U.S. Department of Energy
Office of Environmental Management

Accident Investigation Report

Underground Salt Haul Truck Fire at the Waste Isolation Pilot Plant February 5, 2014

March 2014

Disclaimer

This report is an independent product of the Accident Investigation Board appointed by Matthew Moury, Deputy Assistant Secretary, Safety, Security, and Quality Programs, U.S. Department of Energy, Office of Environmental Management. The Board was appointed to perform an Accident Investigation and to prepare an investigation report in accordance with Department of Energy (DOE) Order 225.1B, Accident Investigations.

The discussion of the facts as determined by the Board and the views expressed in the report do not assume and are not intended to establish the existence of any duty at law on the part of the U.S. Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

Release Authorization

On February 7, 2014, an Accident Investigation Board was appointed to investigate a fire at the U.S. Department of Energy, Waste Isolation Pilot Plant site near Carlsbad, New Mexico, that occurred on February 5, 2014. An aged EIMCO 985-T15 dump truck (salt haul truck) caught fire in the underground. The Board's responsibilities have been completed with respect to this investigation. The analysis and the identification of the contributing causes, the root cause and the Judgments of Need resulting from this investigation were performed in accordance with DOE Order 225.1B, *Accident Investigations*.

The report of the Accident Investigation Board has been accepted and the authorization to release this report for general distribution has been granted.

MB Moury

Matthew Moury
Deputy Assistant Secretary
Safety, Security, and Quality Programs
Office of Environmental Management

3/13/14

Date

Table of Contents

Figures

Tables

Acronyms

ALARA	As Low as Reasonably Achievable
BNA	Baseline Needs Assessment
CAS	Contractor Assurance System
CBFO	Carlsbad Field Office
CC	contributing cause
CH	contact handled
CHAMPS	Computerized History and Maintenance Planning System
CLR	Conveyance Loading Room
CMC	Carlsbad Medical Center
CMR	Central Monitoring Room
CMRO	Central Monitoring Room Operator
CMS	Central Monitoring System
CMT	Crisis Management Team
CON	Conclusion
CONOPS	Conduct of Operations
DOE	U.S. Department of Energy
DC	Direct Cause
DNFSB	Defense Nuclear Facilities Safety Board
EAL	emergency action level
EAP	Employee Assistance Program
EMCBC	Office of Environmental Management Consolidated Business Center
EMS	Emergency Medical Services
EOC	Emergency Operations Center
EPA	U.S. Environmental Protection Agency
ERO	Emergency Response Organization
ERT	Emergency Response Team
EST	Emergency Services Technician
EXO	Enriched Xenon Observatory
FHA	Fire Hazard Analysis
FLIRT	First Line Initial Response Team
FPP	Fire Protection Program
FR	Facility Representative
FSM	Facility Shift Manager
FSS	Fire Suppression System
GET	General Employee Training

HEPA	high-efficiency particulate absorption
HQ	Headquarters
ICS	Incident Command System
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
JHA	Job Hazard Analysis
JON	Judgments of Need
JIC	Joint Information Center
LPU	Local Processing Unit
M&O	Management and Operations
MRT	Mine Rescue Team
MST	Mountain Standard Time
MW	Megawatt
NFPA	National Fire Protection Association
NWP	Nuclear Waste Partnership LLC
MSHA	Mine Safety and Health Administration
MST	Mountain Standard Time
OE	Operational Emergency
O&M	Operations and Maintenance
PA	public address
RH	Remote handled
RC	Root Cause
RCRA	Resource Conservation and Recovery Act
SAA	Shaft Access Area
SCFM	standard cubic feet per minute
SCSR	Self-Contained Self-rescuer
SLA	Service Level Agreement
SME	subject matter expert
SMP	Safety Management Program
TRU	Transuranic
U/G	Underground
WH	Waste Handling
WIPP	Waste Isolation Pilot Plant

Executive Summary

On Wednesday, February 5, 2014, at approximately 1045 Mountain Standard Time, an underground mine fire involving an EIMCO Haul Truck 74-U-006B (salt haul truck) occurred at the Department of Energy (DOE) Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. There were 86 workers in the mine (underground) when the fire occurred. All workers were safely evacuated. Six workers were transported to the Carlsbad Medical Center (CMC) for treatment for smoke inhalation and an additional seven workers were treated on-site.

On February 7, 2014, Matthew Moury, Deputy Assistant Secretary for Safety, Security, and Quality Programs, U.S. Department of Energy, Office of Environmental Management formally appointed an Accident Investigation Board (the Board) to investigate the accident in accordance with DOE Order (O) 225.1B, based on this accident meeting Accident Investigation Criteria 2.d.1 of DOE O 225.1B, *Accident Investigations*, Appendix A.

The Board began the investigation on February 10, 2014, completed the investigation on March 8, 2014, and submitted findings to the Deputy Assistant Secretary for Safety, Security, and Quality Programs Environmental Management on March 11, 2014.

The Board concluded that this accident was preventable.

Accident Description

The fire is believed to have originated in the truck's engine compartment and involved hydraulic fluid and/or diesel fuel which contacted hot surfaces on the truck, possibly the catalytic converter, and then ignited. The fire burned the engine compartment and consumed the front tires which contributed significantly to the amount of smoke and soot in the underground.

The Operator had just unloaded salt from the truck at approximately 1045 Mountain Standard Time (MST) when he noticed an orange glow and then flames between the engine and the dump sections of the truck (see Figure ES-1). The Operator attempted to extinguish the fire with a portable fire extinguisher stored on the truck and then by activating the salt haul truck's fire suppression system. Both attempts to extinguish the fire were unsuccessful. The Operator then used a mine phone to notified Maintenance of the fire, and his Supervisor overheard the conversation over a nearby mine phone, which can also be heard throughout the underground. Two nearby workers heard the discussion on the mine phone and, based on the urgency of the Operator's voice, went to the scene to see if they could assist. They began pushing a nearby 300-pound fire extinguisher to the fire when their carbon monoxide monitor alarmed and the smoke worsened. One of the workers called the Central Monitoring Room (CMR) to report the fire and smoke, and recommended evacuation of the underground.

Figure ES-1: EIMCO Haul Truck 74-U-006B after Fire

At 1051, the Central Monitoring Room Operator (CMRO) sounded the evacuation "yelp" alarm for approximately two seconds and then made a public address system (PA) announcement that there was a fire in the underground and for all personnel to evacuate via the area egress stations. A subsequent announcement directed the workers to the waste hoist. As reported by some workers, this instruction was not heard throughout the underground. Some workers learned of the fire and need to evacuate through the "chatter" (discussions) on the mine phone, through co-workers, or through their supervisors.

At 1058, the Facility Shift Manager (FSM) directed the CMRO to switch the ventilation system from normal to filtration mode believing this would reduce both the fire and smoke in the underground. However, this resulted in the flow of smoke into areas of the underground, which the workers expected to have "good" air. The first group of workers arrived at the waste hoist and the first of three trips to evacuate the workers from the mine via the Waste Hoist (mantrips) to the surface was completed. The CMR activated the Emergency Operations Center (EOC) at 1103 and the Joint Information Center (JIC) was activated at 1125.

Other workers continued to make their way on foot or on electric carts from various locations throughout the underground to the waste hoist. At this point, there was smoke in most areas of the underground and smoke could be seen on the surface exiting the Salt Handling Shaft. Workers had difficulty reaching the waste hoist due to poor visibility from their primary evacuation routes and obscured evacuation route reflectors; this was compounded by a delay in activating the evacuation strobe lights. Some workers also had difficulty opening and/or donning their self-rescuers or self-contained self-rescuers (SCSRs). The second mantrip of underground

personnel was completed at 1120 and the third and final mantrip was completed at 1134. Full accountability of all underground workers was achieved at 1135.

All surface waste-handling activities were suspended and the Mine Rescue Team (MRT) was activated at 1120.

Once on the surface, workers were evaluated by Emergency Service Technicians (ESTs) and six personnel were transported to the CMC for treatment of smoke inhalation. At 1420, all personnel were released from the CMC.

The MRT performed carbon monoxide gas checks and entered the underground via the Air Intake Shaft at 1746. They proceeded to the reported fire location via the Air Intake Shaft and arrived at the salt haul truck at 1825. No fire was observed. Oxygen levels were at 21 percent and methane and carbon monoxide were at 0 percent. The MRT noted that the air was clear but that there were embers at the location of the right front tire. They expended their fire extinguishers on these embers and proceeded to the surface at 1915.

At 2202, a second MRT entered the underground via the salt hoist, took additional air quality readings, and drove the underground rescue vehicle to the scene of the fire. They applied all the extinguishing foam from the rescue vehicle and the fire appeared to be fully extinguished. They then unchained a number of bulkhead doors which had been chained open prior to the incident. On Thursday, February 6, 2014, at 0025, the MRT exited the underground via the salt hoist.

At 0105 on February 6, 2014, the event was terminated and the EOC and JIC were deactivated.

Direct, Root, and Contributing Causes

Direct Cause (DC) – the immediate events or conditions that caused the accident.

The Board identified the direct cause of this accident to be contact between flammable fluids (either hydraulic fluid or diesel fuel) and hot surfaces (most likely the catalytic converter) on the salt haul truck, which resulted in a fire that consumed the engine compartment and two front tires.

Root Cause (RC) – causal factors that, if corrected, would prevent recurrence of the same or similar accidents.

The Board identified the root cause of this accident to be the failure of Nuclear Waste Partnership LLC (NWP) and the previous management and operations (M&O) contractor to adequately recognize and mitigate the hazard regarding a fire in the underground. This includes recognition and removal of the buildup of combustibles through inspections and periodic preventative maintenance (e.g., cleaning), and the decision to deactivate the automatic onboard fire suppression system.

Contributing Causes (CC) – events or conditions that collectively with other causes increased the likelihood or severity of an accident but that individually did not cause the accident. For the purposes of this investigation, contributing causes include those related to the cause of the fire, as well as those related to the subsequent response.

The Board identified ten contributing causes to this accident or resultant response:

1. The preventative and corrective maintenance program did not prevent or correct the buildup of combustible fluids on the salt truck. There is a distinct difference between the way waste-handling and non-waste-handling vehicles are maintained.
2. The fire protection program was less than adequate in regard to flowing down upper-tier requirements relative to vehicle fire suppression system actuation from the Baseline Needs Assessment into implementing procedures. There was also an accumulation of combustible materials in the underground in quantities that exceeded the limits specified in the Fire Hazard Analysis (FHA) and implementing procedures. Additionally, the FHA does not provide a comprehensive analysis that addresses all credible underground fire scenarios including a fire located near the Air Intake Shaft.
3. The training and qualification of the operator was inadequate to ensure proper response to a vehicle fire. He did not initially notify the CMR that there was a fire or describe the fire's location.
4. The CMR Operations response to the fire, including evaluation and protective actions, was less than adequate.
5. Elements of the emergency/preparedness and response program were ineffective.
6. A nuclear versus mine culture exists where there are significant differences in the maintenance of waste-handling versus non-waste-handling equipment.
7. The NWP Contractor Assurance System (CAS) was ineffective in identifying the conditions and maintenance program inadequacies associated with the root cause of this event.
8. The DOE Carlsbad Field Office (CBFO) was ineffective in implementing line management oversight programs and processes that would have identified NWP CAS weaknesses and the conditions associated with the root cause of this event.
9. Repeat deficiencies were identified in DOE and external agencies assessments, e.g., Defense Nuclear Facility Safety Board (DNFSB) emergency management, fire protection, maintenance, CBFO oversight, and work planning and control, but were allowed to remain unresolved for extended periods of time without ensuring effective site response.
10. There are elements of the Conduct of Operations (CONOPS) program that demonstrate a lack of rigor and discipline commensurate with the operation of a Hazard Category 2 Facility.

Table ES-1: Conclusions and Judgments of Need

Conclusion (CON)	Judgments of Need (JON)
CON 1: The FSM and Central Monitoring Room Operator (CMRO) did not fully follow the procedures for response to a fire in the underground (U/G). This can be attributed to the complexity of the alarm and communication system, lack of effective drills and training, and additional burdens placed on the FSM due to the lack of a structured Incident Command System (ICS).	**JON 1:** NWP needs to evaluate and correct deficiencies regarding the controls for communicating emergencies to the underground, including the configuration and adequacy of equipment (alarms, strobes, and public address). **JON 2**: NWP needs to evaluate the procedures and capabilities of the FSM and CMRO in managing a broad range of emergency response events through a comprehensive drill and requalification program.
CON 2: NWP management allows expert-based, rather than a process/systems-based approach to decision making, e.g., shift to filtration during a fire, sheltering decisions, etc.	**JON 3**: NWP needs to evaluate and apply a process/systems-based approach for decision making relative to credible emergencies in the U/G, including formalizing response actions, e.g., decision to change to filtration mode during an ongoing evacuation.
CON 3: The emergency management program was not structured such that personnel were driven to adequately size up, properly categorize, and classify emergency events. The WIPP (NWP and CBFO) emergency management program is not fully compliant with DOE O 151.1C, *Comprehensive Emergency Management System*, e.g., activation of the EOC, classification and categorization, emergency action levels, implementation of the ICS, training, triennial exercise, etc. Weaknesses in classification, categorization, and emergency action levels (EALs) were previously identified by external reviews and uncorrected.	**JON 4**: NWP and CBFO need to evaluate their corrective action plans for findings and opportunities for improvement identified in previous external reviews, and take action to bring their emergency management program into compliance with requirements. **JON 5**: NWP and CBFO need to correct their activation, notification, classification, and categorization protocols to be in full compliance with DOE O 151.1C and then provide training for all applicable personnel. **JON 6**: NWP and CBFO need to improve the content of site-specific EALs to expand on the information provided in the standard EALs contained in DOE O 151.1C. **JON 7**: NWP and CBFO need to develop and implement an Incident Command System (ICS) for the EOC/CMR that is compliant with DOE O 151.1C and is capable of assuming command and control for all anticipated emergencies.

Conclusion (CON)	Judgments of Need (JON)
CON 4: Actions to be taken by the Operator in the event of a U/G vehicle fire were not clear. There were inconsistencies between procedures and training for fire response that led to an ineffective response to the salt haul truck fire.	**JON 8**: NWP needs to review procedures and ensure consistent actions are taken in response to a fire in the U/G. **JON 9**: NWP, CBFO and DOE need to clearly define expectations for responding to fires in the U/G, including incipient and beyond incipient stage fires.
CON 5: NWP and CBFO failed to ensure that training and drills effectively exercised all elements of emergency response to include practical demonstration of competence, e.g., donning of self-rescuers and SCSRs, U/G personnel response to a fire, use of portable fire extinguishers, EOC roles, classification and categorization, notifications and reporting, and allowance of unescorted access for over 500 personnel, etc.	**JON 10**: NWP and CBFO need to develop and implement a training program that includes hands-on training in the use of personal safety equipment, e.g., self-rescuers, SCSRs, portable fire extinguishers, etc. **JON 11**: NWP and CBFO need to improve and implement an integrated drill and exercise program that includes all elements of the ICS, including the MRT, First Line Initial Response Team (FLIRT) and mutual aid; unannounced drills and exercises; donning of self-rescuers/SCSRs; and full evacuation of the U/G. **JON 12**: NWP needs to evaluate and improve their criteria for granting unescorted access to the U/G such that personnel with unescorted access to the underground are proficient in responding to abnormal events.
CON 6: NWP preventive and corrective maintenance program did not prevent or correct the buildup of combustible fluids on the salt haul truck.	**JON 13**: NWP management needs to reevaluate and modify the approach to conducting preventative and corrective maintenance on all U/G vehicles such that combustible fluids are effectively managed to prevent the recurrence of fires.
CON 7: NWP and CBFO management is not adequately considering overall facility impact with regard to operations, emergency response, and maintenance, which affects the safety posture of the facility, e.g., salt haul truck combustible build-up, conversion of the automatic fire suppression system to manual, removal of the automatic fire detection capability, not using fire resistant hydraulic fluid, discontinued use of the vehicle wash	**JON 14**: NWP and CBFO need to develop and implement a rigorous process that effectively evaluates: • changes to facilities, equipment, and operations for their impact on safety, e.g., plant operations review process; • impairment and corresponding compensatory measures on safety-related equipment; and • the impact of different approaches in

Conclusion (CON)	Judgments of Need (JON)
station, chaining of ventilation doors and an out-of-service regulator and fans, inoperable mine phones, and other non-waste-handling related equipment.	maintaining waste-handling and non-waste-handling equipment. **JON 15**: NWP needs to determine the extent of this condition and develop a comprehensive corrective action plan to address identified deficiencies.
CON 8: NWP and CBFO management have not effectively managed the quantity and duration of out-of-service equipment.	**JON 16**: NWP needs to develop and implement a process that ensures comprehensive and timely impact evaluation and correction of impaired or out-of-service equipment. **JON 17**: CBFO needs to ensure that its contractor oversight structure includes elements for comprehensive and timely evaluation and correction of impaired or out-of-service equipment.
CON 9: NWP management has allowed less than acceptable rigor in the performance of equipment inspections, resulting in the operation of U/G equipment in unacceptable condition.	**JON 18**: NWP needs to develop and reinforce clear expectations regarding the performance of rigorous equipment inspections in accordance with manufacturer recommendations, established technical requirements; corrective action; and trending of deficiencies.
CON 10: NWP did not ensure the Baseline Needs Assessment (BNA) addressed requirements of DOE O 420.1C and Mine Safety and Health Administration (MSHA) with the results completely incorporated into implementing procedures.	**JON 19**: NWP needs to ensure that all requirements of DOE O 420.1C and MSHA are addressed in the BNA, with the results completely incorporated into implementing procedures and the source requirements referenced, and that training consistent with those procedures is performed.
CON 11: NWP and CBFO management did not make conservative or risk-informed decisions with respect to developing and implementing the fire protection program. There is inadequate fire engineering analysis due to a lack of integration with ventilation design and operations, and U/G operations, for recognizing, controlling, and mitigating U/G fires.	**JON 20**: NWP and CBFO need to perform an integrated analysis of credible U/G fire scenarios and develop corresponding response actions that comply with DOE and MSHA requirements. The analysis needs to include formal disposition regarding the installation of an automatic fire suppression system in the mine.
CON 12: NWP and CBFO have failed to take appropriate action to correct combustible loading issues that were	**JON 21**: NWP and CBFO need to review the combustible control program and complete corrective actions that demonstrate compliance

Conclusion (CON)	Judgments of Need (JON)
identified in previous internal and external reviews.	with program requirements. These issues remain unresolved from prior internal and external reviews.
CON 13: NWP and CBFO have allowed housekeeping to degrade and other conditions to persist that potentially impede egress.	**JON 22**: NWP and CBFO need to evaluate and address deficiencies in housekeeping to ensure unobstructed egress and clear visibility of emergency egress strobes, reflectors, SCSR lights, etc.
CON 14: NWP has not fully developed an integrated contractor assurance system that provides assurance that work is performed compliantly, risks are identified, and control systems are effective and efficient.	**JON 23**: NWP needs to develop and implement a fully integrated contractor assurance system that provides DOE and NWP confidence that work is performed compliantly, risks are identified, and control systems are effective and efficient.
CON 15: CBFO failed to adequately establish and implement line management oversight programs and processes to meet the requirements of DOE O 226.1B and hold personnel accountable for implementing those programs and processes.	**JON 24**: CBFO needs to establish and implement an effective line management oversight program and processes that meet the requirements of DOE O 226.1B and hold personnel accountable for implementing those programs and processes.
CON 16: CBFO management does not have adequate communication processes to ensure awareness of issues that warrant attention from all levels of the DOE staff.	**JON 25**: CBFO needs to accelerate the implementation of a mechanism for all levels of CBFO staff to document, communicate, track, and close issues both internally and with NWP. **JON 26**: The CBFO Site Manager needs to institutionalize and communicate expectations for the identification, documentation, reporting, and correction of issues.
CON 17: DOE HQ failed to ensure that CBFO was held accountable for correcting repeatedly identified issues involving fire protection, maintenance, emergency management, work planning and control, and oversight.	**JON 27**: DOE HQ needs to ensure that repeatedly identified issues related to safety management programs (SMPs) are confirmed closed and validated by the local DOE office. This process should be considered for application across the DOE complex and include tracking, closure, actions to measure the effectiveness of closure (line management accountability), and trending to identify precursors and lessons learned. **JON 28**: DOE HQ should enhance its required oversight to ensure site implementation of the emergency management policy and requirements

Conclusion (CON)	Judgments of Need (JON)
	are consistent and effective. Emphasis should be placed on ensuring ICSs are functioning properly and integrated exercises are conducted where personnel are evacuated.
CON 18: DOE HQ failed to ensure CBFO was provided with qualified technical resources to oversee operation of a Hazard Category 2 Facility in a mine.	**JON 29**: DOE HQ needs to develop and implement a process for ensuring that technical expertise is available to provide support in the unique area of ground control, underground construction, and mine safety and equipment. **JON 30**: DOE HQ needs to assist CBFO with leveraging expertise from MSHA, in accordance with the DOE/MSHA Memorandum of Understanding (MOU), in areas of ground control, underground construction, and mine safety where DOE does not have the expertise. **JON 31**: DOE HQ needs to re-evaluate resources (i.e., funding, staffing, infrastructure, etc.) applied to the WIPP project to ensure safe operations of a Hazard Category 2 Facility.
CON 19: The Office of Environmental Management Consolidated Business Center (EMCBC) and CBFO failed to ensure support services as described in the Service Level Agreement were provided.	**JON 32**: EMCBC and CBFO need to develop and implement clear expectations and a schedule for EMCBC to provide support in the areas of regulatory compliance, safety management systems, preparation of program procedures and plans, quality assurance, lessons learned, contractor assurance, technical support, DOE oversight assistance, etc.
CON 20: There are elements of the CONOPS program that demonstrate a lack of rigor and discipline commensurate with operation of a Hazard Category 2 Facility.	**JON 33**: NWP and CBFO need to evaluate and correct weaknesses in the CONOPS program and its implementation, particularly with regard to flow-down of requirements from upper-tier documents, procedure content and compliance, and expert-based decision making.
CON 21: NWP and CBFO did not analyze and disposition differences between waste-handling and non-waste-handling vehicles for similar hazards and impacts, e.g., allowing a truck in this condition to be at the waste face.	**JON 34**: NWP and CBFO need to identify and control the risk imposed by non-waste-handling equipment, e.g., combustible buildup, manual vs. automatic fire suppression system, fire-resistant hydraulic oil, etc., or treat waste-handling equipment and non-waste-handling equipment the same.

CON 22: NWP and CBFO management allowed a culture to exist where there are differences in the way waste-handling equipment and non-waste-handling equipment are maintained and operated.	**JON 35**: NWP and CBFO management need to examine and correct the culture that exists regarding the maintenance and operation of non-waste-handling equipment.
Positive Statement: All supervisors and employees in the U/G actively used the mine phone to alert other workers of the fire and the need to evacuate before the evacuation alarm was sounded. **Positive Statement**: Workers assisted other workers during the evacuation, including helping them to don self-rescuers and SCSRs. **Positive Statement**: Personnel in the U/G exhibited detailed knowledge of the underground and ventilation splits. **Positive Statement**: NWP on-site medical response was effective in treating personnel.	

1.0 Introduction

1.1 Appointment of the Board

On February 7, 2014, an Accident Investigation Board (the Board) was appointed by Matthew Moury, Deputy Assistant Secretary, Safety, Security, and Quality Programs, U.S. Department of Energy (DOE), Office of Environmental Management (EM), to investigate the fire on the EIMCO 985-T15 salt haul truck in the underground at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, that occurred February 5, 2014. The Board's responsibilities have been completed with respect to this investigation. The analysis and the identification of the contributing causes, the root cause and the Judgments of Need resulting from this investigation were performed in accordance with DOE Order (O) 225.1B, *Accident Investigations*.

This accident meets Accident Investigation Criteria 2.d.1 of DOE O 225.1B, Appendix A (i.e., estimated loss of or damage to DOE property, including aircraft, equal to or greater than $2.5 million or requiring estimated costs equal to or greater than $2.5 million for cleaning, decontaminating, renovating, replacing, or rehabilitating property).

DOE appointed an Accident Investigation team on February 7, 2014. The accident scene was preserved to the extent practical considering the entries needed to facilitate preparation of the mine for occupancy.

The Board began the investigation on February 10, 2014, completed the investigation on March 8, 2014, and submitted findings to the appointing official on March 11, 2014. The Board concluded that this accident was preventable.

On February 5, 2014, three entries into the underground were performed by the Mine Rescue Team (MRT) to extinguish and overhaul the fire. Nuclear Waste Partnership LLC (NWP) had a procedure for event reporting and investigation, WP 15-MD3102, Rev. 2, *Event Investigation Management Control Procedure*. A written Notification report, EM-CBFO-NWP-WIPP-2014-0001, *Underground Salt Haul Truck Fire*, was transmitted February 7, 2014. NWP took action to establish control of the accident scene by placing security seals on entrances to the above-ground waste-handling area and the mine itself. Subsequent entries were required to be performed by NWP to facilitate the Board's entry on February 13, 2014.

1.2 Carlsbad Field Office

The DOE created the Carlsbad Area Office in Carlsbad, New Mexico, in late 1993 to lead the nation's transuranic (TRU) waste disposal efforts. In September 2000, the office was elevated in status to become the Carlsbad Field Office (CBFO). As a field office, CBFO has continued its primary mission of operating WIPP in conformance with the WIPP Land Withdrawal Act (Public Law 102-579 as amended by Public Law 104-201). CBFO is responsible for oversight of the management and operations (M&O) contract for the WIPP site and the National TRU Program. CBFO has taken on additional roles to support the DOE-EM, such as serving as an international center for the study of waste management and enabling the unique capabilities of WIPP to be utilized to support basic scientific research. This includes the Enriched Xenon

Observatory (EXO) laboratory in the north end of the repository. In addition to operations in southeastern New Mexico, the CBFO coordinates the TRU waste characterization and shipping programs at waste-generating sites and national laboratories around the nation.

The organizational components of the CBFO include the Office of the Manager, and the Offices of Site Operations, the National TRU Program, Environment, Safety and Health, Business, Quality Assurance, and Science and International Programs.

1.3 Nuclear Waste Partnership LLC

NWP is the M&O for the WIPP facility and the National TRU Program. DOE awarded the contract to NWP on April 20, 2012. NWP is a partnership between URS Energy and Construction, Inc. (URS), the Babcock and Wilcox Company (B&W), and Areva, Inc. (Areva). NWP assumed responsibility for management and operation of the WIPP facility October 1, 2012, after a 90-day transition period. The prior M&O was Washington TRU Solutions, LLC (WTS). WTS and its predecessor entities held the contract from 2000 until NWP took over WIPP operations. WTS was an entity comprised of URS and Weston Solutions, Inc.

Upon transition from WTS to NWP, the management of the WIPP facility did not see a substantial change in management personnel. A new site operations manager from B&W was brought in from the Pantex facility. Additionally, a new business manager was brought in from the B&W Oak Ridge operations. NWP also made revisions to the organizational reporting structure.

