Underground Ventilation and Geotechnical Engineering Assessment at the Waste Isolation Pilot Plant

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Acronyms

ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
CM	Configuration Management
CSE	Cognizant System Engineer
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
ECN	Engineering Change Notice
ETO	Technical Operability Evaluation or Evaluation of Technical Operability
HEPA	High-efficiency Particulate Air
IVS	Interim Ventilation System
MSHA	Mine Safety and Health Administration
MVP	Mine Ventilation Plan
NQA	Nuclear Quality Assurance
NWP	Nuclear Waste Partnership, LLC
OFI	Opportunity for Improvement
RC	Radial Convergence
SDD	System Design Description
SRK	SRK Consulting
SVS	Supplemental Ventilation System
TSR	Technical Safety Requirements Document
UVFS	Underground Ventilation Filtration System
UVS	Underground Ventilation System
WCM	Wire Convergence Meter
WF	WIPP Form
WIPP	Waste Isolation Pilot Plant

Underground Ventilation and Geotechnical Engineering Assessment at the Waste Isolation Pilot Plant April – August 2020

Summary

Scope

This assessment evaluated the effectiveness of underground ventilation and geotechnical engineering processes as implemented at the Waste Isolation Pilot Plant by the facility contractor, Nuclear Waste Partnership, LLC (NWP). All assessment activities were conducted remotely due to COVID-19 pandemic related travel constraints. The Office of Enterprise Assessments (EA) assessed key aspects of the engineering function that are essential to operating engineered underground ventilation and ground control systems, including engineering product development, the cognizant system engineer (CSE) program, configuration management, and engineering program issues management.

Significant Results for Key Areas of Interest

Overall, the NWP engineering program continues to mature since the accidental underground truck fire and radiological release events of February 2014. Underground ventilation and geotechnical engineering processes are, in general, adequately implemented by NWP. However, control of engineering changes and some engineering documentation were inadequate. In addition, geotechnical engineering procedure implementation was inadequate.

Underground Ventilation Engineering

NWP implements its underground ventilation engineering processes to design, analyze, and ensure the effective operation of underground ventilation systems, which also provide safety-significant controls. Improvements, such as unverified assumption tracking and the validation of airflow modeling software, have been made since EA's 2015 assessment of the NWP engineering program and have enhanced program implementation. Most engineering products examined generally met requirements for technical quality, and the CSE and engineering issues management programs are well-implemented for underground ventilation engineering. Nevertheless, this assessment identified some deficiencies related to inaccurate system design inputs and performance evaluations; how changes to the underground ventilation system configuration are being managed and documented in the mine ventilation plan; inadequate independent verification of some approved engineering changes; and how the design of the underground ventilation system is described. Also, although the underground ventilation system adequately controls nuclear safety hazards, the analysis and documentation of those control functions contained some deficiencies.

Geotechnical Engineering

NWP's geotechnical engineering processes are generally effective in identifying deteriorating ground conditions. Most engineering products examined generally met requirements for technical quality, and the CSE and engineering issues management programs are well implemented for geotechnical engineering. The implementation of a guide to facilitate this process has been a significant improvement to ground control operations. In addition, geotechnical engineering adequately supports decisions on allowing or disallowing access to areas of the mine. Nevertheless, geotechnical engineering lacks a formal change control process; some procedural requirements that drive consistency in ground control operations are deficient; some ground control monitoring instrumentation is not consistently maintained; and some geotechnical engineering instructions are not documented in approved work instructions.

Best Practices and Findings
There were no best practices identified as part of this assessment.

The assessment team identified three findings: (1) some functional requirements for the installed Underground Ventilation System design are not met, (2) the *Mine Ventilation Plan* is not updated annually, and (3) documentation of the technical basis for proposed changes to the facility is not required. The third finding is a recurrence of a previous EA finding.

Follow-up Actions
EA plans to perform field-level observations of underground ventilation and ground support system implementation and surveillance.

Underground Ventilation and Geotechnical Engineering Assessment at the Waste Isolation Pilot Plant

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Office of Nuclear Safety and Environmental Assessments, within the independent Office of Enterprise Assessments (EA), performed an assessment of the conduct of engineering pertaining to underground ventilation and geotechnical engineering at the Waste Isolation Pilot Plant (WIPP). The purpose of this EA assessment was to evaluate the effectiveness of engineering processes implemented by the facility contractor, Nuclear Waste Partnership, LLC (NWP). This assessment was conducted remotely from April to August 2020 due to the COVID-19 pandemic.

This assessment was conducted as described in the *Plan for the Assessment of Underground Ventilation and Geotechnical Engineering Program Performance at the Waste Isolation Pilot Plant, April – August 2020*. EA has conducted independent oversight of the various programs that support the WIPP mission since the shutdown of waste emplacement operations in February 2014, including assessments of the engineering program, as documented in EA reports *Office of Enterprise Assessments Review of Waste Isolation Pilot Plant Engineering and Procurement Processes – November 2015* and *Office of Enterprise Assessments Assessment of Conduct of Engineering at the Waste Isolation Pilot Plant – November 2017*. These previous assessments did not specifically review underground ventilation and geotechnical engineering, but did identify weaknesses in cross-cutting engineering processes. Between 2018 and 2020, EA conducted multiple operational awareness activities to monitor progress in improving the habitability of the WIPP mine and in restoring and maintaining normal operations.

2.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A, *Independent Oversight Program*, which is implemented through a comprehensive set of internal protocols, operating practices, assessment guides, and process guides. This report uses the terms "best practices, deficiencies, findings, and opportunities for improvement (OFIs)" as defined in DOE Order 227.1A.

