Office of Enterprise Assessments Review of the Los Alamos National Laboratory Transuranic Waste Facility Construction Quality

January 2016

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

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Acronyms

ACI	American Concrete Institute
ASTM	American Society for Testing and Materials International
CFR	Code of Federal Regulations
CJP	Complete Joint Penetration
CRAD	Criteria, Review and Approach Document
CWSB	Characterization and Waste Storage Building
DOE	U.S. Department of Energy
EA	Office of Enterprise Assessments
FIPT	Federal Integrated Project Team
LANL	Los Alamos National Laboratory
LANS	Los Alamos National Security, LLC
NA-LA	Los Alamos Field Office
NCR	Nonconformance Report
NNSA	National Nuclear Security Administration
NA-APM	NNSA Office of Acquisition and Project Management
NQA	Nuclear Quality Assurance
NRMCA	National Ready Mixed Concrete Association
OFI	Opportunity for Improvement
PDSA	Preliminary Documented Safety Analysis
psi	Pounds Per Square Inch
QA	Quality Assurance
QAP	Quality Assurance Program
QC	Quality Control
SC	Safety Class
SS	Safety Significant
TA	Technical Area
TC	Tension Control (high strength bolts)
TRU	Transuranic
TWF	Transuranic Waste Facility
USACE	United States Army Corps of Engineers
UT	Ultrasonic Testing
WSB	Waste Storage Building

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Office of Environment, Safety and Health Assessments, within the independent Office of Enterprise Assessments (EA), conducted an independent review of construction quality at the Los Alamos National Laboratory (LANL) Transuranic Waste Facility (TWF) from March 2 to 5 and May 12 to 15, 2015. This review was performed in the broader context of an ongoing program of assessments of construction quality at DOE major construction projects. For the scope of this review, EA observed ongoing and completed work activities; reviewed drawings, specifications, and the quality control program for the TWF; examined implementation of selected requirements in the LANL quality assurance program; and reviewed the Federal oversight of TWF construction activities. Los Alamos National Security, LLC (LANS), is the management and operations contractor for LANL, and J. B. Henderson Construction Company, Inc. is the general construction contractor for TWF. Federal project management and oversight is provided by the National Nuclear Security Administration (NNSA) Office of Acquisition and Project Management (NA-APM); the NNSA Los Alamos Field Office provides support through the Federal Integrated Project Team and is the safety basis approval authority for the TWF project.

Overall, the construction quality (including earthwork, concrete, and structural steel erection) at TWF is satisfactory in the areas reviewed. However, weaknesses were identified in the TWF Concrete and Earth Moving project specifications and the LANL Master Specifications that are the basis for the TWF project specifications. The concrete specifications permit the LANS field engineer to accept concrete with entrained air contents that exceed the limits established in the concrete mix design without establishing an upper limit on entrained air content. The earth moving specifications did not incorporate American Society for Testing and Materials recommendations concerning the necessity to verify soil compaction data determined using the nuclear method with other established test methods.

The Federal oversight of the construction phase of the TWF project is effective with the exception of construction safety reviews and issues management performance. The Federal project office has established a cohesive team that is effective at both project management and field oversight of the construction activities. Supplementing the Federal Integrated Project Team with experienced construction managers from the United States Army Corp of Engineers as field representatives has resulted in a strong day-to-day Federal oversight field presence. However, draft oversight procedures were used that did not establish and implement the required oversight program and issues management program defined in DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*, for the TWF project. The requirements to categorize findings based on risk and priority, ensure relevant line management findings are effectively communicated to the contractors, and ensure that problems are evaluated and corrected on a timely basis are not adequately implemented. Also, NA-APM has not ensured periodic construction safety reviews by a subject matter expert were performed at TWF.

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1.0 PURPOSE

The U.S. Department of Energy (DOE) Office of Environment, Safety and Health Assessments, within the independent Office of Enterprise Assessments (EA), conducted a review of construction quality and Federal assurance capability at the Los Alamos National Laboratory (LANL) Transuranic Waste Facility (TWF). This review was conducted from March 2 to 5 and May 12 to 15, 2015, within the broader context of an ongoing program of assessments of construction quality at DOE major construction projects. These reviews are performed to ensure construction contractors meet the requirements of 10 CFR 830 Subpart A, *Quality Assurance Requirements*. This report discusses the scope, background, methodology, results, and conclusions of the review. A summary of the findings and opportunities for improvement (OFIs) that EA identified is included.

2.0 SCOPE

EA conducted this review of TWF construction quality processes in accordance with the *Plan for the Office of Enterprise Assessments Review of the Los Alamos National Laboratory Transuranic Waste Facility Construction Quality*. 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. This review included examination of implementation of selected requirements in the LANL QA program and review of Federal oversight of construction activities. The review focused on the Federal field oversight of the TWF construction project rather than the project management aspects of the Federal Integrated Project Team (FIPT). Design and procurement programs were not included in the scope of this review.

3.0 BACKGROUND

The overall mission of TWF is to provide LANL with capability to stage and certify newly generated transuranic (TRU) waste before shipping to the DOE Waste Isolation Pilot Plant. The TWF is being constructed at Technical Area (TA)-63. The TWF processes involve only TRU waste container handling and noninvasive operations that certify the waste meets Waste Isolation Pilot Plant acceptance criteria. TWF is not designed to open TRU waste containers. The existing TRU waste staging and certification capabilities are currently being performed at TA-54, Material Disposal Area G, which is targeted for closure because of consent agreements with the State of New Mexico. Because of the consent agreement timing and ongoing generation of TRU waste from LANL operations, the TWF is considered a high priority new nuclear facility project for National Nuclear Security Administration (NNSA).

