Office of Enterprise Assessments
Review of the
Waste Isolation Pilot Plant
Recovery Plan for Operating Diesel Equipment with Available Underground Airflows

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Table of Contents

Acronyms

AIB	Accident Investigation Board
CAP	Corrective Action Plan
CBFO	Carlsbad Field Office
cfm	Cubic Feet per Minute
CFR	Code of Federal Regulations
CO	Carbon Monoxide
DOE	U.S. Department of Energy
DPM	Diesel Particulate Matter
EA	Office of Enterprise Assessments
EPA	Environmental Protection Agency
ESS	Evaluation of the Safety of the Situation
HEPA	High Efficiency Particulate Air
hp	Horsepower
$\mu g/m^3$	Micrograms per Cubic Meter
MSHA	Mine Safety and Health Administration
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NWP	Nuclear Waste Partnership, LLC
OFI	Opportunity for Improvement
PI	Particulate Index
POD	Plan of the Day
rpm	Revolutions per Minute
TC	Total Carbon
TLV	Threshold Limit Value
TRU	Transuranic
WIPP	Waste Isolation Pilot Plant

EXECUTIVE SUMMARY

The Office of Nuclear Safety and Environmental Assessments, within the U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA), conducted an independent review of the adequacy of the Waste Isolation Pilot Plant (WIPP) plan for safely operating diesel equipment underground to support ongoing recovery and rehabilitation efforts during significantly restricted underground airflow conditions. EA conducted the onsite portion of its review during June 10-12, August 12-13, and October 14-16, 2014.

The current conditions at WIPP present significant challenges to safe operation of underground diesel equipment. Since a radioactive release event in February 2014 involving a transuranic waste container, high efficiency particulate air filters have been required to be in service to remove radioactive particles and mitigate further radioactive releases. However, using these filters also significantly restricts the total airflows in the underground working areas.

The site contractor (Nuclear Waste Partnership, LLC (NWP)) and the responsible DOE field office (the Carlsbad Field Office (CBFO)) recognize that ventilation will be a significant challenge as the recovery efforts progress because of the significantly reduced airflow. They have devoted significant attention to developing the WIPP Recovery Plan for Operating Diesel Equipment with Available Underground Airflows and to the long-term plan to upgrade the ventilation systems.

However, the current version of this Recovery Plan is not fully sufficient to ensure safe conditions underground. The most significant concern is that NWP does not have a sound engineering approach for determining the minimum ventilation rates that will ensure safe conditions for underground workers. In addition, the WIPP Ventilation Plan, a document required by the Mine Safety and Health Administration (MSHA) to provide comprehensive information on ventilation, does not reflect current conditions and is missing some key information necessary for managing safety. Further, some diesel engines at WIPP have not been approved for use by the MSHA, and WIPP lacks enough information about this equipment to determine the minimum ventilation needed to protect workers. The identified deficiencies are significant and need to be addressed before WIPP begins to use diesel engines underground. Although operation of diesel equipment at WIPP under the current conditions will be challenging, it can be accomplished safely underground if appropriate safety controls and restrictions are developed using a sound engineering approach.

Since the EA review, NWP and CBFO have accepted the need to address the identified deficiencies and have initiated some positive steps, such as evaluating compensatory measures and seeking external expertise to help review, evaluate and recommend solutions to the ventilation needs for diesel equipment operations. Although these steps are encouraging, increased management attention is needed to ensure that the required improvements are made before WIPP starts to operate diesel engines underground. In addition, management attention is needed to ensure that WIPP receives all the needed technical support and expertise to ensure the return to underground diesel generator operations is safe.

Office of Enterprise Assessments
Review of the Waste Isolation Pilot Plant
Recovery Plan for Operating Diesel Equipment with Available Underground Airflows

1.0 PURPOSE

The Office of Nuclear Safety and Environmental Assessments, within the U.S. Department of Energy (DOE) Office of Enterprise Assessments (EA), conducted an independent review of the adequacy of the Waste Isolation Pilot Plant (WIPP) plan for safely operating diesel equipment underground to support ongoing recovery and rehabilitation efforts during significantly restricted underground airflow conditions. EA conducted the onsite portion of its review during June 10-12, August 12-13, and October 14-16, 2014.

The current conditions at WIPP present significant challenges to safe operation of underground diesel equipment. Since a radioactive release event in February 2014 involving a transuranic (TRU) waste container, high efficiency particulate air filters have been required to be in service to remove radioactive particles and mitigate further radioactive releases. However, using these filters also significantly restricts the total airflows in the underground working areas.

2.0 SCOPE

EA assessed the adequacy of the WIPP Recovery Plan for Operating Diesel Equipment with Available Underground Airflows (the Recovery Plan), which is one important element of WIPP's broad effort to recover from the February 2014 event. EA focused on the scope, content, and initial implementation of the Recovery Plan, which describes WIPP's approach for using diesel equipment in the underground areas during the initial stages of repository rehabilitation and recovery.

3.0 BACKGROUND

WIPP is the nation's only deep geologic repository for permanent disposal of defense-generated TRU waste. WIPP is located in southeast New Mexico, about 26 miles from Carlsbad, and is managed by Nuclear Waste Partnership, LLC (NWP). Within DOE, the Office of Environmental Management's Carlsbad Field Office (CBFO) has primary responsibility for oversight of WIPP.

WIPP was constructed in the 1980s for underground disposal of TRU waste and, since 1999, has been accepting TRU waste from 22 generator sites across the United States. TRU waste is long-lived and must be isolated to protect public health and the environment. Waste canisters are placed in rooms mined from a 2,000 foot thick salt bed to isolate them from the environment and prevent radioactive materials from reaching the groundwater.