As identified in the assessment plan, this assessment considered requirements in 10 CFR 830, *Nuclear Safety Management*; DOE Order 420.1C, *Facility Safety*; and other rules and standards that have been specifically applied to WIPP operations. The assessment team used the following objectives from Criteria and Review Approach Document 31-13, *Conduct of Engineering*, Section 4.0, *Criteria and Review Approach*:

- Objective 2 – *Engineering Products*
- Objective 3 – *Cognizant System Engineer Program*
- Objective 4 – *Configuration Management*
- Objective 5 – *Issues Management within the Engineering Organization*.

The assessment team examined engineering products, including engineering change notices (ECNs)/engineering change orders (ECOs) (i.e., change packages), design change notices, drawings, the documented safety analysis (DSA) and technical safety requirements document (TSR), surveillance reports, surveillance procedures, system design descriptions (SDDs), and memorandum reports, as well as other key documents, such as work packages, manuals, analyses, policies, and training and qualification

records. The assessment team interviewed key personnel responsible for developing and implementing the associated processes. The members of the assessment team, the Quality Review Board, and management responsible for this assessment are listed in Appendix A.

The 2015 and 2017 EA assessments evaluated the overall NWP engineering program implemented at WIPP. While some concerns remained, the 2017 assessment noted improvements since the previous review in several areas, including overall engineering performance (e.g., the processes for validating as-built drawings, developing technical and functional requirements, and controlling temporary modifications were adequately defined by procedure). Because this current assessment was targeted to evaluate underground ventilation and geotechnical engineering, only the overarching and cross-cutting engineering processes that intersect with these engineering disciplines were re-evaluated. This assessment focused on the products that result from the implementation of those processes pertaining to underground ventilation and geotechnical engineering. However, where an inadequate engineering product revealed a deficient process, this assessment identified it as such.

The 2015 EA assessment identified five findings relating to the origination, review, and approval of calculations, document control, and change control; two of these findings remained unresolved in the 2017 EA assessment. This current assessment followed up on one of the two remaining unresolved findings. This follow-up is discussed in Section 3.5 of this report, while the follow-up on the second finding will require a site visit to perform.

3.0 RESULTS

3.1 Engineering Products

The objectives of this portion of the assessment were to evaluate whether (1) design engineering work is being performed consistent with technical standards, DOE requirements, and safety basis requirements and commitments, and (2) design documents and related analyses are technically adequate to effectively implement the requirements of the DSA.

3.1.1 Overall Engineering Program

The assessment team reviewed cross-cutting technical procedures and other documents used to implement engineering programs and determined them to be generally adequate. The overall NWP engineering program continues to mature since the events of February 2014. For example, processes to track unverified assumptions and formalize ground control activities have been fully implemented.

However, as observed during previous independent oversight activities, NWP has not always met all storage, shipping, and handling requirements for procured items (e.g., required maintenance on rotating equipment that was not performed while in storage; high-efficiency particulate air (HEPA) filters that were not stored in accordance with the manufacturer's recommendations; and some stocked items that did not have the required shelf life determination, as discussed in WIPP Form (WF) 19-969). Nuclear Quality Assurance (NQA)-1-1989, *Quality Assurance Requirements for Nuclear Facilities*, Supplement 13S-1, *Supplementary Requirements for Handling, Storage, and Shipping*, requires the identification of items that need specific procedures. NWP has adequate mechanisms to address these conditions when they are identified. However, NWP lacks a requirement for the engineer to consider degradation during storage, shipping, and handling when originally specifying the item, which does not support implementation of an NQA-1-1989 compliant specification preparation process. In particular, WP 09-8, *WIPP Specification Preparation*, does not require the inclusion of special item-specific requirements in the specification. (See **OFI-NWP-1**.)

3.1.2 Underground Ventilation Engineering

The assessment team reviewed engineering products related to underground ventilation, including 10 ECNs/ECOs, 1 SDD, 4 design change notices, 7 drawings, the WIPP DSA and TSR, 6 surveillance reports, 2 surveillance procedures, and 3 memorandum reports from the engineering subcontractor that performs ventilation modeling (SRK Consulting, or SRK). Most of these engineering products reviewed met requirements for technical quality, with the exceptions discussed below.

The following issues with SDD VU00, *Underground Ventilation System Design Description*, were identified:

- Section 3.4.1, *System Functional Requirements*, requires that "Air used for ventilating the fuel stations shall not be recirculated but shall be directly exhausted to an exhaust drift." However, drawing 54-W-001-W2, *Current Underground Mine Ventilation System with UVFS, IVS, and SVS*, shows that an overcast[1] has been installed near the intersection of North-150 and East-0 drifts, and ventilation ducting has been installed from the overcast to the fuel station in the West-170 drift, just south of the North-150 drift. This design does not always directly exhaust air to the exhaust drift, and is therefore contrary to the functional requirement. When the Supplemental Ventilation System (SVS) is not in operation, air from the fuel station may be allowed to pass through a significant portion of the mine prior to entering an exhaust drift. (See **Finding F-NWP-1**.)

- Some system boundaries are not correctly identified, as required by WP 09-10, *WIPP Preparation Guide for System Design Description Documents*. (See **Deficiency D-NWP-1**.) For example:
  - Section 1.2, *Limitations of this SDD*, states that "The [Underground Ventilation System] UVS consists of the Underground Ventilation Filtration System (UVFS) and the Interim Ventilation System (IVS)." However, Section 2.3.14 states that "System VU00 has six subsystems which act in concert to provide the complete UVS." This discrepancy represents an inconsistency in the SDD.
  - Section 2.1.1, *Underground Ventilation System (UVS)*, states that "The UVS consists of the Underground Ventilation Filtration System (UVFS) and the Interim Ventilation System (IVS). The Supplemental Ventilation System (SVS) is an interfacing system but it is not part of the UVS." This statement contradicts other statements in the SDD, including Section 2.3.14 as noted above. Also, SVS is not identified as an interfacing system in the appropriate section of the SDD.
  - Section 4.1.2, *Boundaries and Interfaces*, does not identify the system boundaries of the UVS.