The TWF is designated as a Hazard Category 2 nuclear facility for radioactive material management. The safety significant (SS) structures at TWF are the five WSBs that will store the TRU waste containers, the characterization and waste storage building (CWSB), the Utility Building, and the fire water tank. These structures are designed to survive a Performance Category 2 seismic event. The buildings will be constructed using structural steel frames with sheet metal siding and roofs on a reinforced concrete slab and grade beam foundation. The safety class (SC) components at the TWF include the onsite vehicle barriers and the seismic power cutoff system. The SC structures are designed to survive a Performance Category 3 seismic event. The critical characteristics for the TWF design and layout identified in the

Preliminary Documented Safety Analysis (PDSA) include:

- Maintaining a minimum separation distance between adjacent SS structures (e.g., the WSBs and CWSB)

- Constructing the TWF in accordance with the prescribed WSB/CWSB layout, with onsite vehicle barriers that restrict vehicle access to the WSBs and CWSB

- Constructing the WSBs and CWSB floor slabs with a minimum grade of one percent that slopes toward the retention basin

- Paving and grading the exterior access and parking areas to provide a minimum grade of one percent that slopes toward the retention basin.

QA requirements for design, construction, and procurement activities for the TWF project are specified in the LANL Quality Assurance Program (QAP) document SD330, *Quality Assurance Program.* DOE Order 414.1D, *Quality Assurance,* is referenced in the LANL QAP as the regulation that is applicable to the LANL QAP. Design and construction of the TWF is a two phase project. Phase A included utility relocation, rough site grading, and construction of a perimeter retaining wall along the north and west site boundary. Phase A construction was completed in December 2012. Phase B includes constructing the buildings, support facilities, and vehicle barrier. The design for Phase B was completed by a joint venture of the architect-engineering firms Weidlinger Associates, Inc. and Navarro Research and Engineering (Weidlinger-Navarro Northern New Mexico Joint Venture) under contract to Los Alamos National Security, LLC (LANS), the management and operations contractor for LANL. The safety basis for the TWF is the PDSA that was approved by NNSA through a Safety Evaluation Report, dated March 18, 2014. The Phase B design is complete and was approved in July 2014.

J. B. Henderson Construction Company, Inc. (also referred to as JB Henderson) is the general construction contractor for the Phase B construction. JB Henderson is a nuclear quality assurance (NQA-1) contractor with a QA program that was audited by LANS prior to the contract being awarded. JB Henderson is responsible for performing QC inspections of quality related work activities using their own staff or third party NQA-1 inspection agencies. Inspection activities are performed under the supervision of the onsite JB Henderson QA manager. A separate NQA-1 third party dedicator subcontractor is responsible for procuring long lead SS equipment, such as the seismic cutoff switch, fire pump, and standby diesel generator.

LANS performs management and oversight of construction, as described in the *TRU Waste Facility Project Construction Execution Plan*, dated February 2014. Members of the LANS QA organization perform QA surveillances to monitor the contractor's QA program implementation. LANS field engineers perform independent in-process inspections to ensure that construction is completed in accordance with the design specifications and drawings.

The NNSA Office of Acquisition and Project Management (NA-APM) is assigned the line management responsibility for the TWF project during the construction phase of the project (between Critical Decision 2 and Critical Decision 4). An NA-APM Federal Project Director is assigned to the project. A FIPT, comprised primarily of NNSA Los Alamos Field Office (NA-LA) subject matter experts, is responsible to the Federal Project Director for Federal management and oversight of the TWF project. The NA-LA Manager is the safety basis approval authority for the TWF project safety basis documentation.

4.0 METHODOLOGY

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 TWF components. This review considered the requirements of 10 CFR 830, Subpart A, *Quality Assurance Requirement*, and DOE Order 414.1D, *Quality Assurance*, which require the contractor to use appropriate national consensus standards to implement DOE QA requirements. The national consensus standards and basis for the LANL QAP are ASME NQA-1-2008 and NQA-1a-2009 addenda, *Quality Assurance Requirements for Nuclear Facility Applications*. LANL Document SD330, *Quality Assurance Program*, describes the QA requirements and the application of the 18 NQA-1-2008 and NQA-1a-2009 addenda requirements to the LANL QAP.

This EA review focused on earthwork and foundation preparation and the implementation of construction quality processes, and the effectiveness of NNSA oversight of the contractor, utilizing selected portions of the following criteria, review and approach documents (CRADs):

- CRAD 64-15, *Construction – Structural Concrete*
- CRAD 64-16, *Construction – Structural Steel*
- CRAD 45-21, *Feedback and Continuous Improvement Inspection Criteria and Approach – DOE Field Element*.

EA conducted several construction site walkthroughs concurrently with the NNSA TWF project staff to determine whether work activities were completed in accordance with the appropriate design drawings, specifications, and installation procedures. EA reviewed the specifications for earthwork, concrete, and structural steel. EA observed testing and placement of concrete in waste storage building (WSB) 153 and in a duct bank. EA also examined concrete placed in the Operations Support Building, the Utility Building, and WSB 149 through 152 and reviewed the corresponding records of quality control (QC) tests performed on samples of concrete from these placements. EA observed erection of structural steel for WSB 149 and inspected the completed structural steel frame for the Operations Support Building. EA also reviewed nonconformance reports (NCRs), quality records for structural steel and structural bolts, LANL QA assessment reports, and the concrete inspection records that the LANS project engineer prepared for WSB 149 and 153.

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, findings are listed in Section 7, opportunities for improvement (OFIs) are included in Section 8, and items for follow-up are discussed in Section 9.