1.4 Facility Description

DOE was authorized by Public Law 96-164, Department of Energy National Nuclear Security and Military Applications of Nuclear Energy Authorization Act of 1980, to provide a research and development facility for demonstrating the safe, permanent disposal of TRU wastes from national defense activities and programs of the United States exempted from regulations by the U.S. Nuclear Regulatory Commission.

The WIPP Land Withdrawal Act, Public Law 102-579 (as amended by Public Law 104-201), authorized the disposal of 6.2 million cubic feet of defense TRU waste at the WIPP facility. The WIPP facility operates in several regulatory regimes. DOE has authority over the general operation of the facility, including radiological operations prior to closure. The U.S. Environmental Protection Agency (EPA), through its regulations at 40 CFR Parts 191 and 194, certifies the long-term radiological performance of the repository over a 10,000-year compliance period after closure of the facility. The State of New Mexico, through EPA delegation of the Resource Conservation and Recovery Act (RCRA), has issued a Hazardous Waste Facility Permit for the disposal of the hazardous waste component of the TRU waste. Additionally, the Mine Safety and Health Administration (MSHA) is required to perform four inspections per year of WIPP.

WIPP, located in southeastern New Mexico near Carlsbad, was constructed to determine the efficacy of an underground repository for disposal of TRU waste (Figure 1). Disposal operations began in 1999 and are scheduled to continue for 35 years.

Figure 1: Waste Isolation Pilot Plant near Carlsbad, New Mexico

1.5 Waste Isolation Pilot Plant

The WIPP facility is a geologic repository mined within a bedded salt formation. The underground is 2,150 feet beneath the ground surface. TRU mixed waste management activities underground are confined to the southern portion of the 120-acre mined area.

Four shafts connect the underground area with the surface. The Waste Shaft headframe and hoist are located within the Waste Handling Building and are used to transport TRU mixed waste, equipment, and materials to the repository. The waste hoist can also be used to transport personnel and materials. The Air Intake Shaft and the Salt Handling Shaft provide ventilation to all areas of the mine except for the Waste Shaft station. This area is ventilated by the Waste Shaft itself. The Salt Handling Shaft is also used to hoist mined salt to the surface and serves as the principal personnel transport shaft. The Exhaust Shaft serves as a common exhaust air duct for all areas of the mine (Figure 2).

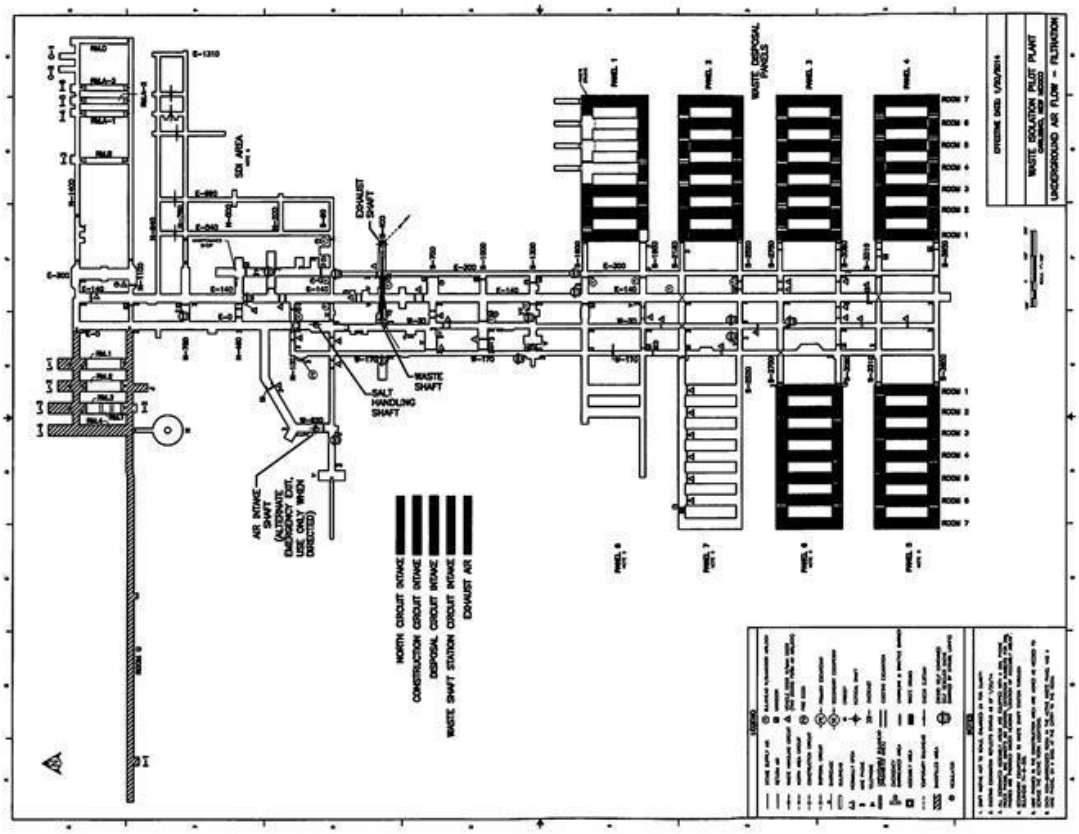


Figure 2: Mine Layout

The WIPP underground consists of the waste disposal area, construction area, north area, and Waste Shaft station area. The location of the accident is shown in Figure 3.

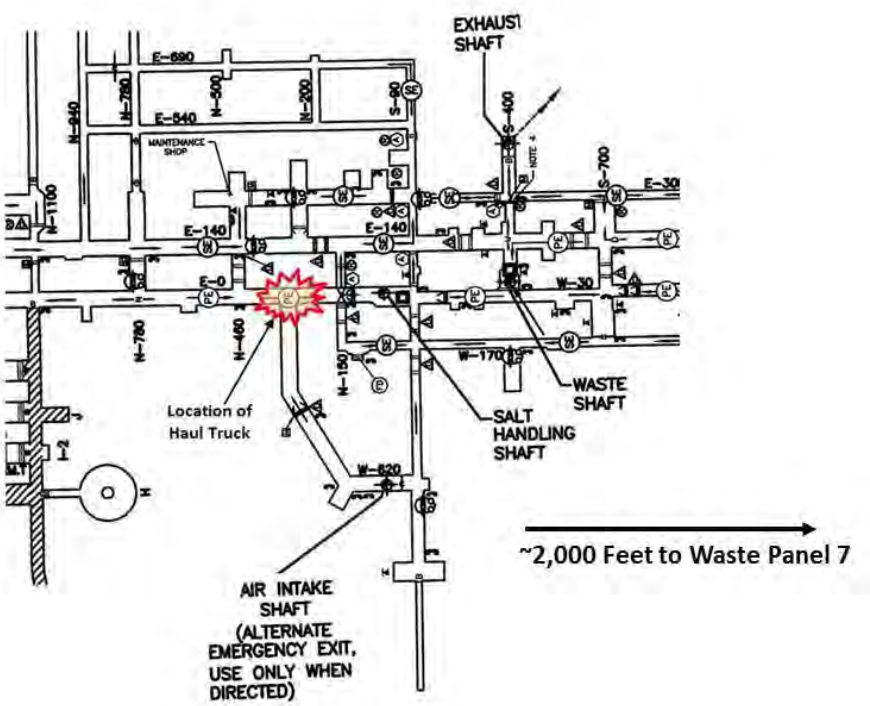


Figure 3: Location of the Haul Truck during the Fire

The principle contact-handled (CH) waste operations at the WIPP involve (1) the receipt and disposal of TRU waste, and (2) the mining of underground rooms in which the waste is disposed. In the underground, the waste containers are removed from the waste hoist conveyance, placed on the underground transporter, and moved to a disposal room. In the disposal rooms, the CH waste containers are removed from the transporter and placed in the waste stack. Remote-handled (RH) waste is placed in boreholes in the walls (ribs) of the disposal rooms.

The site has 55 permanent buildings and four temporary buildings (trailers) in operation, one temporary building (lab trailer) in excess status, and various connexes (used for storage). The site buildings provide a total of 358,647 square feet of office and industrial space. Additional leased office space, the Skeen-Whitlock Building, is located in Carlsbad. Approximately 800 workers are assigned to the WIPP, representing the CBFO, the management and operating contractor, the security subcontractor, the warehouse, the document services subcontractor, the information technologies subcontractor, the CBFO Technical Assistance Contractor, Los Alamos National Laboratory-Carlsbad, Sandia National Laboratories-Carlsbad, and the New Mexico Environment Department-Carlsbad. Prominent features of the WIPP site include:

- **Air Intake Shaft**. The primary source of intake for the underground ventilation and also used for emergency egress.
- **Waste Handling Building**. This structure provides a confinement barrier. Ventilation is operated to maintain a negative pressure with high-efficiency particulate air (HEPA) filtration.

- **Waste Hoist**. The Waste Hoist transports waste, material and personnel from the surface to the underground and is designed to prevent an uncontrolled fall or descent of the waste conveyance into the Waste Shaft.
- **Salt Handling Shaft Hoist**. This hoist transports mined salt to the surface, material, and personnel between the surface and the underground.
- **Radiation Monitoring**. Consists of continuous air monitors, fixed air samplers, and other external radiation monitors.
- **Central Monitoring Room**. Provides a monitoring function and must be staffed and operational, with the ability to shift underground ventilation to filtration.
- **Waste Handling Equipment**. Selected items are designated safety class or safety significant.
- **Emergency Services Bay**. Houses the ambulance, rescue truck, and fire engine.
- **Guard and Security Building**. Houses the security monitoring and alarm systems.
- **Parking Lot**. The east portion of the front parking lot is used for employee parking, and the two west rows of the lot are designated for trailer storage and staging of empty transuranic package transporters (TRUPACTs) for DOE carrier transport to the generator sites and trailer maintenance facility.

1.6 Background

On February 5, 2014, an underground (U/G) fire involving an EIMCO haul truck 985-T15 (salt haul truck), property ID 74-U-006B, occurred at the DOE WIPP site near Carlsbad, New Mexico. The fire necessitated the evacuation of 86 workers from the U/G, and 13 of the workers required treatment for smoke inhalation, six at the Carlsbad Medical Center (CMC) and seven on-site.

EIMCO Model 985T-15 haul truck 74-U-006B was purchased in May 1985 and has been used continuously over the past 29 years to transport mined salt to the salt hoist for removal from the underground. A second Model 985-15 salt haul truck 74-U-006A is also in operation in the mine. Figure 4 is a photograph of a Model 985 haul truck (74-U-006A)

Figure 4: EIMCO 985T 15 Haul Truck (74-U-006A)

The truck has a capacity of 15 tons and is powered by a Deutz V-8 air cooled diesel engine. The truck is equipped with a remote-mounted three-speed (in both forward and reverse) Clark powershift transmission, engine-mounted torque converter, and four-wheel drive with planetary gear wheel ends and integral liquid-cooled brakes. Two 12 volt DC batteries provide electrical power to the vehicle.

The truck when purchased did not include a fire suppression system. The site contractor had an automatic fire suppression system installed sometime before 1995. Due to numerous inadvertent activations, including some which occurred while the vehicle was parked and not running, the site contractor had Southwest Fire Safety switch the automatic system to manual activation in 2003.

In September 2005, there was a fire on this salt haul truck caused by an electrical short, which was extinguished by manually activating the fire suppression system.

The truck contains combustible fluids, including diesel fuel (33-gallon tank capacity); engine oil (3.3 gallons); torque converter/transmission fluid (10.5 gallons); hydraulic fluid for steering, brakes, and the dump box (35 gallons); differential oil (6.25 gallons); wheel end lubricant (2 gallons); and joint lubricant. In the past, trucks were periodically cleaned underground in a wash station but this was taken out of service prior to 2004 because of the difficulty in removing the wash water to the surface.

The truck undergoes a quarterly emissions test, 100-hour preventative maintenance, and 500-hour preventative maintenance. Record review and interviews indicate that the engine has been rebuilt once since it was put into service at the WIPP.

The work history over the last three years includes the above preventative maintenance, a battery replacement, hydraulic hose replacement, and troubleshooting for electrical shorts.

1.7 Scope, Purpose and Methodology of the Accident Investigation

The Accident Investigation Board began its activities on February 10, 2014, and completed its investigation on March 8, 2014. The scope of the Board's investigation was to identify relevant facts; analyze the facts to determine the direct, contributing, and root causes of the event; develop conclusions; and determine Judgments of Need for actions that, when implemented, should prevent recurrence of the accident. The investigation was performed in accordance with DOE Order 225.1B, *Accident Investigations*, using the following methodology:

- Facts relevant to the event were gathered through interviews and reviews of documents and other evidence, including photographs and visits to the event scene.
- Facts were analyzed to identify the causal factors using event and causal factors analysis, barrier analysis, change analysis, root cause analysis, and Integrated Safety Management analysis.
- Judgments of Need for corrective actions to prevent recurrence were developed to address the causal factors of the event.

Figure 5 defines the accident investigation terminology used throughout this report.

Accident Investigation Terminology

A **causal factor** is an event or condition in the accident sequence that contributes to the unwanted result. There are three types of causal factors: direct cause(s), which is the immediate event(s) or condition(s) that caused the accident; root causes(s), which is the causal factor that, if corrected, would prevent recurrence of the accident; and the contributing causal factors, which are the causal factors that collectively with the other causes increase the likelihood of an accident, but which did not cause the accident.

The **direct cause** of an accident is the immediate event(s) or condition(s) that caused the accident.

Root causes are the causal factors that, if corrected, would prevent recurrence of the same or similar accidents. Root causes may be derived from or encompass several contributing causes. They are higher-order, fundamental causal factors that address classes of deficiencies, rather than single problems or faults.

Contributing causes are events or conditions that collectively with other causes increased the likelihood of an accident but that individually did not cause the accident. Contributing causes may be longstanding conditions or a series of prior events that, alone, were not sufficient to cause the accident, but were necessary for it to occur. Contributing causes are the events and conditions that "set the stage" for the event and, if allowed to persist or recur, increase the probability of future events or accidents.

Event and causal factors analysis includes charting, which depicts the logical sequence of events and conditions (causal factors that allowed the accident to occur), and the use of deductive reasoning to determine the events or conditions that contributed to the accident.

Barrier analysis reviews the hazards, the targets (people or objects) of the hazards, and the controls or barriers that management systems put in place to separate the hazards from the targets. Barriers may be physical or administrative.

Change analysis is a systematic approach that examines planned or unplanned changes in a system that caused the undesirable results related to the accident.

Error precursor analysis identifies the specific error precursors that were in existence at the time of or prior to the accident. Error precursors are unfavorable factors or conditions embedded in the job environment that increase the chances of error during the performance of a specific task by a particular individual, or group of individuals. Error precursors create an error-likely situation that typically exists when the demands of the task exceed the capabilities of the individual or when work conditions aggravate the limitations of human nature.

Figure 5: Accident Investigation Terminology

2.0 The Accident

2.1 Description of Work Activity

The WIPP facility is designed for the excavation of eight panels branching off of the main drifts. WIPP uses the concept of "just-in-time excavation" (Figure 6). Just-in-time excavation is based on the concept that when additional room is needed for waste disposal, a new panel would be excavated and ready for use "just in time." This means that each panel would be excavated, filled, and closed in a time frame that would minimize the potential for developing hazardous ground conditions.

Excavation of a new panel is performed by a mining machine that uses a rotary bit to remove the salt. Salt from mining must be removed from the underground and salt haul trucks (trucks) are used to move the salt to the loading pocket where it is dumped and then taken to the surface via the salt hoist.

Panel 7 was completed and certified in late 2013 and CH and RH waste were being disposed in Panel 7 during January and early February 2014.

Panel 8 excavations began after completion of Panel 7 in 2013, and two rooms had been excavated in Panel 8.

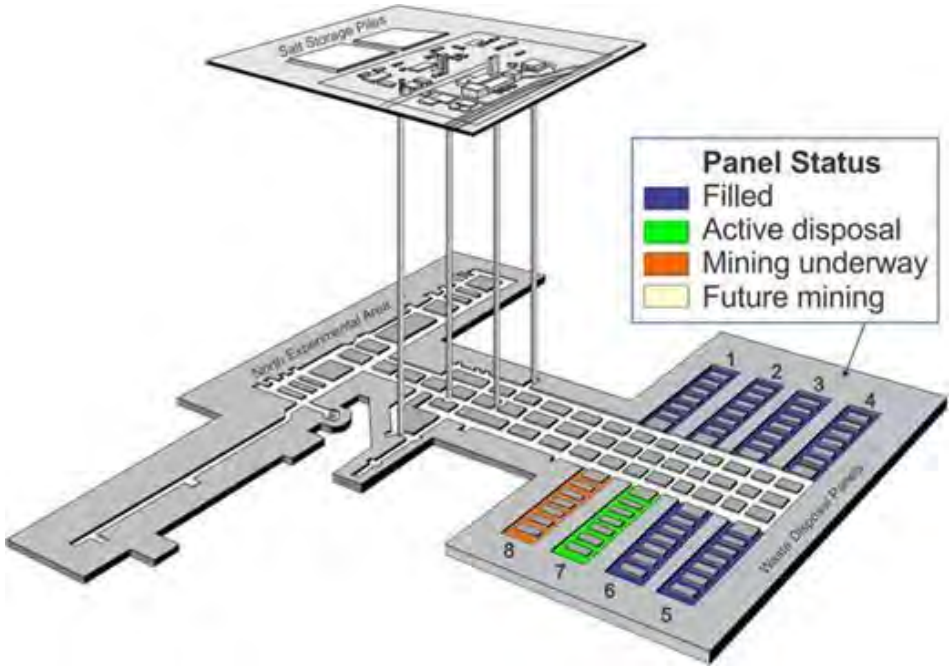


Figure 6: Panel Layout

2.2 Accident Description

An Operator picked up a load of salt using haul truck 74-U-006B at Panel 8 at approximately 1045 and headed north on W-170 toward the loading pocket (Figure 7) to dump the load. Figure 8 shows the Operator's route from Panel 8 to the scene of the fire. He turned right on S-90, left on E-0, dropped half of his load at the loading pocket, continued north in E-0, and passed N-150 to drop the rest of his load. The Operator pulled into N-300, backed up into E-0, and unloaded the rest of the truck. As the Operator lowered the bed, he looked back to see if it was clear of muck. It was at this point that he noticed an orange glow and then flames between the engine and the dump sections of the truck.

Figure 7: The Loading Pocket "The Grizzly"

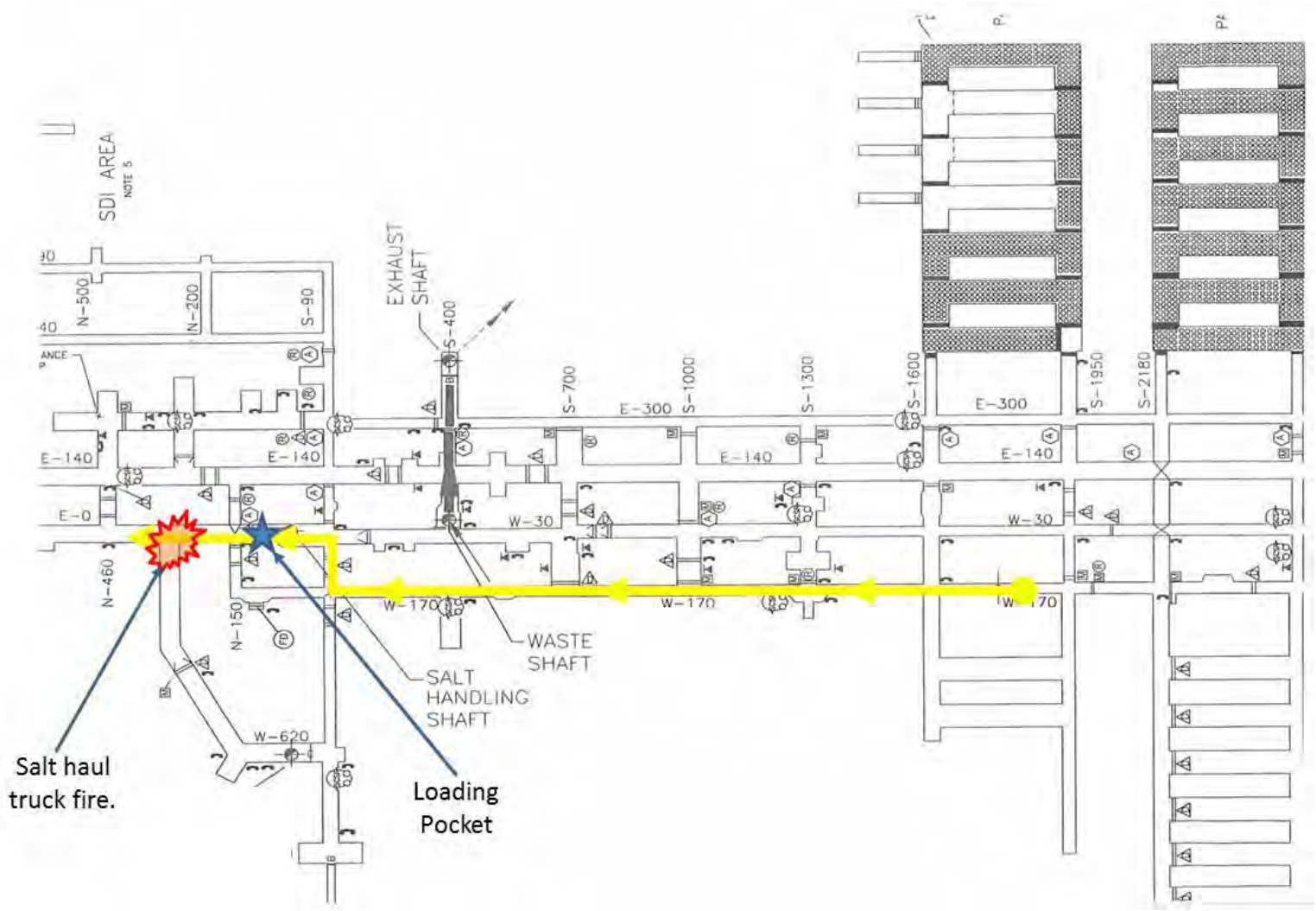


Figure 8: Route of Haul Truck from Panel 8 to Accident Scene

2.3 Event Chronology

Table 1: Chronology of the Salt Haul Fire Events

Date and Time (hours) (MST)	EVENT
May 1, 1985	EIMCO Salt Haul Truck 74-U-006B (Truck 6B) is purchased. Does not include an onboard fire suppression system (FSS).
1985 – 2013	Truck 6B is in service, receives scheduled maintenance, refurbished at least once (July 2004).
~1993	Automatic FSS is added to Truck 6B.
October 2003	Due to inadvertent actuations, the automatic FSS is converted to manual activation.
~2003 - 2004	Wash station taken out of service/replacement wash station not in service.
2004	Truck 6B engine is rebuilt.
October 23, 2013	Quarterly emissions tests were performed on Truck 6B, results satisfactory.
November 26, 2013	100 hour preventative maintenance is performed on Truck 6B, results satisfactory.
December 17, 2013	Batteries are replaced on Truck 6B via an expedited work package.
December 21, 2013	500 hour preventative maintenance is performed on Truck 6B, results satisfactory.
January 20, 2014	100 hour preventative maintenance is performed on Truck 6B, results satisfactory.
January 21, 2014	Replaced hydraulic hose on Truck 6B per expedited work package.
January 24, 2014	Quarterly emissions tests were performed on Truck 6B, results satisfactory.
January 24 – February 5, 2014	Truck 6B was in service, transporting salt from the mined panels to the loading pocket for dumping and then removal from the underground via the salt hoist.

Date and Time (hours) (MST)	EVENT
February 5, 2014 0000 hours	The Facility Shift Manager (FSM) directed the Central Monitoring Room Operator (CMRO) to put ventilation system in maintenance bypass mode, filtration is enabled.
February 5, 2014 0555 hours	Salt hoist checks are completed.
February 5, 2014 0816	Contact –handled (CH) waste bay was configured for waste-handling (WH) mode.
February 5, 2014 0834	CMRO disabled filtration for underground (U/G) local processing unit (LPU) testing.
February 5, 2014 0835	LPU testing was unsatisfactory (results required a manual shift to filtration upon a loss of power scenario).
February 5, 2014 0848	FSM directed CMRO to configure the shaft access area (SAA) and U/G for CH waste handling.
February 5, 2014 0859	FSM directed CMRO to configure the SAA and U/G for remote handled (RH) waste handling.
February 5, 2014 1007	FSM directed CMRO to configure the RH bay for waste handling.
February 5, 2014 ~1045	Salt Haul Truck Operator (Operator) was at Panel 8 in Truck 6B and was loaded with salt (last load before lunch).
February 5, 2014 ~1046	Operator headed down W-170 in Truck 6B towards the loading pocket.
February 5, 2014 ~1046	Operator turned right on S-90 through the bulkhead, turned left into E-0, and dropped his load of salt at the loading pocket. Not all discharged into the loading pocket.
February 5, 2014 ~1047	Operator headed up north on E-0 and passed N-150 to drop rest of the load on the floor of the drift.
February 5, 2014 ~1048	Operator pulled Truck 6B into N-300, backed up to the rib, and raised the bed on the dump portion of Truck 6B to unload the rest of the load.
February 5, 2014 ~1048	As the Operator was lowering bed, he looked to see if all the muck (salt) was clear of the bed.

Date and Time (hours) (MST)	EVENT
February 5, 2014 ~1048	Operator noticed an orange light and then flames coming from the bottom of the truck in the area between the tractor and the dump.
February 5, 2014 ~1048	Operator stopped truck, put on the brake, and shut off the engine.
February 5, 2014 ~1049	Operator got off the truck and grabbed the truck's portable fire extinguisher.
February 5, 2014 ~1050	Operator walked around the truck and discharged the portable fire extinguisher into a hole in the area where he had observed the flames. He also discharged it underneath the truck.
February 5, 2014 ~1050	The fire was not extinguished, so Operator dropped the portable fire extinguisher and activated the onboard FSS on the truck.
February 5, 2014 ~1050	Operator was unsure if the FSS actuated, observed a large puff of smoke (or suppressant).
February 5, 2014 ~1050	Operator was increasingly alarmed and walked to the nearest mine phone (out of the smoke), called Maintenance and then his Supervisor to inform them of the fire.
February 5, 2014 ~1050	Two U/G Services workers begin to respond from their office at S-550/W-30 and the Supervisor responded from S-3080/W-30.
February 5, 2014 ~1050	An U/G Services worker in the office called the CMRO and told the CMRO that there was a fire at N-150/E-0, that they were getting smoke in the office, and to let everyone in the U/G know to get to the waste hoist.
February 5, 2014 ~1050	Operator entered the airlock bulkhead at N-150.
February 5, 2014 ~1050	Two U/G Services personnel attempted to push a 300-pound wheeled fire extinguisher to the airlock at E-0/N-150; as they began to open the airlock, their carbon monoxide monitor alarmed and they saw smoke begin to "boil in" under the outer airlock.
February 5, 2014 ~1050	U/G Services personnel arrived in the area of the fire (brought a carbon monoxide monitor and their self-rescuers).