- Section 3.4.9, *Performance Criteria*, cites a report "Mine Ventilation Services, Inc., *Modeling UVFS/IVS Fan Configurations with Various NVPs and Upset Conditions*" in evaluating system performance to meet a safety-significant requirement. However, contrary to WP 09-10 requirements, the Mine Ventilation Services, Inc. report does not consider the impact of SVS operation on system performance, and therefore, the performance evaluation is incomplete. (See **Deficiency D-NWP-2**.)

- Section 3.5.5.1, *Design Conditions*, cites a design summer dry bulb temperature that is lower than the operating limits in Table VU G-1 (Section 4.1.6.1). An operating limit that lies outside the bounds of design conditions is an inadequate design input and, therefore, is not in accordance with 10 CFR 830.122(f)(1) requirements. (See **Deficiency D-NWP-3**.)

Independent reviews of the following two ECNs were not performed in accordance with 10 CFR 830.122(f)(4) and 10 CFR 830.122(f)(5) requirements (see **Deficiency D-NWP-4**):

[1] Overcasts are "air bridges" that allow intake and exhaust airways to cross each other without mixing.

- ECN 14147, *Update SDD VU00 for Itigrating* [sic] *the SVS Fan and Related Changed* [sic] *to the Underground Ventilation System*, was independently reviewed by a qualified engineering manager but did not identify any of the issues in SDD VU00 noted above.

- ECN 14298, *Changing SVS Airflow Set Point*, includes SRK technical memorandum DN-486300.50-03, *Increased flow to the North Circuit via Increased Fan Flow*, which summarizes a number of calculational flow model analyses. ECN 14298 contains an independent review form, but NWP did not document the performance of an independent review of the flow models, which in this case are an integral part of the calculation.

The WIPP DSA performance evaluations for UVS are incomplete, contrary to DOE-STD-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*, Section 4.3.X.4. (See **Deficiency D-NWP-5**.) The assessment team identified the following weaknesses:

- The performance evaluation for the UVFS and IVS, DSA Table 4.4.5-2, invokes a flow model analysis memorandum that does not include operating the 860-series fan and two 960-series fans concurrent with the SVS fan in operation, i.e., an operational configuration that is frequently used and identified in TSR Table 3.2.3-1 as an approved operating fan configuration. Based upon analyses performed in DC-486300.050-02, *Increased Flow to the North Circuit via Increased SVS Fan Flow*, the DSA Table 4.4.5-2 performance criteria for the UVFS and IVS are met in the aforementioned operational configuration; however, this analysis is not referenced in the performance evaluation.

- DSA Section 4.4.5.2, *System Description*, states that the design of the SVS components and configuration in the Underground, in accordance with analyzed alignments, precludes unfiltered exhaust flow from the Underground Disposal Areas. However, the analysis of the alignments is not discussed in the DSA performance evaluation.

Contrary to 10 CFR 830.122(f)(1), calculation DC-486300.050-02, performed by SRK in August 2018, has not been updated with the most recent design inputs. The resistance data used in the analysis was taken from the 2017 SVS Test and Balance Report, rather than a more recent test and balance report, issued on May 13, 2019. (See **Deficiency D-NWP-6**.)

Procedures PM041214, *In-place Testing of U/G Exhaust Filter Units*, for Filters 956 and 957, and PM041155, *Annual In-place Testing of Underground Exhaust Filter Units*, for Filters 856 and 857, are used to conduct the required Annual In-place HEPA Filter Efficiency Test, which is a required TSR surveillance. These procedures contain the following weaknesses (see **OFI-NWP-3**):

- Although upstream and downstream aerosol concentrations are documented in the *Nucon Field Test Transmittal*, this data has not been incorporated or referenced in procedures PM041214 and PM041155. Though NWP has not been contractually required to follow it, American Society of Mechanical Engineers (ASME) AG-1, *Code on Nuclear Air and Gas Treatment*, calls for the concentrations of test aerosol upstream and downstream be determined, and that penetration (efficiency) should be calculated from the ratio of these concentrations.

- The procedures require that the in-place test be performed under actual conditions and within the range of design flow rates; however, procedures PM041214 and PM041155 do not require documentation of the HEPA filter efficiency test flow rate.

- Aerosols upstream of the 856 and 857 HEPA filters may not completely mix with the sampled air volume. A prerequisite of the test is a demonstrated ability to achieve good mixing of the test aerosol

and air at the upstream and downstream sample points (ASME N510, *Testing of Nuclear Air Treatment Systems*, Section 9, and AG-1, Mandatory Appendix TA-V). The current standard, ASME AG-1, states that the recommended minimum distance for aerosol injection be at least 10 duct diameters upstream of the HEPA filters, which equates to a distance sufficient to ensure adequate mixing. However, HEPA Filter Housing drawing 41-G-512-W1 shows that the aerosol injection ports on the 856 and 857 cabinets are significantly closer than 10 duct diameters away from the HEPA filters.

- Due to containing only one sampling port, the downstream aerosol sampling manifold is not consistent with the current standard, ASME AG-1, manifold configuration requirements. ETO-K-008, *Validity of Efficiency Testing of HEPA Filters*, recommended that the replacement of the sampling manifold be evaluated because an error is introduced to the efficiency determination by use of a single sampling port. The Carlsbad Field Office accepted NWP's position that the radiation monitor at Station B, which is covered by a safety management program, would signal a high radiation release, and decided that, with the Safety Significant Confinement Ventilation System forthcoming, no change would be made.

