeling of panels in the Water Treatment building and in the LAW and the incorrect sizing of breakers are unresolved. WCD inspectors and EA are tracking these issues to resolution.

7.0 OPPORTUNITIES FOR IMPROVEMENT

EA identified one OFI. This potential enhancement is not intended to be prescriptive or mandatory. Rather, it is a suggestion offered by the EA assessment team that may assist site management in implementing best practices, or provide potential solutions to minor issues identified during the review. In some cases, OFIs address areas where program or process improvements can be achieved through minimal effort. This OFI should be evaluated by the responsible line management organizations and either accepted, rejected, or modified as appropriate, in accordance with site-specific program objectives and priorities.

OFI-WTP-1: BNI should consider improving its electrical wiring installation processes/planning with the goal of terminating all available cables in a particular cabinet as one work task. Specific process improvements to consider include:

- When planning the work, it would be efficient to terminate all the wires in a particular panel at the same time.
- The use of computer tablets or portable electronic means to allow craft personnel to have real-time access to drawings, specifications, and SETROUTE cards.
- Ensure there is better independent verification of pre-job conditions and post-installation inspections, even for CM equipment.

8.0 ITEMS FOR FOLLOW-UP

EA will continue to follow up on inspection of welding activities, piping and pipe supports, pressure testing of piping, cable pulling, and installation of electrical equipment and the HVAC system. EA will continue to review corrective actions to address identified discrepancies in the PICA installation process and will perform additional reviews of self-assessments that BNI Field Engineering conducted. Additionally, EA will review actions taken by BNI to resolve deficiencies in cable termination work and other issues identified by EA during the 2014 quarterly reviews involving equipment labeling inconsistencies, support of electrical cables from the point the cables exit cable trays to where they enter cabinets, and breaker sizing in some systems.

Appendix A
Supplemental Information

Review Dates

December 15-18, 2014

Office of Independent Enterprise Assessments Management

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
William E. Miller, Director, Office of Nuclear Safety and Environmental Assessments
Patricia Williams, Director, Office of Worker Safety and Health Assessments

Quality Review Board

William A. Eckroade
Thomas R. Staker
William E. Miller
Karen L. Boardman
T. Clay Messer
Michael A. Kilpatrick