Date and Time (hours) (MST)	EVENT
February 5, 2014 ~1051	CMRO sounded the emergency evacuation alarm (yelp) for approximately two seconds, stated that there was a fire (no location), and that personnel should evacuate via the waste hoist. The alarm and instruction could not be heard and/or understood throughout the U/G. The CMRO operator forgot to activate the emergency evacuation strobe lights.
February 5, 2014 ~1052	Supervisor, Operator, and two U/G services workers decided that the carbon monoxide level was too high to fight the fire and decided to evacuate via W-170, S-1950, W-30, S-1000, and E-140, but encountered thick smoke. They encountered others enroute and informed them of the need to evacuate and to don their self-rescuers.
February 5, 2014 ~1058	CMRO was directed by FSM to change ventilation to filtration mode, believing this would reduce both the fire and smoke. This caused significant changes in air flow and smoke in the U/G.
February 5, 2014 ~1051 - 1134	Workers throughout the U/G were attempting to evacuate the mine in response to the alarm and announcement, what they heard over the mine phones, and/or interactions with other personnel. Some workers encountered difficulties (heavy smoke, strobes not on or not working, smoke in areas expected to have "good" air, obscured evacuation reflectors) and improvised routes to the waste hoist, at times cutting holes in ventilation curtains. Workers reported near-collisions between personnel, carts, and other equipment. Not all workers donned self-rescuers at the first indication of fire (it appears that three never donned them at all) and some had difficulty opening and/or donning self-rescuers or self-contained self-rescuers (SCSRs). Workers helped each other don and check self-rescuers and SCSR and made their way in the heavy smoke to the waste hoist.
February 5, 2014 ~1103	The FSM activated the Emergency Operations Center (EOC). CBFO Facility Representative (FR) notified by CBFO Security Manager; the FSM notified CBFO FR at 1135. The EOC did not classify or categorize the event as an operational emergency, and did not notify the DOE HQ watch office.
February 5, 2014 ~1108	EOC held briefing on the fire location and status.

Date and Time (hours) (MST)	EVENT
February 5, 2014 ~1101	The first evacuation of workers via the waste hoist (mantrip) to the surface was underway.
February 5, 2014 ~1111-1112	Mine Safety and Health Administration (MSHA) and the State Mine Inspector were notified of the event.
February 5, 2014 ~1115	The CMRO suspended surface waste handling activities.
February 5, 2014 ~1120	The CMRO activated the Mine Rescue Team (MRT).
February 5, 2014 ~1125	The second mantrip was made at the waste hoist.
February 5, 2014 ~1126	The Joint Information Center (JIC) was activated.
February 5, 2014 ~1130	Mine rescue team made a request to the Intrepid and Mosaic (local potash mining companies) to put their MRTs on standby for support.
February 5, 2014 ~1134	The third and final mantrip was made at the waste hoist.
February 5, 2014 ~1134	Full accountability of the U/G was achieved.
February 5, 2014 ~1144	One ambulance and two Emergency Safety Technicians (ESTs) were on scene. FSM contacted Carlsbad Fire Department (CFD) for additional transportation support.
February 5, 2014 ~1151 - 1251	Six workers were examined by site medical personnel and were transferred via ambulance to the Carlsbad Medical Center (CMC) for observation (possible smoke inhalation).
February 5, 2014 ~1147	CMRO secured U/G ventilation.
February 5, 2014 ~1125	Seven additional workers were examined by the site nurse but additional medical attention was not needed.
February 5, 2014 ~1311	CMRO halted release of waste shipments to WIPP.

Date and Time (hours) (MST)	EVENT
February 5, 2014 ~1312	CMRO shifted ventilation to CH HVAC to "once through" ventilation (versus recirculation) due to smoke upcasting in the waste hoist shaft and into the CH bay.
February 5, 2014 ~1336	MSHA arrived onsite to support DOE in accordance to the Memorandum of Understanding (MOU).
February 5, 2014 ~1348	MSHA issued a K-Order to WIPP to obtain the approval of the MSHA representative regarding any plan to recover the mine.
February 5, 2014 ~1420	All workers were released from the CMC.
February 5, 2014 ~1420	The CMRO continued monitoring air quality at the mine shafts.
February 5, 2014 ~1614	CMRO shifted from waste handling mode for Technical Safety Requirements (TSR) compliance.
February 5, 2014 ~1722	The first MRT (MRT1) entered the U/G via the air intake shaft.
February 5, 2014 ~1746	MRT1 reported gas checks at the station level (0 percent methane, 0 percent carbon monoxide, oxygen 21 percent).
February 5, 2014 ~1825 - ~1900	MRT1 arrived at the haul truck. No fire was detected but embers were noticed on the front tires, and ground checks were performed. Discharged portable fire extinguishers on the embers.
February 5, 2014 ~1958	MRT1 arrived back at surface.
February 5, 2014 ~2205	The second MRT (MRT2) entered the U/G via the air intake shaft.
February 5 - 6, 2014 ~2208-~0059	MRT2 performed air quality checks, checked and/or closed ventilation louvers and doors.
February 5, 2014 ~2300	MRT2 drove U/G rescue truck to the scene, discharged all foam fire suppressant, and noted that the fire appeared to be out.
February 6, 2014 ~0059	MRT2 arrived back at surface and U/G accountability was declared complete.

Date and Time (hours) (MST)	EVENT
February 6, 2014 ~0105	Event is terminated, EOC and JIC are deactivated.
February 6, 2014	Initial all-hands meetings hosted by CBFO and NWP management.
February 7, 2014 1000	Critique meeting was held to gather facts and establish the initial timeline.
February 7, 2014	Occurrence Reporting and Processing System (ORPS) notification report filed.
February 7, 2014	Accident Investigation Board appointed.

3.0 Emergency Response

3.1 Accident Response

Upon noticing the fire, the Operator stopped the truck, shut off the engine, set the brake, and exited the vehicle, taking a portable fire extinguisher which was mounted on the left front fender. The Operator proceeded to the opposite side of the vehicle, near the articulation joint and attempted to extinguish the fire by discharging the fire extinguisher into the area where the Operator had observed the fire (Figure 9).

Figure 9: Photo Showing the Area on the Salt Haul Truck where the Fire Extinguisher was Discharged

When this proved unsuccessful, the Operator attempted to actuate the onboard manual fire suppression system, which resulted in a large puff of either smoke or suppressant. This also proved ineffective. At this point, the Operator proceeded to the nearest mine phone (out of smoke) and called Maintenance to report the fire. At approximately 1050, the Operator entered the bulkhead N-150 airlock and encountered two U/G Services workers who had come from the S-550/W-30 office to assist. They had become aware of the fire via the Operator's conversation over the mine phone, which could be heard throughout the U/G, and had observed smoke in W-30 coming south from the Salt Handling Shaft area (Figure 10). Another member of U/G Services called the CMRO to report the fire and indicated that an evacuation was necessary.

At 1051, the CMRO sounded the evacuation "yelp" alarm for approximately two seconds, and then made a public address (PA) system announcement that there was a fire in the underground and for all workers to evacuate via their area egress points. A subsequent announcement directed

personnel to the waste hoist. The CMRO forgot to activate the emergency egress lights until he received a call from the bottom lander, which contributed to U/G personnel delays in exiting.

At 1058, the Facility Shift Manager (FSM) directed the CMRO to change ventilation to filtration mode believing this would reduce both the fire and smoke. This caused changes in air flow and smoke in the U/G and contributed to confusion as people attempted to make their way to the waste hoist. Workers throughout the U/G attempted to evacuate the mine in response to the alarm and announcement, what they heard over the mine phones, and/or interactions with other personnel.

Figure 10: Smoke Visible Exiting through the Salt Shaft

At 1103, the FSM activated the Emergency Operations Center (EOC) and notified the CBFO Facility Representative. The EOC did not classify or categorize the event as an operational emergency, and did not notify the DOE-HQ watch office.

At 1108, the EOC held a briefing on the fire location and status and the first evacuation of workers via the waste hoist (mantrip) to the surface was underway. MSHA and the State Mine Inspector were notified of the event at 1112.

At 1115, the CMRO suspended surface waste-handling activities and the CMRO activated the Mine Rescue Team at 1120.

Workers continued to be evacuated from the U/G, with the second mantrip at the waste hoist at 1125 and the third and final mantrip at 1134. Full accountability of all personnel was achieved at 1134.

Figure 11: 300-Pound Extinguisher in the Underground

The Joint Information Center (JIC) was activated at 1126 and all external notifications were completed. As noted above, because the site did not classify and categorize the event as an operational emergency, the DOE HQ watch office was not notified.

The two U/G Services workers attempted to push a 300-pound wheeled fire extinguisher (see Figure 11) to the airlock at E-0/N-150. When the workers opened the airlock, their ITX (carbon monoxide) monitor alarmed and the smoke worsened. The Operator's supervisor (after notifying his room closure crew and the Mine Manager of the fire)

arrived at the scene via W-170. The group realized at this point that the fire was beyond their control. They then began moving south in W-170 towards the waste hoist, at one point having to cut a ventilation curtain to continue toward the waste hoist. During the workers' egress they encountered other personnel in carts. They informed them of the fire and to put on their self-rescuers. The group then crossed into E-140 and travelled to the Waste Shaft where they were evacuated to the surface.

During the evacuation, some personnel encountered difficulties (heavy smoke, strobes not on or not working, smoke in areas expected to have "good" air, obscured evacuation reflectors) and had to improvise routes to the waste hoist, at times cutting holes in ventilation curtains.

There were a number of near-collisions between personnel, carts, and other equipment reported. Additionally, not all personnel donned their self-rescuers at the first indication of fire (three reported that they never donned them at all) and others had difficulty opening and/or donning self-rescuers or SCSRs.

There were several reports that personnel helped each other don and check self-rescuers and SCSRs and make their way in the heavy smoke to the waste hoist.

Between 1151 and 1251, six personnel were examined by site medical personnel and transferred via ambulance to the CMC for observation (possible smoke inhalation). Seven additional personnel were examined by the site nurse, but no further treatment was necessary. At 1420, the six workers were released from the CMC.

At 1336, MSHA arrived onsite and issued a K-Order to obtain the approval of the MSHA representative regarding any plan to recover the mine.

The first MRT entered the U/G via the Air Intake Shaft at 1722, conducted gas checks, and upon arrival at the truck found no fire but the presence of embers on the front tires, and performed ground checks. They discharged four portable fire extinguishers on the embers. They arrived back at the surface at 1758.

The second MRT entered the U/G via the Salt Handling Shaft at 2205, performed air quality checks, checked and/or closed ventilation louvers and doors, and drove the U/G rescue truck to the scene where they discharged all foam fire suppressant, and noted that the fire appeared to be out. They arrived back at the surface at 0059, on February 6, 2014.

At 0105, the event was terminated and the EOC and JIC were deactivated.

3.2 Emergency Management Program Implementation

The WIPP Emergency Management Program is implemented through WP 12-9 series emergency response procedures, and the WP 12-ER series emergency management procedures. These procedures are designed to provide guidance, define the responsibilities for Operational Emergency (OE) categorization and classification, and define the organization structure and responsibilities. The WP 12-9 series identifies actions to activate the emergency response organizations and respond to emergencies, and defines the lines of authority. Additionally, WP

12-ER3906, *Categorization and Classification of Operational Emergencies*, identifies Emergency Action Levels (EAL) that provides the criteria to categorize an OE.

During on-site emergency conditions, the FSM is in control of the facility, and is the Incident Commander. The FSM is also responsible for event categorization and classification, and activates the EOC. When the EOC is activated, a Crisis Manager assists the FSM with emergency actions. WIPP also has a Central Monitoring Room Operator (CMRO) that is responsible for reporting information concerning events to the FSM and notifying WIPP emergency response teams (ERTs) and support groups.

The Board reviewed execution of the WIPP Emergency Management Program and identified the following facts via witness statements, personnel interviews and program documents.

3.2.1 Fire Response and Evacuation

During the event, the evacuation alarm was not activated for a full five seconds and the evacuation strobe lights were not turned on as required by WP 12-ER4911, *Underground Fire Response*. Additionally, the CMRO did not inform personnel of the fire location or to suspend all U/G operations. Interviews with NWP employees also stated that the voice coming from the PA system was garbled and not understandable.

The CMRO was not immediately notified of the fire event because the Operator had first contacted the Maintenance Department, and then notified his supervisor via the mine phone. Underground Services heard of the fire via the mine phone and notified the CMRO. The WIPP Underground Fire Response procedure requires that the emergency notification be made to the CMR first.

The U/G ventilation was shifted to filtration mode. This unannounced shift resulted in an unexpected condition for the U/G personnel as they attempted to evacuate the mine. U/G personnel are familiar with ventilation mode changes, and could tell by movement of louvers and reduction of airflow in evacuation paths that ventilation was changed. Interviews with workers indicated that the change in ventilation mode resulted in an increase in anxiety for the U/G personnel.

Large quantities of material were staged haphazardly throughout the mine. The contents of the maintenance shop lined both sides of the drift. Additionally, the U/G green and red reflectors that provide an indication of where to proceed during an evacuation were not effective. Some were obscured by being placed under the mesh fence along the ribs, while others were hidden from sight by other material stored in the mine. The Board also identified that these reflectors were covered in soot from the fire, and were located at irregular spacing (Figure 12).

Figure 12: Obscured Reflectors

Analysis

Procedural non-compliances and off-script actions by the CMRO and the FSM represent a response that could have endangered workers as they attempted to evacuate. The unannounced change in ventilation to filtration mode was not in any procedure and quite possibly contributed to higher local concentrations of smoke and carbon monoxide in the drifts. The procedure used in the CMR did not anticipate a full spectrum of potential emergency situations. This requires the FSM to make decisions based on his expert knowledge in a given situation. Communication problems and unclear announcements contributed to confusion throughout the mine. The Board determined that there was a lack of effective drills and training, there was complexity of the alarm and communication system, and there were additional burdens placed on the FSM due to the lack of a structured Incident Command System. The Board also determined that the poor housekeeping observed throughout the mine had a negative impact on the ability of workers to navigate to the egress point in the reduced visibility environment.

CON 1: The FSM and Central Monitoring Room Operator (CMRO) did not fully follow the procedures for response to a fire in the U/G. This can be attributed to the complexity of the alarm and communication system, lack of effective drills and training, and additional burdens placed on the FSM due to the lack of a structured Incident Command System (ICS).

JON 1: NWP needs to evaluate and correct deficiencies regarding the controls for communicating emergencies to the underground, including the configuration and adequacy of equipment (alarms, strobes, and public address).

JON 2: NWP needs to evaluate the procedures and capabilities of the FSM and CMRO in managing a broad range of emergency response events through a comprehensive drill and requalification program.

CON 2: NWP management allows expert-based, rather than a process/systems-based approach to decision making, e.g., shift to filtration during a fire, sheltering decisions, etc.

JON 3: NWP needs to evaluate and apply a process/systems based approach for decision making relative to credible emergencies in the U/G, including formalizing response actions, e.g., decision to change to filtration mode during an ongoing evacuation.

3.2.2 Emergency Categorization and Classification

During the event, the EOC was activated at approximately 10 minutes into the incident. EOC staff is considered the Crisis Management Team (CMT). This team includes a Crisis Manager, Deputy Crisis Manager, Safety Representative, Operations Representative, EOC Coordinator, Consequence Assessment Support, and a DOE representative called the CBFO Emergency Representative (CER). Also, the following support personnel may be located in the EOC: Public Affairs Coordinator, Human Resources Manager, Safety Coordinator, and Security Coordinator.

As stated earlier, during an incident the FSM has full authority and responsibility for coordinating all emergency response measures. The contractor's plans do not allow the FSM to transfer the Emergency Director position to a more senior official such as the Crisis Manager in the EOC. In a previous HS-45 assessment of August 2012, it was recommended that WIPP consider transferring some of the FSM's responsibility to the EOC's Crisis Manager to relieve some of the burden on the FSM. For this event:

- The fire event was not classified as Operational Emergency;
- The fire event was reported into the ORPS as a Significance Category 2, *Any Fire Emergency or Fire Incident in a Nuclear Facility*; and
- The DOE Facility Representative was notified by the FSM approximately 15 minutes after discovery.

Analysis

The current response organization does not provide the recommended Incident Command System (ICS) span of control for the FSM position during a large incident and could constrain the FSM in making quick and sound decisions. The Board recommends that WIPP should reevaluate the Emergency Response Organization (ERO) structure and responsibilities

NWP chose not to classify this event as an OE, although WIPP procedure WP 12-ER3906, *Categorization and Classification of Operational Emergencies*, provides criteria for the FSM to do so. Additionally, the Crisis Manager failed to ensure that the event had been categorized correctly. This event represented a facility evacuation in response to an actual occurrence that required time-urgent response by specialist personnel. The WIPP emergency response structure diminished the ability of the FSM to focus on strategic and tactical response. Eighty-six workers were in the U/G and a total of 13 workers were treated; six transported to a local hospital and seven treated on-site. Had an OE been declared, required notification to DOE-HQ could have

possibly been made in a timely manner and would have activated additional DOE assets to be placed on standby to assist if the situation were to deteriorate further.

CON 3: The emergency management program is not structured such that personnel are driven to adequately size up, properly categorize, and classify emergency events.

The WIPP (NWP and CBFO) emergency management program is not fully compliant with DOE O 151.1C, *Comprehensive Emergency Management System*, e.g., activation of the EOC, classification and categorization, emergency action levels, implementation of the ICS, training, triennial exercise, etc. Weaknesses in classification, categorization, and emergency action levels (EALs) were previously identified by external reviews and uncorrected.

JON 4: NWP and CBFO need to evaluate their corrective action plans for findings and opportunities for improvement identified in previous external reviews, and take action to bring their emergency management program into compliance with requirements.

JON 5: NWP and CBFO need to correct their activation, notification, classification, and categorization protocols to be in full compliance with DOE O 151.1C and then provide training for all applicable personnel.

JON 6: NWP and CBFO need to improve the content of site-specific EALs to expand on the information provided in the standard EALs contained in DOE O 151.1C.

JON 7: NWP and CBFO need to develop and implement an Incident Command System (ICS) for the EOC/CMR that is compliant with DOE O 151.1C and is capable of assuming command and control for all anticipated emergencies.

3.2.3 Training, Qualifications, Drills & Exercise

Some U/G workers recognized the need to don self-rescuers at the first indication of a fire; however, many workers were unable to open and don the self-rescuers and SCSRs. One worker stated that he did not want to don the SR. Evacuation drill exercises did not include donning self-rescuers and SCSRs. Evacuation drill exercises included long duration yelps and the use of strobe lights. Fully integrated exercises involving all of WIPP's assets have not been conducted. Some qualified FSMs had not received Incident Command System training, even though they are expected to perform in that capacity during an emergency. Additionally, there is no position-specific training for the various EOC roles and responsibilities. The Facility Operations training week had been discontinued.

The Operator that responded to the fire did not receive hands-on training in the use of a portable fire extinguisher. During qualification, the Operator did receive a signature indicating training in the operation of the onboard manual fire suppression system. However, recent training provided as an updated portion of General Employee Training (GET), as well as the *Underground Fire Response* procedure, stressed the use of a portable extinguisher for incipient fire response.

The Board identified 506 personnel with unescorted access to the mine. Many of these personnel rarely visit the mine and possess only the minimum required training for mine access.

3.2.4 Fire Brigade and Fire Department Interface

The Mine Rescue Teams were activated. Both teams entered the mine. The Mine Rescue Teams extinguished smoldering embers from the fire using the foam unit mounted on the U/G Rescue Truck. The FSM maintained incident command of the Fire Brigade, as well as being RCRA Emergency Coordinator throughout the emergency.

3.2.5 Facilities and Equipment

Underground workers have handheld fire extinguishers available throughout the mine. A 300-pound wheeled dry chemical fire extinguisher is available in the U/G. The U/G Rescue Truck is equipped with a 300-pound dry chemical extinguisher and a 150- gallon foam extinguisher. During the fire, U/G personnel attempted to drag the 300-pound wheeled extinguisher to the fire until they elected to stop due to an increase in carbon monoxide levels.

Analysis

Several deficiencies were identified in training, qualifications, and drills. The Operator had not had hands-on training on the use of a portable fire extinguisher. There is a multitude of fire suppression equipment staged in the underground, but there is no clear fire-fighting strategy developed to inform personnel how to employ it. During evacuation drills and exercises, it was common for the evacuation alarms (yelps) to continue for a long period of time (greater than five minutes). Additionally, the evacuation strobe lights would be on during the entire drill or exercise. The absence of alarms and strobe lights during the fire event contributed to U/G personnel being unsure why they were evacuating and what they should be doing. During evacuation drills, WIPP workers were not required to demonstrate the donning of self-rescuers and SCSRs in the U/G. Evidence from the accident scene revealed many difficulties that employees encountered in attempting to utilize self-rescuers and SCSRs.

The Board was unable to determine the need for granting unescorted mine access to 506 personnel. Additionally, the Board questions if all of the 506 personnel possess the requisite knowledge to respond appropriately in an emergency situation.

CON 4: Actions to be taken by the Operator in the event of a U/G vehicle fire were not clear.

There were inconsistencies between procedures and training for fire response that led to an ineffective response to the salt haul truck fire.

JON 8: NWP needs to review procedures and ensure consistent actions are taken in response to a fire in the U/G.

JON 9: NWP, CBFO and DOE HQ need to clearly define expectations for responding to fires in the U/G, including incipient and beyond incipient stage fires.

CON 5: NWP and CBFO failed to ensure that training and drills effectively exercised all elements of emergency response to include practical demonstration of competence, e.g., donning of self-rescuers and SCSRs, U/G personnel response to a fire, use of portable fire extinguishers, EOC roles, classification and categorization, notifications and reporting, allowance of unescorted access for over 500 personnel, etc.

JON 10: NWP and CBFO need to develop and implement a training program that includes hands-on training in the use of personal safety equipment, e.g., self-rescuers, SCSRs, portable fire extinguishers, etc.

JON 11: NWP and CBFO need to improve and implement an integrated drill and exercise program that includes all elements of the ICS, including the MRT, First Line Initial Response Team (FLIRT) and mutual aid; unannounced drills and exercises; donning of self-rescuers/SCSRs; and full evacuation of the U/G.

JON 12: NWP needs to evaluate and improve their criteria for granting unescorted access to the U/G such that personnel with unescorted access to the underground are proficient in responding to abnormal events.

3.2.6 Medical Response

One ambulance and two Emergency Service Technicians (ESTs) responded to the top of the Waste Shaft. Thirteen employees were assessed by medical staff. Of those assessed, six employees displayed symptoms of carbon monoxide exposure and were transported to the CMC.

The following medical documentation regarding six NWP employees was made available to the DOE Chief Medical Officer for review:

- WIPP Emergency Medical Services (EMS) Service Reports;
- WIPP Personal and Occupational History Forms;
- Emergency Department Physician Documentation from the CMC;
- Discharge Instructions from the CMC;
- Medical Reconciliation Forms from the CMC to be provided to the next provider of medical services, with emphasis on prescribed medications;
- Individual Encounter Forms from TRU Solutions Health Services;
- Worker's Injury/Illness Visit forms; and
- DOE Health Care Assets, Mutual Aid Agreements, Terrorism Response-Related Expertise.

Analyses

The above referenced information was made available for six WIPP workers, although the documentation was incomplete for one of the individuals, in that case consisting only of Discharge Instructions from the CMC. The totality of that information resulted in observations in several areas.

Processes

Emergency medical support services appeared to be in place to address mine-related hazards, including fire.

- Staffing of EMS personnel who could potentially be activated for off-site events at times when they would be needed on-site was unclear.
- The use of written protocols by on-site nursing staff and EMS personnel was documented, but indications for communications to/from the Incident Commander, the "on-shift EST Coordinator," were not.
- Measures such as the availability of escape respirators were demonstrated. Limited information was available regarding the distribution of escape respirators or fit-testing to ensure their effectiveness. In particular, the medical documentation provided by WIPP on-site medical personnel and emergency medical technician (EMT)-level services only specified the use of escape respirators in a minority of the six cases treated for inhalational injuries.
- WIPP EMS was limited to Basic Life Support, rather than Advanced Cardiac Life Support, which would generally prevent the responding personnel from intubating workers with significant respiratory injuries or distress.

Response

- Information was provided that reflected a coordinated medical response involving on-site medical personnel and EMT-level services for the stabilization and transport of injured personnel to the CMC.
- Limited information was made available regarding the apparent delay between the call being "received" by WIPP EMS (i.e., 1051) and the activation of WIPP EMS (i.e., 1147) nearly an hour later.

Quality of Care

- Efforts to assess health effects, treat symptoms of affected workers, and speed their return to work were evident. In particular, medical documentation on-site, during transport, and following arrival at the CMC was comprehensive, addressing occupational exposures and evaluation of both the underlying medical histories of affected employees and the results of laboratory and radiographic tests for inhalational injuries.
- Follow-up medical evaluations by WIPP were noteworthy for their consistency across all affected workers, their aggressive management of symptoms, and their effectiveness in return-to-work of affected workers.
- Information was made available to all site personnel and the individuals directly involved via the Employee Assistance Program (EAP) on February 9, 2014. Subsequent EAP counseling was available to groups and individuals from February 11 through February 13, 2014.

4.0 Maintenance Program

Maintenance at WIPP is governed by WP 10-WC3011, *Work Control Process*, Rev. 31, effective October 18, 2013, and WP 10-WC3010, *Preventive Maintenance Controlled Document Processing*. Preventive maintenance is initiated through the Computerized History and Maintenance Management System (CHAMPS), based on required frequency. Work planners, along with a planning team in some cases, further develop the activity level work control document and participate in development of a job hazard analysis.