WIPP experienced two recent events that raised questions about safety management practices. The first, on February 5, 2014, was an underground mine fire involving a salt haul truck; the fire is believed to have originated in the truck's engine compartment, with hydraulic fluid and/or diesel fuel contacting hot surfaces on the truck, possibly the catalytic converter, and then igniting. The DOE accident investigation board (AIB) identified the root cause of this accident as the failure of NWP and the previous management and operations contractor to adequately recognize and mitigate the underground fire hazards. This root cause encompasses insufficient attention to the recognition and removal of combustible materials through inspections and periodic preventive maintenance (e.g., cleaning) and the earlier decision to deactivate the truck's automatic onboard fire suppression system.

The second event was a radioactive release on February 14, 2014. In this event, americium and plutonium were released when one or more TRU waste containers failed as a result of an energetic reaction. The exact cause and mechanism of the release are still being investigated, but the result was a failed container, a fire/reaction, and an underground dispersal of airborne contaminants. The contaminated airborne release was detected by an underground continuous air monitor and then directed through HEPA filter banks located in the surface exhaust building. However, a measurable portion of the contaminants bypassed the HEPA filters via design leakage through two ventilation system dampers and was discharged directly to the environment from an exhaust duct. Trace amounts of americium and plutonium were detected off site. For this event, the AIB concluded that a thorough and conservatively considered hazard analysis, coupled with a robust, tested, and well maintained HEPA filter capable exhaust ventilation system, could have prevented the unfiltered aboveground release.

WIPP uses a ventilation system to ensure that underground air is circulated and that conditions are safe for the workers. The total airflow into the repository is split into four distinct intake ventilation circuits: the North Circuit, the Construction Circuit, the Disposal Circuit, and the Waste Shaft Circuit. In normal repository operations, the airflow capacity of the ventilation systems is about 425,000 cubic feet per minute (cfm). However, since the February 14, 2014, release event, the ventilation system has been operated in filter mode (i.e., with air exhaust routed through the HEPA filters) to remove contaminants and prevent further releases to the environment. While in filter mode, the airflow capacity of the ventilation systems is about 60,000 cfm, significantly less than in normal operations.

Various underground activities need to be performed to inspect systems and components and maintain the repository. Some of these activities require the use of diesel equipment, such as roof bolters, forklifts, and scissor lifts. NWP developed its WIPP Ventilation Plan, as required by 30 CFR §57.8520, *Ventilation Plan*, which includes a description of the use of diesel powered equipment. In addition, as the recovery progresses, NWP will need to use diesel equipment to repair damage and install new equipment (e.g., an enhanced ventilation system, supplemental roof control, and panel closure).

NWP recognizes that the drastically reduced airflow at WIPP (about 60,000 cfm in filter mode, which is less than one-seventh of the normal air capacity of 425,000 cfm) is a significant challenge. The drastically reduced airflow limits the ventilation system's ability to dilute diesel exhaust gases to concentrations that are harmless to workers and to carry the gases away from the work areas. As a result, the mine recovery activities may be limited by the ability to operate the diesel engines safely. Accordingly, NWP developed the Recovery Plan, which is the subject of this EA assessment.

4.0 METHODOLOGY

To understand NWP's Recovery Plan, EA reviewed the WIPP Ventilation Plan, MSHA regulations and procedural manuals, and other pertinent documents. EA met with appropriate responsible officials from the CBFO and NWP to gain an understanding of NWP's plans and limitations in ensuring that workers are protected from toxic and noxious diesel emissions. At the time of the onsite portions of this review, underground diesel equipment operations were not permitted because of the radiological conditions in the repository. As such, EA did not observe the actual underground operation of diesel equipment or confirm conformance with the Recovery Plan but will do so when diesel operations underground are resumed.

Nevertheless, EA evaluated WIPP performance against applicable MSHA regulations. MSHA regulations are implemented by the WIPP Worker Safety and Health Program Description Document, WP 15-GM.02 Rev.9 , which implements Title 30 CFR *Mine Safety and Health Administration* Parts 47, 48, 49, 57, and 62 "Safety and Health Standards-Underground Metal and Nonmetal Mines." These regulations are applied for worker protection and consistency throughout the WIPP site, for purposes of

Part 851; however, it applies only to the WIPP site underground area and related surface structures, including all shaft collars and hoist houses, and the operation of all WIPP hoists, including the waste hoist operating station, which are also invoked by 10 CFR 851. MSHA regulations reviewed include:

- Title 30 CFR §57.8520, which requires development of a ventilation plan
- Title 30 CFR §57.5067, which addresses requirements for diesel engines.

EA also evaluated performance against the WIPP Ventilation Plan, which was developed in accordance with 30 CFR §57.8520.

Appendix A provides supplemental information about the EA team and management. Appendix B summarizes some of the EA team's key activities, including key documents reviewed, interviews, and observed activities. Appendix C provides additional information about diesel equipment at WIPP and regulations for testing diesel equipment.

5.0 RESULTS

The EA review identified concerns about the Recovery Plan in the following three areas:

- The WIPP Ventilation Plan
- Restricted diesel equipment
- Minimum ventilation for operation of diesel equipment.