3.1.3 Geotechnical Engineering

The assessment team reviewed geotechnical engineering products related to the basis for governing requirements, engineering documents, and ground control.

Basis for Governing Requirements

NWP geotechnical engineering is not designated as a safety management program, as defined in 10 CFR 830.3, *Definitions*. Because the DSA did not determine geotechnical engineering to be necessary for mitigating hazards to nuclear safety, its requirements do not flow explicitly from DOE Order 420.1C. Therefore, the requirements established by the Mine Safety and Health Administration (MSHA), and applied and enforced through a memorandum of understanding between DOE and MSHA, govern WIPP geotechnical engineering.

Previous oversight activities by EA and the Defense Nuclear Facilities Safety Board have questioned whether 10 CFR 830 should apply to geotechnical engineering based on a concern that ground control processes are needed to mitigate and/or prevent a hypothetical roof fall event that may not have been adequately evaluated in the current WIPP DSA. The assumption in the DSA that a postulated roof fall event, prior to mine closure, would not involve the full length of a room is rooted in the well-controlled condition of the ground in the mine and the subsequent predictability of ground movement. However, this predictability is provided by the conduct of effective mine ground control, which is guided by effective geotechnical engineering, thus making geotechnical engineering necessary to protect assumptions applied to safety basis analyses.

WIPP-019, *WIPP DSA External Event and Natural Hazard Phenomena (NHP) Event Hazard Analysis (HA) and Accident Analysis (AA) Calculations*, Rev. 12, supports the WIPP safety basis to evaluate a worst-case roof fall event involving the full length of a room, and determined that the unmitigated consequences would not require hazard controls to meet the applicable evaluation guideline. Therefore, based on the current safety basis analyses, the explicit requirements of 10 CFR 830 and DOE Order 420.1C have not been directly applied to the evaluation of geotechnical engineering processes for this current EA assessment. MSHA requirements, and other requirements that have been established by the implementation of NWP procedures, help define the criteria upon which evaluations in this assessment are made.

Engineering Documents

WIPP ground support systems are designed and maintained through implementation of the NWP geotechnical engineering processes, and are governed by the ground control requirements of 30 CFR 57, *Safety and Health Standards - Underground Metal and Nonmetal Mines*; the ground control requirements of the Hazardous Waste Facility Permit; the related requirements of the U.S. Environmental Protection Agency; and the policies and procedures established by DOE and NWP for implementing these requirements. The assessment team evaluated numerous engineering documents relating to geotechnical engineering, including two ECNs/ECOs, one SDD (AU00, *Underground Facilities and Equipment*), procedures and analyses related to design, system component performance, and surveillance of the overall system performance for compliance with these applicable requirements. The reviewed analyses and procedures, and the processes that they support, were generally found to be based on sound geotechnical engineering principles and practices, and were in accordance with applicable laws, regulations, and procedures. With the exceptions noted below, all adequately met requirements for technical quality.

- ECN 14123, *Crib Installation on South End of Mine*, contains ETO (Technical Operability Evaluation; Evaluation of Technical Operability) F-397, *Fire Safety Assessment for ECN 14123*. The ETO includes a calculation, and contrary to WP 09-CN3031, *Engineering Calculations*, neither ECN 14123, F-397, nor the calculation contained within received the independent review required for design calculations. (See **Deficiency D-NWP-4**.)

- An email titled, *Removing failed roof bolt plates from the back*, dated October 22, 2019, and attached to WF 19-862, contains detailed information that would normally be incorporated into a procedure or other more permanent reference in accordance with Section 2.p of DOE Order 422.1, *Conduct of Operations*. When not contained in a controlled document, the detailed direction provided in this email will not be subjected to the same level of periodic review, testing, and control that DOE Order 422.1 requires. (See **Deficiency D-NWP-7**.)

Products Specific to Ground Control

A general description of the ground control processes that flow down from NWP geotechnical engineering is in WP 02-AD.22, *Mine Ground Control Guide*. This guide adequately explains the potential ground failure mechanisms applicable to WIPP, as well as monitoring, evaluation, and maintenance activities necessary to ensure worker safety and mine habitability. Photographs of actual mine conditions shown in WP 02-AD.22 provide useful examples of underground conditions. For many of the activities described in the guide, such as periodic inspections, instrument installation, and bolt installation, reference is made to appropriate technical procedures. However, WP 02-AD.22 also provides the criteria for determining that an area should be either restricted or prohibited, and describes the actions required to be taken. Such criteria are required by WP 04-CO.01-16, *Conduct of Operations Program – Operations Procedures*, to be in a technical procedure. (See **Deficiency D-NWP-8**.)

As discussed below, processes used for ground control include visually inspecting underground openings, monitoring roof beam expansion and vertical convergence, and tracking and analyzing support component failures (e.g., in situ testing; evaluation of ground control components and systems in the field; and roof bolt safety factors, which describe the ability of intact bolts to safely carry the roof beam load). Together, these processes help establish the ground control system, which is relied upon to predict and prevent potentially hazardous ground movement in the mine.