4.1 Salt Haul Truck Maintenance

The EIMCO 985 series manufacturer service manual provides a recommended maintenance regimen, including a note that states: "The time intervals specified in the following maintenance schedule may be shortened, according to the severity of working conditions. These intervals may not, however, be lengthened unless otherwise stated without prior consultation with the EIMCO service representative." The recommended maintenance regimen is as follows:

- Every shift or every 10 hours of operation, prior to operation; check hour meter to see if any scheduled maintenance is due, check the fuel level, check the engine oil level and fill as necessary to bring level to the upper dash mark on the dipstick, inspect the air cleaner for dents/cracks/loose connections, check tire pressure is between 85 and 100 pounds, check the fire extinguisher for security and readiness (to include that the pressure gauge indicates the proper range), check the fire suppression equipment for security and readiness for operation (to include looking for damaged tanks/hoses/other parts), inspect the operator compartment for cleanliness and wash out as required/check for damaged gauges and controls/operate all controls/test horn and all lights/verify all cables and linkage are clean and secure with no evidence of binding or sloppiness, and perform a general inspection to check the truck for any leaks/loose nuts and bolts and other damage to the truck with direction to correct or report any deficiencies to the service man. After starting the engine; monitor the transmission temperature as the engine warms to operating temperature (if the transmission temp exceeds 250° F, run engine at half-speed until the oil cools), check the ammeter and observe that the needle reads charge (+) and slowly returns to zero, observe that the engine oil pressure warning light goes off and that oil pressure is at least 30 psi at fast idle, continue to monitor gauges as the engine warms to operating temperature and observe that indications remain in the green zone, with the transmission in neutral reduce engine idle to half-speed and check the transmission oil level (add oil through the oil filler pipe as required to bring level up to the full mark), check the hydraulic oil level (with the dump box lowered and the oil at normal operating temperature 120° F) and fill as necessary to bring level up to the high mark, and check the parking brake by applying the brake and increase the throttle in second gear and service brake by rolling the truck forward and applying the brake to ensure the vehicle comes to an immediate stop.
- Every 125 hours or two weeks; perform all the 10 hour checks, wash the truck, check the (battery electrolyte level, differential oil level, front axle bolster rubber pads/bushings, and wheel end oil level), lubricate the (service brake pedal/1 fitting, center pivot ends/two fittings, throttle pedal/one fitting, steering cylinders/4 fittings, drivelines/16 fittings, front

axle bolster/1 fitting, dump box pivot pins/2 fittings, tailgate latch bar/2 fittings, dump cylinder pins/4 fittings, and tailgate pivot/2 fittings). Additionally, the fire suppressions system nozzle coverings and hose fittings are checked.

- Every 250 hours or monthly; perform all 125 hour items, check the air intake vacuum at 20" on a manometer, check the exhaust backpressure at 30" on a manometer, change the engine oil and dual filters, clean the air blower oil filter, check and adjust the engine valves (referring to Section 3 of the Deutz instruction manual), check the engine drive belts, clean the transmission breather, change the transmission oil filters, check the torque on wheel lug nuts at 450 feet/pounds, and check accumulator pressure at 900 psi.
- Every 500 hours or every two months; perform all 250 hour items, check the engine temperature gauges, check and clean the fuel injectors (including test of spray pattern), change the (fuel filters, transmission oil filters, and the hydraulic filters), check and clean the differential breathers, check the front and rear suspension (check bolt torque at 700 feet/pounds).
- Every 1,000 hours or every six months; perform all 500 hour items, change the air cleaner, check the alternator by testing the output, and change the differential oil/wheel end oil/hydraulic system fluid.
- Every 3,000 hours; have the complete fuel injection system inspected and serviced by a qualified diesel fuel system specialist.

WIPP performs the following preventive maintenance at the below specified intervals of equipment hours:

- Per the Underground Haulage Truck Equipment Operator qualification, the operator is trained to; check tire condition/inflation and lug nuts, check that the park and service brake are operational, check fuel/transmission/oil/hydraulic fluid levels, engine belt condition, readiness test for the fire suppression system, lights and horn are functional, check that the back-up and bed lower alarms are functional, and perform a walk-around inspection. Results are documented each shift on an Operator's Checklist.
- Every 100 hours of operation (per PM074061, Underground Diesel Mobile Equipment 100 Hour Inspection and Maintenance, Revision 8); the oil is changed, grease is applied to various components, the engine cooler/oil cooler/transmission cooler/boom/engine cooling fins around cylinders are cleaned using compressed air, the power train components are inspected for loose bolts/missing parts/oil leaks/motor mounts and the tires and wheels are checked, including torque lug nuts. Post maintenance testing specifically includes, "ENSURE proper oil level and NO oil leaks."
- Quarterly (per PM074027, Quarterly Diesel Emissions Test, Revision 8); test emissions for compliance with the WIPP Hazardous Waste Facility Permit.
- Every 500 hours of operation (per PM074080, EIMCO Haul Truck, Revision 3); the engine/cooling fins/oil cooler/transmission cooler/battery are cleaned using compressed air, the fan belts are checked for wear/cracks/gouges/tears as well as tension (0.28-0.35" deflection), inspect for loose bolts/missing parts/oil leaks, check and adjust tires for proper air pressure per the Operations and Maintenance Manual, check and restore water level in the batteries, check wheel lug bolt torque at 450 feet/pounds, change oil and filters, change

fuel filters, change hydraulic return filter, check and restore hydraulic fluid level, change transmission fluid filters, check and restore transmission fluid level, clean transmission breather, clean differential breathers, check and restore front/rear axle fluid level, and lubricate the (service brake pedal/one fitting, center pivot ends/two fittings, throttle pedal/one fitting, steering cylinders/4 fittings, drivelines/16 fittings, front axle bolster/1 fitting, dump box pivot pins/two fittings, tailgate latch bar/two fittings, dump cylinder pins/4 fittings, and tailgate pivot/two fittings).

- Every 1,000 hours of operation (per PM074080); perform all actions listed in the 500 hour maintenance, and sample the hydraulic fluid/transmission fluid/front & rear differential fluid/all four wheel end oils.
- Every 4,000-8,000 hours of operation; mechanical rebuild of the underground haul truck. Maintenance records of the 4,000 to 8,000 hour PMs were not provided to the Board.

The Board compared the WIPP preventive maintenance program for the salt haul trucks to the manufacturer recommendations and identified the following:

- The service manual prescribes several activities to be performed after starting the vehicle that were not listed on the Operations Checklist. Additionally, the Operations Checklist does not reflect all of the items listed in the Operations and Maintenance (O&M) Manual.
- Although the pre-operational checks are to be done referring to the O&M Manual, the items listed in the Underground Haulage Truck Equipment Operator qualification guide do not match the level of rigor identified in the O&M Manual.
- Operator's Checklists were not representative of the as-found condition of the underground vehicles.
    - On February 13, 2014, Salt Haul Truck 74U006A had active engine oil and hydraulic leaks observed by the Board that were not documented on the Operator's Checklist. The truck was taken out of service on the day of the event, but that action was due to a malfunctioning light.
    - Although provided on the checklist, restoration of fluid levels was not recorded.
- The service manual recommends washing the vehicle every 125 hours or two weeks and NWP accomplishes this task with compressed air.
- NWP performs activities prescribed for 125 and 250 hours at 100 hour intervals.
- The service manual recommends battery level be checked/restored at 125 hour intervals and NWP performs it every 500 hours.
- The service manual recommends inspection of the front axle bolster rubber pads and bushings every 125 hours and NWP performs it every 500 hours.
- The following recommended maintenance items listed in the Service Manual were not found in the NWP procedures:
    - Check the air intake vacuum at 20 inches on a manometer every 250 hours.
    - Check the exhaust back pressure at 30 inches on a manometer every 250 hours.

- Check and adjust the engine valves per the Deutz Instruction Manual every 250 hours.
- Check accumulator pressure at 900 psi every 250 hours.
- Clean the fuel injectors and test the spray pattern every 500 hours.
- Check front and rear suspension bolt torque at 700 feet/pounds every 500 hours.
- Check the alternator output every 1,000 hours.
- Change the wheel end oil and differential oil every 1,000 hours.
- Have the complete fuel injection system inspected and serviced by a qualified diesel fuel system specialist every 3,000 hours.

Additionally, during review of the service manual, the Board discovered that although the salt haul truck was built to use a fire resistant fluid in the hydraulic oil system, standard hydraulic fluid is used.

Corrective maintenance is initiated via submission of an Action Request (AR). The action request is screened, validated, and prioritized at the plan of the day meeting. If accepted, the scope is developed, an optimum work window is assigned, and the level of rigor in planning is determined to be minor maintenance, expedited work or planned work. Work planners, along with a planning team in some cases, further develop the activity level work control document and participate in development of a job hazard analysis.

The Board reviewed corrective maintenance records associated with the EIMCO Salt Haul Truck 74U006B. The following is a summary of corrective maintenance actions performed in the last ten years:

- Hydraulic Oil - 17 hydraulic oil leaks repaired since July 2004.
- Engine Oil - three oil leaks repaired since July 2004.
- Fuel System - four fuel-related leaks since July 2004.
- An insulating blanket was installed between the cab and the engine compartment to reduce the heat in the operator's compartment June 23, 2005.
- A Fire Investigation was performed on 74U006B following a fire on September 1, 2005.
- Electrical Repairs - 50 total (batteries, alternator, back-up alarm, headlights, taillights, horn and wiring repairs).

The engineer responsible for the haul truck and personnel in the maintenance organization were interviewed by the Board. Maintenance personnel indicated that the older haul trucks (74U006B, which was the truck involved in the fire, and an identical truck, 74U006A) were much more reliable and easier to work on than the newer haul trucks. Personnel also offered that equipment drivers prefer the newer haul trucks since they run cooler and ride more comfortably. When questioned regarding which underground equipment was more problematic, the interviewees indicated that the bolting machines were the main maintenance problem in the underground.

4.2 Salt Haul Truck Manual Onboard Fire Suppression System

Southwest Safety Specialists are under contract to perform maintenance of the manual onboard fire suppression system installed on the salt haul truck. Semiannually, the system undergoes a 25-step process to confirm that it conforms to National Fire Protection Association (NFPA) requirements. To date, there have been no significant anomalies identified.

4.3 Other Maintenance Related Issues

The Board visited the CMR and the underground, including the accident scene, on February 13 and 14, 2014. The following maintenance-related issues were identified:

- There was significant buildup of engine and hydraulic oil on other mining equipment including Salt Haul Truck 74U006A. (Figure 13)

Figure 13: Buildup of Engine Fluids on the Underside of Vehicles in the Mine

- There was a three-foot diameter puddle of hydraulic fluid underneath Salt Haul Truck 74U006A. (Figure 14)
- The daily Operator's Checklist was completed on February 5, 2014, for Salt Haul Truck 74U006A with no deficiencies indicated.
- There was an Out of Service tag on Salt Haul Truck 74U006A indicating that a lighting deficiency existed.
- Several mine phones were found to be inoperable (run to battery failure). Twelve of 40 phones tested were non-functional.
- Numerous components of the mine ventilation system were out of

Figure 14: Hydraulic Fluid under Truck 74U006A

service or otherwise impaired for an extended period of time, some since installation:

- Exhaust Fan 413, 41-B-700-A since January 27, 2014.
- Exhaust Fan 413, 41-B-700-B since June 15, 2013.
- 707 bulkhead door that divides the construction split from the disposal split requires manual operation and cannot be remotely shut, which is necessary for shifting to filtration mode. During the initial entries after the event, underground services shut the 707 bulkhead door and regulator the afternoon of February 14, 2014. This allowed the ventilation system to be placed in filtration mode. After the radiological event the evening of February 14, 2014, it would not have been possible to place the ventilation in filtration mode if 707 bulkhead door had remained open.
- 401 bulkhead door has been chained open for a long period of time. It cannot be operated remotely from the CMR in the chained condition. This is the bulkhead door from the Air Intake Shaft. See Figure 15 for an example.
- EXO regulator was not working. The garage door was opened about two feet, and allowed smoke in the EXO space. In its current configuration, this regulator cannot be remotely operated from the CMR.
- 504 bulkhead door was chained open for a long period of time. It cannot be operated remotely from the CMR in the chained condition. This is the bulkhead door to the Salt Handling Shaft.
- 308 bulkhead regulator cannot be remotely operated from the CMR due to the regulator being out of service or impaired. This bulkhead is located between the Waste Shaft and the exhaust shaft.

Figure 15: One of Chained Bulkhead Doors

Numerous other pieces of equipment were out of service or otherwise impaired:

- 534-CAM-001-152 has only been operational a total of 29 days in the last 22 months.
- Building 463 Compressor Building trouble alarm has not been energized since May 21, 2013.
- Area 451 CMR Fire Alarm Panel impaired since June 5, 2013.
- Building 486 Northeast site, Riser Flow Switch Valve closed due to system leaking on August 9, 2013.
- Hydrant #23 out of service since September 10, 2013.
- Hydrant #3 out of service due to no flowing water since September 16, 2013.
- Auxiliary Warehouse FAP Broken Pull Station since October 27, 2013.
- Fire Water PIV #FW-Y-PIV-21 unable to operate in the closed direction since December 23, 2013.
- Fire Water PIV #FW-Y-PIV-27 is shut to isolate Hydrant #5 due to leakage since December 30, 2013.
- Fire Panel 031 not sending alarm signal to CMR since January 6, 2014.
- Gate House fire panel light going out since January 28, 2014.

Additionally witness statements and interviews from personnel yielded the following:

- PA announcements were difficult to hear or understand.
- There is a difference in expectations for waste-handling vs non-waste-handling vehicles.
- Pre-operational checks are not identifying equipment problems that need to be addressed other than light and horn issues.
- Some mine phones were reported as not working properly or difficulty in hearing was experienced.
- Thirty-three emergency lights in the Waste Handling Building have been inoperable for as long as two years.

Analysis

The Board determined that the use of fire resistant fluid in the hydraulic system could have significantly reduced the quantity of combustible liquid on the haul truck. Additionally, rigorous inspections and policing of oil and grease accumulation could have further reduced the combustible loading on the haul truck.

The Board determined that there is a significant delta between the preventive maintenance prescribed in the service manual and what is performed. Routine monitoring and adjustments that are not included in the NWP procedures are important maintenance items that could affect engine performance, resulting in higher than normal operating temperatures. Additionally, several decisions regarding maintenance and upkeep of the salt haul trucks were made without sound engineering judgment and evaluation. Discontinuing use of the wash station and opting

for compressed air as the means to keep the vehicle clean significantly inhibits the ability of maintenance personnel to identify and correct fluid leaks, resulting in continued buildup of combustibles.

The Board reviewed the equipment status and condition in the CMR and the U/G. The condition of critical pieces of equipment, such as the 700 exhaust fans, indicates that management has not taken prompt action to resolve longstanding deficiencies. Many items have been out of service or in a reduced status for more than six months. It was not clear that NWP had a clear approach to prioritizing maintenance activities in regard to critical equipment or that there is an effective formal process to identify compensatory measures other than a fire watch for impaired safety-related equipment. Additionally, the equipment and components that affect normal operation of the mine ventilation system did not appear to have been effectively evaluated and dispositioned regarding their impact on system operation. (Figure 16)

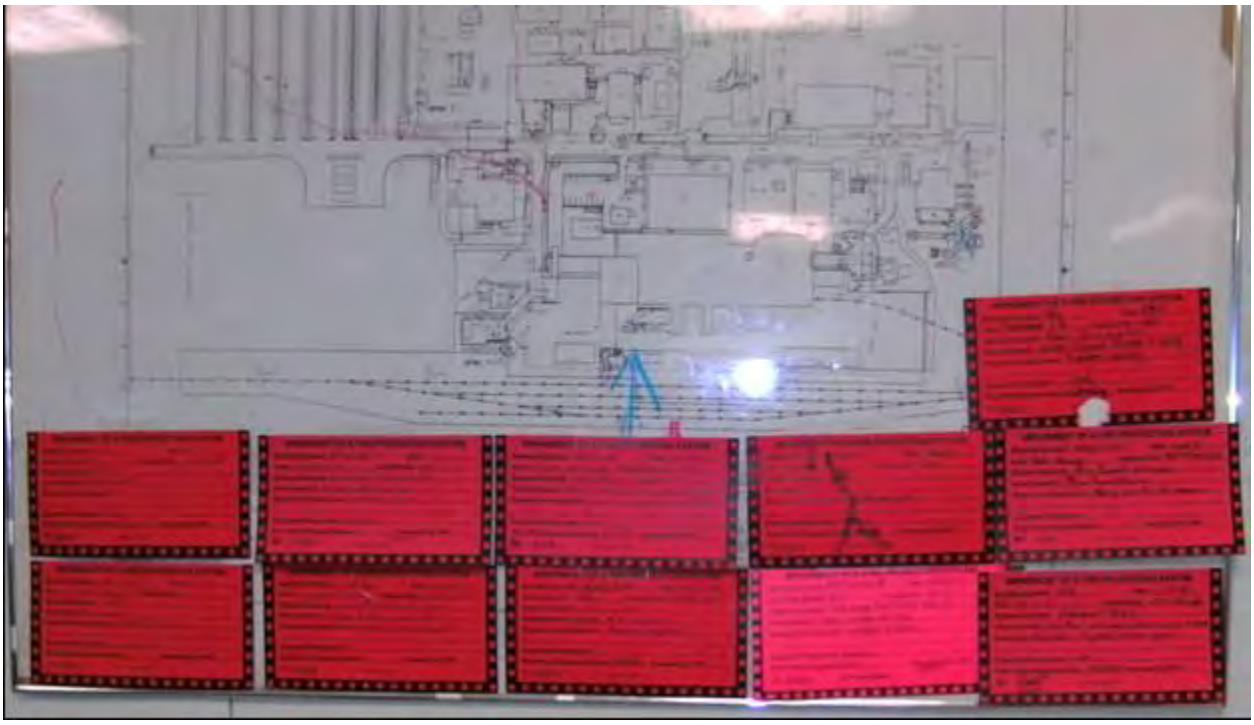


Figure 16: Fire Protection System Impairment (Out-of-Service Tags) in the CMR

CON 6: The NWP preventive and corrective maintenance program did not prevent or correct the buildup of combustible fluids on the salt haul truck.

JON 13: NWP management needs to reevaluate and modify the approach to conducting preventative and corrective maintenance on all underground (U/G) vehicles such that combustible fluids are effectively managed to prevent the recurrence of fires.

CON 7: NWP and CBFO management is not adequately considering overall facility impact with regard to operations, emergency response, and maintenance, which affects the safety posture of the facility, e.g., salt haul truck combustible build-up, conversion of the automatic fire suppression system to manual, removal of the automatic fire detection capability, not using fire resistant hydraulic fluid, discontinued use of the vehicle wash station, chaining of ventilation doors and an out-of-service regulator and fans, inoperable mine phones, and other non-waste-handling related equipment.

JON 14: NWP and CBFO need to develop and implement a rigorous process that effectively evaluates:

- changes to facilities, equipment, and operations for their impact on safety, e.g., plant operations review process;
- impairment and corresponding compensatory measures on safety-related equipment; and
- the impact of different approaches in maintaining waste-handling and non-waste-handling equipment.

JON 15: NWP needs to determine the extent of this condition and develop a comprehensive corrective action plan to address identified deficiencies.

CON 8: NWP and CBFO management have not effectively managed the quantity and duration of out-of-service equipment.

JON 16: NWP needs to develop and implement a process that ensures comprehensive and timely impact evaluation and correction of impaired or out-of-service equipment.

JON 17: CBFO needs to ensure that its contractor oversight structure includes elements for comprehensive and timely evaluation and correction of impaired or out-of-service equipment.

CON 9: NWP management has allowed less than acceptable rigor in the performance of equipment inspections allowing the operation of U/G equipment in unacceptable condition.

JON 18: NWP needs to develop and reinforce clear expectations regarding the performance of rigorous equipment inspections in accordance with manufacturer recommendations, established technical requirements; corrective action; and trending of deficiencies.

5.0 Fire Protection Program

Understanding fire hazards is essential to risk reduction and fire protection decision-making. DOE O 420.1C, *Fire Protection*, requires a documented fire protection program including comprehensive, written fire protection criteria or procedures, fire hazards analysis (FHA) and a baseline needs assessment (BNA) of the fire protection emergency response organization.

An FHA is a tool used to understand fire hazards. The process of quantifying the fire hazard is driven by the need to determine the overall hazard of a process or facility or to have a decision-making tool for fire protection systems. An FHA is an important element of risk assessment and can also be used as a stand-alone hazard evaluation tool.

The benefits of conducting an FHA include:

- An inventory of fire hazards, including quantities.
- A comprehensive understanding of the fire hazard, including potential magnitude and duration.
- An estimate of the potential impact of a fire on personnel, equipment, the community, and the environment.
- Development of a list of appropriate mitigation options.

A BNA establishes the site firefighting capabilities necessary to suppress all fires. It also establishes the necessary emergency medical and hazardous materials response capabilities. This includes an evaluation of staffing, apparatus, facilities, equipment, training, preplans, offsite assistance, and procedures.

The Board reviewed the fire protection program with a focus on the implementation of requirements documented in the FHA, BNA and requirements related to the combustible material control program. The FHA is documented in WIPP-023, *Fire Hazard Analysis for the Waste Isolation Pilot Plant*, Rev. 6. The BNA is documented in DOE/WIPP-11-3471, Rev. 1.

5.1 Fire Hazard Analysis

The FHA indicates that it is implementing the requirements of DOE O 420.1C, and DOE-STD-1066-12, *Fire Protection*. The FHA evaluates fire in the following sections:

- Underground Disposal Circuit (5.2.2),
- Underground Construction Circuit (5.2.3),
- Underground North Circuit (5.2.4), and
- Common Facility Fire Scenarios (5.2.5).

The Board found the following in the FHA:

- The FHA does not address the possibility that the vehicle fire suppression system does not perform as intended. The FHA does not consider the possibility that the onboard vehicle fire suppression system could fail to extinguish the vehicle fire.
- The FHA addresses a fire near the air intake on the surface, but does not consider the smoke/products of combustion migration throughout the underground if the fire is in the air intake drift.
- The analysis of a vehicle fire does not differentiate the level of protection provided by a manual fire suppression system versus the level of protection provided by an automatic fire suppression system.
- Life Safety for the Shafts and Underground (7.6) is not evaluated using the same criteria as all other facilities at WIPP. The above ground facilities use DOE O 420.1C and NFPA 101, *Life Safety Code,* versus MSHA requirements used in the underground. The FHA references the 1998 version of 30 CFR 57, *Safety and Health Standards*, "Underground Metal and Non-metal Mines" (MSHA).
- The reflectors intended to mark the worker egress evacuation direction were difficult to see during the evacuation of the underground. This was a concern for several personnel as they evacuated the underground.
- The FHA does not address how omitting automatic fire suppression systems from the underground and its various vehicles and enclosures meet the requirement of DOE O 420.1C (Attachment 2, Chapter II, Section 3.c.(2)(b)).
- Additionally, the Safety Class fire systems (4.3.3) on the waste haulers are not designed to meet single-point failure criteria.

The DOE-STD-2012, *Fire Protection*, Appendix B, Section B.25 states the FHA should evaluate the consequence of a single worst case automatic fire system malfunction.

Analysis

The FHA does not provide a comprehensive analysis that addresses all credible underground fire scenarios, including a fire located in the air intake drift. The FHA did not consider the ventilation system movement of smoke/products of combustion throughout the mine. Additionally, the FHA analysis of vehicle fires is insufficient to provide an advance understanding of potential impacts or necessary mitigative actions associated with this or other potential vehicle fires. The FHA fails to address the impacts caused by the difference in the level of protection provided by manual versus automatic detection and fire suppression systems.

DOE O 420.1C requires an FHA to be prepared for nuclear facilities and for facilities with unique hazards. The underground meets both of these criteria. The FHA does not identify, discuss, evaluate, and analyze the unique hazards in the underground. The FHA must describe the controls necessary to address these unique hazards.

The Documented Safety Analysis has identified the waste-handling vehicles' fire suppression system as safety class; however, the FHA fails to identify how these systems are protected

against single-point failures. In addition, these systems are focused risk reduction tools that address specific vehicle fire scenarios. They are not comprehensive protection systems equivalent to automatic sprinkler systems in buildings. DOE facilities have historically credited manual intervention and detection that automatically notifies a response organization for protection against single-point failures. Since there is not a fully defined response organization to fight fires in the underground, the FHA needs to identify the suppression system that is required.

The FHA discussion on life safety does not include a reference to a DOE-approved exemption/equivalency for application of the MSHA requirement instead of the NFPA 101. The FHA implies the MSHA requirements provide an equivalent level of protection without objective evidence to support the assumption. Objective evidence in the form of an approved exemption/equivalency for meeting the DOE Fire Protection program requirements must be established.

A lack of thorough analysis and development of the fire program requirements resulted in a lack of adequate information to ensure risk-informed, conservative decision making could be applied with regard to the fire protection program.

5.2 Baseline Needs Assessment

The BNA and the status of recommendations from the BNA were reviewed and the following items were identified:

- BNA Recommendation 2012-10 states: "WP 12-ER4911 does not define minimum response, response roles or resource capabilities. It is recommended to amend this procedure to more clearly define such things as FLIRT response actions and Rescue Truck #2 response (page 32)." This issue is from the 2010 version of the BNA and was not resolved in the 2012 revision to the BNA.

  > *"The MRT is not dispatched to fight fires in the U/G. They will be activated if the fire is beyond the incipient stage and search, rescue and/or recovery operations are needed. They will engage in firefighting only as necessary to carry out rescue operations."* BNA, page 35

- Underground Fire Response analysis in section 7.3.1.2 states:

  > *"U/G fire response is documented in WP12-ER4911, U/G Fire Response. Workers discovering fire in the U/G are trained to contact the CMR. Workers are expected to evaluate and respond to incipient fires with portable fire extinguishers. If the fire is vehicle-related, initial U/G fire response is to use automatic or manual vehicle fire suppression systems.*
  >
  > *The CMR will contact Underground Services personnel who will make an evaluation of the fire. Based on that evaluation, Underground Services will extinguish the incipient stage fire with a portable fire extinguisher or initiate U/G evacuation through the CMR Operator. The CMR will make an announcement informing personnel of the fire location, instructing personnel in smoke to don self-rescuer, suspending all U/G operations, and instructing to U/G personnel report to egress hoist stations. Per the*

direction of the CMR and U/G Services, Emergency responders or FLIRT members will respond to S700/E140 to bring Rescue Truck #2 to the incident. Once evacuation is complete, a response plan is developed depending upon the status of the fire. The plan may include ventilation control, barrier erection, and waiting for the fire to self-extinguish or implement active ventilation." (p.32)

- 9.1 Existing Recommendations states that:

  "The communicator paging system is old and needs to be updated or replaced. The old system has been replaced. The new system was placed in service in August 2012. Status: "Completed in August 2012"

- Recommendation 2012-10 states: "Define minimum response and response capability in procedure WP12-ER4911."
- Recommendation 2012-10 Supporting Statement states:

  "The U/G fire response procedure does not define minimum response, response roles or resource capabilities, such as FLIRT actions to be taken, nor does it outline deployment of possible resources, Rescue Truck #2 and the 300-pound wheeled ABC fire extinguisher.

  During review of documentation, the response provided by Rescue Truck #2 and the 300-pound wheeled ABC fire extinguisher was not evident. Rescue Truck #2 contains an onboard 150-pound foam extinguisher and 125-pound dry chemical extinguisher. Documentation was not found to indicate who is authorized to use them nor is intended use specified. If these resources are proven to not be value added, then recommend removing them from the U/G to prevent confusion or misuse." Page 62

  - Hazardous Material and Radiological Event Responses, section 7.3.2 states**:**

    "For a fire that may damage TRU waste containers or radioactive sources, the CMR sounds an alarm and makes an announcement for all personnel in the affected area to evacuate to an area with clean air to await Radiological Control Technician (RCT) arrival. The CMR will activate the FB. If the event occurred U/G, ventilation will be adjusted to ensure negative differential pressure in the affected areas and verify the high-efficiency particulate air filter bank differential pressures are normal."