5.1 WIPP Ventilation Plan

Adequate ventilation is essential to safe operation of any underground mine/repository. An up-to-date and accurate ventilation plan is vital to ensuring that workers are protected during normal operations and emergency situations and that critical and often lifesaving information is provided to individuals going underground and to mine officials and government regulators. History shows that when decision makers rely on inaccurate or inadequate mine ventilation plans, mine emergency situations can have disastrous consequences. For these reasons, 30 CFR §57.8520 specifies that mines must establish a written "mine ventilation plan," updated at least annually and with revisions being noted. Inherent in the requirement to establish a mine ventilation plan is that the plan must reflect both the system as it is configured and the actual conditions underground.

Criterion: *The applicable MSHA regulation in 30 CFR § 57.8520, Ventilation Plan, requires in pertinent part:*

Development and adoption of a plan of the mine ventilation system set out by the operator in written form. Revisions of the system shall be noted and updated at least annually. The ventilation plan or revisions thereto shall be submitted to the District Manager for review and comments upon his written request. The plan is required to contain a number of specific items. Those applicable to this review include:

- *The current mine map or schematic or series of mine maps or schematics of an appropriate scale, not greater than five hundred feet to the inch, showing:*
  (1) Direction and quantity of principal air flows;
  (2) Locations of seals used to isolate abandoned workings;
  (3) Locations of areas withdrawn from the ventilation system;

(4) Locations of all main, booster and auxiliary fans;
(5) Locations of air regulators and stoppings and ventilation doors;
(6) Locations of overcasts, undercasts and other airway crossover devices;
(7) Locations of known oil or gas wells;
(8) Locations of known underground mine openings adjacent to the mine;
(9) Locations of permanent underground shops, diesel fuel storage depots, oil fuel storage depots, hoist rooms, compressors, battery charging stations and explosive storage facilities. Permanent facilities are those intended to exist for one year or more; and
(10) Significant changes in the ventilation system projected for one year.

- *Mine fan data for all active main and booster fans, including manufacturer's name, type, size, fan speed, blade setting, approximate pressure at present operating point, and motor brake horsepower rating.*

- *Diagrams, descriptions or sketches showing how ventilation is accomplished in each typical type of working place, including the approximate quantity of air provided, and typical size and type of auxiliary fans used.*

- *The number and type of internal combustion engine units used underground, including make and model of unit, type of engine, make and model of engine, brake horsepower rating of engine, and approval number.*

NWP issued the most recent update to its WIPP Ventilation Plan (00CD-0001 Revision 36) on November 15, 2013. In this document, NWP states, "This plan satisfies the requirements for a mine ventilation plan as required by Title 30 Code of Federal Regulations (CFR) §57.8520, Ventilation Plan, and the New Mexico Safety Code for All Mines. It is based on the current plans, conditions, and assumptions concerning the operation of WIPP. This document will be revised at least annually to reflect any ventilation system changes." EA confirmed that the document has been updated at least annually since 2000.

However, EA's review of the WIPP Ventilation Plan and supporting information identified a number of discrepancies between the Plan and actual mine conditions, as well as several deficiencies in the content of the plan (see Finding **F-WIPP-1** and **OFI-WIPP-1**). For example:

- The WIPP Ventilation Plan maps indicate that the E-300 entry is a secondary escapeway, while more recent Evaluation of the Safety of the Situation (ESS) documents (i.e., the October 7, 2014 Underground RBA Map) shows this escapeway as an ESS Prohibited Area. Because the WIPP Ventilation Plan is intended for use in emergency situations, it is essential that it include accurate and current information, even if other documents, such as ESS documents, provide updated information.

- MSHA regulations require two distinct escapeways from all underground workplaces to the surface to ensure that if an event or situation (a mine fire, massive ground failure, or other situation preventing travel through that travel way) impacts the primary escapeway, personnel have a second, unimpeded escape path so they will not be trapped underground. A basic premise of this requirement is that escapeways must be routinely examined to ensure that they are passable. However, it does not appear that the E-300 entry at WIPP is currently available for routine travel. Furthermore, reliance on an entry as an escapeway can be problematic because the design of some entryways could make them impassable for emergency egress (e.g., barriers that cannot readily be opened from the inside).

- The WIPP Ventilation Plan is lacking diagrams, descriptions, or sketches showing how ventilation is to be accomplished for each typical type of working place[1], including the approximate quantity of air provided. Appendix D of the WIPP Ventilation Plan provides seven typical face ventilation scenarios for configuring local ventilation but does not include the approximate air quantities for these scenarios. Of particular concern, the Plan does not provide ventilation diagrams or minimum air quantities required for conducting supplemental roof bolting operations, which are expected to be one of the most common activities during the initial phases of the recovery.

- The WIPP Ventilation Plan does not adequately address minimum ventilation rates for situations in which multiple diesel units are operated in the same split of air. NWP personnel indicated that the reader is intended to refer to Table 2 of the Ventilation Plan, which specifies the minimum ventilation airflow provided for each diesel operated underground, and to add the airflow values for all diesels operating in the split to determine the overall minimum ventilation required for that split. However, the Plan does not make this process and limitation clear and thus lacks the approximate air quantities for typical working places where diesels are operating, as required by MSHA regulations.

- WIPP recently made a number of alterations and modifications of the main mine fan system to accommodate the current HEPA filtering system but did not revise the WIPP Ventilation Plan accordingly. In addition, the Plan does not provide significant projections for one year and does not address the revised plans the proposed interim ventilation system enhancements for adding filtering capacity, as required by §57.8520 of the MSHA regulations.

- The listing of diesel equipment in Table 2 of the WIPP Ventilation Plan does not provide the MSHA approval numbers, as required by §57.8520(e), for diesel equipment operated underground. At least three diesel Fletcher Roof Bolters are listed as Tier 2 and 3 Environmental Protection Agency (EPA) certified equipment and would be expected to have MSHA approval, but the Plan does not list the MSHA approval numbers for these items (and possibly other equipment).