Inspections

WP 02-AD.22 provides guidance to perform mine inspections, some of which are required by MSHA regulations and implemented through other NWP procedures. "Shiftly" (i.e., once per shift) inspections, as described in WP 02-AD.22, Section 4.2.1, *Shiftly Inspections*, are to be performed by a competent person before work begins, and identify and document conditions that may adversely affect safety or health. Daily inspections, as described in WP 02-AD.22, Section 4.2.2, *Daily Inspections*, examine and test ground conditions in areas where work is to be performed, prior to work commencing, after blasting, and as ground conditions warrant during the work shift. Annual inspections, as described in WP 02-AD.22, Section 4.2.5, *Annual Inspections*, are physical inspections of all accessible areas to identify cracks, fractures, separations, and loose ground and roof bolts. NWP is not performing either the shiftly or daily inspections, as required by 30 CFR 57.18002, *Examination of working places*; 30 CFR 57.3401, *Examination of Ground Conditions*; and NWP procedures WP 04-AU2006, *Underground Work Area Shiftly Inspection*, and WP 04-AU1007, *Underground Openings Inspection Procedure*. In addition, NWP has not provided documentation that annual inspections are being performed, as required by WP 04-AU1007. (See **Deficiency D-NWP-9**.)

Nine weekly inspection reports reviewed by the assessment team met technical requirements and show that weekly inspection records are being adequately maintained in accordance with 30 CFR 57.3401 and WP 04-AU1007. However, because the required weekly inspection record (form) simply captures the unanalyzed observations of the individual conducting the examination, little indication is provided in the record as to whether a true hazard exists as the result of an observed condition. For example, an observed condition may indicate numerous broken or dislodged roof bolts; however, the area where the observation is recorded may be barricaded to prevent entry and posted in accordance with MSHA regulations and WIPP procedures. In this case, the degraded condition of the roof bolts would not constitute a hazard requiring immediate action. In addition, the form used to record the weekly inspection observations does not allow for characterizing the fraction of failed roof bolts, which indicates the roof bolt safety factor in a given segment of roof, and thereby the significance of a given observation (e.g., 20 broken bolts out of 1000 intact in a roof segment versus 20 broken out of 100). (See **OFI-NWP-4**.)

Convergence Monitoring

The most revealing parameter to indicate deteriorating roof conditions is the rate of vertical displacement of the roof in a section of mine drift, referred to as convergence. Increasing or accelerating rates of displacement are an indication of instability.

The most common convergence monitoring instruments in the WIPP Underground are radial convergence (RC) points, which are used to measure roof-to-floor convergence and provide the most critical information for identifying deteriorating roof conditions. RC points are manually monitored in accessible areas of the mine at least monthly. RC measurements and geotechnical engineering determinations based on those measurements were reviewed during previous operational awareness visits and found to be valid. Measurements were made in appropriate locations, and the resulting displacement rates were properly applied to restricting or prohibiting access, or determining that the conditions did not pose a hazard.

Extensometers are used to measure the dilation (expansion) of the roof from anchors installed in boreholes. The reviewed cognizant system engineer (CSE) records indicate that many of the extensometer measuring points have either exceeded their useful life, or are no longer operable. However, because extensometer measuring points in critical locations, such as in active waste rooms, are maintained and operable, the risk to worker safety and health is reduced.

Wire convergence meters (WCMs) are mostly used to remotely measure roof-to-floor convergence. WCMs require a mechanical connection between the sensing element of the instrument, which can be located either on the floor or back, and the opposite surface. Such connections can obstruct vehicle traffic; therefore, WCMs are normally installed in restricted areas prior to the area being designated as prohibited. Geotechnical engineering records reviewed show that many of these devices are no longer operable at WIPP. These devices provide useful information for increasing the understanding of roof behavior, but like extensometers, WCMs are typically located in prohibited or inaccessible areas, and therefore, their lack of operability does not significantly increase risks to worker safety and health.

Convergence monitoring systems have deteriorated since the WIPP shutdown in 2014. (See **OFI-NWP-5**.) However, NWP geotechnical engineering maximizes the use of available information, and the measurements and analyses that are conducted provide adequate assurance that areas of the mine where ground conditions are declining are identified and corrected before posing a hazard to workers.

Support Component Surveillance

Surveillances of the ground control systems provide data to support the continuous assessment of the design for underground facilities; provide for the early detection of conditions that could affect operational safety; evaluate disposal room closure to ensure adequate access; provide guidance for design modifications and remedial actions; and support interpreting the behavior of underground openings compared to the established design criteria. For all evaluated surveillance records, appropriate conclusions were drawn associated with the observed ground and roof bolts conditions. In addition, adequate roof bolt safety factors were being maintained, and areas were restricted or prohibited appropriately.

3.1.4 Contact Handled Waste Handling Confinement Ventilation System

Although not part of the UVS, the credited HEPA filter efficiency associated with the safety-significant Contact Handled Waste Handling Confinement Ventilation System (CHWHCVS) is not consistent throughout the DSA and TSR. Specifically, Section 4.4.6, *Contact Handled Waste Handling Confinement Ventilation System*, performance criteria establishes that the CHWHCVS HEPA filters shall provide filtration efficiency of greater than (>) 99.95% for particles with an aerodynamic equivalent diameter between 0.3-0.7 micrometers. However, the DSA Table 4.4.6-2 performance evaluation for the CHWHCVS and the associated safety basis accident analysis, conservatively assume a filter efficiency of > 99% for particles with an aerodynamic equivalent diameter between 0.3-0.7 micrometers. In addition, TSR Limiting Condition for Operation (LCO) 3.2.1 requires an "IN SERVICE HEPA" filter unit efficiency of greater than or equal to (≥) 99%, and TSR Surveillance 4.2.1.4 requires verification that each HEPA filter bank of each IN SERVICE HEPA filter unit has an efficiency of ≥ 99%. Therefore, though the DSA performance evaluation and TSR are consistent with the credited accident analysis, they are not consistent with the performance criteria established in the DSA for the CHWHCVS, contrary to DOE-STD-3009-2014 requirements. Currently, this error has not resulted in a non-conservative analysis; however, it can potentially result in the elimination of operational margin between the analyzed and operationally maintained HEPA filtration efficiency. (See **Deficiency D-NWP-10**.)