5.1 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; LANL QAP Requirement 16 – Corrective Action; DOE Order 414.1D)

JB Henderson Procedure PSP 16.01, *Corrective Action*, defines the requirements for identifying, documenting, reporting, controlling, and dispositioning nonconforming conditions at the TWF project. EA reviewed the six NCRs issued by JB Henderson in 2014 and sixteen NCRs issued in 2015 to evaluate the types of nonconforming issues that were identified, as well as their apparent causes and subsequent corrective actions. The NCR categories included 14 NCRs related to construction or installation errors; 5 NCRs for incorrect fabrication or shipping damage to structural steel; 1 NCR for a supplier deficiency for violation of the Buy American Act; and 1 NCR for an engineering issue related to a drawing discrepancy. Corrective actions were completed for 16 of the 22 NCRs that were closed. The contractor has developed appropriate corrective actions to disposition the specific problems identified in the completed and closed NCRs that EA reviewed. The corrective action program and implementation is adequate to address and resolve specific construction quality deficiencies.

5.2 Engineered Fill Placement

Criterion:
Work, such as placement and compaction of engineered fills, 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, Requirement 5; LANL QAP Requirement 5 – Instructions, Procedures, and Drawings; and DOE Order 414.1D)

Prior to the TWF design, a series of subsurface explorations and tests of the in situ soils at the TWF project site were completed by the consulting engineering firm, Kleinfelder, to determine subsurface conditions at the site and the acceptability of the site for the proposed TWF project. Kleinfelder is a geotechnical engineering design and testing consultant with a LANL approved NQA-1 QA program. A description of the subsurface conditions at the TWF project site, in situ soils test results, recommendation for foundation design criteria for the TWF structures, and recommendations for engineered fill placement and compaction are summarized in a geotechnical report titled *Kleinfelder Report Project 116662, Geotechnical Investigation TRU Waste Facility Technical Area 63 (TA-63) LANL*. The LANL TWF Project Specification Section 31 2000, *Earth Moving*, specifies the requirements for fill materials, compaction, and QC testing. EA reviewed TWF Project specification Section 31 2000 and verified that it incorporated the technical recommendations in the geotechnical report regarding type of fill material and fill placement, including lift thickness, percent compaction, and soil moisture content at time of compaction. The percent compaction required is 95 percent of the maximum dry density, as determined by American Society for Testing and Materials (ASTM) D1557, *Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.* The geotechnical report also recommended installation of a moisture barrier on the foundation subgrade prior to placement of concrete. EA noted two minor variations between the recommendations contained in the geotechnical report and the TWF Specification Section 31 2000. The TWF specification permits engineered fill to be placed in 8 inch lifts, whereas the geotechnical report recommended a maximum 6 inch lift. A revision to the TWF specification by Field Change Request 080 and Design Change Notice 249 increased the maximum percent by weight of silt and clay size particles in the fill material from 45 percent to 47 percent. (Note: One criterion geotechnical engineers use to determine the acceptability of soils for engineered fills is based on the distribution of particle sizes in representative samples determined by an ASTM test method using a series of standard sized sieves. Soil particles with dimensions less than 0.074 millimeters are classified as silt or clay sized particles). EA concluded that these deviations from the recommendations in the geotechnical report were not significant enough to affect the stability of the building foundations.

EA inspected the onsite laboratory that Kleinfelder uses to perform QC testing of soils and ready mix concrete for the project, and reviewed the qualification records of the laboratory and field testing personnel. Calibration stickers on the laboratory equipment were current, and copies of current test procedures were available. EA reviewed the training and work experience records for the laboratory testing personnel and verified that they were qualified in accordance with NQA-1 requirements.

The QC program for the engineered fill placement was discussed with the independent testing laboratory (Kleinfelder) field inspector. QC testing of the engineered fill on the project is performed using ASTM D6938, *Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth),* to determine the moisture content and density of the engineered fill. The Kleinfelder field inspector demonstrated the nuclear test method and the daily calibration checks that he performs on the nuclear density/moisture instrument. EA reviewed the calibration records for the previous 30 days. EA questioned the NNSA staff and LANS engineers as to whether the results of the nuclear method were validated by comparing the soil density and moisture results obtained using other methods, such as the sand cone method, per ASTM D1556, *Standard Test Method for Density and Unit Weight of Soil in place by Sand Cone Method*, or the rubber balloon method, per ASTM D2167, *Standard Test Method for Density and Unit Weight of Soil in place by the Rubber-Balloon Method*. These discussions disclosed that no comparison tests are performed since they are not specified in TWF Project Specification Section 31 2000, *Earth Moving*. The basis for the TWF Project Specification is the LANL Master Specification Section 31 2000, *Earth Moving.* There are also no requirements in the Master Specification to perform independent tests to validate or calibrate the nuclear method results. (See **OFI-LANS-1.**)

The manual of instructions for the nuclear test device published by the manufacturer states that the equipment is calibrated to measure materials with a density between 70 and 170 pounds per cubic foot. ASTM D6938, Section 5, *Interferences*, discusses various factors that could affect moisture and density measurements. Section 5.2 of ASTM D6938 states the soil moisture content is affected by the chemical composition of the material being tested. ASTM D6938 does not specifically require performance of alternate density and moisture tests to validate the nuclear method results, but Section 10.6 of ASTM D6938 recommends that periodic checks should be made by comparing the water (moisture) content values obtained using the nuclear method to another ASTM method, such as ASTM 2216, *Standard Test Method for Laboratory Determination of Content (Moisture) of Soil and Rock*, to verify that the soil moisture measurements obtained using the nuclear method are accurate. (See **OFI-LANS-1.**)