In a mining/repository operation, it is imperative that individuals understand how the mine is to be ventilated so they can recognize a developing, potentially hazardous situation or system malfunction while they are underground. It is also important to have accurate information for emergency planning and response. The current version of the WIPP Ventilation Plan does not sufficiently meet these needs. In addition, EA's review of this Plan indicated that non-waste handling equipment, such as diesel equipment and ventilation systems, is not subject to effective maintenance, configuration control, and quality assurance processes. (See Finding **F-WIPP-1** and **OFI-WIPP-1**.)

5.2 Restricted Diesel Equipment

Criterion: *The applicable MSHA regulation in 30 CFR § 57.5067, Engines, requires:*

> *(a) Any diesel engine introduced into an underground area of a mine covered by this part after July 5, 2001, other than an engine in an ambulance or firefighting equipment which is utilized in accordance with mine firefighting and evacuation plans, must either:*
>
> *(1) Have affixed a plate evidencing approval of the engine pursuant to subpart E of Part 7 of this title or pursuant to Part 36 of this title; or*
> *(2) Meet or exceed the applicable particulate matter emission requirements of the*

[1] The MSHA regulation, in §57.2 "Definitions," defines "working place" as meaning any place in or about a mine where work is being performed.

Environmental Protection Administration listed in Table 57.5067-1. [Table is omitted for brevity; specifies that the use of EPA Tier 1, 2, 3, or 4 off-road diesel engines is acceptable.]

(b) For purposes of paragraph (a):

(1) The term "introduced" means any engine added to the underground inventory of engines of the mine in question, including:

(i) An engine in newly purchased equipment;
(ii) An engine in used equipment brought into the mine; and
(iii) A replacement engine that has a different serial number than the engine it is replacing; but

(2) The term "introduced" does not include engines that were previously part of the mine inventory and rebuilt.
(3) The term introduced does not include the transfer of engines or equipment from the inventory of one underground mine to another underground mine operated by the same mine operator.

Title 30 CFR §57.8520(e) requires that the ventilation plan include the number and type of internal combustion engine units used underground, including make and model of the unit, type of engine, make and model of engine, brake horsepower rating of engine, and approval number. Table 2 of the WIPP Ventilation Plan is intended to comply with this provision.

The table has a column labeled "MSHA Cert #" that indicates whether each diesel unit has MSHA approval (30 CFR Part 24 or 7 as appropriate) or meets EPA regulations (Tier 1, 2, 3, or 4) for off-road diesel engines. A "NONE" is placed in the column if the equipment has not been confirmed to meet MSHA or EPA engine requirements. While such equipment does not necessarily produce more emissions, the absence of MSHA approval or EPA compliance indicates either that such equipment has not been tested in accordance with the MSHA or EPA regulations, or that it was tested and failed to meet the required emission standards.

A few entries listed in the table appear to provide incomplete information about MSHA approval. For example, several Fletcher Roof Bolters (WIPP Equipment Numbers 74-U-128, 74-U-131, and 74-U-137) are listed as meeting EPA Tier 2 or Tier 3 requirements but their MSHA approval numbers are not listed, even though the equipment is MSHA approved (Approval Numbers 7E-B084 or 7-ENA070006).

More significantly, this table lists ten specific pieces of diesel equipment that do not have MSHA approval or EPA certification. These include six Toyota Forklifts (WIPP Equipment Numbers 52-H-007C, 52-H-033, 52-H-126, 52-H-127, 74-H-026, and 74-H-027), a Yanmar/Hatachi Sanitation Trailer (WIPP Equipment Number 74-GE-001), a Prime Mover Skid Steer (WIPP Equipment Number 74-H-014), and two Yamaha Portable Generators (WIPP Equipment Numbers 74-PE-001 and 74-PE-003). MSHA regulations (30 CFR § 57.5067) prohibit the introduction of diesel engines after July 5, 2001, that are not approved by MSHA or certified by the EPA. NWP has updated its WIPP Ventilation Plan at least ten times since July 2001, and thus has had numerous opportunities to take action to gain approval or certification for all diesel equipment used underground. (See **OFI-WIPP-2.**)

If any of the ten specific pieces of diesel equipment that lack MSHA approval or EPA certification were introduced into the mine after July 5, 2001, NWP would be in violation of MSHA regulations (30 CFR § 57.5067). Although NWP personnel indicated they were not aware of the actual dates these specific pieces of diesel equipment were introduced into the mine, they agreed to gather that information.

Subsequently, NWP reported that all ten diesels were introduced prior to the effective date of the MSHA prohibition. NWP personnel also indicated that they were not aware of the MSHA requirement prohibiting use of off-road diesel equipment that is not MSHA approved or EPA certified. It was also evident that NWP purchasing processes did not consider the MSHA regulation. Although the equipment was introduced prior to July 5, 2001 and no violation has occurred, the presence of equipment that could not readily be verified as certified shows a lack of an NWP process to control introduction of equipment. (See **OFI-WIPP-2**.)

5.3 WIPP Minimum Ventilation for Diesel Operation

As noted in Section 3, the current ventilation system airflow capacity (filtering all the air exhausted from the mine) at WIPP is limited to approximately 60,000 cfm, which is less than normal (non-filter mode) by a factor of more than seven. Still, underground diesel engines must be used for recovery activities (e.g., roof bolters, forklifts, and scissor lifts at a minimum for supplemental roof bolting).