3.1.5 Engineering Products Conclusions

Overall, the engineering products that result from the NWP engineering program were found to be generally adequate; the program has continued to mature since the events of February 2014. Program enhancements, such as unverified assumption tracking, the validation of airflow modeling software used for ventilation engineering processes, and the development and implementation of WP 02-AD.22 to guide geotechnical engineering processes, strengthen the technical integrity of program processes. However,

the assessment team identified numerous problems with engineering products, including incorrect identification of system boundaries, inadequate design inputs in calculations, and no evidence of design verification for some calculations included in change packages. Further, the assessment team identified weaknesses associated with the inadequate implementation of inspection requirements and incorrect classification of procedural requirements versus guidance.

3.2 Cognizant System Engineer Program

The objective of this portion of the assessment was to evaluate whether NWP has implemented a CSE program in accordance with DOE Order 420.1C, addressing CSE training and qualification, ownership of system documentation, and system health reporting.

NWP has a robust CSE program, with CSEs assigned to all systems regardless of their functional classification. Therefore, not only are safety significant systems assigned a CSE in accordance with DOE Order 420.1C, Attachment 2, Chapter V.3.a.(1), but NWP has also designated CSEs for non-safety underground ventilation systems, ground support systems, as well as additional support staff. Consistent with DOE Order 420.1C, Attachment 2, Chapter V.3.a.(4) requirements, CSEs for both UVS and ground support systems are qualified in accordance with WP 09-CN.08, *WIPP Cognizant System Engineer Training Program Plan (Safety Significant Systems)*.

The assessment team reviewed the UVS and Underground Facilities and Equipment SDDs, both of which showed evidence of adequate CSE involvement in developing and maintaining SDDs. The technical quality of the SDDs was adequate except for the issues associated with the UVS SDD as discussed in Section 3.1.2 of this report.

To meet the requirements of DOE Order 420.1C, Attachment 2, Chapter V.3.a.(2) and V.3.a.(3), both CSEs perform annual system health monitoring following WP 09-CN3025, *System Health Walkdown and Health Reports*, and then make the information available to operations and maintenance organizations. However, a CSE would typically perform system health reporting quarterly to ensure safety controls remain capable of meeting their credited performance. Without frequent reporting of remotely-read ground support system health (e.g., convergence monitoring instruments) by CSEs, funding for replacement of obsolete equipment is more difficult to justify. Currently, WIPP has ground control equipment located in locations inaccessible to the CSE due to area access prohibitions. Although the data from the instruments is not required to protect worker safety, the CSE could use the data to enhance predictions of the future performance of the mine and engineered systems. (See **OFI-NWP-5**.)

Cognizant System Engineer Program Conclusions

The NWP CSE program ensures the continued operational readiness of systems supported by underground ventilation and geotechnical engineers. The CSE program is effective in providing opportunities to maintain awareness of the health of the engineered systems in support of operations and maintenance, and NWP CSEs maintain overall cognizance of the systems to which they are assigned.

3.3 Configuration Management

The objective of this portion of the assessment was to evaluate whether NWP has established and implemented a documented configuration management (CM) program in accordance with DOE Order 420.1C that ensures consistency between system requirements and performance criteria, system documentation, and physical configuration of the systems within the scope of the program.

The NWP CM program is adequately described in WP 09-11, *NWP Configuration Management Plan*. EA previously reviewed the NWP CM processes during the 2015 and 2017 EA assessments. This current assessment confirmed that the overall design of the CM program continues to adequately address the requirements of DOE Order 420.1C. Because geotechnical engineering is not a nuclear safety management program at WIPP, DOE Order 420.1C requirements do not directly apply. Therefore, geotechnical engineering is not in the scope of the NWP CM program. (See **OFI-NWP-5**.)

To evaluate the implementation of CM for underground ventilation engineering, the assessment team reviewed the UVS flow models, the SDD for the UVS, and the Mine Ventilation Plan (MVP) for consistency. The UVS uses ventilation ducts and auxiliary fans that are locally installed and operated in the Underground to increase the circulation of air through specific work areas. The operating status of these fans is not currently required to be monitored by the Central Monitoring System. However, three auxiliary fans located near the base of the waste shaft must operate during waste movement to provide the necessary air flow. Although air flow modeling software has now been validated, which corrected a previously identified EA finding, design inputs to the UVS flow models do not account for the system boundaries and interfaces of locally installed and regularly used ventilation ducts and auxiliary fans. Consequently, the DSA Section 4.4.5.4, *System Evaluation*, system performance evaluation, which cites these flow models, does not acknowledge the installation of these auxiliary fans and does not state and justify that there is no impact on overall air movement. (See **OFI-NWP-2**.)

Further, NWP 00CD-0001, *Mine Ventilation Plan*, Rev. 43 was last updated in January 2018, rather than annually, as required by 30 CFR 57.8520. The development of an accurate MVP is the responsibility of the NWP Engineering organization. The lack of a baseline calculation of mine ventilation flows that accurately reflect the actual underground air movement and conditions is a vulnerability to the safe operation of WIPP. Inadequate documentation of underground ventilation flows on MVP Maps and Mine Escape and Evacuation Plans can create unnecessary confusion and possibly lead to chaos in the event of an emergency evacuation of the mine. The significance of this issue grows as more changes are made to the mine and the UVS. MSHA has also identified this noncompliance, as documented in MSHA Citation/Order Number 8966078, issued 12/07/2020. MSHA has also identified this noncompliance, as documented in MSHA Citation/Order Number 8966078, issued 12/07/2020. (See **Finding F-NWP-2**.)