The contractor is required to provide emergency response capabilities, as necessary, to meet site needs as established by the BNA, safety basis requirements, and applicable regulations, codes and standards as required by DOE O 420.1C, section 3.e. Evidence to support implementation of the above recommendations could not be found. These recommendations, some of them going back to 2010, remain unresolved and unimplemented.

The audibility of the communicator paging system was a concern for some of the personnel evacuating the underground. It has been noted that some of the old amplifiers are still installed in the communicator paging system, although the BNA identifies that the old communicator paging system has been updated.

There is no formal documentation (e.g., equivalency or exemption) describing the alternative method for ensuring the safe egress of underground personnel and how the alternate method fulfills the requirements of DOE O420.1C, 3.c.1.

If relying on manual fire suppression, DOE O 420.1C, Attachment 2, Chapter II, section 3.e. (1)(a) requires pre-incident strategies, plans, and standard operating procedures to be established to enhance the effectiveness of manual fire suppression activities. The existing procedures do not address this.

The CBFO approved the BNA without comment regarding the longstanding open recommendations.

The BNA indicates that fighting anything past an incipient stage fire in the underground is only done by the MRT. The MRT only fights fires to support rescue of personnel, not to protect property. The BNA should be updated to reflect the actual MRT approach to limit fire damage, but only after the underground is fully evacuated. Also, the MRT will typically avoid direct suppression of a fully developed fire, and instead erect barriers from a safe location that directs ventilation away from fires. The effect of this approach limits fire damage while the fire self-extinguishes by consumption of fuel.

Workers evacuating the underground were confused by the shift in ventilation mode, adding stress to the existing emergency condition.

Analysis

The BNA has not met one of its basic functions, determination of the current and future needs for the emergency service aspects of fire suppression in the underground. It does not determine the minimum manpower, equipment and training needed to manage a fire in the underground. Instead it assigns a recommendation to "Define minimum response and response capability in procedure WP12-ER4911." Assigning the task to evaluate the minimum response and response capabilities to an operations procedure puts an undue burden on the procedure writer. The BNA must indicate training, staffing and equipment necessary for safe operations. The implementing procedure can then address how to make the best use of the defined staffing as established in the BNA. The BNA must be developed to identify the necessary requirements and flow those requirements into the implementing procedures.

The BNA section 7.3.1.2 allows for adjustment of ventilation without any analysis of the effect of a ventilation change or under what circumstances an adjustment is inappropriate. The BNA should incorporate an analysis and determine the appropriate limitations on the use of ventilation system changes in the event of an underground fire.

The BNA closed out a past recommendation concerning the paging system without the new installation being completed. It clearly states the paging system replacement was completed in

August 2013. However, the facts indicate old amplifiers are still installed and have not been replaced. The recommendation needs to be reopened and closure needs to be validated by NWP and verified by CBFO to ensure the new system is actually capable of performing its intended function.

The WIPP facility needs to embrace its dual nature of being a mine as well as a Hazard Category 2 Facility. As such, WIPP has two distinct requirement sets, MSHA and DOE O 420.1C. Both of these have fire protection program requirements that must be met. There is a common misconception that MSHA is the only program requirements for underground operations. Both sets of requirements must be met and any deviation fully addressed. Therefore, NWP needs to perform a line by line review of DOE O 420.1C requirements (Attachment II, Chapter 2) and MSHA requirements to ensure both requirement sets are fulfilled. Where differences exist, they need to be identified, evaluated and reconciled properly. This is not limited to just the evaluation of automatic suppression and Life Safety code. It should also include emergency response requirements for the underground, including strategies and preplans for fire events.

5.3 Underground Combustible Material Storage

Good housekeeping and control of combustible/ignition sources are basic components of any fire protection program (FPP). External reviews from the DNFSB have identified a long-standing issue with the control of combustible materials at WIPP. Additionally, an EM HQ assist-visit noted that "Combustible loading limits establish safe storage arrangements for spools of wire and combustible materials in the underground. Current conditions far exceed those limits. The FPP has not been adequately assessing the combustible material limits established for the underground."

Figure 17: Combustible Loading in the Mine

While these fire protection reviews addressed only the control of combustible materials, material storage and staging is really the issue. Salt movement requires periodic touchup to the ribs and back (walls and ceiling) to maintain the non-waste work areas, and the floors throughout the mine, in good repair. As a result, equipment and materials are moved out of an area and staged in the drifts. Although this staging is temporary storage, the condition can last several months. The Board observed materials

stored on either side of the drifts, materials that obscured reflectors, and stored combustibles exceeding the 5 megawatt (MW) limit. Personnel group interviews indicated storage on only one side of drift could have made navigation in drift easier.

This 5 MW limit has not been enforced and NWP is not in compliance with the limits. The use of office furniture in some areas will exceed the 5 MW limit. There were numerous examples of accumulation of combustible materials in the underground that exceed either the spacing requirement or the 5 MW accumulation limit, as evidenced in Figure 17.

Analysis

NWP and CBFO have allowed for the use and accumulation of combustible material in the U/G in excess of the limits allowed by the fire analysis and implementing procedures. NWP does not appear to practice an "As Low As Reasonably Achievable" (ALARA) posture regarding the use and storage of combustible materials in the underground.

CON 10: NWP did not ensure the BNA addressed requirements of DOE O 420.1C and MSHA with the results completely incorporated into implementing procedures.

JON 19: NWP needs to ensure that all requirements of DOE O 420.1C and MSHA are addressed in the BNA with the results completely incorporated into implementing procedures and the source requirements referenced, and that training consistent with those procedures is performed.

CON 11: NWP and CBFO management did not make conservative or risk-informed decisions with respect to developing and implementing the fire protection program.

There is inadequate fire engineering analysis due to a lack of integration with ventilation design and operations, and U/G operations, for recognizing, controlling, and mitigating U/G fires.

JON 20: NWP and CBFO need to perform an integrated analysis of credible U/G fire scenarios and develop corresponding response actions that comply with DOE and MSHA requirements.

The analysis needs to include formal disposition regarding the installation of an automatic fire suppression system in the mine.

CON 12: NWP and CBFO have failed to take appropriate action to correct combustible loading issues that were identified in previous internal and external reviews.

JON 21: NWP and CBFO need to review the combustible control program and complete corrective actions that demonstrate compliance with program requirements. These issues remain unresolved from prior internal and external reviews.

CON 13: NWP and CBFO have allowed housekeeping to degrade and other conditions to persist that potentially impede egress.

JON 22: NWP and CBFO need to evaluate and address deficiencies in housekeeping to ensure unobstructed egress and clear visibility of emergency egress strobes, reflectors, SCSR lights, etc.

5.4 Fire Forensics

This fire description has been prepared based on a partial visual inspection conducted on February 13, 2014, Board interviews, evaluation of numerous photos taken on February 13, 2014, and other available data. Further inspection was prevented by a radiological contamination event that occurred on February 14, 2014.

Fire ignition is presumed to have occurred near the exhaust system piping on the lower left side of the haul truck forward of the front wheel (see Figure 18). This area is enclosed by steel construction, making early visual detection difficult. The initial material ignited was a combustible liquid leaking onto the exhaust system. The liquid could have been free flowing or an accumulation on exposed surfaces. The flashpoint temperatures for haul truck fluids are listed in Table 2. The operating temperature of a typical catalytic converter will range from 300 to 500° C; however, this may exceed 500° C during abnormal engine operation (NFPA 921-2014, *Fire and Explosion Investigations*). All of these values exceed the flashpoints shown in Table 2.

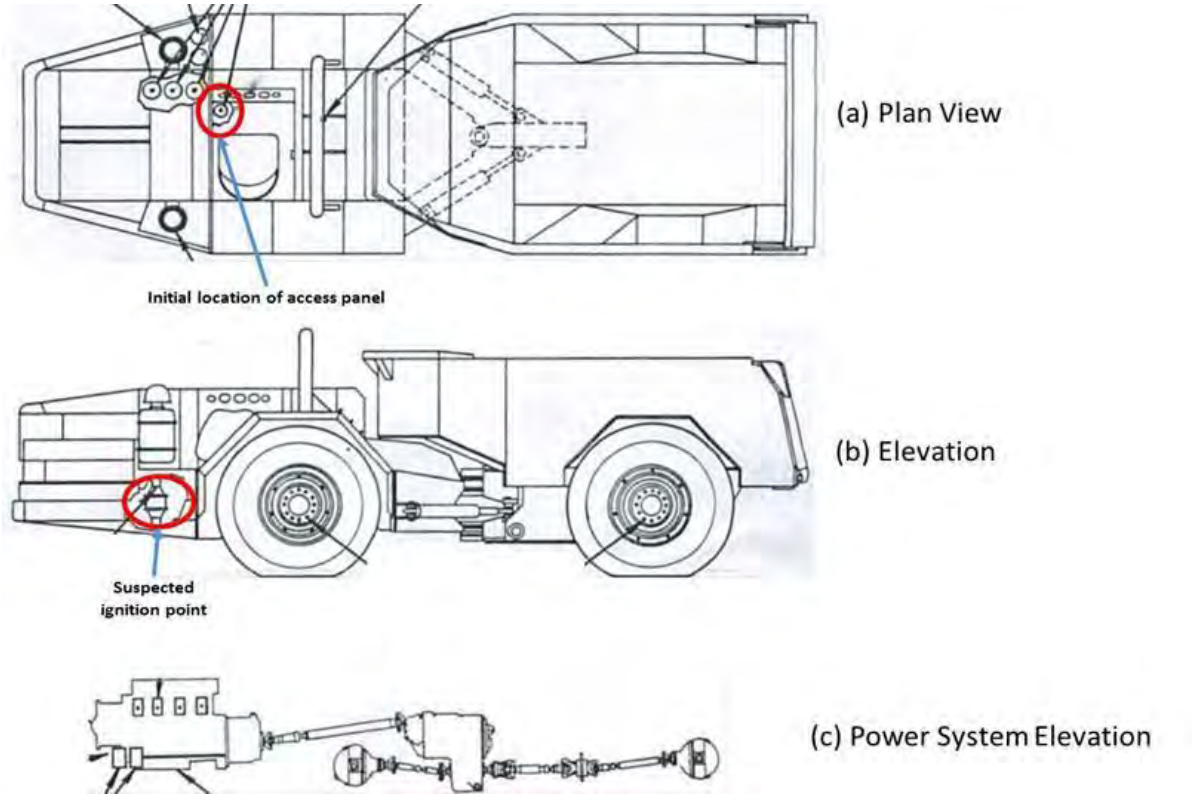


Figure 18: Salt Haul Truck

Table 2: Liquid Fuels on Salt Haul Truck

System	Product	Flashpoint °C
Engine	Exxon Mobil XD-3 30 Oil	220
Hydraulic	Citgo A/W Hydraulic Oil 68	242
Transaxial differential	Citgo Regular Gear Oil, SAE 90	236
Transmission	Citgo Transgard® MP ATF	208

Figure 19: Engine Cooling Coils

The Board observed accumulated grime in the engine compartment of other salt haul vehicles that would have been sufficient to create a sustained fire that would result in additional fluid leaks. The normal hauler ventilation flow pulls air through the front grill and directs it across the cooling coils above the engine block (see Figure 19). This flow exits at the back of the engine compartment and would push the fire towards the transmission (see Figure 18, illustration (c)). In the actual fire, this condition occurred within about 5 to 10 minutes of initial ignition (assumed start time is 1043) and was recognized by the truck Operator at 1048. The Operator shut down the engine, exited the hauler on the left side, and moved to the right side. The Operator then discharged his hand-held fire extinguisher through the transmission access hole, which is forward of the pivot pin (see Figure 20) and under the haul truck. Because the fire was enclosed, using a handheld fire extinguisher was ineffective. The delay between initial ignition and activation of the engine compartment fire suppression system resulted in development of multiple leaks.

Figure 20: Transmission Fluid Stick Access

When the Operator had discharged the hand-held fire extinguisher, he returned to the left side of the haul truck to initiate release of the on-board fire suppression system. The effectiveness of suppression system is uncertain. At activation, the fire could have been too severe to control, or if initially controlled, a hot surface within the engine compartment might

have reignited the fire. When the engine was shut down, the cooling fan stopped. Because of the haul truck orientation, mine ventilation flow was opposed to the cooling system airflow. This prevented further propagation towards the rear of the haul truck and prevented ignition of the rear tires. The change in engine compartment airflow direction also created a V-shaped discoloration on the haul truck grill. This discoloration was created by the most intense flaming. Sooty deposits occurred on either side of this V where the flames were less intense.

Ignition of the front tires likely occurred within 10 minutes of fire ignition (see Figure 21). Involvement of the tires produced heavy black smoke at the Salt Handling Shaft station before 1053 (1051 plus two minutes for the Salt Handling Shaft Bottom Lander to move to the station).

Figure 21: Salt Haul Truck Damage
(Engine Cowling Was Opened Post-Fire**)**

The majority of the airflow entered the underground via the Air Intake Shaft, moved by the flaming salt haul truck, and moved towards the Salt Handling Shaft. This airflow, which moved from the back to the front of the truck, created a well-ventilated fire within the truck. Flames from the combustible liquid and tires impinged on the salt rib and caused spalling of the salt (see Figure 22). A smoke signature carried from this impingement point to the bulkhead doors at the base of the Salt Handling Shaft (see Figure 23). The doors created a well-mixed flow at the Salt Handling Shaft. The Exhaust Shaft flow pulled the well-mixed combustion products into the Waste and Construction Air Handling Circuits. The elevated local temperature also created an upcast flow through the Salt Handling Shaft.

Figure 22: Haul Truck and Rib Spalling

Figure 23: Smoke Signature on Rib (Looking South)

A portion of the airflow entering the underground traveled through the North Air Handling Circuit. The salt haul truck fire created a smoke layer in this circuit. This layer was approximately two feet deep, and traveled to the partially opened rollup door in E140. This arrangement trapped the upper smoke layer since the lower layer moved through the door.

At 1058, the FSM initiated a reduction of airflow; however, the fire remained well-ventilated. The change significantly decreased airflow through the North Air Handling Circuit and permitted combustion products to drop to the floor (see Figure 24). Combustion products continued to travel to the Salt Handling Shaft station to be pulled into the Waste and Construction Air Handling Circuits by the Exhaust Shaft flow, or to be upcast through the Salt Handling Shaft.

Figure 24: Soot Deposits in North Ventilation Circuit

Sometime during the intense burning period an accumulator within the engine compartment burst. This ejected an end-cap which ruptured an access plate and went through the hauler operator compartment. The end-cap traveled approximately 10 feet beyond the back of the haul truck (see Figure 25). The access plate was severely deformed and traveled approximately 20 feet beyond the end of the haul truck (see Figure 26).

Figure 25: Accumulator Endcap (MG 3591)

Figure 26: Damaged Access Plate

Significant combustion continued for 20 to 40 minutes (Time 1103 to 1123). Underground evacuation continued until 1134. The fire continued to smolder until the Mine Rescue Team applied foam fire suppressant at 2300.

The above analysis is consistent with the report from Investigator Robert Brader, attached in Appendix F.

6.0 Safety Equipment

The Board reviewed safety equipment to determine the impact on the event. The salt haul truck fire suppression system, emergency breathing equipment, underground ventilation, and the U/G communication and emergency notification systems were evaluated.

6.1 Salt Haul Truck Fire Suppression System

6.1.1 System Description

The fire suppression system installed on the salt haul truck (Vehicle 74-U-06B) is an ANSUL A-101-30 Dry Chemical Fire Suppression System that contains 30 pounds of FORAY dry chemical agent for Class A, B, and C fires. The ANSUL A-101 Fire Suppression System is a Factory Mutual (FM) approved pre-engineered, cartridge-operated dry chemical system with a fixed nozzle distribution network designed for use on large, off-road type construction and mining equipment, underground mining equipment and specialty vehicles.

The system is released manually by activation of one of two mushroom buttons (pneumatic actuator) located on the front wheel fenders. When pushed by the vehicle operator (or an observer) the pneumatic actuator ruptures a seal disc in the expellant gas cartridge. This, in turn, pressurizes and fluidizes the dry chemical extinguishing agent in the tank, ruptures the burst disc when the required pressure is reached, and propels the dry chemical through the network of distribution hose. The dry chemical is discharged through fixed nozzles and into the protected areas, suppressing the fire. According to the Southwest Fire Safety Company, responsible for maintaining this system for the past 19 years, there are six nozzles, four in the engine compartment and two in the transmission compartment where the fire was first observed.

There were no design drawings for the system provided. Physical verification of the complete system configuration was not possible due to inability to reenter the mine.

6.1.2 System Configuration

The salt haul truck was originally procured without a fire suppression system. The ANSUL A101 system was originally installed on vehicle 74-U-006B at an unknown time, but records indicate that it was prior to 1995. The following items identify activities that affected the fire system:

1. The system was recharged in April of 2000 after discharge.

2. The automatic suppression system defeat switch was removed May of 2000. The vendor responsible for fire suppression system maintenance indicated that this switch's function was to delay the automatic discharge of the dry chemical.

3. The system was changed from automatic to manual operations on October 21, 2003, via Work Order ID 0300900, created January 28, 2003. This transition included replacing the actuator with new A-101 actuator with accessories. The new system configuration did not include automatic detection or automatic engine shutdown. Both of these were functions from the original installation.

4. After investigation of the haul truck fire of September 2005, a subsequent work order was executed to replace a battery cable that was damaged in the fire. No other damage was cited. A PM done on April 17, 2006, that included providing 30 pounds of dry chemical agent.

Analysis

A vehicle fire suppression system is designed to suppress a fire and reduce fire size and heat output, but not necessarily extinguish all fires. The onboard fire extinguisher should be used to extinguish residual small fires remaining after system discharge.

The manual system is only discharged when an operator takes two conscious actions: pull the pin and push the actuator. Vehicle shutdown is an additional step that is necessary to remove the engine heat to ensure extinguishment of the fire. The automatic system contained detection and automatic vehicle shutdown capability that would not require human intervention.

The combination of the operator using a hand held extinguisher before initiating the manual fire suppression system provides an example of why the automatic system is the preferred approach. The delay in activation of the manual system is likely to allow the fire to grow beyond the incipient stage by the time it is detected by the truck operator. Automatic detection and extinguishment is preferred. The impact of switching the suppression system from automatic detection and activation to manual activation modes was not fully analyzed.

CON 4: Actions to be taken by the Operator in the event of a U/G vehicle fire were not clear.

There were inconsistencies between procedures and training for fire response that led to an ineffective response to the salt haul truck fire.

JON 8: NWP needs to review procedures and ensure consistent actions are taken in response to a fire in the U/G.

JON 9: NWP, CBFO and DOE HQ need to clearly define expectations for responding to fires in the U/G, including incipient and beyond incipient stage fires.

6.2 Emergency Breathing Equipment

6.2.1 Description of Self-Rescue and Self-Contained Self-Rescue Devices Underground (Manufacturer)

W-65 Self Rescuer: The W-65 Self Rescuer is designed to protect the wearer from carbon monoxide only and will support the user for 60 minutes in a carbon monoxide environment. This device should not be used in atmospheres containing less than 19.5 percent oxygen. The W-65 Self Rescuer is belt worn and should never be farther than arms reach away from the person it is assigned to. Under no circumstances should the distance from the employee and the W-65 Self Rescuer ever exceed 25 feet. It is to be used in the event of a fire or smoke for emergency egress or to get to a cache of Self Contained Self Rescuers (SCSR's).

OCENCO EBA 6.5 Self Contained Self Rescuers (SCSR's): The OCENCO EBA 6.5 has been approved as a 1 hour closed circuit self-contained self-rescuer. Extensive testing has shown that the OCENCO EBA 6.5 will provide the user with over 60 minutes of life saving oxygen in escape situations requiring heavy physical activity. There are 425 of these units at storage locations throughout the underground facilities.

Similarly, the OCENCO EBA 6.5 has demonstrated the ability to provide the user with up to 8 hours of oxygen if he remains at rest and follows the procedures necessary for maximum conservation as explained in the Instructions for Use for Users at Rest.

MSHA requires that all persons who may depend on the OCENCO EBA 6.5 for survival be thoroughly trained in the operation and use of the unit.

FireHawk M7 Air Masks: The FireHawk M7 Air Masks are pressure-demand, self-contained breathing apparatus (SCBA) certified by the National Institute for Occupational Safety and Health (NIOSH) for use in atmospheres immediately dangerous to life or health (IDLH).

This Air Mask complies with the National Fire Protection Association (NFPA) for Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters. The Air Mask will protect the user from CBRN (chemical, biological, radiological, and nuclear). Four of these units are stored underground at the WIPP mine. They can be found on the Emergency Rescue Wagon located at S-700 and E-140. These units are for Fire Fighting Use in the event of an Emergency only by specifically trained and qualified personnel.

Both the W-65 Self Rescuers and the SCSRs were used by underground workers during the evacuation from the mine during the haul truck fire incident. The Board has reviewed the statements of workers who were in the mine at the time of the incident. The Board was able to look at the results of the evacuation on documents from 61 of the 86 workers that successfully escaped the haul truck fire.

Six employees (10 percent) of those who provided documentation did not use the W-65 Self Rescuer. Three of the six employees did not use a self-rescuer at all during the evacuation. The other three used the SCSR. Fifty-five of the employees performed as trained and donned their W-65 Self Rescuers (90 percent).

- Four of the 61 had difficulty opening the W-65;
- Thirteen of the employees were able to successfully use the SCSR; and
- Twenty one of the SCSRs did not open properly and could not to be used.

Analysis

Many individuals had difficulty donning either the SCSR or W-65 self-rescuer. There is no training that simulates use in likely emergency conditions (i.e., limited visibility due to dark or smoke filled areas). The annual refresher is a video that does not require donning of the SCSR. It is at the trainee's discretion whether or not they desire to don the SCSR or W-65 during training. The existing training program for use of the SCSR and W-65 self-rescuer does not evaluate the competency of the user.

CON 5: NWP and CBFO failed to ensure that training and drills effectively exercised all elements of emergency response to include practical demonstration of competence, e.g., donning of self-rescuers and SCSRs, U/G personnel response to a fire, use of portable fire extinguishers, EOC roles, classification and categorization, notifications and reporting, and allowance of unescorted access for over 500 personnel, etc.

JON 10: NWP and CBFO need to develop and implement a training program that includes hands-on training in the use of personal safety equipment, e.g., self-rescuers, SCSRs, portable fire extinguishers, etc.

JON 11: NWP and CBFO need to improve and implement an integrated drill and exercise program that includes all elements of the ICS, including the MRT, First Line Initial Response Team (FLIRT) and mutual aid; unannounced drills and exercises; donning of self-rescuers/SCSRs; and full evacuation of the U/G.

6.3 WIPP Underground Mine Ventilation

The underground ventilation system (UVS) serves all underground facilities and provides the equipment, controls, and monitoring necessary to provide a suitable environment for underground personnel and equipment during normal activities. It also provides confinement and channeling of potential airborne radioactive material in the event of an accidental release or smoke and fumes in the event of an underground fire. It further provides high-efficiency particulate air (HEPA) filtration of exhaust air to minimize any doses to onsite and offsite personnel. Under normal operating conditions, the effluent exhaust is not filtered. The status of the system equipment is continuously monitored, and the data are provided to the CMR, as well as local stations underground.

The air is supplied to the underground, at 2,150 feet below the surface, through three shafts and exhausted through a single shaft by exhaust fans located on the surface. The fresh air supply is divided into four separate streams.

The air drawn down the Air Intake Shaft and the Salt Handling Shaft is split into three separate air streams serving the construction, north area and waste disposal areas. The air drawn down the Waste Shaft serves the Waste Shaft station operation and is exhausted directly to the Exhaust Shaft station, where it joins the exhaust streams of the other three areas. The combined exhaust streams are drawn up the Exhaust Shaft, and discharged directly to the atmosphere under normal operation or via the HEPA filtration system under certain off-normal conditions.

Standby HEPA filtration, also located on the surface, is engaged upon detection of radioactive particulates in the waste disposal exhaust stream.

6.3.1 The Normal Mode (Exhaust Filtration Bypassed)

The Normal Mode of ventilation is with the exhaust filtration system bypassed. Five different levels of Normal Mode ventilation can be established to provide five different air flow quantities. These five levels of air flow are achieved by the use of the various exhaust fans as follows:

- **Normal Ventilation**: Two of three main exhaust fans operating to provide 425,000 standard cubic feet per minute (scfm) unfiltered.
- **Alternative Ventilation**: Any one of the three main exhaust fans operating to provide 260,000scfm unfiltered.
- **Reduced Ventilation**: Any two of three filtration fans operating as ventilation fans to provide 120,000scfm unfiltered.
- **Minimum Ventilation**: Any one of three filtration fans operating as a ventilation fan to provide 60,000scfm unfiltered.
- **Maintenance Ventilation**: Any one or two of the three main exhaust fans operating in parallel with one or two of the filtration fans to provide approximately 260,000scfm to 425,000scfm.

6.3.2 Filtration Mode

The filtration mode of ventilation is designed to confine airborne radiological contamination released by a breached waste container in the underground, minimizing any release to the environment. Filtration shall be automatically initiated by detection of radioactive airborne contaminants above the set point. A single 860 Series fan provides up to 60,000scfm in filtration mode exhausted through the HEPA bank.

6.3.3 Dynamic Pressure Effects

The underground ventilation system is basically a steady state system. When it becomes necessary to make a change in operating mode there are dynamic pressure changes which must be considered. These are primarily only in ventilation, such as a shift to filtration that may cause temporary localized pulses. The magnitude and location of these may be affected by the proximity of the shafts.

On February 5, 2014, the ventilation was in the maintenance mode until a fire was reported in the underground at 1050. When the FSM received notice of smoke in the underground in unexpected locations, he made the decision to switch ventilation to the Filtration Mode at 1058 in an attempt to control and slow the spread of smoke throughout the underground.

Analysis

There was a ventilation change made eight minutes into the reported vehicle fire in the underground areas of WIPP. When the ventilation was changed to filtration mode, the ventilation in the mine was reduced from 260,000 scfm to approximately 60,000 scfm. The reduction in ventilation did slow the distribution of the smoke, but had the potential of causing the workers to be exposed to heavier smoke and higher levels of carbon monoxide. This is based

on studies from mining experts when mine fires and explosions occur. This unanalyzed change to filtration mode resulted in a change in air flow in the underground altering the conditions in the primary and secondary evacuation routes. The switch to filtration was unannounced and confused workers as to their proper egress routes.

Early understanding of the exact location of the fire may have enabled decisions on ventilation door closure that would have minimized smoke flow into evacuation routes. The ability to change ventilation configuration remotely to control smoke was hampered by chained doors and a regulator in need of repair, i.e., 707 bulkhead regulator.

CON 2: NWP management allows expert-based, rather than a process/systems-based approach to decision making, e.g., shift to filtration during a fire, sheltering decisions, etc.

JON 3: NWP needs to evaluate and apply a process/systems based approach for decision making relative to credible emergencies in the U/G, including formalizing response actions, e.g., decision to change to filtration mode during an ongoing evacuation.