The nuclear method measures the moist density of the soil in pounds per cubic foot and the moisture content of the soil in percent by weight. The date readout from the nuclear test instrument indicates the dry density of the soil in pounds per cubic foot and the moisture content of the soil. The dry density of the soil is calculated internally by the nuclear test instrument by deducting the weight of the moisture (water) from the moist density of the soil. Therefore, if the nuclear test incorrectly measures the soil moisture content, the dry density of the soil reported by the nuclear instrument will be incorrect. An incorrect soil dry density value reported by the nuclear instrument could result in acceptance of fill materials that have not been compacted to the percent of maximum dry density required by the specifications and foundation design criteria. EA reviewed several technical reports that summarize results of soil testing using the nuclear density method (ASTM D6938). Several of the reports discussed problems with the results obtained from the nuclear method and recommended that alternative soil density/moisture methods be used to validate the nuclear method. Although there are no specific requirements to validate soil density and moisture results obtained through the nuclear method by an alternate method, LANS has not addressed the recommendations from the reviewed soil testing technical reports and Section 10.6 of ASTM D6938 (discussed above). Other factors that could affect the measurements obtained by the nuclear instrument are the presence of natural or man-made radioactive elements in the fill materials. (See **OFI-LANS-1**.)

Despite these uncertainties, EA determined that the specification properly incorporated the recommendations of the geotechnical report, and the QC testing program is adequate to ensure that the engineered fills for the foundations of SC and SS structures are completed in accordance with design and specification requirements.

5.3 Structural Concrete

Criterion:
Work, such as manufacture and placement of structural concrete, 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, Requirement 5; LANL QAP Requirement 5 – Instructions, Procedures, and Drawings; and DOE Order 414.1D)

Specification Section 03 03001-01, *Reinforced Concrete - High Confidence*, covers the manufacture, placement, curing, and QC and QA requirements for concrete used to construct the TWF SC and SS structures. Concrete for the foundation and support structure for the SC seismic power cutoff system and the onsite vehicle barriers is required to meet the requirements of American Concrete Institute (ACI) Specification ACI-349, *Code Requirements for Nuclear Safety-Related Structures*. The concrete for SS structures is required to comply with ACI-301, *Specifications for Structural Concrete*, and ACI-318, *Building Code Requirements for Structural Concrete*.

Accompanied by Defense Nuclear Facilities Safety Board staff members and two United States Army Corps of Engineers (USACE) field representatives, EA inspected the offsite commercial concrete batch plant that supplies the concrete for the TWF project. The concrete batch plant was in good condition and had been inspected by a professional engineer in accordance with National Ready Mixed Concrete Association (NRMCA) standards. Concrete batch records are generated and controlled and indicate placement location, mix number, weight/volume of ingredients, batch volume, date, batch time, water-cement ratio, and quantity of water withheld. The batch plant scales and meters are calibrated at the necessary frequency and to specified tolerances. Storage and handling of materials are controlled. Cement and fly ash are protected from moisture, aggregates are segregated by sizes and protected from contamination, and admixtures are prevented from freezing. Ice and chilled water are used to produce concrete during hot weather. A water heating facility is in place to produce concrete during cold weather. Moisture probes continuously monitor the moisture content of concrete aggregates and adjust the quantity of mix water to account for the free water in the aggregate. EA reviewed the records that document the concrete batch plant was inspected and certified by NRMCA and records that the concrete trucks used for transporting the concrete were inspected and certified in accordance with NRMCA standards.

The LANL materials laboratory obtains samples of the concrete aggregates at the concrete batch plant every three months for testing. The sampling and testing requirement is specified in both the TWF Project Concrete Specification and the LANL Master Reinforced Concrete Specification. EA reviewed the reports for gradation tests performed on samples of the concrete aggregates obtained from the concrete batch plant in February 2015. The test results showed the aggregates met the requirements of ASTM C33, *Standard Specification for Concrete Aggregates.*

During the March review, EA observed placement and consolidation of non-safety concrete in an electrical duct bank. During the May review, EA examined installation of reinforcing steel, observed preparation of the forms and cleaning activities prior to concrete placement, reviewed the pre-placement inspection records, and observed placement and consolidation of concrete for WSB 153. The LANS project engineer was also on site to observe both concrete placements. The quality of ready mix concrete

for the TWF project was checked prior to placement by testing the concrete by use of ASTM approved test standards to verify concrete temperature, slump, unit weight, and entrained air content complied with Specification requirements. These tests were performed by independent laboratory QC inspectors. EA and the LANS project engineer reviewed the concrete delivery tickets to verify the proper concrete mix was being delivered, observed the concrete tests, reviewed the test results, and verified the concrete was discharged from the delivery truck within 90 minutes of batching and before the truck drum had revolved 300 times, in accordance with the requirements of ASTM Specification C-94, *Ready-Mixed Concrete*.

The WSB 153 concrete placement was terminated because of inclement weather (rain) after 45 to 50 cubic yards of concrete were placed in the footings (grade beams) for the structure. In order to protect the concrete that had been placed, the contractor had made prior preparations to cover the placement with tarps and acted swiftly to install tarps, which were sloped to prevent water from accumulating within the structure. The LANS project engineer consulted with the design engineer about stopping the placement and providing a construction joint in the structure. The design engineer concluded this was a good location for an unplanned construction joint since the concrete elevation was below the level of the WSB floor slab prior to stopping the placement. The concrete surface was roughened, a keyway was installed, and additional vertical reinforcing steel was added to the footings to strengthen the bond at the construction joint. NCR number 14055-15-021 was initiated to document the concrete placement stoppage. Before starting the concrete placement for WSB 153, the contractor had reviewed the weather forecast which indicated weather conditions were favorable for starting and completing the concrete pour. When the weather conditions changed rapidly, the contactor was well prepared to place the construction joint and protect the concrete that had been placed from damage.