Two types of emissions are of concern to worker safety: gases and particulates. Gases of concern include carbon monoxide (CO), nitric oxide (NO), and nitrogen dioxide (NO_2). MSHA-approved equipment has an MSHA ventilation rate (name plate quantity) that will safely dilute the exhaust gases to levels below the threshold limit values (TLVs) for these gases. Particulates, however, are typically the limiting factor for establishing the minimum ventilation rates to ensure worker safety. MSHA regulations in 30 CFR §57.5060, *Limit on Exposure to Diesel Particulate Matter*, establish that after May 19, 2006, any mine operator must limit the concentration of diesel particulate matter (DPM) to which miners are exposed in underground areas by restricting the average eight-hour equivalent full-shift airborne concentration of total carbon (TC), in areas where miners normally work or travel, to 160 micrograms TC per cubic meter of air (160_{TC} $\mu g/m^3$).

Currently, NWP does not have a sound engineering approach for determining minimum ventilation rates. With the reduced airflow capacity, it is essential that NWP carefully evaluate the use of diesel equipment to ensure that workers are adequately protected. However, discussions with EA, NWP and CBFO indicated that WIPP personnel have limited experience in analyzing equipment and establishing controls to ensure that airflows are sufficient to ensure worker safety (i.e., that airflows are greater than the minimum ventilation rates established by the MSHA approval for the equipment in use). This limited experience is understandable because before the filter mode was necessary, airflows during normal operations were sufficiently high that operation of diesel equipment did not present significant challenges. With the much lower airflow, however, determining the minimum ventilation rates for diesel equipment operation is of vital importance and will become considerably more complex as more work and workers are underground and multiple diesel units are operated. After EA's onsite visit, NWP and CBFO personnel recognized that additional efforts are needed to develop a sound engineering approach that considers all relevant factors (e.g., use of multiple diesel engines at the same time). Though the contractor has recently recognized the scope of the problem, the safety of underground workers cannot be ensured until a sound engineering approach is established for determining minimum ventilation rates. Diesels should not continue operating in the absence of supplemental controls. (e.g., using only MSHA approved equipment, or using other equipment with close scrutiny and measurement of gaseous constituents in the area of equipment operation). Some of the specific issues that NWP and CBFO have not fully addressed are discussed in the following paragraphs. (See **Finding F-WIPP-2** and **OFI-WIPP-3**.)

NWP has not established a method and associated controls to address the range of potential scenarios involving diesel equipment. With total airflow into the mine at only 60,000 cfm, split into four distinct intake ventilation circuits, the intake air available to dilute, render harmless, and carry away diesel exhaust gases will be a challenge based on the information relating to the airflow necessary to control the

diesel exhaust gases. As shown in Appendix C, some of the equipment requires as much as 50,000 cfm to reduce DPM to safe levels. NWP personnel indicated that they plan to develop controls for each work activity, using an activity-specific work plan and approval process. However, the methods for determining minimum airflows are not established, and various related issues need to be addressed. For example, the process for determining the minimum airflow when multiple diesels are in use is not established or institutionalized in the WIPP Ventilation Plan. (See **Finding F-WIPP-2** and **OFI-WIPP-3**.)

Additionally, NWP does not have all the information it needs to determine minimum ventilation. Appendix C lists the diesel equipment that could be used underground at WIPP. For most (but not all) of this equipment, the contractor has MSHA approvals and associated information, including the MSHA ventilation rate (name plate quantity) that will safely dilute the exhaust gases to levels below the TLV for the gases of concern (e.g., CO, NO, and NO_2). For some equipment, WIPP has information about ventilation rates needed to reduce DPM to safe levels. For a few pieces of equipment, the WIPP documents provide no information about minimum ventilation. In addition, NWP personnel were not aware of the basis for the minimum ventilation rates listed in Table 2 of the WIPP Ventilation Plan for equipment listed as EPA Tier certified or for equipment with neither MSHA approval nor EPA certification. They postulated that these ventilation rates were based on the once-used "rule of thumb" of 125 cfm per horsepower (hp); however, examination of this listing demonstrates that this basis could not have been used, since some equipment is listed with higher minimum ventilation rates and some with lower, judging by the rule of thumb. Additionally, MSHA determined that such an approach was inadequate and promulgated a major set of regulations including §57.5060 through §57.5075 to protect miners from exposure to DPM through limiting exposures, specifying maintenance practices, training miners, monitoring the mine environment for DPM and maintaining records of emission measurements. NWP is investigating this issue further and is pursuing a subcontract to develop an engineering basis for defensible minimum ventilation rates for equipment that meets EPA Tier standards but may not also be MSHA approved. (See **Finding F-WIPP-2, OFI-WIPP-2,** and **OFI-WIPP-3**.)

NWP has not fully addressed the condition and maintenance of equipment. The equipment has been underground without regular use or maintenance, at least since the February events. The MSHA gaseous ventilation rate and the particulate index (PI) ventilation rate data apply only to well-maintained equipment that has been maintained in approved condition. Therefore, this information cannot currently be applied at WIPP, since the equipment has been underground without regular use or maintenance. (See **Finding F-WIPP-2** and **OFI-WIPP-4**.)

6.0 CONCLUSIONS

NWP and CBFO recognize that ventilation will be a significant challenge as the recovery efforts progress because of the significantly reduced airflow. They have devoted significant attention to developing the WIPP Recovery Plan for Operating Diesel Equipment with Available Underground Airflows and to the long-term plan to upgrade the ventilation systems.