6.4 Underground Communications and Emergency Notification Systems Description

The Board reviewed the Underground Communications Systems that are in use at the WIPP and were used during the U/G fire of February 5, 2014. The following is a description of the systems in use.

The Central Monitoring System (CMS) is a supervisory control and data acquisition (SCADA) system consisting of a mix of functional units communicating on a redundant network throughout the facility on the surface and in the underground. The network is made up of optical fiber and the associated fiber distribution units, switches, etc. The functional units are LPUs, operator, server PCs, printers and uninterruptible power supplies.

The CMS is used for real-time site data acquisition, display, storage, alarming and for the control of site components. The CMS monitors process, environmental, electrical, mechanical, radiation, and fire protection systems and provides manual and automatic control of underground ventilation, backup power, underground evacuation alarm automatic shift to filtration, and electrical distribution.

The CMR, located on the second floor of the Support Building, is the central location for monitoring site data and conditions. It is the location of the primary man-machine interface with the CMS, Remote Fire Alarm Reporting (RFAR) station, a satellite weather service and a commercial television weather station. The operator is in voice contact with the on-site and off-site activities via the dial phones, mine pager phones, public address and intercom system and two-way radio. The master control console for public address and evacuation alarm control is located in the CMR. Space, phones, and furniture are provided in the CMR for the activities of the Operations Assistance Team during emergency conditions.

The Dial Phones system is a private automatic telephone exchange for on-site and off-site telephone communications. Dial phones and other terminal devices are located throughout the site. The telephone switchgear, backup batteries and battery charger are located in the telephone hut (Building 468) near the Support Building. Telephone communications are carried off of the site by cable and a microwave system that are owned and operated by the telephone company.

Mine pager phones is a network of independent, interconnected, self-contained, battery-powered paging phones used for two-way emergency and routine communication between the underground and the surface. The mine phones are interconnected on a two wire system. Each phone includes a speaker for paging and a handset for initiating pages and for normal phone communication between one or more other mine pager phones on the system. The speaker signal and the handset signal are electronically amplified at each phone.

Plant PA and Alarm Systems includes the site-wide public address installations and a separate and additional underground evacuation alarm system (strobe lights). The public address system master control console is located in the CMR. Submaster paging stations are located in the support building, Waste Handling Building, water pump house, guard and security building, salt handling hoist house and head frame, exhaust filter building, safety and emergency services facility, engineering building, training building, warehouse/shops building, and underground.

The Hoist Radio system is comprised of a wireless, medium frequency FM radio system that provides two-way voice communication between the hoist control room and the shaft conveyance (cage) in the waste-handling and salt-handling shafts. Programmable logic controller and radio modems provide for control of the movement of the waste-handling shaft hoist from the cage for special activities such as shaft inspection and maintenance. The voice radio system uses the hoist rope as a signal path (antenna), and the radio modems use antennae mounted on the cage and at the hoist tower on the surface.

The WIPPnet wide area network provides inter-connectivity between the WIPP, the underground facilities, and in-town buildings. Fiber-optic cable provides connectivity between buildings and the Underground areas at the WIPP site. Microwave and fiber links established through contracts with the local telephone provider provide connectivity between the WIPP site and the in-town network elements.

The EOC is the designated, centralized location from which the site emergency response organization evaluates, coordinates and manages response activities and communicates with DOE and other federal, state, and local organizations. The EOC is located on the site in the safety and emergency services facility. It contains communication devices that are a part of the Dial Phones, Plant PA and Alarm Systems, Mine Pager Phones, and Radio and other systems.

The Board has reviewed documents and statements from the workers that specifically stated that they could not hear the yelps or see the strobe lights, and the messages on the pagers were muffled and could not be understood.

Analysis

The procedure to begin evacuation of the underground requires the CMRO to turn on the strobe lights and activate the yelp alarm. The yelp alarm was only activated for about three seconds

instead of the procedurally required five seconds. Within a few minutes of the yelp alarm, the CMRO was notified by one of the workers that the strobe lights were not activated. The CMRO immediately activated the strobe lights. The strobe lights are a critical piece of the communication system in alerting the workers underground of an evacuation. Due to the heavy equipment operations and other activities, the audible alarm could not be heard by everyone underground. Most workers rely on the strobe lights for notification.

The FSM and the CMRO did not fully follow the procedures for response to the fire in the underground. This can be attributed to the complexity of the alarm and communication system, lack of effective drills and training, and additional burdens placed on the FSM due to the lack of a structured Incident Command System. Unreasonable expectations are placed on the FSM and CMRO in an emergency situation. Critical elements of the system should be evaluated and automated.

CON 16: There are elements of the CONOPS program that demonstrate a lack of rigor and discipline commensurate with operation of a Hazard Category 2 Facility.

JON 25: NWP and CBFO need to evaluate and correct weaknesses in the CONOPS program and its implementation, particularly with regard to flow-down of requirements from upper-tier documents, procedure content and compliance, and expert-based decision making.

CON 2: NWP management allows expert-based, rather than a process/systems-based approach to decision making, e.g., shift to filtration during a fire, sheltering decisions, etc.

JON 3: NWP needs to evaluate and apply a process/systems based approach for decision making relative to credible emergencies in the U/G, including formalizing response actions, e.g., decision to change to filtration mode during an ongoing evacuation.

CON 1: The FSM and Central Monitoring Room Operator (CMRO) did not fully follow the procedures for response to a fire in the U/G. This can be attributed to the complexity of the alarm and communication system, lack of effective drills and training, and additional burdens placed on the FSM due to the lack of a structured Incident Command System (ICS).

JON 1: NWP needs to evaluate and correct deficiencies regarding the controls for communicating emergencies to the underground, including the configuration and adequacy of equipment (alarms, strobes, and public address).

JON 2: NWP needs to evaluate the procedures and capabilities of the FSM and CMRO in managing a broad range of emergency response events through a comprehensive drill and requalification program.

7.0 NWP Contractor Assurance System

The NWP Contractor Assurance System (CAS) is described in the CBFO approved Quality Assurance Program Description (QAPD), Section 1.1.9. This section captures the criteria specified in the Contracts Requirements Document of DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy.* The CAS commits to ensuring that work performance meets the applicable requirements for environment, safety, and health; integrated safety management; safeguards and security; and emergency management. The CAS states that it is designed to identify deficiencies and opportunities for improvement, report deficiencies to responsible managers, complete corrective actions, and share in lessons learned.

The Contracts Requirements Document of DOE O 226.1B requires the contractor to submit to DOE for approval a CAS Description Document. The contractor, NWP, utilizes the Quality Assurance Program Description (QAPD) to meet this requirement. The QAPD does not refer to other procedures or processes on how the CAS is executed.

The Board reviewed additional resources and found that NWP has numerous policies, procedures and tools for conducting supervision and oversight of work. The Board reviewed several mechanisms on the WIPP Intranet such as lessons learned (many types and databases), trending reports, surveillance plans, and environment, safety and health tools, for example: automated job hazards analysis, radcon, health services, industrial safety, and industrial hygiene databases. NWP also implements other oversight and management processes like quality assurance, CONOPS, WIPP forms/logs, root cause analysis, and environmental management systems.

The Board reviewed the NWP CAS implementation and found the following issues that have not been corrected:

- Multiple external reviews have identified deficiencies in Work Planning & Control, Emergency Management, Issues Management, and Fire Protection.
- Post-drill emergency exercises did not identify deficiencies in the emergency response program, e.g., functionality of egress strobe lights, reflectors, PA system, donning SRs and SCSRs.
- The Emergency Program triennial program assessment was not performed, and it is indeterminate when the last assessment was conducted.
- Combustible material was allowed to build up on non-waste haul vehicles, and in addition, combustible material was allowed to build up in some areas of the Underground.
- Thirty-three emergency lights in the waste handling building have been inoperable for as long as two years.
- Twelve of 40 mine phones tested were found to be non-functional in a spot check by the Board.
- Pre-operational underground vehicle check list did not include performance criteria from the owner's manual.

- There were over 10 red tags related to critical safety equipment posted in the CMR. Some were seven months old. Critical safety equipment includes, but is not limited to, ventilation fans, fire suppression systems, bulkhead doors, and continuous air monitors.
- Lessons Learned from previous underground vehicle fires were not applied.
- Salt haul trucks are designed and built to use fire resistant hydraulic fluid, but it was not used in non-waste haul trucks.
- Surveillances and oversight are more focused on waste-handling and certification activities and less on maintenance activities and the safe operation of the mine.

7.1 NWP Supervision and Oversight of Work

NWP has numerous policies, procedures and tools for conducting supervision and oversight of work. The Board reviewed several mechanisms on the WIPP Intranet such as lessons learned (many types and databases), trending reports, surveillance plans, and environment, safety and health tools, for example: automated job hazards analysis, radcon, health services, industrial safety, and industrial hygiene databases. NWP also implements other oversight and management processes like quality assurance, CONOPS, WIPP forms/logs, root cause analysis, and environmental management systems.

An area that the Board specifically reviewed was the Management Assessment Program for NWP. The data that were analyzed included an interview with the Performance Assurance Manager as well as information provided on the WIPP intranet. This manager's duties include occurrence reporting processing system, and there is a Facility Management Designee (FMD) who fulfills and has ownership of this program. He also has the Directive Management Processes where he would ensure and track the implementation of the DOE Directives within the NWP contract. The FMD told the Board that he has the Lessons Learned Program, the Root Cause Analysis Process, and he is the Chairman of the Senior Managers Corrective Action Review Board. The Price-Anderson Amendments Act (PAAA) Coordinator also reports to the FMD and has combined responsibility for Security, Nuclear Safety, and Worker Safety. The WIPP does not protect classified material, it protects nuclear material. Each of the group managers performs the assessments for his/her own group.

The Board has reviewed Attachment 1 of the Management Assessment performance indicator chart. The quality of Management Assessment reports and compliance to program requirements continues to improve per the reviewed 2013 report. The FMD duties seem to be excessive and are performed with little assistance.

Results from the Management Assessment: Based on the review of ten NWP management assessment reports, and on the results of the independent audit, the management assessment team concluded that the weaknesses identified in the UCOR ISMS I\II Review (Finding QA-P2-06) are not prevalent in the implementation of the NWP Management Assessment Program.

Overall, NWP expends considerable resources performing oversight activities, most of which are focused on waste management and quality assurance activities to ensure permit requirements are met.

Analysis

The Board determined that the progress toward effectively implementing Work Planning & Control, Emergency Management, Issues Management, and Fire Protection programs is inadequate. NWP has not fully developed a CAS that provides assurance to both DOE and NWP that work is performed compliantly, risks are identified and managed, and control systems are effective and efficient.

Overall, NWP expends considerable resources performing oversight activities, most of which are focused on waste management and quality assurance activities to ensure permit requirements are met.

CON 14: NWP has not fully developed an integrated contractor assurance system that provides assurance that work is performed compliantly, risks are identified, and control systems are effective and efficient.

JON 23: NWP needs to develop and implement a fully integrated contractor assurance system that provides DOE and NWP confidence that work is performed compliantly, risks are identified, and control systems are effective and efficient.

8.0 DOE Programs and Oversight

8.1 CBFO Facts

The Carlsbad Field Office (CBFO) provides primary oversight to the site contractor Nuclear Waste Partnership (NWP) and its subcontractors. Day-to-day oversight of field activities at the site is mostly completed by the CBFO staff from the Office of Site Operations and the Office of Environment, Safety, and Health within the CBFO. The CBFO manager has implemented a practice to be at the site at least twice a week.

CBFO oversight staff members include a diverse set of talents and backgrounds including: facility representatives, systems engineering, mine operations, waste operations, work control, quality assurance, electrical safety, environmental protection, regulatory specialist, RCRA, compliance, emergency management, fire protection, health physics, and safety.

CBFO has several policies and procedures that address oversight activities such as QA audits, surveillances, and other project verifications. CBFO is required to implement an oversight program in accordance with DOE O 226.1B. CBFO also implements a Technical Qualification Program (TQP) in accordance with DOE O 426.1.

Per the CBFO Integrated Safety Management System Description, DOE/CBFO 09-3442, Rev. 3, *Introduction*:

> *"The CBFO mission is to provide safe, compliant, and efficient characterization, transportation, and disposal of defense transuranic (TRU) waste. CBFO is committed to fulfilling its mission in a manner that affords protection of the public, our Federal, contractor, and subcontractor worker, and the environment. CBFO is dedicated to performing its mission in compliance with the statues enacted by Congress for the protection of workers, the public, and the environment, and for exercising good stewardship of public property. This protection is put into operation at all levels (site, facility, task, and activity) by requiring and routinely verifying that work is conducted following the five ISM Core Functions in a manner consistent with the seven ISM Guiding Principles established in DOE P 450.4."*

The Board interviewed several of the CBFO management and oversight staff and reviewed numerous documents during the course of this investigation. Periodically, CBFO oversight functions are supplemented by DOE-HQ, DNFSB, DOE-EMCBC, MSHA, and other outside entities to ensure safe and compliant operations at the facility.

The Waste Isolation Pilot Plant Land Withdrawal Act, Public Law 102-579, and a Memorandum of Understanding (MOU) between the U.S. Department of Energy and the U.S. Department of Labor (dated July 1987) state, in part, that MSHA will shall inspect WIPP not less than four times each year and in the same manner as it evaluates mine sites under the Federal Mine Safety and Health Act of 1977, and shall provide the results of its inspections to DOE so DOE can implement its policy of compliance to MSHA standard (as though WIPP was a commercial mine) by taking the necessary actions with the DOE contractors and to assure the prompt and

effective correction of any deficiencies and to otherwise ensure general compliance with MSHA's mining health and safety requirements.

CBFO and EMCBC have signed a Service Level Agreement (SLA) that describes support functions to be provided by EMCBC in order for CBFO to be able to focus its resources on project and technical management, and oversight of CBFO contractors. The SLA describes EMCBC functions such as support in the areas of regulatory compliance, safety management systems, quality assurance, lessons learned, contractor assurance, technical support, and DOE oversight assistance. The SLA also states the EMCBC can provide preparation, review and issuance of program procedures and plans, as required to support the mission and conduct/support audits and surveillances per DOE management guidance.

DOE Headquarters provides support to WIPP in the form of policies, DOE orders, resources, mission support, emergency management, and independent oversight. DOE HQ does not currently provide resources to WIPP that address the unique challenge of operating a Hazard Category 2 facility in a mine.

Analysis

The Board reviewed the CBFO Integrated Evaluation Plans from FY11 to the present to assess the completion status of planned assessments. While several of the scheduled assessments were completed and documented, many of the scheduled evaluations logged within the Integrated Evaluation Plans. Examples included scheduled senior management walkthroughs, Safety System Oversight (SSO) for ventilation, nuclear safety management program review, Office of Site Operations (OSO) management assessment, vital safety systems (VSS) walk down of CAMS systems, Technical Qualification Program (TQP) assessments, Maintenance procedure assessment, FHA/BNA assessment, etc., were completed as listed on the Plan).

In addition, from interviews with several CBFO staff members, there is a strong perception that contractor and mid-level CBFO management do not welcome negative findings or observations and that CBFO staff have to individually follow up on corrective actions from NWP (rather than getting timely responses in accordance with site corrective action processes) in order to ensure effective actions have been taken. It was not apparent that follow-up is pursued in all cases by CBFO staff. Several CBFO staff members indicated that they can convey issues verbally to the contractor with mixed results for correction; however, there is not an effective mechanism to convey documented issues to the contractor. In addition, from review of the recent Safety Conscious Work Environment employee survey, 59 percent of the CBFO staff members that completed the survey answered "somewhat" to "yes" on the question of the existence of a chilled work environment.

CBFO staff members have been required to use the Office of Quality Assurance corrective action report (CAR) system to identify nonconformances. Interviews with several CBFO staff members indicate that this process is cumbersome, administratively burdensome, and many do not use it. In reviewing CAR submittals since the beginning of FY2012, the Board found that only 15 CARS have been generated by site staff outside of the CBFO QA group. Only one CAR has been generated by a facility representative in the last year.

The Facility Representative program has been reviewed several times over the last few years. Deficiencies have been identified related to staffing not meeting the staffing analysis, procedures that are incomplete and not used, no structured surveillance/oversight program, and no clear mechanism being used to communicate issues to management and the contractor (see Table 3). While CBFO management has brought in supplemental support from HQ and EMCBC to try to correct these issues, the FR program is still not effectively implemented.

Several externally (DOE-HQ, DNFSB, HS, EMCBC, etc.) generated oversight documents that contained findings, observations, and opportunities for improvement for the CBFO and WIPP site were reviewed by the Board. In many cases, no corrective action plans were developed or implemented, corrective action responses were not developed in a timely manner (for example, a year lapsed between the assessment and development of a corrective action plan), or implementation of corrective actions was either incomplete or ineffective. Several of the deficiencies have been identified numerous times. Table 3 includes examples of external oversight reports that were reviewed by the Board.

Table 3: Reviews of the WIPP Project

Date of External Assessment		External Assessment Title	Areas Evaluated
January 26 – 30, 2009	EM-43	Environmental Management Quality Assurance Audit Department Of Energy Carlsbad Field Office Washington TRU Solutions and Central Characterization Project EM-PA-09-013	Quality Assurance (QA) audit of Planning and Control
March 31, 2009	EM-64 (EM-43)	Environmental Management Quality Assurance Program Audit of the Waste Isolation Pilot Plant Transmittal Letter	Flowdown of requirements; adequacy of CBFO oversight of the QA program; appropriateness of the interface controls; adequacy of purchase items; and adequacy of identifying conditions adverse to quality.
March 9-12, 2010	EM-22 (EM-42)	Waste Isolation Pilot Plant Washington TRU Solutions, LLC EM-22 Office of Safety Operations Assurance Assessment Report	Ongoing and regular evaluation of the effectiveness of the WIPP operations. Evaluated CONOPS, Radiological Protection, Work Planning and Control Programs, and CBFO oversight.
February 15-17, 2011	EM-22 (EM-42)	EM-22 Office of Safety Operations Assurance Waste Isolation Pilot Plant Review	Evaluate Washington TRU CONOPs, Work Planning and Control and Contractor Assurance System processes. Follow-up to March 2010 EM-22 assessment.

Date of External Assessment		External Assessment Title	Areas Evaluated
June 24, 2011	DNFSB	Forwarding the Staff Issue report for a staff review conducted January 25-26, 2011, on the fire protection program at WIPP, including both above-ground and underground operations.	Identified issues with the Fire Hazard Analysis, contractor's fire protection program, CBFO oversight, WIPP fire brigade, baseline needs assessment, and CBFO's emergency management program.
September 7, 2011	HSS	Office of Enforcement and Oversight conducted an orientation visit to the DOE Carlsbad Field Office (CBFO) and the nuclear facility at the Waste Isolation Pilot Plant (WIPP).	The purpose of the visit was to discuss the nuclear safety oversight strategy, describe the site lead program, increase HSS personnel's operational awareness of the site's activities, and identify specific activities that HSS can perform to carry out its independent oversight and mission support responsibilities.
May 7-10, 2012	MSHA	Mine Safety and Health Administration (MSHA) inspection of surface and underground safety systems	9 underground Compliance Assistance Visit (CAV) notices and 9 surface CAV notices.
July 23-26, 2012	EM-42	EM-22 Office of Safety Operations Assurance Waste Isolation Pilot Plant Maintenance Management Review	Evaluate the Washington TRU Solutions Maintenance Management Program and the CBFO oversight of this program. Prompted by June 27, 2012 letter from DNFSB to Senior Advisor for EM detailing safety issues with the site.

Date of External Assessment		External Assessment Title	Areas Evaluated
October 5, 2012	EMCBC	The assessment was completed at the request of the CBFO Manager, and was covered over a period of time of August 6-9, 2012.	The review was conducted on safety programs and oversight implementation in response to a previous organizational assessment and due to concerns reported through the EMCBC Employee Concern Program.
November 12-15, 2012	EM-42	EM-42 Office of Operational Safety Waste Isolation Pilot Plant Maintenance Management Assist Visit	Evaluate the status of commitments made by EM Senior Advisor for EM in September 2012 in response to the DNFSB June 24, 2012, letter detailing actions taken and planned to correct to issues with the WIPP maintenance management program.
November 29, 2012	HSS	Independent Oversight review of Site Preparedness for Severe Natural Phenomena Events at the Waste Isolation Pilot Plant – November 2012	Office of Enforcement and Oversight independent oversight review of the WIPP emergency management program during June 5 –July 12, 2012. The HSS Office of Safety and Emergency Management Evaluations performed this review to evaluate the processes for identifying emergency response capabilities and maintaining them in a state of readiness in case of a severe NPE.

Date of External Assessment		External Assessment Title	Areas Evaluated
January 14-18, 2013	HS-12 (VPP)	DOE-HSS evaluation of security Walls Voluntary Protection Program (VPP)	Security Walls (security contractor under Washington TRU Solutions (WTS)) had received the Star Level under VPP but gave it up when they became a part of NWP. NWP has a transition plan in place as part of the new contract and received a legacy award in August 2013 for the transition plan. They will need to meet additional criteria including completing the ISMS implementation verification and validation reviews.
April 2013	EM-43	Follow-Up Assessment of QAP Implementation at the Department of Energy Environmental Management Carlsbad Field Office in Carlsbad, New Mexico, EM-PA-12-14, January 28-31, 2013	Follow up assessment of implementation of the QAP.
April 2013	HSS	Report documenting 2 onsite reviews: first on June 25-28, 2012, and a follow-up visit on January 22-24, 2013.	Objectives of the Independent Oversight review were to evaluate selected portions of 1) CBFO's oversight of the contractor's effectiveness review documentation; and 2) CBFO's performance of the annual ISMS declaration review of the contractor's work planning and control element.

Date of External Assessment		External Assessment Title	Areas Evaluated
June 2013	EM-42	WIPP CBFO Oversight And Management Assist Visit	The team found continued immaturity in the CBFO oversight and issues management processes which resulted in a burdensome process for FR issues to be transmitted to the CBFO management and contractor.
June 11-13, 2013	EM-42	EM-42 Office of Operational Safety Waste Isolation Pilot Plant Carlsbad Field Office Oversight and Maintenance Management Assist visit	Provide assistance to the DOE Carlsbad Office in improving its oversight of NWP operations at WIPP.
June 27, 2012	DNFSB	Forwarding the Staff Issue Report for an on-site review conducted during the week of march 5, 2012, on the WIPP maintenance program.	Deficiencies were identified by the staff with respect to quality of and compliance with maintenance work control documents, post-maintenance testing, pre-job reviews, annual system walk downs, maintenance resources, placekeeping, and DOE oversight.
July 2013	EM-42	Triennial Assessment of the CBFO Facility Representative Program	EM-42 staff was requested by the CBFO to perform this assessment in accordance with DOE-STD-1063.
August 19-29, 2013	EM-44	Verification of WIPP Assessment for HS-45 and EM-44 Corrective Actions	Review of corrective actions identified by HSS-45 and EM-44 regarding the implementation of an integrated and comprehensive Emergency Management Program

Date of External Assessment		External Assessment Title	Areas Evaluated
August 22, 2013	DNFSB	DNFSB Staff visit on WIPP Status	Areas of discussion included work planning and control, fire protection, plans and concepts for WIPP's future, DOE-CBFO contractor oversight program, and underground and above-ground tours.
January 28-30, 2014	MSHA	MSHA inspection of surface and underground safety systems	CAV notices have been transmitted to CBFO but have not yet been processed into corrective actions by CBFO.

Per the MOU and Land Withdrawal Act, MSHA is required to provide the site with safety inspections no less than four times per year. Records indicate that MSHA has only performed inspections two times over the last three years. This is a missed opportunity to identify mine safety issues from experienced inspectors. CBFO does not have equivalent resources to perform this function, nor have they identified the lack of MSHA oversight support as an issue that needs attention.

At the request of the CBFO manager, EMCBC provided a Line Management Oversight Review in October 2012 that identified several weaknesses in oversight programs and implementation. Subsequent to the issuance of this report, there has been inadequate follow up to ensure that CBFO was provided the necessary technical and oversight support functions as described in the SLA.

Overall, CBFO needs to establish and implement an effective line management oversight program and processes that meet the requirements of DOE O 226.1B and hold personnel accountable for implementing those program and processes.

DOE HQ needs to ensure that adequate resources are available for mission support (e.g. specialized expertise to support WIPP's unique work scope, and resources to ensure safe mine operations) and that projects are held accountable for effective and timely corrective actions to issues identified during independent oversight activities.

CON 15: CBFO failed to adequately establish and implement line management oversight programs and processes to meet the requirements of DOE O 226.1B and hold personnel accountable for implementing those programs and processes.

JON 24: CBFO needs to establish and implement an effective line management oversight program and processes that meet the requirements of DOE O 226.1B and hold personnel accountable for implementing those programs and processes.

CON 16: CBFO management does not have adequate communication processes to ensure awareness of issues that warrant attention from all levels of the DOE staff.

JON 25: CBFO needs to accelerate the implementation of a mechanism for all levels of CBFO staff to document, communicate, track, and close issues both internally and with NWP.

JON 26: The CBFO Site Manager needs to institutionalize and communicate expectations for the identification, documentation, reporting, and correction of issues.

CON 17: DOE HQ failed to ensure that CBFO was held accountable for correcting repeatedly identified issues involving fire protection, maintenance, emergency management, work planning and control, and oversight.

JON 27: DOE HQ needs to ensure that repeatedly identified issues related to safety management programs (SMPs) are confirmed closed and validated by the local DOE office.

This process should be considered for application across the DOE complex and include tracking, closure, actions to measure the effectiveness of closure (line management accountability), and trending to identify precursors and lessons learned.

JON 28: DOE HQ should enhance its required oversight to ensure site implementation of the emergency management policy and requirements are consistent and effective. Emphasis should be placed on ensuring ICSs are functioning properly and integrated exercises are conducted where personnel are evacuated.

CON 18: DOE HQ failed to ensure CBFO was provided with qualified technical resources to oversee operation of a Hazard Category 2 Facility in a mine.

JON 29: DOE HQ needs to develop and implement a process for ensuring that technical expertise is available to provide support in the unique area of ground control, underground construction, and mine safety and equipment.

JON 30: DOE HQ needs to assist CBFO with leveraging expertise from Mine Safety and Health Administration (MSHA), in accordance with the DOE/MSHA MOU, in areas of ground control, underground construction, and mine safety where DOE does not have the expertise.

JON 31: DOE HQ needs to re-evaluate resources (i.e. funding, staffing, infrastructure, etc.) applied to the WIPP project to ensure safe operations of a Hazard Category 2 facility.

CON 19: The Office of Environmental Management Consolidated Business Center (EMCBC) and CBFO failed to ensure support services as described in the Service Level Agreement were provided.

JON 32: EMCBC and CBFO need to develop and implement clear expectations and a schedule for EMCBC to provide support in the areas of regulatory compliance, safety management systems, preparation of program procedures and plans, quality assurance, lessons learned, contractor assurance, technical support, DOE oversight assistance, etc.