Fulfilling the objective of CM is accomplished in part through the important elements of document and change control. As stated, there have been numerous changes to the UVS that are not documented in the MVP. However, there is no change control process in place to post change notices to the MVP, identifying interim changes affecting underground ventilation pending the required annual update. CM requires system changes to be continuously documented in order to determine whether these system modifications create a potential hazard, violate additional MSHA requirements, or create situations that contribute to difficulties or challenges in meeting other requirements. Some of the more significant departures from the Carlsbad Field Office-approved MVP include deviations in airflow direction underground (as observed during site visits); the addition and operation of auxiliary fans; the addition and operation of diesel equipment underground; and ventilation system changes, such as modification of SVS fan operation.

Configuration Management Conclusions

NWP has established and implemented a CM program in accordance with DOE Order 420.1C. In general, the NWP CM program helps to ensure consistency between UVS requirements and performance criteria, system documentation, and the physical configuration of the systems within the scope of the program where applicable. However, the incorporation of auxiliary fans in the Underground without addressing them in safety basis documentation, and the lack of updates made to the MVP, reflect weaknesses attributed to inadequate CM program implementation.

3.4 Engineering Program Issues Management

The objective of this portion of the assessment was to evaluate whether the NWP issues management program is adequately implemented within the Engineering organization for underground ventilation and geotechnical engineering. This assessment includes evaluating whether individual engineers identify and document problems when they occur, and whether corrective action plans correct the problems that have been identified by addressing both extent of condition and recurrence control where appropriate.

WFs are documents used to input identified issues into the WIPP Issues Management Processing System for resolution by management. The assessment team reviewed all 30 issues identified over the last 2 years related to the UVS, as captured in WFs, and all were satisfactorily managed. The resulting corrective actions were determined and accomplished in a timely manner and were generally effective in correcting the problem.

Further, the assessment team reviewed all 21 issues identified over the last 2 years related to ground control and geotechnical engineering, as captured in WFs, and all but one were satisfactorily managed. As discussed in Section 3.1.3 of this report, for WF 19-862, an email was used to provide technical direction for work, instead of a more formal method such as work instructions or procedures.

During a previous assessment, EA noted that not all issues of concern are tracked with WFs, as some are addressed directly with Action Requests (ARs). ARs are generally used to capture maintenance requests with varying levels of significance and technical complexity. For example, as discussed in Section 3.5, a previously identified EA finding was temporarily resolved in a satisfactory manner, but the issue reoccurred. By not always documenting issues of concern with WFs, there is a missed opportunity to comprehensively track and trend all repeat problem areas. (See **OFI-NWP-6**.)

Engineering Program Issues Management Conclusions

In general, the NWP issues management program is adequately implemented for underground ventilation and geotechnical engineering. Problems are identified when they occur, and engineers appropriately develop corrective action plans to correct the problems that have been identified.

3.5 Follow-Up on Previous Finding

The objective of this portion of the assessment was to evaluate whether NWP prepared, implemented, and tracked to completion corrective actions to address findings identified in EA assessment reports. In accordance with DOE Order 227.1A, EA performs follow-up reviews of issues identified as findings in prior assessment reports to ensure that those issues have been adequately addressed by the facility or site assessed.

Finding F-NWP-02 from the 2015 EA assessment stated that WP 09-CN3007, *Engineering Change Order Preparation and Design Document Change Control*, Revision 44, did not require documentation of the technical basis for proposed changes to the facility. The 2017 EA assessment followed up on this finding and determined that WP 09-CN3007, Revision 46, included changes requiring documentation of the technical basis for the proposed design change; however, the requirement was removed in Revision 47. The current version of WP 09-CN3007, *Engineering Change Notice*, Revision 50, still does not require documentation of the technical basis for proposed changes to the facility, contrary to 10 CFR 830, Section 830.122 (c)(2). (See **Finding F-NWP-3**.) Therefore, NWP has not adequately addressed this finding. Though this may represent a potential weakness of the NWP issues management program, the issue initially occurred over 5 years ago, and the reintroduction occurred nearly 4 years ago. In both cases, this was prior to significant changes to the NWP engineering management and staff. At this time,

the NWP issues management program is adequately implemented for underground ventilation and geotechnical engineering, as discussed in Section 3.4 of this report.

4.0 BEST PRACTICES

There were no best practices identified as part of this assessment.

5.0 FINDINGS

Findings are deficiencies 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. DOE line management and/or contractor organizations must develop and implement corrective action plans for findings. Cognizant DOE managers must use site- and program-specific issues management processes and systems developed in accordance with DOE Order 226.1, *Implementation of Department of Energy Oversight Policy*, to manage the corrective actions and track them to completion.

Nuclear Waste Partnership, LLC

Finding F-NWP-1: NWP does not meet the functional requirements for the installed UVS design, as specified in SDD VU00, *Underground Ventilation System Design Description*, Section 3.4.1, *System Functional Requirements*. (10 CFR 830, Section 830.122(f)(1))

Finding F-NWP-2: NWP has not annually updated the MVP, and the MVP no longer represents the current configuration of airflow in the mine. MSHA has also identified this noncompliance, as documented in MSHA Citation/Order Number 8966078, issued 12/07/2020. (30 CFR 57, Section 57.8520)

Finding F-NWP-3: NWP does not require documentation of the technical basis for proposed changes to the facility in the ECN process described in WP 09-CN3007, *Engineering Change Notice*. (10 CFR 830, Section 830.122 (c)(2))

6.0 DEFICIENCIES

Deficiencies are inadequacies in the implementation of an applicable requirement or standard. Deficiencies that did not meet the criteria for findings are listed below, with the expectation from DOE Order 227.1A for site managers to apply their local issues management processes for resolution.