However, the current version of this Recovery Plan is not sufficient to ensure safe conditions. The most significant concern is that NWP does not have a sound engineering approach for determining the minimum ventilation rates that will ensure safe conditions for underground workers. In addition, the WIPP Ventilation Plan does not reflect current conditions and is missing some information necessary for managing safety. Further, some diesel engines at WIPP have not been approved for use by the MSHA, and WIPP lacks enough information about this equipment to determine the minimum ventilation needed to protect workers. The identified deficiencies need to be addressed before WIPP begins to use diesel engines underground. Although operation of diesel equipment at WIPP under the current conditions will

be challenging, it can be accomplished safely underground if appropriate safety controls and restrictions are developed using a sound engineering approach.

Since the EA review, NWP and CBFO have accepted the need to address the identified deficiencies and have initiated some positive steps, such as evaluating compensatory measures and seeking a qualified consultant to help evaluate ventilation needs for diesel equipment. Although these steps are encouraging, increased management attention is needed to ensure that improvements are made before WIPP starts to operate diesel engines underground. In addition, WIPP personnel do not have significant experience in dealing with activities that are limited by ventilation capacity, which was not an issue during the years of operation before February 2014; additional management attention is needed to ensure that WIPP receives the needed technical support and expertise.

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. Corrective action plans must be developed and implemented for EA 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.

Nuclear Waste Partnership, LLC

Finding F-WIPP-1: The current WIPP Ventilation Plan does not adequately reflect the mine ventilation system as currently configured or the conditions and assumptions governing mine operations under the Recovery Plan.

Finding F-WIPP-2: NWP does not have a sound engineering approach for determining minimum ventilation rates for diesel equipment lacking MSHA 30 CFR Part 7 or Part 24 certification/approval to ensure safe underground diesel equipment operations.

8.0 OPPORTUNITIES FOR IMPROVEMENT

This EA review identified four opportunities for improvement (OFIs). These potential enhancements are not intended to be prescriptive or mandatory. Rather, they are suggestions offered by the EA team to assist site management in implementing best practices, or provide potential solutions to minor issues identified during the review. In some cases, OFIs address areas where program or process improvements can be achieved through minimal effort. It is expected that these OFIs will be evaluated by the responsible line management organizations and accepted, rejected, or modified as appropriate, in accordance with site-specific program objectives and priorities.

Nuclear Waste Partnership, LLC

OFI-WIPP-1: Update the WIPP Ventilation Plan and correct deficiencies and omissions related to the use of diesel equipment underground with the current limited ventilation capabilities in the mine. Specific actions to consider include:

- Ensure that the revised plan specifies the limitations and conditions under which equipment will be operated during initial mine recovery activities, including the workplace ventilation method, the specific equipment that will be operated, the minimum air quantities under specific operating conditions, and the safeguards or other controls in place to ensure safe operation.

- Include the elements of operation and control that are currently in ESS documents and address ventilation in the WIPP Ventilation Plan, including processes to ensure implementation.
- As the ventilation system is modified and the conditions in the repository change as recovery progresses, develop a formal and efficient process for updating the WIPP Ventilation Plan frequently to reflect the current status.

OFI-WIPP-2: Update Table 2 in the WIPP Ventilation Plan to correct deficiencies and clarify ambiguous entries. Specific actions to consider include:

- Ensure that the table identifies equipment that lacks MSHA approval or EPA certification, and include the date when the equipment was put into operation at WIPP.

- Ensure that any equipment that does not comply with the requirements of 30 CFR §57.5067 is removed from service or addressed through a variance process.

- For each entry in the table, identify minimum ventilation rates for gaseous and DPM ventilation, along with the method for the determination (MSHA approval or some other method).

- For the longer term, establish a robust process for ensuring that all equipment has accurate and complete information about MSHA approvals and EPA certification and that NWP can promptly determine when equipment was introduced to the repository in order to demonstrate compliance with date-sensitive MSHA regulations.

OFI-WIPP-3: Establish a comprehensive and robust engineering approach for determining minimum ventilation rates for all equipment and situations. Specific actions to consider include:

- Establish controls to ensure that only diesel equipment with validated minimum ventilation rates for both gaseous and DPM emissions is permitted to be operated underground.

- Establish controls to ensure that diesel equipment used underground is MSHA approved or subject to compensatory controls that provide equivalent protection (e.g., close scrutiny with measurement of gaseous constituents in the area of equipment operation).

- Ensure that the WIPP Ventilation Plan is modified to establish both gaseous and particulate minimum ventilation rates and provides a reliable and regularly updated source of information for use in determining minimum ventilation rates for workplaces and activities.

- Ensure that diesel equipment that does not have gaseous emission minimum ventilation rates (diesel equipment lacking MSHA 30 CFR Part 7 or Part 24 certification/approval) is evaluated to determine the needed information in a timely manner (through engagement of a vendor, subcontractor or other means).

- Identify the diesel equipment that is needed for ground control maintenance and cannot wait for resolution.

- As an interim measure for equipment that has an EPA off-road Tier certification but not MSHA approval, develop a formal process for determining the minimum ventilation rates necessary by applying the available data to set minimum ventilation rates and formalize a calculation for converting EPA Tier data (stated in grams/hp-hour) to the MSHA PI. In developing the process and calculations, consider the following information:

    - MSHA and others reported data that presents the results of tests of over 350 diesel engines, including gaseous emission tests and diesel particulate emissions. The reported data used the Gaseous Ventilation Rates, as determined by MSHA, and the PI, as reported by MSHA, to determine the ventilation rate necessary to dilute the DPM to 1000 micrograms per cubic meter over a full shift. Tests were conducted on engines that have MSHA Approvals and EPA Certification as well as engines that do not have either.