9.0 Safety Programs

9.1 Integrated Safety Management Systems

NWP is required to implement a Safety Management System in accordance with 48 CFR 970.5223-1, *Integration of Environment, Safety, and Health into Work Planning and Execution*. The requirement states that in performing work, the contractor shall perform work safely, in a manner that ensures adequate protection for employees, the public, and the environment, and shall be accountable for the safe performance of work. The contractor shall ensure that management of Environment, Safety and Health (ES&H) functions and activities becomes an integral but visible part of the contractor's work planning and execution processes. The five core safety management functions provide the necessary structure for any work activity, including emergency management, which could potentially affect the public, the workers, and the environment.

NWP has not had its (Integrated Safety Management System) ISMS program verified through the DOE ISMS verification process. The ISMS verification was scheduled for May 2013, and later rescheduled for September 2013. The NWP ISMS verification is currently scheduled for May 2014.

NWP and CBFO completed a joint ISMS and QA Declaration for FY12. This declaration concluded that ISMS and QA programs have been implemented and are effective at ensuring safety and quality performance. This declaration was based on multiple external and internal reviews. One joint external review conducted by the DOE Office of Health, Safety and Security (HSS) and CBFO identified 82 issues with NWP's implementation of Work Planning and Control program. This external review also identified a finding in which CBFO did not follow its internal process for documenting findings. NWP and CBFO had not yet completed their FY13 annual ISMS and QA declaration. However, NWP reached back to URS corporate to conduct an assessment of the Work Planning and Control process that concluded improvements in the Work Planning and Control program.

Analysis

The Board highlighted the following deficiencies with each of the five core functions (CF) and its applicable guiding principle (GP).

Define the Scope of Work (CF-1)
Line Management is Responsible for Safety (GP-1)
Competence Commensurate with Responsibilities (GP-3)
Balanced Priorities (GP-4)
Identification of Safety Standards and Requirements (GP-5)

- NWP and CBFO did not effectively establish a work environment where the requirements for nuclear safety, mine safety, and occupational safety are integrated and understood by their employees.
- NWP and CBFO did not ensure that emergency training and drills were performed such that employees were able to respond and evacuate the U/G during an actual emergency condition.

Identify and Analyze the Hazards Associated with the Work (CF-2)

Identification of Safety Standards and Requirements (GP-5)

Hazard controls tailored to work performed (GP-6)

- NWP did not implement a pre-operational vehicle use checklist process in accordance with the vehicle manufacturer's instructions.
- The Fire Hazard Analysis did not consider the impact of a vehicle fire near the Air Intake Station.
- NWP failed to recognize the consequences of not maintaining U/G vehicles in accordance with manufacturer's instructions.
- NWP did not fully analyze and develop response plans to various emergency scenarios.

Develop and Implement Hazard Controls (CF-3)

Identification of Safety Standards and Requirements (GP-5)

Hazard controls tailored to work performed (GP-6)

Operations authorized (GP-7)

- The emergency response procedures did not clearly define points when U/G ventilation should be secured and/or changed, egress methods for conditions when multiple people are in the U/G, and when to activate the EOC.
- NWP did not implement its housekeeping program such that egress is not impeded and combustible loading is not exceeded.
- General employee training and the U/G fire response procedure are inconsistent in regard to responding to an incipient-stage fire.

Perform Work within Controls (CF-4)

Clear Roles and Responsibilities (GP-2)

Competence commensurate with responsibilities (GP-3)

Operations authorized (GP-7)

- The management systems supporting the decision to change ventilation during an emergency condition did not require the FSM to consult with the subject matter expert (SME) and U/G personnel.
- U/G vehicle pre-operational use checklists were not performed in accordance with the manufacturer's instructions, including the verification of vehicle performance criteria, e.g., oil pressure.
- U/G personnel were unable to don SRs and/or SCSRs.
- Haul truck operator did not notify the CMR of the fire, after failure of the portable fire extinguisher and the vehicle fire suppression system.

Feedback and Improvement (CF-5)

Line Management is Responsible for Safety (GP-1)

- Multiple opportunities were missed to mitigate the hazards and risks associated with the pre-operational condition of U/G vehicles.
- Multiple opportunities were missed to apply Lessons Learned from other events when U/G vehicles caught on fire.
- NWP did not adequately evaluate the effectiveness of training in donning and use of SR and/or SCSR in the U/G.
- NWP did not fully develop a Contractor Assurance System where both DOE and NWP are assured that work is performed compliantly, risks are identified and managed, and control systems are effective and efficient.
- CBFO has not fully established an oversight program that effectively evaluates the health and effectiveness of CBFO and NWP management systems, and fosters an environment where issues are raised, track and trended, and effectively resolved.

9.2 Conduct of Operations Implementation

Operations of the WIPP are described in the WP 04-CO.01, *WIPP Conduct of Operations* procedure series. The series includes procedures for Shift Routines and Operating Practices, Control Area Activities, Communications, Control of On-Shift Training, Notifications, Control of Equipment and System Status, and Operations Procedures. In accordance with DOE Order 422.1, *Conduct of Operations*, NWP has a CBFO-approved CONOPS matrix.

The Board reviewed the CONOPS program and identified the following:

- Maintenance procedure PM074080, EMCO Haul Truck 74-U-006A/B, does not refer to the CHAMPS Preventative Maintenance process, nor include performance requirements from manufacturer's instructions. While "Various O&M Manuals" are listed as a reference in the procedure, there are no steps in the procedure that direct the user to refer to the manufacturer's instructions and validate performance criteria.

- Operator's Checklists are not completely filled out. On several occasions, the initial and/or final meter reading was not filled out, and the salt haul truck is not marked as safe to use.
- The emergency response procedures did not clearly identify points when U/G ventilation should be secured and/or changed, egress methods for conditions when multiple people are in the U/G, or when to activate the EOC.
- The BNA requirement for use of the manual onboard FSS before use of a portable fire extinguisher was not included in the U/G fire response procedure.
- The U/G fire response procedure required the CMRO to direct U/G Services to respond and evaluate fires after a decision was already made to evacuate the mine.
- As identified in training and written in procedures, the haul truck operator did not notify the CMR of the fire after the portable fire extinguisher and manual FSS failed. Instead, the Operator contacted the maintenance department.
- Although required by the evacuation procedure, the CMR did not sound the evacuation alarm for a full five seconds and illuminate the emergency strobe lights.
- Many U/G personnel were unable to don SRs and/or SCSRs.
- Critical safety equipment had red tags in which NWP employees via interviews did not fully understand the status of the impaired safety-related equipment. Safety equipment included fans, FSS, and CAM.
- The U/G haul truck operator did not receive hands-on training on the use of portable fire extinguishers.

Analysis

The elements of the NWP CONOPS program reviewed by the Board indicate weaknesses in implementation. NWP has not developed procedures and processes that ensure:

- U/G vehicles are maintained in accordance with the manufacturer's instructions.
- Emergency drill U/G evacuations demonstrated proficiency in donning of SRs and SCSRs, activating alarms and lights, making DOE notifications, and activating the EOC.
- Emergency condition procedures, e.g., U/G Fire, Mine Evacuation, could be executed without expert-based decision making.
- FSM fully understood impacts of changing ventilations modes while personnel are in the U/G during an emergency condition.
- BNA and FHA requirements are flowed in implementing documents.

The Board determined that NWP approached CONOPS from different perspectives, not fully understanding that the entire WIPP facility is a Hazard Category 2 facility. Interviews with workers indicated that the terminology "operations" primarily referred to those daily activities, resources, management, and communication needed to support TRU waste storage operations. This disconnect has reduced the level of rigor applied to operations that are not related to TRU waste handling.

CON 20: There are elements of the CONOPS program that demonstrate a lack of rigor and discipline commensurate with operation of a Hazard Category 2 Facility.

JON 33: NWP and CBFO need to evaluate and correct weaknesses in the CONOPS program and its implementation, particularly with regard to flow-down of requirements from upper-tier documents, procedure content and compliance, and expert-based decision making.

9.3 Human Performance Improvement

The goal of Human Performance Improvement (HPI) is to facilitate the development of a facility structure that recognizes human attributes and develops defenses that proactively manage human error and optimize the performance of individuals, leaders, and the organization. The Department's *Human Performance Improvement Handbook*, Volumes 1 and 2 (DOE-HDBK-1028-2009), describe the HPI tools available for use at DOE sites. The Board did not look at HPI from the perspective of program implementation. The Board evaluated Human Performance to determine if it played a part in this accident. Human error is not a cause of failure alone, but rather the effect or symptom of deeper trouble in the system. A review of Human Performance is a review of an individual's abilities, tasks, and operating environment to determine if the organization supports them for success.

The significance, or severity, of a particular event lies in the consequences suffered by the physical plant or personnel, not the error that initiated the event. The error that causes a serious accident and the error that is one of hundreds with no consequence can be the same error that has historically been overlooked or uncorrected. In most cases, for a significant event to occur, multiple breakdowns in defenses must first occur. Whereas human error may trigger an event, it is the number and extent of flawed defenses that dictate the severity of the event. The existence of many flawed defenses is directly attributable to weaknesses in the organization or management control systems. The Anatomy of an Event Model (Figure 21) illustrates the elements that exist before an event occurs and is a very useful model to guide the analysis of an event from an HPI perspective. The elements analyzed are the flawed defenses that allowed the event to occur or did not mitigate the consequences of the event; the error precursors that existed; the latent organizational conditions that allowed those to be in existence; and finally the vision, beliefs and values of management and workers.

Much of the information provided in this section is based on the analysis of the events, conditions, processes, and barrier information presented in this report.

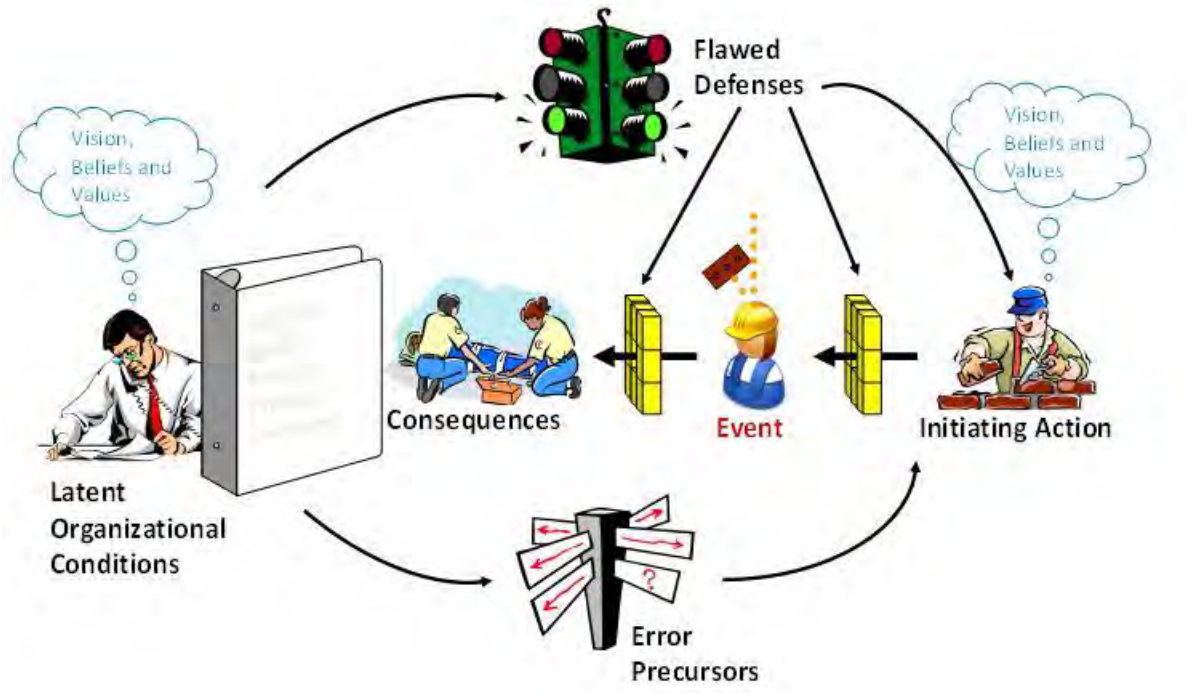


Figure 27: Anatomy of an Event Model

9.3.1 Error Precursors

Error precursors are unfavorable conditions that increase the probability for error during a specific action and create what are known as error-likely situations. An error-likely situation typically exists when the demands of the task exceed the capabilities of the individual or when work conditions exceed the limitations of human nature. Human nature comprises all mental, emotional, social, physical, and biological characteristics that define human tendencies, abilities, and limitations. For instance, humans tend to perform poorly under high stress and undue time pressure. Error-likely situations such as these are also known as error traps. Error precursors exist in the work place before the error occurs, and thus are manageable. If identified before or during the performance of work, the conditions can be changed or managed to reduce the chance for error(s) leading to an event.

Error precursors (conditions) associated with Human Performance attributes were analyzed by the Board to identify specific conditions that may have provoked error and led to the accident (Figure 28).

9.3.2 Human Performance Attributes

Task Demands. Specific mental, physical, and team requirements to perform an activity that may either exceed the capabilities or challenge the limitations of human nature of the individual assigned to the task; for example, excessive workload, hurrying, concurrent actions, unclear roles and responsibilities, or vague standards.

Individual Capabilities. Unique mental, physical, and emotional abilities of a particular person that fail to match the demands of the specific task; for example, unfamiliarity with the task, unsafe attitudes, level of education, lack of knowledge, unpracticed skills, personality, inexperience, health and fitness, poor communication practices, or low self-esteem.

Work Environment. General influences of the workplace, organizational, and cultural conditions that affect individual behavior; for example, distractions, awkward equipment layout, complex tagout procedures, at-risk norms and values, work group attitudes toward various hazards, or work control processes.

Human Nature. Generic traits, dispositions, and limitations of being human that may incline individuals to err under unfavorable conditions; for example, habit, short-term memory, fatigue, stress, complacency, or mental shortcuts.

HUMAN PERFORMANCE ATTRIBUTES

Task Demands. Specific mental, physical, and team requirements to perform an activity that may either exceed the capabilities or challenge the limitations of human nature of the individual assigned to the task; for example, excessive workload, hurrying, concurrent actions, unclear roles and responsibilities, or vague standards.

Individual Capabilities. Unique mental, physical, and emotional abilities of a particular person that fail to match the demands of the specific task; for example, unfamiliarity with the task, unsafe attitudes, level of education, lack of knowledge, unpracticed skills, personality, inexperience, health and fitness, poor communication practices, or low self-esteem.

Work Environment. General influences of the workplace, organizational, and cultural conditions that affect individual behavior; for example, distractions, awkward equipment layout, complex tagout procedures, at-risk norms and values, work group attitudes toward various hazards, or work control processes.

Human Nature. Generic traits, dispositions, and limitations of being human that may incline individuals to err under unfavorable conditions; for example, habit, short-term memory, fatigue, stress, complacency, or mental shortcuts.

Figure 28: Human Performance Attributes

9.3.3 Error Precursor Analysis

The Board conducted an Error Precursor Analysis based on the information obtained from documents and interviews as documented throughout this report. The results of this analysis are

presented in Table 4. The analysis resulted in the identification of 21 different error precursors on the day of the accident. Four of the identified error precursors existed more than one time that day. The following is a discussion of some of the more predominant error precursors.

9.3.4 Human Performance Mode

Human Performance describes three modes in which errors occur. The performance mode in which an error occurs is based on the individual's familiarity with the task being performed. The three modes, progressing from most familiar to the task to the least familiar to the task are: skill based, rules based, and knowledge based. Errors will most likely occur in the knowledge based performance mode.

1. **Donning SRs and SCSRs**. Underground workers were familiar with the use of the SRs and SCSRs. They understood and had been trained in the steps required to don the SRs and SCSRs. During the fire, in some cases, the SRs and SCSRs could not be opened or were not used. Underground workers failed to recognize how changes (e.g. stress, smoke) could complicate donning the SRs and SCSRs. In some instances, the decision was made not to use the SR due to the belief that the individual could reach "good" air quicker by not donning the SR. The Board later determined that SR and SCSR training was not sufficient and that there was no hands-on training that simulates use in likely emergency conditions (i.e., limited visibility due to dark or smoke filled areas). The annual refresher is a video that does not require donning of the SCSR.

2. **Use of Fire Extinguisher**. The Operator did not have adequate training in the use of appropriate fire suppression systems and portable fire extinguishers. The Operator training on the use of the manual suppression system on the salt haul truck was not clear. Workers received video training on use of fire extinguishers; however, they had to rely on assumptions to make a decision on the correct use of a fire extinguisher. No hands-on training had been provided.

3. **Changing Ventilation to Filtration Mode**. FSM did not have all the information necessary to make an informed decision on changing the ventilation mode during the evacuation from the mine. The FSM relied on assumptions and analytical skills to make a decision to reduce smoke from the fire. The unannounced change in ventilation to filtration mode was not in any procedure and quite possibly contributed to higher local concentrations of smoke and carbon monoxide in the drifts. The procedure used in the CMR did not anticipate a full spectrum of potential emergency situations. FSM did not solicit input from other knowledgeable individuals to better understand the conditions or potential impact of the ventilation mode change on the U/G conditions.

4. **Allowing combustible fluid leaks and buildup of combustible "grime" on salt haul truck**. The Operator did not identify any conditions associated with fluid leaks or "grime" buildup on the salt haul truck during pre-use inspections. The frequency of fluid leaks and buildup of "grime" was known by workers. This issue did not get addressed and over time the expectations associated with the condition of the salt haul truck were relaxed to accept these conditions.

Table 4: Error Precursors

TASK DEMANDS (TD)			INDIVIDUAL CAPABILITIES (IC)		
x[1]	1	Time Pressure (In a hurry)	xx	1	Unfamiliarity with Task/First time
xx	2	High Workload (large memory)	xx	2	Lack of Knowledge (faulty mental model)
x	3	Simultaneous, Multiple Tasks	xx	3	New Technique not used before
	4	Repetitive Actions/Monotony	x	4	Imprecise Communications
x	5	Irreversible Acts	xx	5	Lack of Proficiency/Inexperience
xx	6	Interpretation Requirements		6	Indistinct Problem-solving Skills
x	7	Unclear goals, Roles, or Responsibilities		7	"Unsafe" Attitudes
xx	8	Lack of or Unclear Standards		8	Illness/Fatigue (general health)

[1] X = single occurrence, xx = multiple occurrences.

WORK ENVIRONMENT (WE)			HUMAN NATURE (HN)		
xx	1	Distractions/Interruptions	x	1	Stress
xx	2	Changes/Departure from Routine		2	Habit patterns
	3	Confusing Displays/Controls	xx	3	Assumptions (inaccurate mental picture)
x	4	Work-arounds		4	Complacency/overconfidence
xx	5	Hidden System/Equipment Response	x	5	Mindset (intentions)
xx	6	Unexpected Equipment Conditions	xx	6	Inaccurate Risk Perception
	7	Lack of Alternative Indication		7	Mental Shortcuts (biases)
	8	Personality Conflicts		8	Limited Short-term Memory

Task Demands

There were several examples of a lack of clear standards, interpretation of requirements, and high work load that contributed to the severity of the incident. Lacking the establishment and reinforcement of clear standards and expectations, front line workers will establish their own standards of behavior based on their visions, beliefs, and values. The Operator did not have a clear understanding of expectations with regard to the use of the manual vehicle fire suppression system before the system.

Work Environment

There were numerous unexpected equipment conditions and equipment response encountered by the workers during this event (i.e., alarm not sounded for five seconds as expected, strobe lights not activated immediately, mine phone and pagers could not be heard throughout the mine, the manual fire suppression system did not fully actuate). These conditions affected the most effective and timely evacuation of the mine. Also, the manual vehicle fire suppression system could have eliminated the fire, or significantly slowed the progress of the fire.

Individual Capabilities

There were numerous issues related to individual capabilities in the area of proficiency, first time use, and a lack of knowledge for the intended task. There was no hands-on training in many areas necessary to provide worker proficiency. Several people had difficulty donning self-rescuers and SCSRS. The drill and exercises performed to date did not prepare individuals for this particular fire accident scenario. Inadequate guidance and training exists to support the FSM to make decisions without the requisite knowledge to fully understand the potential impact of the decision.

Human Nature

There were six different examples of Inaccurate Risk Perception error precursors on the part of personnel involved in the accident. Personnel that have an inaccurate risk perception typically base that on personal appraisal of hazards and uncertainty based on incomplete information or assumptions and/or an unrecognized or inaccurate understanding of a potential consequence or danger. The degree of risk-taking behavior is based on an individual's perception of the possibility of error and understanding of the consequences. There was an inaccurate risk perception on the part of FSM with regard to shifting ventilation modes.

Questioning Attitude

Individuals demonstrate a questioning attitude by challenging assumptions, investigating anomalies, and considering potential adverse consequences of planned actions. All employees must be watchful for conditions or activities that can have an undesirable effect on safety, and they do not proceed if faced with uncertainty. A reluctance to fear the worst is aggravated by human nature, since humans tend to accentuate the positive. A healthy questioning attitude must overcome the temptation to rationalize away something that is not right. A team approach where everyone is looking, questioning, and challenging every aspect of the work is required to increase the chances of identifying the job site hazards to ensure protection of the workers.

Based on interviews, there was little evidence that the workers displayed a questioning attitude. It was clear that if management has made a decision, workers do not challenge the decision.

9.4 Nuclear Culture and Mine Culture

9.4.1 Safety Culture

Production and prevention practices always compete in the minds of workers. Leaders have to constantly work hard to keep the facility, environment, and personnel safe. Well-informed leadership at all levels of the organization will ensure that the vision, beliefs, and values (prevention-centered attributes) do not conflict with the mission, goals, and processes (production-centered attributes). Consistency and alignment promote both production and prevention behaviors - together generating the desired long-term results.

In normal human behavior, production behaviors naturally take precedence over prevention behaviors unless there is a strong safety culture - nurtured by strong leadership. Sometimes managers err when they assume people will be or are safe. Safety and prevention behaviors do not just happen. They are value-driven, and people may not choose the conservative approach because of what is believed or perceived to be a stronger production focus.

It is critically important that the visions, values, and beliefs established by the leadership to support a strong safety culture are clearly communicated, and constantly reinforced. In many cases, management believes that their visions and values have been established and communicated through the development of a policy or procedure, or the posting of signs. That is an initial step and meets minimum compliance requirements, but it takes more than that. Leaders must constantly reinforce these expectations through observation and coaching at all levels of the organization.

Within DOE, most serious events do not occur when performing complex or high hazard operations. They rarely occur when starting up new facilities or performing operations for the first time. That is because everyone is paying close attention, there are lots of people involved, things move slowly, and everyone is very "mindful." Natural tendency is to primarily focus on what are considered "high hazard" or "high risk" operations. The challenge for leadership is to establish and reinforce the safety culture expectations continuously so that workers are mindful and careful during all operations.

There are several examples concerning the accident where personnel "did not do" what was written down in a training briefing or what management expected them to do. There are several reasons for this, but foremost is a lack of strong safety expectations. The Board observed that there were examples of decisions regarding changes to equipment, maintenance of equipment, procedural compliance and CONOPS that were not conservative with respect to nuclear safety. A nuclear safety review of analyzed accidents with respect to the vehicle fire is provided to understand the expectations of maintaining underground vehicles not associated with waste handling.

The Documented Safety Analysis for the WIPP provides an analysis for a vehicle fire at the waste front. The "Single Liquid-Fueled Vehicle Collision and Fire at Waste Face Pool Fire"

bounds this type of accident. The analysis is developed based on a pool fire encompassing a contact-handled waste disposal array.

The following controls for reducing public risk from the hazardous conditions associated with Event CH-U/G-1-003a (single liquid-fueled vehicle collision and fire at waste face (pool fire)) have been identified as measures requiring inclusion in the TSR:

- U/G Liquid-fueled Waste-Handling Vehicles. The U/G liquid-fueled waste-handling vehicles are designed to prevent and/or mitigate fires.
- U/G Liquid-fueled Waste-Handling Vehicles Fire Suppression System. The U/G liquid-fueled waste-handling vehicles are equipped with a fire suppression system that suppresses fires associated with fuel line leaks and engine compartment fires.
- Vehicle/Equipment Control Program. Non-waste-handling vehicles are maintained greater than or equal to 25 feet from the waste when not attended.
- Liquid-fuel Vehicle/Equipment Inspection Program. Liquid-fueled vehicles/equipment approaching the waste face have pre-operational checks prior to use through the Underground Liquid-Fueled Vehicle/Equipment Inspection Program.

Limiting Condition for Operation 3.3.7, "Liquid-Fueled Vehicle/Equipment Control at a Waste Face," provides controls for limiting vehicles in the disposal room during activities. These controls include only waste-handling equipment selected for waste-handling activities during emplacement, limiting vehicles at the waste front during retrievals, and requirements to attend vehicles at the waste front or emplacing wastes. These controls are intended to ensure operation maintains the assumptions used in the safety analysis.

Analysis

The controls identified in the limiting condition for operations are intended to reduce the likelihood of fuel pool fires or accidents caused by facility equipment or improper equipment operation. Retrieval operations allow one non-waste-handling vehicle at the waste front in addition to one waste-handling vehicle. While there is a clear distinction in the analysis between waste-handling equipment and non-waste-handling (mining) equipment, the underlying assumption is that the non-waste-handling equipment is maintained in accordance with the checklists developed from the manufacturers.

However, the maintenance records and the removal of the automatic suppression from underground non-waste-handling vehicle/equipment do not reflect the degree of rigor necessary to assure that the nuclear safety basis and assumptions will be maintained. The condition of the vehicle in the fire challenges the integrity of the assumptions in the safety basis. The mine operations and nuclear operations underground are interrelated and need to be fully evaluated and better integrated.

CON 21: NWP and CBFO did not analyze and disposition differences between waste-handling and non-waste-handling vehicles for similar hazards and impacts, e.g., allowing a truck in this condition to be at the waste face.

JON 34: NWP and CBFO need to identify and control the risk imposed by non-waste-handling equipment, e.g., combustible buildup, manual vs. automatic fire suppression system, fire-resistant hydraulic oil, etc., or treat waste-handling equipment and non-waste-handling equipment the same.

CON 22: NWP and CBFO management allowed a culture to exist where there are differences in the way waste-handling equipment and non-waste-handling equipment are maintained and operated.

JON 35: NWP and CBFO management need to examine and correct the culture that exists regarding the maintenance and operation of non-waste handling equipment.

10.0 Analysis

10.1 Barrier Analysis

After a basic chronology of events was developed, the Board performed a barrier analysis of the accident. To start the barrier analysis, the Board chose a target (the person or item to be protected) and the hazard (what the person or item is to be protected from). The Board chose underground workers and facilities as the target and exposure to the fire and resultant smoke as the hazard. The Board also chose to include personnel evacuation and emergency response within the scope of the barrier analysis.

Thirty-eight barriers were identified and analyzed by the Board.

The barrier analysis is presented in Appendix B.

10.2 Change Analysis

To further support the development of causal factors, the Board performed a change analysis of the accident, examining the planned and unplanned changes that caused the undesired results or outcomes related to the event.