Nuclear Waste Partnership, LLC

Deficiency D-NWP-1: NWP does not consistently define system boundaries in SDD VU00, *Underground Ventilation System Design Description*. (WP 09-10, *WIPP Preparation Guide for System Design Description Documents*, Section 4.1.2)

Deficiency D-NWP-2: NWP does not consider the impact of SVS operation on the performance of the UVFS/IVS in SDD VU00, *Underground Ventilation System Design Description*, Section 3.4.9. (WP 09-10, *WIPP Preparation Guide for System Design Description Documents*, Section 3.4.6)

Deficiency D-NWP-3: NWP includes inadequate design inputs in SDD VU00, *Underground Ventilation System Design Description*. (10 CFR 830, Section 830.122(f)(1))

Deficiency D-NWP-4: NWP included a calculation in ETO F-397 and approved engineering changes without adequate independent verification. (WP 09-CN3031 and 10 CFR 830, Sections 830.122(f)(5) and 830.122(f)(4))

Deficiency D-NWP-5: NWP did not reference flow model analyses that consider all approved fan operational alignments in the performance evaluations for UVSs described in the WIPP DSA. (DOE-STD-3009-2014, Section 4.3.X.4)

Deficiency D-NWP-6: NWP includes inadequate design inputs in SRK calculation DC-486300.050-02, *Increased Flow to the North Circuit via Increased SVS Fan Flow*. (10 CFR 830, Section 830.122(f)(1))

Deficiency D-NWP-7: NWP did not document instructions used to perform geotechnical engineering and ground control work in an approved work instruction. (DOE Order 422.1, Section 2.p)

Deficiency D-NWP-8: NWP did not incorporate the criteria for determining whether an area of the mine should be restricted or prohibited, or the actions to take once the determination has been made, into an appropriate technical procedure. (WP 04-CO.01-16, *Conduct of Operations Program – Operations Procedures*, and 10 CFR 830, Section 830.122(d)(1))

Deficiency D-NWP-9: NWP does not perform shiftly, daily, and annual inspections of the Underground facility in accordance with procedural requirements and regulations. (WP 04-AU2006, *Underground Work Area Shiftly Inspection*; WP 04-AU1007, *Underground Openings Inspections*; and 30 CFR 57, Sections 57.18002, *Examination of working places*, and 57.3401, *Examination of ground conditions*)

Deficiency D-NWP-10: NWP presents performance criteria in conflict with the performance evaluation and the TSR for the safety-significant Contact Handled Waste Handling Confinement Ventilation System as discussed in the WIPP DSA. (DOE-STD-3009-2014, Section 4.3.X.4)

7.0 OPPORTUNITIES FOR IMPROVEMENT

The assessment team identified six OFIs to assist cognizant managers in improving programs and operations. While OFIs may identify potential solutions to findings and deficiencies identified in assessment reports, they may also address other conditions observed during the assessment process. These OFIs are offered only as recommendations for line management consideration; they do not require formal resolution by management through a corrective action process and are not intended to be prescriptive or mandatory. Rather, they are suggestions that may assist site management in implementing best practices or provide potential solutions to issues identified during the assessment.

Nuclear Waste Partnership, LLC

OFI-NWP-1: Consider revising WP 09-8, *WIPP Specification Preparation*, to require that any special shipping, storage, or handling requirements be addressed in the specification.

OFI-NWP-2: Consider documenting the existence of auxiliary fans incorporated into the UVS in the DSA Table 4.4.5-2 performance evaluation and providing confirmation therein that operation of the auxiliary fans does not result in adverse consequences to the required airflow at the waste face and the required differential pressure across safety-significant Bulkhead 308.

OFI-NWP-3: Consider revising procedures PM041214 and PM041155 to require documentation of, or reference to, key test data in support of HEPA surveillance testing, including measured aerosol concentrations downstream of underground exhaust HEPA filters and filter efficiency test flow rates. In addition, consider modifying the downstream filter test manifold to ensure better sample mixing, more accurately measure filter efficiency, and meet the current ASME AG-1 standard; reference the recommendations in ETO-K-008.

OFI-NWP-4: Consider providing additional guidance in WP 04 AD.22, *Mine Ground Control Guide*, Section 4.2.3, *Weekly Inspections*, for examining underground conditions to characterize the hazard associated with ground condition observations made during weekly inspections.

OFI-NWP-5: Consider benchmarking other DOE sites and implementing guidance and instructions for more frequent system health reporting (e.g., quarterly), as well as more formal control of changes to convergence monitoring equipment and other implemented ground support systems. Implementing formal processes to manage changes to ground support systems driven by geotechnical engineering analyses would be beneficial to managing the configuration of ground support systems and associated design documentation.

OFI-NWP-6: Consider establishing a process to periodically audit each of the other issue/action tracking systems that can capture potential WF issues to verify that a WF has also been created and used to input those issues into the WIPP Issues Management Processing System, as appropriate.

8.0 ITEMS FOR FOLLOW-UP

EA plans to perform field-level observations of underground ventilation and ground support system implementation and surveillance.

Appendix A
Supplemental Information

Dates of Assessment

Remote Assessment: April – August 2020

Office of Enterprise Assessments (EA) Management

John E. Dupuy, Acting Director, Office of Enterprise Assessments
Kevin G. Kilp, Acting Director, Office of Environment, Safety and Health Assessments
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