    - These data demonstrate that, for engines 100 hp or less (engines of concern at WIPP), almost all of these engines that meet EPA Tier 1 or 2 have a gaseous ventilation rate of 90 cfm/hp and a PI of 113 cfm/hp. These rates translate to a gaseous ventilation of 9000 cfm to dilute the gaseous emissions and 56,000 cfm to dilute the particulate emissions to the current MSHA full shift standard. These same data show that for diesel engines that do not meet either MSHA or EPA standards, the gaseous ventilation rate would be 259 cfm/hp, requiring about 26,000cfm to dilute a 100hp engine gases to safe levels, and 466 cfm/hp PI, requiring about 46,000 cfm to dilute the DPM to the MSHA full shift standard. (See references Haney 2012 and Stinnette 2013 in Appendix B.)

- Develop a formal process for using MSHA approval information to evaluate the extent to which airflow will dilute the DPM from the diesel exhaust. The MSHA approval (Parts 7 and 36) provides the results of diesel particulate tests of the approved engine in the form of a PI, which is designed to indicate the ventilation rate necessary to dilute the exhausted DPM to 1000 $\mu g/m^3$. The MSHA DPM standard is now 160 $\mu g/m^3$ TC. Therefore, the PI is the ventilation rate to dilute the DPM to an equivalent of 800 $\mu g/m^3$ TC (considering the conversion factor to account for the percentage of carbon). In order to dilute the exhaust to meet the current standard of 160 $\mu g/m^3$, ensure that the minimum ventilation rate is five times the PI ventilation rate.

- Ensure that assessments of the potential exposures recognize that the TC standard is a full shift (eight-hour average) exposure and that the PI is an indication of the airflow necessary to dilute the exhaust of diesel equipment operating for a full eight-hour shift.

- Ensure that the process includes controls that require the use of respirator protection in situations where the workers could be exposed to concentrations of gases or DPM that exceed the established standards.

- Evaluate the many available technologies for reducing DPM, such as filters or scrubbers, instead of relying solely on dilution ventilation. Recognize that for most diesel equipment, the ventilation rates needed to reduce DPM to safe levels are significantly higher than those needed to dilute gaseous emissions to safe levels, so the resulting minimum ventilation rates could be substantially reduced by applying DPM reduction technology.

OFI-WIPP-4: Develop a process for evaluating underground equipment and ensuring that it is suitable for return to service, with consideration of the extended time that it has not been used or maintained. Specific actions to consider include:

- Ensure that maintenance is performed prior to return to service and that emissions are tested or otherwise verified to be within parameters for well-maintained equipment.

- Ensure that the provisions of 30 CFR § 75.1914, *Maintenance of Diesel-powered Equipment* (included in Appendix C of this report) are addressed for initial return to service and ongoing maintenance.
- Consider applying a "loaded, repeated engine condition test," as defined and required for use in underground coal mines as specified in 30 CFR § 75.1914, to identify equipment that is not operating as approved, and compare the test results to a similar loaded condition from the approval test to determine whether the engine is operating within the expected parameters.

9.0 ITEMS FOR FOLLOW-UP

Given the shortcomings of the WIPP Ventilation Plan, the inconsistencies between this Plan and some of the ESS documents, issues involving the application of the MSHA diesel regulations, and the apparent lack of familiarity with the application of these regulations, EA plans to continue to focus on WIPP efforts to ensure that conditions are safe for workers. EA will consider:

- Periodic reviews of the impact of various ESS documents, such as roof bolting, on the adequacy of the WIPP Ventilation Plan.

- Follow-up on resolution of the potential violation involving the use of prohibited diesel equipment underground.

- Follow-up on resolution of minimum ventilation rates for equipment that does not have an MSHA approval with gaseous ventilation rates.

- Assessment of the overall adequacy of the application of the MSHA regulations relating to diesel equipment in underground mines, including the evaluation of DPM and gaseous diesel emissions in the mine, miner training on diesel particulate control, and maintenance of diesel exhaust systems.

Appendix A
Supplemental Information

Dates of Review

Onsite Review: June 10-12, August 12-13, and October 14-16, 2014

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

Quality Review Board

Karen Boardman
William Eckroade
Thomas Staker
William Miller
Michael Kilpatrick

Enterprise Assessments Site Lead

Jeff Snook

Enterprise Assessments Reviewer

Peter M. Turcic

Appendix B
Key Documents Reviewed, Interviews, and Observations

Documents Reviewed:

- *WIPP Recovery Plan for Operating Diesel Equipment with Available Underground Airflows*
- *WIPP Ventilation Plan*
- *NWP CAP, Haul Truck Fire Accident Investigation Board report*, Rev-2
- *POD, Integrated Recovery Plan for WIPP Haul Truck and Radiological Release Events Schedule*, Multiple Revisions, July 21-24 & August 6, 2014
- *30 CFR PART 57—Safety and Health Standards for Underground Metal and Nonmetal Mines*
- *MSHA, Directorate of Technical Support, Approval and Certification Center, List of Approved Products*
- *30 CFR Part 7 Subpart E – Diesel Engines Intended for Use in Underground Coal Mines*
- *MSHA Program Policy Manual Volume IV - Metal and Nonmetal Mines*
- *Haney, R.A.(2012), Ventilation Requirements for Modern Diesel Engines, 14th US/NA Mine Ventilation Symposium, Salt Lake City, Utah*
- *Stinnette, J.D. (2013), Establishing Total Airflow Requirements for Underground Metal/ Nonmetal Mines with Tier IV Diesel Equipment, Mining Engineer Graduate Thesis, Queen's University*