EA Site Lead for Hanford Site

Robert Farrell

EA Team Composition

Robert Farrell – Team Lead
Joseph Lenahan
James Boyd

Appendix B
Documents Reviewed, Interviews, and Observations

Documents Reviewed

- Construction Procedure 24590-WTP-GPP-CON-3504, Rev. 10B, Pressure Testing of Piping, Tubing and Components, September 25, 2014
- Construction Procedure 24590-WTP-GPP-CON-3205, Rev. 4B, Post Installed Concrete Anchors, April 30, 2014
- Specification 24590-WTP-3PS-DB01-T0001, Rev. 8, Engineering Specification for Furnishing and Delivering Ready-Mix Concrete, March 26, 2007
- Specification No. 24590-WTP-3PS-FA02-T0004, Rev. 7, Engineering Specification for Installation and Testing of Post Installed Concrete Anchors and Drilling/Coring of Concrete, April 29, 2014
- Specification No. 24590-WTP-3PS-SS00-T0001, Rev. 7, Engineering Specification for Welding of Structural Carbon Steel, January 30, 2008
- Procedure 24590-WTP-GPP-MGT-043, Rev. 5E, Corrective Action Management, August 7, 2014
- Procedure 24590-WTP-GPP-MGT-044, Rev. 4, Nonconformance Reporting and Control, November 4, 2013
- Procedure 24590-WTP-GPP-MGT-036, Rev. 4, WTP Self Assessment and Line Surveillance, November 20, 2014
- Procedure 245 90-WTP-GPP-QA-601, Rev. 6C, Quality Assurance Surveillance, May 1, 2013
- Document No. 24590-WTP-MN-CON-01-001-10-10, Rev. 6, Bechtel Nondestructive Examination Standard, Visual Examination VT-AWS D1.1, August 15, 2006
- Document No. 24590-WTP-MN-CON-01-001-10-09, Rev. 8, Bechtel Nondestructive Examination Standard, Visual Examination VT-ASME, August 8, 2013
- Document No. 24590-WTP-QAM-QA-06-001, Rev. 15, Quality Assurance Manual, September 3, 2015
- Construction Deficiency Report numbers 24590-WTP-CDR-CON-14- 0590 through -0660.
- Nonconformance Report numbers 24590-WTP-NCR-CON-14-0140 through -0199.
- WTP Self Assessment Report 24590-WTP-SAR -CON-14-0013, Rotating Equipment Alignment, Performance Assessment and Opportunities for Improvement, October 15, 2014
- WTP Self Assessment Report 24590-WTP-SAR-CON-14-0014, Assessment of Survey Field Books, September 30, 2014
- Quality Control Surveillance Report number 24590-WTP-SV-QC-14-118, Intermech Weld Procedures
- Quality Control Surveillance Report number 24590-WTP-SV-QC-14-119, Intermech Corrective and Preventive Actions
- Quality Control Surveillance Report number 24590-WTP-SV-QC-14-122, Kleinfelder Concrete Laboratory Document Control and Implementation of Procedure KNS-QP-4.1, R2
- Quality Control surveillance Report number 24590-WTP-SV-QC-14-125, Central Pre-Mix Records/Truck Certification
- Quality Control Surveillance Report number 24590-WTP-SV-QC-14-129, Check of Concrete Vibrators Used in LAW and HLW Concrete Placements to Verify They Are Working Properly.
- Quality Control Surveillance Report number 24590-WTP-SV-QC-14-130, Intermech Site Welding Procedure W/IP WTP 9.30
- Quality Control Surveillance Report number 24590-WTP-SV-QC-14-131, Intermech Duct Fabrication and Installation
- Quality Control Surveillance Report number 24590-WTP-SV-QC-14-132, Intermech Duct Accessories Installation