EA examined the completed concrete mat foundations with turned down edges (slabs and grade beams placed as a monolith) for the Operations Support Building; the Utility Building; and WSB 149 through 152. EA measured the finished grade elevation of the concrete floor slabs in WSB 149 through 152 and verified that the slabs sloped downward at a one percent grade toward the area where the future retention basin was to be constructed as required by the PDSA criteria.

The initial placement for structural concrete on the project was completed on December 2, 2014, for the Operations Support Building mat foundations. Discussions with the NNSA Federal oversight staff disclosed that several voids were identified in the floor slab for this non-safety structure at several locations where embedded anchor bolts for structural steel columns were located. NCRs were initiated to document and repair these concrete defects. The voids were under the plywood templates that maintained the correct position of the embedded anchor bolts before and during concrete placement. In addition to the anchor bolts, these areas are congested with additional reinforcing steel (rebar) at the juncture of the mat foundation and grade beam and at building corners. The contractor determined the voids were the result of the plywood templates limiting access to concrete vibrators used to consolidate the concrete. The templates were modified by drilling holes in them to permit access to vibrators to properly consolidate the concrete. These corrective actions were effective. No additional voids occurred in these areas during placement of the Utility Building and WSB 149 through 152. One minor cosmetic surface defect, approximately 8 inches in diameter, was identified by the contractor in the grade beam for WSB 149. An NCR was issued and the defect was repaired before the May review. During the placement of WSB 152, the concrete forms were adjusted slightly at the northwest corner of the building to correct the alignment of the grade beam. Apparently the concrete in the grade beams had started to harden prior to movement of the forms, resulting in several surface defects and voids, known as concrete honeycombs, in the surface of the grade beam when the forms shifted away from the concrete grade beam. NCR number 14055-15-020 was initiated to document this issue. The NCR was submitted to the design engineer who will recommend the repair methods. These concrete defects were minor and do not impact the structural integrity of WSB 152.

EA reviewed the concrete pour cards for the WSB 149 and WSB 153 mat foundations that document inspections performed prior to the concrete placement. TWF project procedures require that the pour card be signed by contractor craft supervisors whose work crews performed various work activities and the LANS project engineer. Attributes on the concrete pour card that are required to be verified prior to the concrete placement included location of structure; concrete forms; installation of moisture barrier; installation of mechanical components; proper installation of rebar, anchor bolts, mechanical items, and ground wires; and cleanliness of the subgrade before concrete placement. The contractor's QC inspectors also sign the pour cards to signify they performed all required inspections before the concrete placement to verify the above attributes. No deficiencies were identified on the pour cards reviewed by EA.

EA reviewed the following records for the Utility Building and WSB 149 through 152 concrete placements: concrete delivery tickets; results of slump, entrained air content, temperature, and unit weight performed on the freshly mixed concrete; and results of unconfined compression testing performed on concrete at 28 days of age for WSB 149, 150, and 151. The concrete for WSB 152 and the Utility Building had not attained the age of 28 days during the review. The strength used for structural design of the TWF reinforced concrete structures, expressed in pounds per square inch (psi), is based on the results of unconfined compression tests performed on concrete cylinders that have been cured under controlled conditions for 28 days. Unconfined compression tests performed on the concrete cylinders from WSB 149, 150, and 151 pours showed that the concrete unconfined compressive strength at 28 days was between 4775 and 5760 psi, exceeding the 4000 psi value used for design.

With the exception of the entrained air content of the concrete placed in the Operations Support Building and WSB 149 and 150, the test data showed that the concrete complied with Specification requirements. Acceptance criteria in the concrete specification require the entrained air to be between 3.5 and 6.5 percent. The results of entrained air tests performed on most of the samples representing the concrete placed in the Operations Support Building and WSB 149 and 150 showed the entrained air exceeded 6.5 percent, with a maximum measured value of 7.2 percent entrained air. Although the unconfined compression tests performed on concrete cylinders cast from these samples demonstrated the concrete exceeded the 4000 psi design requirements, placing concrete that does not meet Specification requirements in a permanent structure circumvents the intent of the NQA-1 Quality Assurance program.

The TWF Project Specification is based on the LANL Master Specification for Concrete. Section 3.11.A.3 of the TWF Specification indicates that the LANS Field Engineer can accept concrete that exceeds the Specification limits by noting the high air content in the inspection report, but that an NCR is not required unless the concrete strength report indicates the concrete is unacceptable (i.e., the strength is low). The Specification also notes that high air content impacts the concrete strength. There is no criterion in the TWF Project Concrete Specification or the LANL Master Concrete Specification that states an absolute upper limit for the percentage of entrained air that requires rejection of the concrete. It was not evident from reviewing the test data that, after a sample had an entrained air content that exceeded the specified upper limit of 6.5 percent, the concrete batch plant was notified to adjust the mix, or that samples from subsequent trucks were tested to determine the entrained air content. Generally, it is standard practice on NQA-1 nuclear construction projects to make adjustments to the mix and test samples from the next truck and each subsequent truck until the test results show that the concrete meets specification requirements. Concrete that does not meet specification requirements is normally rejected and not placed in a safety related concrete pour. If concrete that does not meet specification requirements is placed in a safety related placement, an NCR is initiated and additional concrete test cylinders are generally molded and tested to determine whether the concrete meets design strength requirements. If testing indicates the concrete does not meet design strength requirements, a detailed investigation is performed to determine if removal of the low strength concrete is necessary. Depending on the location of the low strength concrete, it may be necessary to stop concrete work and other work activities until the

investigation is completed and corrective actions, which could include removal of suspected low strength concrete, are completed.