Interviews:

Nuclear Waste Partnership, LLC
- URS Corporation Senior Project Director
- Manager, Underground Operations Integration
- Process Equipment Engineer
- Process System Engineer
- Nuclear Safety SME
- Manager, Geotechnical and Mine Engineering

Carlsbad Field Office
- Facility System SSO
- Mining Ops SSO
- Waste Ops SSO
- Facility Rep

Observations:

- Plan of the Day Meetings (3)

Appendix C
Additional Information about Diesel Equipment and Testing

Diesel Equipment Currently in WIPP

Based on information in the WIPP Ventilation Plan, the types of equipment with MSHA approval (equipment for which a minimum ventilation rate based on gaseous exhaust contaminants is available) include:

- **2 Fletcher 3020N-AD Roof Bolters** with MSHA Approval Number 7-ENA07006 having a Cummings engine rated at 130hp@2500rpm. The ventilation rate necessary to dilute the gaseous emissions is 6000 cfm, and the rate to dilute the DPM to the current MSHA standard is 42,500 cfm.
- **1 Fletcher 3024AD Roof Bolter** with MSHA Approval Number 7E-B084 having a Cummings engine rated at 116hp@2500rpm. The ventilation rate necessary to dilute the gaseous emissions is 6500 cfm, and the rate to dilute the DPM to the current MSHA standard is 37,500 cfm.
- **2 Getman A64 Scissor Lifts** with MSHA Approval Number 24D102-0 having an 82hp engine. The ventilation rate necessary to dilute the gaseous emissions is 7500 cfm. Title 30 CFR Part 24 did not address evaluation of DPM, and it has been superseded by 30 CFR Part 7. However, equipment approved under Part 24 is still permitted for use underground if it was introduced into the mine prior to July 5, 2001.
- **1 Getman A64 Scissor Lift** with MSHA Approval Number 7E-B098 having a Daimler Chrysler engine rated at 174hp@2200rpm. The ventilation rate necessary to dilute the gaseous emissions is 7500 cfm, and the rate to dilute the DPM to the current MSHA standard is 25,000 cfm.
- **1 Taylor TY-820L Forklift** with MSHA Approval Number 24D92-0 having a 231hp engine. The ventilation rate necessary to dilute the gaseous emissions is 20,000 cfm.
- **1 Taylor TYO-400S Forklift** with MSHA Approval Number 24D92-0 having an 185hp engine. The ventilation rate necessary to dilute the gaseous emissions is 16,000 cfm.
- **1 Hoist Lift Truck P260 Forklift** with MSHA Approval Number 07- ENA060010-1 having a Cummings engine rated at 160hp@2300rpm. The ventilation rate necessary to dilute the gaseous emissions is 6500 cfm, and the rate to dilute the DPM to the current MSHA standard is 50,000 cfm.

The types of equipment with EPA certified engines included in the WIPP Ventilation Plan diesel list include:

- **1 Toyota 7FDU70 Forklift** with an 89hp EPA Tier 2 engine.
- **2 Toyota 5FD35 Forklifts** with 89hp EPA Tier 2 engines.
- **1 Genie GS2669RT Forklift** with a 24.5hp EPA Tier 2 engine.

The types of equipment with neither MSHA-approved nor EPA-certified engines included in the WIPP Ventilation Plan diesel list include:

- **3 Toyota 5FD35 Forklifts** with 94hp engines.
- **1 Toyota 7FDU70 Forklift** with an 80hp engine.

Loaded Repeated Engine Condition Test for Underground Diesel Engines

The following information about testing underground diesel engines is extracted from 30 CFR § 75.1914.

Maintenance of diesel-powered equipment.

(a) Diesel-powered equipment shall be maintained in approved and safe condition or removed from service.

(b) Maintenance and repairs of approved features and those features required by Secs. 75.1909 and 75.1910 on diesel-powered equipment shall be made only by a person qualified under § 75.1915.

(c) The water scrubber system on diesel-powered equipment shall be drained and flushed, by a person who is trained to perform this task, at least once on each shift in which the equipment is operated.

(d) The intake air filter on diesel-powered equipment shall be replaced or serviced, by a person who is trained to perform this task, when the intake air pressure drop device so indicates or when the engine manufacturer's maximum allowable air pressure drop level is exceeded.

(e) Mobile diesel-powered equipment that is to be used during a shift shall be visually examined by the equipment operator before being placed in operation. Equipment defects affecting safety shall be reported promptly to the mine operator.

(f) All diesel-powered equipment shall be examined and tested weekly by a person qualified under § 75.1915.

(1) Examinations and tests shall be conducted in accordance with approved checklists and manufacturers' maintenance manuals.

(2) Persons performing weekly examinations and tests of diesel- powered equipment under this paragraph shall make a record when the equipment is not in approved or safe condition. The record shall include the equipment that is not in approved or safe condition, the defect found, and the corrective action taken.

(g) Undiluted exhaust emissions of diesel engines in diesel-powered equipment approved under part 36 and heavy-duty nonpermissible diesel- powered equipment as defined in § 75.1908(a) in use in underground coal mines shall be tested and evaluated weekly by a person who is trained to perform this task. The mine operator shall develop and implement written standard operating procedures for such testing and evaluation that specify the following:

(1) The method of achieving a repeatable loaded engine operating condition for each type of equipment;

(2) Sampling and analytical methods (including calibration of instrumentation) that are capable of accurately detecting carbon monoxide in the expected concentrations;

(3) The method of evaluation and interpretation of the results;

(4) The concentration or changes in concentration of carbon monoxide that will indicate a change in engine performance.