- Quality Control Surveillance Report number 24590-WTP-SV-QC-14-133, Intermech Duct, Piping, and Equipment Suppor.
- Quality Control Surveillance Report number 24590-WTP-SV-QC-14-134, Central Pre-Mix Batch Plant Certifications (CPM #2)
- Quality Control Surveillance Report number 24590-WTP-SV-QC-14-143, Central Pre-Mix Cold Weather Concrete (CPM #70)
- Quality Control Surveillance Report number 24590-WTP-SV-QC-14-153, Central Pre-Mix Batch Plant Ticketing (CPM #8)
- System Pressure Test Document Number 24590-BOF-PPTR-CON-14-0055
- System Pressure Test Document Number 24590-LAB-PPTR-CON-14-0072
- Drawing Number 24590- HLW-SS-S15T-00464, Rev. 3, HLW Vitrification Building, Structural Multi-Commodity Rack at TOS El. 46'-8", February 5, 2011
- Drawing Number 24590- LAW-P3-LMP-WS00047, Rev.1, LAW Vitrification Building Isometric, September 19, 2014
- Intermech Procedure number W/IP WTP 11.20, Visual examination of Duct and Supports, Rev. 3, July 12, 2005
- Intermech Procedure number W/IP WTP 11.30, HVAC Housing/Duct Structural Capability and Leak Testing, Rev. 6, April 7, 2010
- Intermech Procedure number W/IP WTP 11.40, Calibration of Time Measuring Equipment, Rev. 3, February 4, 2014
- Specification No. 24590-WTP-3PS-E00X-T0004 Rev. 8, Engineering Specification for Installation of Cables, September 17, 2013
- Specification No. 24590-WTP-3PS-E00X-T0005 Rev. 5, Engineering Specification for Electrical Raceway and Cable Identification, October 27, 2011
- Specification No. 24590-WTP-3PS-EW00-T0001 Rev. 3, Engineering Specification for Power, Control, and Instrumentation Cable, Medium Voltage Power Cable and Fiber Optic Cable (Safety), July 1, 2011
- Construction Procedure 24950-WTP-GPP-CON-3304 Rev. 2E, Electrical Cable Installation, July 8, 2014
- Construction Procedure 24950-WTP-GPP-CON-3305 Rev. 2E, Electrical Cable Terminations, July 30, 2014
- SETROUTE Work Process Guide, 24590-WTP-GPG-E-001, Rev. 14
- National Electric Code – 1999
- Drawing Number 24590-LAW-E6X-UPE-20046, pages 1 – 6, Rev. 5 Termination/Cable Schedule for 24590-LAW-E6-UPE-20046
- Drawing Number 24590-LAW-E8-UPE-00006, Rev. 6, LAW Vitrification Building Non-ITS UPS 208/120V Panel Schedule UPE-PNL-20046
- Drawing Number 24590-WTP-J9-50-00064, Rev. 4, Controls & Instrumentation CCTV Junction Box – 120VAC General Arrangement
- Drawing Number 24590-WTP-J9-50-00062, Rev. 4, Controls & Instrument CCTV Box General Arrangement
- Drawing Number 24590-LAW-E6X-UPE-20144, Rev. 3, Termination Schedule for 24590-LAW-E6X-UPE-20144
- Drawing Number 24590-LAW-E6X-UPE-20041, Rev. 4, Termination Schedule for 24590-LAW-E6-UPE-20041
- Drawing Number 24590 -LAW-J1-PTJ-00003, Rev. 7, LAW Vitrification System PTJ System Block Diagram Process/Mechanical Handling CCTV System EL -21'0"
- Drawing Number 24590 -LAW-J1-PTJ-00004, Rev. 7, LAW Vitrification System PTJ System Block Diagram Process/Mechanical Handling CCTV System El -21'0"

- Drawing Number 24590 -LAW-J1-PTJ-00009, Rev. 5, LAW Vitrification System PTJ System Block Diagram Process/Mechanical Handling CCTV Sys El 3'-0"
- Drawing Number 24590 -LAW-J1-PTJ-00010, Rev. 5, LAW Vitrification System PTJ System Block Diagram Process/Mechanical Handling CCTV Sys EL 3'-0"
- Drawing Number 24590 -LAW-J1-PTJ-00011, Rev. 5, LAW Vitrification System PTJ System Block Diagram Process/Mechanical Handling CCTV Sys El 3'-0"
- Drawing Number 24590-LAW-E1X-LVE-00005, Rev. 2, Termination Schedule for 24590-LAW-E1X-LVE-00005
- Drawing Number 24590-LAW-E1-LVE-00005, Rev. 8, LAW Vitrification Building 480V Switchboard LVE-SWBD-20201 Single Line Diagram
- CDR 24590-WTP-CDR-CON-14-071

Interviews

- Field Engineering Manager
- Field Engineers
- QC Manager
- QC Inspectors
- Pipe fitters
- Electricians

Observations

- Observed performance of pneumatic pressure tests documented in System Pressure Test Packages 24590-LAB-PPTR-CON-14-0072 and 24590-BOF-PPTR-CON-14-0055
- Witnessed a WCD site inspector perform final visual inspection of column to base plate structural steel weld, number FW-33, on drawing number 24590-HLW-SS-S15T-00464, and a fit up inspection of piping weld GB-009 on line number LMP-WS-00047-S11C-15, a 1.5 inch diameter pipe, on drawing number 24590-LAW-P3-LMP-WS00047
- Observed a leak rate test performed on an HVAC duct under Work Data Package 362173C.
- Termination of Electrical Cables in Panel numbers UPE-PNL-20046 and LVE-PNL-20032, Elevation -21 in the LAW
- Witnessed installation of cables between LVE-SWBD-20201 and LVE-MCC-20201 on Elevation 28 of the LAW