EA reviewed several technical reports published by universities, State Departments of Transportation, and industry organizations summarizing the impact of increased entrained air content on cured concrete. Testing has shown that for each one percent increase in entrained air content, the concrete strength decreases between 2 and 10 percent or more, depending on the concrete mix and type of admixtures used in the concrete. (See **OFI-LANS-2**.)

EA determined that the concrete QC testing program was adequate for the sample reviewed. The concrete specification provides adequate QC and QA controls to produce quality concrete, with the exception of the acceptance criteria for entrained air content, as discussed above.

5.4 Structural Steel Erection

Criterion:
Work, such as erection of structural steel, 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, Requirement 5; LANL QAP Requirement 5 – Instructions, Procedures, and Drawings; and DOE Order 414.1D)

Requirements for erection of structural steel for SC and SS structures are specified in Specification Section 05 1000.01, *Structural Metal Framing – High Confidence*. For non-SS structures, such as the Operations Support Building, structural steel erection requirements are specified in Specification Section 05 - 1000, *Structural Metal Framing – Normal Confidence*. With the exception of receipt inspection, documentation and certification of materials, the requirements for erection and inspection are equivalent for SC, SS, and non-SS structural steel construction.

During the March onsite review, EA examined the completed structural steel frame for the Operations Support Building. EA identified apparent discrepancies in the installation in the base plates for columns supporting door frames and canopy supports at two locations in the Operations Support Building. Anchor bolts were missing at one location, i.e., two out of four in two base plates, and the base plate detail at the other location differed from that shown in the structural steel erection drawings. The contractor disclosed that conflicting design changes had been submitted to revise the base plate and anchor bolt details that had not been approved prior to concrete placement in the Operations Support Building. A design change was issued to install post installed concrete anchors to replace the missing anchor bolts. EA verified that the anchors were installed during the May onsite review.

EA observed erection of the structural steel frame and installation of tension control (TC) bolts in the structural joints for WSB 149 during the May onsite review. Structural steel fabrication is planned to ensure that onsite connections are bolted and that welded connections are completed at the offsite steel fabrication shop. Alignment of the steel frame was in progress to ensure that the vertical and horizontal alignment of the steel frame met American Institute of Steel Construction criteria and the project specification before tensioning of the TC bolts.

Quality records related to structural steel fabrication were reviewed, including steel manufacturer's certified material test reports documenting the chemical and mechanical properties of the structural steel members, steel fabrication and shop weld inspection records, and records of ultrasonic tests (UT) performed on complete joint penetration (CJP) welds on welded beam flanges. In addition to visual weld

inspections, the Structural Steel Specification requires performance of UT to confirm weld quality on CJP welds on steel sections with a thickness of 5/16 inches or more. UT is not required for welds joining materials less than 5/16 inches thick. The flanges on the structural steel shapes with CJP welds used for framing the WSBs were more than 5/16 inches. As a result, UT inspections are required on the flange CJP welds, but not the web CJPs since the webs are less than 5/16 inches in thickness.

EA also reviewed the records (manufacturer's certificates of conformance) documenting chemical and mechanical properties of the high strength TC structural steel bolts. Mechanical properties of the bolts included dimensions (length, diameter, head height, bearing diameter, and thread pitch) and ultimate strength. A sample of TC bolts are checked using a Skidmore testing device to verify that when the TC bolts shear off, they are capable of applying the minimum tension to the joined members specified in Table 8-1 of the Research Council on Structural Connections Specification. The result of onsite testing of the three types of TC bolts used on the TWF project performed by the contractor's QC inspectors using Skidmore testing were also reviewed by EA. The test results exceeded the values specified in Table 8-1.

EA determined that structural steel work was adequate. The structural steel specifications provide adequate QC and QA controls for structural steel construction activities. No deficiencies were identified.

5.5 Quality Assurance Surveillance Activities

Criterion:
Quality Assurance surveillances shall be performed by knowledgeable personnel and shall be scheduled in a manner to provide coverage, consistency, and coordination 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 Requirement 18; LANL QAP Requirement 18, Audits; and DOE Order 414.1D)

LANS has prepared a QA assessment schedule that shows the QA audits that LANS plans to perform to determine the effectiveness and implementation of the JB Henderson (General Contractor's) QA plan. The schedule includes all QA program requirements applicable to the General Contractor's work activities. EA reviewed two completed QA audits documented in Surveillance Report numbers SR (15)-001.000, *JB Henderson Document Control and Records Management*, and SR (15)-003.000, *JB Henderson Control of Purchased Items and Services*. Five audit findings were identified in the document control and records management surveillance. Two concerned administrative control of procedures, another concerned clarification of a procedure regarding training required for individuals managing quality related activities, and two concerned control of access to QA records. Four audit findings were identified in the control of purchased items and services surveillance. These findings concerned the necessity to revise procurement procures to clarify NQA-1 requirements and/or actual practices. The audit findings did not affect hardware or in-process construction activities.

5.6 Program for NNSA/Federal Oversight of the Construction Contractor

Criteria:
DOE field element line management has established and implemented oversight processes that evaluate contractor and DOE programs and management systems, including site assurance systems, for effectiveness of performance (including compliance with requirements). Such evaluations are based on the results of operational awareness activities; assessments of facilities, operations, and programs; and assessments of the contractor's assurance system. The level and/or mix (i.e., rigor or frequency in a particular area) of oversight may be tailored based on considerations of hazards, the maturity and operational performance of the contractor's programs and management systems. (DOE Order 226.1B)

The DOE field element has an issues management process that is capable of categorizing findings based on risk and priority, ensuring relevant line management findings are effectively communicated to the contractors and that problems are evaluated and corrected on a timely basis. For issues categorized as high significance findings, the issues management process ensures that:

- *A thorough analysis of the underlying causal factors is completed*
- *Corrective actions that will address the cause(s) of the findings and prevent recurrence are identified and implemented*
- *After completion of a corrective action or a set of corrective actions, the conduct of an effectiveness review using trained and qualified personnel that can verify the corrective action/corrective action plan has been effectively implemented to prevent recurrences*
- *Documentation of the analysis process and results described in the first bullet above and maintenance tracking to completion of plans and schedules for the corrective actions and effectiveness reviews described in the second and third bullets above, in a readily accessible system. (DOE Order 226.1B 4b(4))*

DOE line management has effective processes in place for communicating oversight results and other issues in a timely manner up the line management chain, and to the contractor as appropriate, sufficient to allow senior managers to make informed decisions. (DOE Order 226.1B 4d)

DOE field element staff are adequately trained and qualified to perform assigned oversight activities. (DOE Order 226.1B; DOE Order 360.1C; DOE Order 426.1, Change 1)

EA reviewed the effectiveness of the Federal field oversight of the TWF construction project. TWF is one of several construction projects at LANL that NA-APM manages and oversees. To support these projects, NA-APM has five Federal Project Directors assigned at LANL. For direct support of these Federal Project Directors, NA-APM has assembled a team of support service contractors and USACE personnel to provide Federal project management oversight functions in accordance with DOE Order 413.3 and the day-to-day construction oversight activities. An interagency agreement between NNSA and USACE allows the NNSA Federal Project Directors to draw on the USACE project management and construction management expertise. The NA-APM project oversight model used for the LANL major construction projects (i.e., providing a cadre of support service contractors and USACE personnel) is effective and provides the Federal Project Directors with experienced personnel who are dedicated to the projects on a fulltime basis. Most FIPT members are subject matter experts from NA-LA who provide part time support to the Federal Project Director upon request. An essential role provided by NA-LA is for the review and approval of the 10 CFR 830, Subpart B, safety basis documentation for TWF. The TWF NA-APM Federal Project Director has established an effective working relationship with the NA-LA safety basis personnel to manage and coordinate the safety basis review and approval process. A separate EA review is being conducted that is focused on the safety basis development and approval process.

USACE field representatives provide the vast majority of the day-to-day oversight of the TWF construction activities. The USACE field representatives are knowledgeable and experienced in the construction field and provide a strong and effective field presence, especially in the area of construction quality. The assigned USACE field representatives have varying training in construction safety, and their experience in the construction field has given them a good foundation and understanding of construction. However, none of the field representatives are safety professionals. As a result, their day-to-day oversight

focused more heavily on project execution than on construction safety. An NA-LA Facility Representative had recently been assigned part time to the TWF construction project, but had not yet established a consistent field presence at the construction site. The assigned Facility Representative will strengthen the NNSA safety oversight for the project. NA-APM has not ensured periodic construction safety reviews by a subject matter expert were performed at TWF. (See **OFI-NA-APM-1**.)

Federal oversight of the construction phase of the TWF project was guided by the draft *PMO Oversight Guide and Checklist*. Many aspects of the document were being implemented, but until the *PMO Oversight Guide and Checklist* is finalized and fully implemented, NA-APM does not have a basis for demonstrating it is fully compliant with DOE Order 226.1B. (See **OFI-NA-APM-2**.) The TWF Federal project office is not using the NA-LA suite of procedures that implement DOE Order 226.1B Federal oversight requirements.

Similarly, the TWF Federal project office is using a primarily ad hoc process for managing issues identified through its oversight. The draft desktop guide *PMO Oversight Guide and Checklist* includes guidance on issues management, but the guidance is not fully implemented. The currently implemented issues management process is not adequate to meet DOE Order 226.1B. Specifically, the requirements to categorize findings based on risk and priority, ensure relevant line management findings are effectively communicated to the contractors, and ensure that problems are evaluated and corrected on a timely basis are not adequately implemented. (See **Finding F-NA-APM-1**.)

EA reviewed the training requirements for the USACE field representatives. The training primarily consisted of general LANL site access requirements and specific TWF construction site access requirements. The training requirements were met for the assigned USACE field representatives and were being tracked.

During interviews and walkthroughs of the TWF construction site, the USACE field representatives displayed a thorough knowledge of the key safety features of the TWF design. They were familiar with the TWF PDSA and the concepts of SC and SS designation for key safety features. However, because the safety basis requirements for nuclear facilities are unique to DOE, the USACE field representatives had some weaknesses in their knowledge and understanding of aspects of the PDSA that, if addressed, would strengthen their oversight of the project. (See **OFI-NA-APM-3**.)

6.0 CONCLUSION

Overall, the construction quality (including earthwork, concrete, and structural steel erection) at TWF is satisfactory in the areas reviewed. However, EA identified weaknesses in the TWF Concrete and Earth Moving project specifications and the LANL Master Specifications that are the basis for the TWF project specifications. The concrete specifications permit the LANS field engineer to accept concrete with entrained air contents that exceed the limits established in the concrete mix design without establishing an upper limit on entrained air content. The earth moving specifications did not incorporate ASTM recommendations concerning the necessity to verify soil compaction data determined using the nuclear method with other established test methods.

Overall, Federal oversight of the construction phase of the TWF project is effective with the exception of construction safety. The approach of using USACE field representatives has resulted in a strong day-to-day Federal oversight field presence, providing the Federal Project Director with the information and input needed to adequately manage the project. NA-APM has not ensured periodic construction safety reviews by a subject matter expert were performed at TWF. Also, NA-APM has not completed the development and implementation of procedures to conduct the oversight and issues management program

required by DOE Order 226.1B.

7.0 FINDINGS

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

NNSA Office of Acquisition and Project Management

Finding F-NA-APM-1: The NA-APM office at LANL has not established and implemented an effective issues management program that is capable of categorizing findings based on risk and priority, ensuring relevant line management findings are effectively communicated to the contractors, and ensuring that problems are evaluated and corrected on a timely basis, as required by DOE Order 226.1B, Section 4.b.(4).

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None.

8.0 OPPORTUNITIES FOR IMPROVEMENT

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

NNSA Office of Acquisition and Project Management

OFI-NA-APM-1: NA-APM should consider identifying construction safety subject matter expert resources to supplement the Federal construction oversight capabilities by providing periodic construction safety walkdowns and reviews.

OFI-NA-APM-2: The NA-APM office at LANL should finalize and fully implement the draft procedures to define and establish an effective oversight program, as required by DOE Order 226.1B, Section 4.a.(1).

OFI-NA-APM-3: NA-APM should consider enhancing Federal oversight of TWF construction by providing periodic discussions/training to the USACE field representatives on the important safety basis assumptions and controls.

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OFI-LANS-1: LANS should consider revising the LANL Master Earth Moving Specification to require use of alternate test methods to validate the in-place soil density and moisture content results obtained using the ASTM D6938 nuclear test method.

OFI-LANS-2: LANS should consider revising the LANL Master Concrete Specification to place an upper limit on the percentage of entrained air that can be accepted at the point of concrete placement.

9.0 ITEMS FOR FOLLOW-UP

EA plans to follow up with a review of the readiness to start operations at TWF.

Appendix A
Supplemental Information

Review Dates

March 2-5 and May 12-15, 2015

Office of 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
Gerald M. McAteer, Director, Office of Emergency management Assessments

Quality Review Board

William A. Eckroade
Karen L. Boardman
John S. Boulden III
Thomas R. Staker
William E. Miller
Patricia Williams
Gerald M. McAteer
Michael A. Kilpatrick

EA Site Lead for LANL

Ron Bostic

EA Team Composition

Ron Bostic – Team Lead
Joseph Lenahan

Appendix B
Key Documents Reviewed, Interviews, and Observations

Documents Reviewed

- Specification Section 0303001-01 Reinforced Concrete High Confidence, Revision 2
- Specification Section 05 1000, Structural Metal Framing – Normal Confidence, Revision 1
- Specification Section 05 1000.01, Structural Metal Framing – High Confidence, Revision 3
- Specification Section 05 2100, Structural Joist Framing, Revision 1
- Specification Section 05 5000, Metal Fabrications, Revision 1
- Specification Section 31 2000, Earth Moving. Revision 1
- Kleinfelder Report Project 116662, Geotechnical Investigation TRU Waste Facility Technical Area 63 (TA-63) LANL, Revision 0, dated May 18, 2011
- LANL Document SD330, LANL Quality Assurance Plan, Revision 7, dated February 23, 2015
- TWF Project Document No. 102355-PLAN-00001, Project Quality Management Plan, Revision 5, dated February, 2014
- TRU Waste Facility Project, Construction Execution Plan, Project ID No. 102355, Rev. 4, February, 2014
- JB Henderson Nonconformance Report numbers 14-002 through 14-007 and 15-001through 15-014, 15-020, and 15-021
- JB Henderson Quality Assurance Program Manual, Rev. 3, dated June 17, 2014
- Surveillance Report number SR (15)-001.000 JB Henderson Document Control and Records Management, October 1, 2014
- Surveillance Report number SR (15)-003.000 JB Henderson Control of Purchased Items and Services, October 8, 2014
- Drawing Number C55444 Sheet S-0002, Rev. 2, General Structural Notes
- Drawing Number C55444 Sheet S-1000, Rev. 2, Foundation Plan
- Drawing Number C55444 Sheet S-2001, Rev. 1, Structural Elevations
- Drawing Number C55444 Sheet S-3000, Rev. 1, Structural Sections
- Drawing Number C55444 Sheet S-5000, Rev. 2, Typical Details
- Drawing Number C55444 Sheet S-5001, Rev. 1, Typical Details
- Drawing Number C55444 Sheet S-5010, Rev. 1, Foundation Details
- Drawing Number C55444 Sheet S-5011, Rev. 2, Foundation Details
- Drawing Number C55444 Sheet S-5025, Rev. 1, Framing Details
- Drawing Number C55444 Sheet S-7000, Rev. 1, Schedules
- LANL Master Specification Section 31 2000, Earth Moving, Rev. 10, May 13, 2015
- LANL Master Specification Section 31 3001, Reinforced Concrete, Rev. 8, January 14, 2014
- LANL Master Specification Section 31 3021, Reinforced Concrete – High Confidence, Rev. 0, January 9, 2015
- USACE Field Representative Observation Reports
- PMO Oversight Guide and Checklist, Revision 0, September 17, 2014 (draft)
- FIPT Charter and assignment memorandum
- LANS Contract Modification 288
- Interagency Agreement (DE-NA0000392/007)

Interviews

- LANS TWF Project Manager
- LANS Field Engineer

- Henderson QA Manager
- Klienfelder QC Inspectors
- NA-APM TWF Federal Project Director
- NA-APM Lead Federal Project Director at LANL
- FIPT members (Federal, USACE, and support service contractors)

Observations

- Observed placement of concrete in a duct bank
- Observed placement of concrete in a grade beams for WSB 153
- Examined concrete batch plant
- Examined completed foundations and floor slabs for Operations Support Building, Utility Building, WSB 149, WSB 150, WSB 151, AND WSB 152
- Examined completed structural steel frame for Operation Support Building
- Observed erection of structural steel for WSB 149
- Measured slopes of WSB 149, 150, and 151 floor slabs
- Project Management Weekly Meetings (Federal and contractor)