Thirty-nine changes were identified and analyzed by the Board.

The change analysis is presented in Appendix C.

10.3 Event and Causal Factors Analysis

After performing the barrier and change analyses, the Board assigned the results of the various analyses to the conditions that were related to or caused the events in the chronology. Correlating these conditions with events resulted in the events and causal factors chart provided in Appendix E. When the correlation was complete, the Board examined the chart to determine which events were significant (i.e., which events played a role in causing the accident). The Board then assessed the significant events (and the conditions of each) to determine the causal factors of the accident.

The causal factors that resulted are described below.

Direct, Root, and Contributing Causes

Direct Cause (DC) – the immediate events or conditions that caused the accident.

The Board identified the direct cause of this accident to be contact between flammable fluids (either hydraulic fluid or diesel fuel), and hot surfaces (most likely the catalytic converter) on the salt haul truck, which resulted in a fire that consumed the engine compartment and two front tires.

Root Cause (RC) – causal factors that, if corrected, would prevent recurrence of the same or similar accidents.

The Board identified the root cause of this accident to be NWP failure to adequately recognize and mitigate the hazard regarding a fire in the underground. This includes recognition and removal of the buildup of combustibles through inspections, and periodic preventative maintenance, e.g., cleaning and the decision to deactivate the automatic onboard fire suppression system.

Contributing Causes (CC) – events or conditions that collectively with other causes increased the likelihood or severity of an accident but that individually did not cause the accident. For the purposes of this investigation, contributing causes include those related to the cause of the fire as well as those related to the subsequent response.

The Board identified ten contributing causes to this accident or resultant response:

1. The preventative and corrective maintenance program did not prevent or correct the buildup of combustible fluids on the salt truck. There is a distinct difference between the way waste-handling and non-waste-handling vehicles are maintained.
2. The fire protection program was less than adequate in regard to flowing down upper-tier requirements relative to vehicle fire suppression system actuation from the Baseline Needs Assessment into implementing procedures. There was also an accumulation of combustible materials in the underground in quantities that exceeded the limits specified in the Fire Hazard Analysis (FHA) and implementing procedures. Additionally, the FHA does not provide a comprehensive analysis that addresses all credible underground fire scenarios including a fire located near the Air Intake Shaft.
3. The training and qualification of the operator was inadequate to ensure proper response to a vehicle fire. He did not initially notify the CMR that there was a fire or describe the fire's location.
4. The CMR response to the fire, including evaluation and protective actions, was less than adequate.
5. Elements of the emergency/preparedness and response program were ineffective.
6. A nuclear versus mine culture exists where there are significant differences in the maintenance of waste-handling versus non-waste-handling equipment.
7. The NWP Contractor Assurance System (CAS) was ineffective in identifying the conditions and maintenance program inadequacies associated with the root cause of this event.
8. DOE Carlsbad Field Office (CBFO) was ineffective in implementing line management oversight programs and processes that would have identified NWP CAS weaknesses and the conditions associated with the root cause of this event.
9. Repeat deficiencies were identified in DOE and external agencies assessments, e.g., Defense Nuclear Facility Safety Board (DNFSB) emergency management, fire protection, maintenance, CBFO oversight, and work planning and control, but were allowed to remain unresolved for extended periods of time without ensuring effective site response.

10. There are elements of the Conduct of Operations (CONOPS) program that demonstrate a lack of rigor and discipline commensurate with the operation of a Hazard Category 2 Facility.

The causal factors and related functions chart is presented in Appendix D.

The events and causal factors chart is presented in Appendix E.

11.0 Conclusions and Judgments of Need

Conclusions (CONs) are significant deductions derived from the investigation's analytical results. They are derived from and must be supported by the facts plus the results of testing and the various analyses conducted.

Judgments of Need (JONs) are the managerial controls and safety measures determined by the Board to be necessary to prevent or minimize the probability or severity of a recurrence. These JONs are linked directly to the causal factors which are derived from the facts and analysis. They form the basis for corrective action plans which must be developed by line management. The Board's conclusions and JONs are listed below in Table 5.

Table 5: Conclusions and Judgments of Need

Conclusion (CON)	Judgments of Need (JON)
CON 1: The FSM and Central Monitoring Room Operator (CMRO) did not fully follow the procedures for response to a fire in the U/G. This can be attributed to the complexity of the alarm and communication system, lack of effective drills and training, and additional burdens placed on the FSM due to the lack of a structured Incident Command System (ICS).	**JON 1:** NWP needs to evaluate and correct deficiencies regarding the controls for communicating emergencies to the underground, including the configuration and adequacy of equipment (alarms, strobes, and public address). **JON 2**: NWP needs to evaluate the procedures and capabilities of the FSM and CMRO in managing a broad range of emergency response events through a comprehensive drill and requalification program.
CON 2: NWP management allows expert-based, rather than a process/systems-based approach to decision making, e.g., shift to filtration during a fire, sheltering decisions, etc.	**JON 3**: NWP needs to evaluate and apply a process/systems based approach for decision making relative to credible emergencies in the U/G, including formalizing response actions, e.g., decision to change to filtration mode during an ongoing evacuation.
CON 3: The emergency management program was not structured such that personnel were driven to adequately size up, properly categorize, and classify emergency events. The WIPP (NWP and CBFO) emergency management program is not fully compliant with DOE O 151.1C, *Comprehensive Emergency Management System*, e.g.,	**JON 4**: NWP and CBFO need to evaluate their corrective action plans for findings and opportunities for improvement identified in previous external reviews, and take action to bring their emergency management program into compliance with requirements. **JON 5**: NWP and CBFO need to correct their activation, notification, classification, and categorization protocols to be in full

Conclusion (CON)	Judgments of Need (JON)
activation of the EOC, classification and categorization, emergency action levels, implementation of the ICS, training, triennial exercise, etc. Weaknesses in classification, categorization, and emergency action levels (EALs) were previously identified by external reviews and uncorrected.	compliance with DOE O 151.1C and then provide training for all applicable personnel. **JON 6**: NWP and CBFO need to improve the content of site-specific EALs to expand on the information provided in the standard EALs contained in DOE O 151.1C. **JON 7**: NWP and CBFO need to develop and implement an Incident Command System (ICS) for the EOC/CMR that is compliant with DOE O 151.1C and is capable of assuming command and control for all anticipated emergencies.
CON 4: Actions to be taken by the Operator in the event of a U/G vehicle fire were not clear. There were inconsistencies between procedures and training for fire response that led to an ineffective response to the salt haul truck fire.	**JON 8**: NWP needs to review procedures and ensure consistent actions are taken in response to a fire in the U/G. **JON 9**: NWP, CBFO and DOE HQ need to clearly define expectations for responding to fires in the U/G, including incipient and beyond incipient stage fires.
CON 5: NWP and CBFO failed to ensure that training and drills effectively exercised all elements of emergency response to include practical demonstration of competence, e.g., donning of self-rescuers and SCSRs, U/G personnel response to a fire, use of portable fire extinguishers, EOC roles, classification and categorization, notifications and reporting, and allowance of unescorted access for over 500 personnel, etc.	**JON 10**: NWP and CBFO need to develop and implement a training program that includes hands-on training in the use of personal safety equipment, e.g., self-rescuers, SCSRs, portable fire extinguishers, etc. **JON 11**: NWP and CBFO need to improve and implement an integrated drill and exercise program that includes all elements of the ICS, including the MRT, First Line Initial Response Team (FLIRT) and mutual aid; unannounced drills and exercises; donning of self-rescuers/SCSRs; and full evacuation of the U/G. **JON 12**: NWP needs to evaluate and improve their criteria for granting unescorted access to the U/G such that personnel with unescorted access to the underground are proficient in responding to abnormal events.
CON 6: NWP preventive and corrective maintenance program did not prevent or correct the buildup of combustible fluids on	**JON 13**: NWP management needs to reevaluate and modify the approach to conducting preventative and corrective maintenance on all U/G vehicles such that

Conclusion (CON)	Judgments of Need (JON)
the salt haul truck.	combustible fluids are effectively managed to prevent the recurrence of fires.
CON 7: NWP and CBFO management is not adequately considering overall facility impact with regard to operations, emergency response, and maintenance, which affects the safety posture of the facility, e.g., salt haul truck combustible build-up, conversion of the automatic fire suppression system to manual, removal of the automatic fire detection capability, not using fire resistant hydraulic fluid, discontinued use of the vehicle wash station, chaining of ventilation doors and an out-of-service regulator and fans, inoperable mine phones, and other non-waste-handling related equipment.	**JON 14**: NWP and CBFO need to develop and implement a rigorous process that effectively evaluates: • changes to facilities, equipment, and operations for their impact on safety, e.g., plant operations review process; • impairment and corresponding compensatory measures on safety-related equipment; and • the impact of different approaches in maintaining waste-handling and non-waste-handling equipment. **JON 15**: NWP needs to determine the extent of this condition and develop a comprehensive corrective action plan to address identified deficiencies.
CON 8: NWP and CBFO management have not effectively managed the quantity and duration of out-of-service equipment.	**JON 16**: NWP needs to develop and implement a process that ensures comprehensive and timely impact evaluation and correction of impaired or out-of-service equipment. **JON 17**: CBFO needs to ensure that its contractor oversight structure includes elements for comprehensive and timely evaluation and correction of impaired or out-of-service equipment.
CON 9: NWP management has allowed less than acceptable rigor in the performance of equipment inspections, resulting in the operation of U/G equipment in unacceptable condition.	**JON 18**: NWP needs to develop and reinforce clear expectations regarding the performance of rigorous equipment inspections in accordance with manufacturer recommendations, established technical requirements; corrective action; and trending of deficiencies.
CON 10: NWP did not ensure the BNA addressed requirements of DOE O 420.1C and MSHA with the results completely incorporated into implementing procedures.	**JON 19**: NWP needs to ensure that all requirements of DOE O 420.1C and MSHA are addressed in the BNA with the results completely incorporated into implementing procedures and the source requirements

Conclusion (CON)	Judgments of Need (JON)
	referenced, and that training consistent with those procedures is performed.
CON 11: NWP and CBFO management did not make conservative or risk-informed decisions with respect to developing and implementing the fire protection program. There is inadequate fire engineering analysis due to a lack of integration with ventilation design and operations, and U/G operations, for recognizing, controlling, and mitigating U/G fires.	**JON 20**: NWP and CBFO need to perform an integrated analysis of credible U/G fire scenarios and develop corresponding response actions that comply with DOE and MSHA requirements. The analysis needs to include formal disposition regarding the installation of an automatic fire suppression system in the mine.
CON 12: NWP and CBFO have failed to take appropriate action to correct combustible loading issues that were identified in previous internal and external reviews.	**JON 21**: NWP and CBFO need to review the combustible control program and complete corrective actions that demonstrate compliance with program requirements. These issues remain unresolved from prior internal and external reviews.
CON 13: NWP and CBFO have allowed housekeeping to degrade and other conditions to persist that potentially impede egress.	**JON 22**: NWP and CBFO need to evaluate and address deficiencies in housekeeping to ensure unobstructed egress and clear visibility of emergency egress strobes, reflectors, SCSR lights, etc.
CON 14: NWP has not fully developed an integrated contractor assurance system that provides assurance that work is performed compliantly, risks are identified, and control systems are effective and efficient.	**JON 23**: NWP needs to develop and implement a fully integrated contractor assurance system that provides DOE and NWP confidence that work is performed compliantly, risks are identified, and control systems are effective and efficient.
CON 15: CBFO failed to adequately establish and implement line management oversight programs and processes to meet the requirements of DOE O 226.1B and hold personnel accountable for implementing those programs and processes.	**JON 24**: CBFO needs to establish and implement an effective line management oversight program and processes that meet the requirements of DOE O 226.1B and hold personnel accountable for implementing those programs and processes.
CON 16: CBFO management does not have adequate communication processes to ensure awareness of issues that warrant attention from all levels of the DOE staff.	**JON 25**: CBFO needs to accelerate the implementation of a mechanism for all levels of CBFO staff to document, communicate, track, and close issues both internally and with NWP.

Conclusion (CON)	Judgments of Need (JON)
	JON 26: The CBFO Site Manager needs to institutionalize and communicate expectations for the identification, documentation, reporting, and correction of issues.
CON 17: DOE HQ failed to ensure that CBFO was held accountable for correcting repeatedly identified issues involving fire protection, maintenance, emergency management, work planning and control, and oversight.	**JON 27**: DOE HQ needs to ensure that repeatedly identified issues related to safety management programs (SMPs) are confirmed closed and validated by the local DOE office. This process should be considered for application across the DOE complex and include tracking, closure, actions to measure the effectiveness of closure (line management accountability), and trending to identify precursors and lessons learned. **JON 28**: DOE HQ should enhance its required oversight to ensure site implementation of the emergency management policy and requirements are consistent and effective. Emphasis should be placed on ensuring ICSs are functioning properly and integrated exercises are conducted where personnel are evacuated.
CON 18: DOE HQ failed to ensure CBFO was provided with qualified technical resources to oversee operation of a Hazard Category 2 Facility in a mine.	**JON 29**: DOE HQ needs to develop and implement a process for ensuring that technical expertise is available to provide support in the unique area of ground control, underground construction, and mine safety and equipment. **JON 30**: DOE HQ needs to assist CBFO with leveraging expertise from MSHA, in accordance with the DOE/MSHA MOU, in areas of ground control, underground construction, and mine safety where DOE does not have the expertise. **JON 31**: DOE HQ needs to re-evaluate resources (i.e. funding, staffing, infrastructure, etc.) applied to the WIPP project to ensure safe operations of a Hazard Category 2 Facility.
CON 19: The Office of Environmental Management Consolidated Business Center (EMCBC) and CBFO failed to ensure	**JON 32**: EMCBC and CBFO need to develop and implement clear expectations and a schedule for EMCBC to provide support in the

Conclusion (CON)	Judgments of Need (JON)
support services as described in the Service Level Agreement were provided.	areas of regulatory compliance, safety management systems, preparation of program procedures and plans, quality assurance, lessons learned, contractor assurance, technical support, DOE oversight assistance, etc.
CON 20: There are elements of the CONOPS program that demonstrate a lack of rigor and discipline commensurate with operation of a Hazard Category 2 Facility.	**JON 33**: NWP and CBFO need to evaluate and correct weaknesses in the CONOPS program and its implementation, particularly with regard to flow-down of requirements from upper-tier documents, procedure content and compliance, and expert-based decision making.
CON 21: NWP and CBFO did not analyze and disposition differences between waste-handling and non-waste-handling vehicles for similar hazards and impacts, e.g., allowing a truck in this condition to be at the waste face.	**JON 34**: NWP and CBFO need to identify and control the risk imposed by non-waste-handling equipment, e.g., combustible buildup, manual vs. automatic fire suppression system, fire-resistant hydraulic oil, etc., or treat waste-handling equipment and non-waste-handling equipment the same.
CON 22: NWP and CBFO management allowed a culture to exist where there are differences in the way waste-handling equipment and non-waste-handling equipment are maintained and operated.	**JON 35**: NWP and CBFO management need to examine and correct the culture that exists regarding the maintenance and operation of non-waste-handling equipment.
Positive Statement: All supervisors and employees in the U/G actively used the mine phone to alert other workers of the fire and the need to evacuate before the evacuation alarm was sounded. **Positive Statement**: Workers assisted other workers during the evacuation, including helping them to don self-rescuers and SCSRs. **Positive Statement**: Personnel in the U/G exhibited detailed knowledge of the underground and ventilation splits. **Positive Statement**: NWP on-site medical response was effective in treating personnel.	

12.0 Board Signatures

Theodore A. Wyka
DOE Accident Investigation Board Chairman
U.S. Department of Energy, Office of Environmental Management

T.J. Jackson
DOE Accident Investigator and Deputy Chair
U.S. Department of Energy, Office of Environmental Management
Consolidated Business Center

Jack Zimmerman
DOE Accident Investigator and Board Member
U.S. Department of Energy, Office of Environmental Management
Portsmouth/Paducah Project Office

Roger Claycomb
DOE Accident Investigator and Board Member
U.S. Department of Energy, Office of Environmental Management
Idaho Operations Office

13.0 Board Members, Advisors and Consultants

Board Members

Theodore A. Wyka	Board Chair, EM-40 Chief Nuclear Safety Advisor
T.J. Jackson	Board Deputy Chair, EMCBC, Trained Accident Investigator
Roger Claycomb	Board, ID, Trained Accident Investigator
Jack Zimmerman	Board, LEX, Trained Accident Investigator

Advisor/Team Coordinator

Advisor/Consultant	Greg Campbell EMCBC, Emergency Management
Advisor/Consultant	Frank Moussa EM-44, Emergency Management
Advisor/Consultant	James Landmesser EM-41, Fire Protection
Advisor/Consultant	Ed Westbrook EM-42, Work Controls
Advisor/Consultant	Jason Armstrong Oakridge EM, Work Controls
Advisor/Consultant	Richard Lagdon, EM-1, DOE HQ, Chief of Nuclear Safety
Advisor/Consultant	Micheal Ardaiz, MD, MPH, CPH, DOE HQ, Chief Medical Officer
Advisor/Consultant	George Hellstrom, CBFO, Legal Counsel
Advisor/Consultant	Randy Elmore CBFO, Systems Engineering
Advisor/Consultant	Lina Pacheco CBFO, Facility Representative
Advisor/Consultant	Don Galbraith CBFO, Mine Ops Project Manager
Advisor/Consultant	Mark Williams Supervisory Mine Safety and Health

Analyst/Advisor	Jack Gerber MJW Technical Services
Analyst/Advisor	Robert Seal, MAS Consultants
Advisor/Consultant	Rick Callor, CSP URS Professional Solutions, Boise
Advisor/Consultant	D. Allan Coutts, PE (SC), PhD, FSFPE URS Professional Solutions, Aiken
Advisor/Consultant	Jim Stafford, CHP, PE, CSP URS Professional Solutions
Observer	Todd Davis, DNFSB
Observer	Charles March, DNFSB
Administrative Coordinator/ Technical Writer	Susan M. Keffer, Project Enhancement Corporation Trained Accident Investigator

Appendix A. Appointment of the Accident Investigation Board

Department of Energy
Washington, DC 20585
February 7, 2014

MEMORANDUM FOR GLENN S. PODONSKY
CHIEF HEALTH, SAFETY AND SECURITY OFFICER
OFFICE OF HEALTH, SAFETY AND SECURITY

FROM: MATTHEW MOURY
DEPUTY ASSISTANT SECRETARY
SAFETY, SECURITY, AND QUALITY PROGRAMS
ENVIRONMENTAL MANAGEMENT

SUBJECT: Determination of the Need to Conduct an Accident Investigation of the February 5, 2014 Fire Event at the Waste Isolation Pilot Plant

In accordance with the January 28, 2014, David Huizenga memorandum to Matthew Moury, *Delegation of Safety Authorities*, I have determined an Accident Investigation (AI) in accordance with Department of Energy Order 225.1B, *Accident Investigations,* is warranted for the February 5, 2014, fire at the Waste Isolation Pilot Plant in Carlsbad, New Mexico. Mr. Ted Wyka will be the Chairperson for the AI. He is assembling his AI team now and will be on site as soon as possible.

If you have any questions, please contact me or Mr. Ted Wyka, Chief Nuclear Safety Advisor, at (202) 287-5502.

cc: Jose Franco, WIPP
David Huizenga, EM-1
James Owendoff, EM-2 (Acting)
Jack Craig, EM-2.1 (Acting)
Frank Marcinowski, EM-30
James Hutton, EM-40
Ted Wyka, EM-40

Appendix B. **Barrier Analysis**

Barrier analysis is based on the premise that hazards are associated with all tasks. A barrier is any means used to control, prevent, or impede a hazard from reaching a target, thereby reducing the severity of the resultant accident or adverse consequence. A hazard is the potential for an unwanted condition to result in an accident or other adverse consequence. A target is a person or object that a hazard may damage, injure, or fatally harm. Barrier analysis determines how a hazard overcomes the barriers, comes into contact with a target (e.g., from the barriers or controls not being in place, not being used properly, or failing), and leads to an accident or adverse consequence. The results of the barrier analysis are used to support the development of causal factors.

Table B-1: Barrier Analysis

Hazard: Fire and Smoke in the Underground			**Target: Workers in the Mine**	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
Local Barriers for Preventing and/or Extinguishing the Salt Haul Truck Fire				
B1: Onboard fire suppression system	Ineffective	Didn't fully discharge (no visible evidence)	Fire continued to burn	HPI: WE-5,6 ISMS: CF-3
B2: Onboard portable fire extinguisher	Ineffective	Wasn't applied at source of the fire	Fire continued to burn	HPI: WE-5,6 ISMS: CF-3; GP-6

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
B3: Salt haul truck is designed to use non-flammable hydraulic fluid	Truck contains flammable hydraulic fluid	Did not analyze? Is being used in the waste-handling vehicles.	May have contributed to fire	HPI: N/A ISMS: CF-2; GP-1,5
B4: 300 pound fire extinguisher	Ineffective	Unable to get to scene	Fire continued to burn	HPI: IC-1, 3, 5 ISMS: CF-1,3,4; GP-3,6
B5: Rescue truck	Ineffective	Not used	Fire continued to burn	HPI: WE-6 ISMS: CF-2,3,4; GP-1,3,5,6
B6: Maintenance/ housekeeping program for haul truck	Ineffective	Truck had accumulations of combustibles	Provided fuel source for fire	HPI: TD-8,IC-2,HN-6 ISMS: CF-2,3; GP-1,5,6

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
B7: Operator training for responding to fire on the truck	Partially effective	Did not call CMRO, did not activate onboard FPS first	Delayed application of fire suppression Delayed response and evacuation	HPI: IC-1,5 WE-5 ISMS: CF-4; GP-5
B8: Integrity of fluid systems	Ineffective (assumed)	Acceptance of leaks based on review of daily inspections and AIB walkdown of vehicles	There were fluid leaks	HPI: HN-6,IC-2 ISMS: CF-1,3,4; GP-1,5,6,7
B9: Automatic detection and actuation of FPS	Ineffective	Removed due to inadvertent actuations	Was not applied until operator activated it	HPI: TD-5,6; WE-2 ISMS: CF-3,4; GP-1,5,6
B10: Lessons learned from other fires, e.g, catalytic converter	Ineffective	Unaware (inadequacy in NWP Contractor Assurance System (CAS) – Lessons Learned (LL) program	LLs were not applied	HPI: HN-6,3 ISMS: CF-2,5; GP-1,6,7

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
B11: Self-assessment and oversight of haul truck condition	Ineffective	Identification and resolution of issues not performed adequately	Conditions were not identified	HPI: N/A ISMS: CF-5; GP-1,5,6,7
B12: Pre-operational checks	Ineffective	Performed but did not identify deficiencies	Combustibles were allowed to exist	HPI: HN-3,6 ISMS: CF-3,4,5; GP-1,5,6,7
Local Barriers for Ensuring the Successful Evacuation of Personnel from the Underground After the Salt Haul Truck Fire				
B13: Training and drills for underground fires	Partially effective	On POD, usually on Family day, no hands on practice, no integrated full scale exercise	Difficulties with donning both self-rescuers and SCSRs Difficulties egressing	HPI: WE-1,6; TD-1,IC-1,5, HN-1 ISMS: CF-4,5; GP-3,5,6
B14: PA system	Partially effective	Location, quantity, and volume of speakers inadequate	Inaudible in some areas or difficult to understand	HPI: WE-6 ISMS: CF-2,3; GP-3,5,6

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
B15: Alarms (yelp)	Partially effective	Did not alarm for 5 full seconds (CMRO action) Do not ensure all mine phones are operable	Personnel trained to expect 5 second alarm Not heard throughout the UG	HPI: TD-2, WE-4,6 ISMS: CF-4; GP-3,6
B16: Strobes (evacuation lights)	Ineffective	Not turned on until called from UG May not be operable throughout the UG (assumed) Limited visibility (location) throughout the mine Limited intensity (brightness) Non uniform spacing	Difficulty in egress	HPI: TD-2, WE-2,5, HN-1 ISMS: CF-2,3,4; GP-2,6,7
B17: Mine phones	Partially effective	May not be operable throughout the UG (run to failure)	Could not be heard throughout the UG, impeded understanding of fire	HPI: N/A ISMS: CF-3; GP-6

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
B18: Mine reflectors	Partially effective	Some obscured by other equipment, mesh, salt dust, etc. Not visible in heavy smoke Non uniform spacing and heights	Impeded egress	HPI: N/A ISMS: CF-3; GP-6
B19: Ventilation (shift to filtration)	Partially effective	Counter to worker training on egress during evacuation Contrary to industry practice Contrary to step in UG Fire Response procedure Not analyzed prior to event	Confusion in worker egress (smoke in areas expected to be safe)	HPI: WE-2, HN-3,5,6, TD-6,7, IC-3,4 ISMS: CF-2,3; GP-2,3,5,6,7
B20: Ventilation control	Ineffective (inoperable for remote actuation)	Chained doors and regulator	Limited the options to control ventilation	HPI: N/A ISMS: CF-3,5; GP-1,5,7

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
B21: Central Monitoring Room Operations	Partially effective	Did not follow procedures Relied on FSM expertise and knowledge	Inadequate reporting and notifications Confused workers UG	HPI: WE-1,2, HN-3,6, TD-3,8, IC-2 ISMS: CF-3,4; GP-1,2,3,5,6
B22: Emergency Operations Center	Ineffective	Played no leadership role No training for specific EOC position roles Incident Command structure is not fully developed or implemented	Inadequate reporting and notifications Failure to categorize Failure to support the FSM by pushing resources	HPI: N/A ISMS: CF-2,3,4; GP-1,2,3,5,6
B24: Self-rescuers	Partially effective	No actual use (training)	Could not be donned by some personnel	HPI: IC-5 ISMS: CF-4; GP-3
B25: SCSRs	Partially effective	No actual use (training)	Could not be donned by some personnel	HPI: IC-5 ISMS: CF-4; GP-3

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
Systemic Barriers for Ensuring the Safety of WIPP Personnel and the Environment				
B26: Fire Protection Program	Ineffective – did not minimize the likelihood of the fire. Program allowed: • accumulation of combustibles in the vehicle near an ignition source. • removal of automatic fire detection and suppression system (FPS) from truck.	Program addresses basic elements but BNA is less than adequate (previously identified by external reviews). BNA states to contact CMRO, CMRO to dispatch UG Services to evaluate and fight fire, and then CMRO makes evacuation decision. FHA did not evaluate a fire near a shaft underground. Automatic FPS required for waste-handling vehicles but not for non-waste handling vehicles except if they are used near the waste face. UG fire response procedure only	Uncontrolled fire in the underground. Ineffective response to the fire. Could cause significant delay in evacuation of the UG.	HPI: N/A ISMS: CF-1,3,4; GP-1,2,5,6

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
		addresses automatic FPS and use or a portable fire extinguisher		
B27: Maintenance Program	Partially effective	Does not adequately consider management and control of combustibles. Numerous red tagged fans, alarms, valve, pull station; some for greater than seven months. Inoperable mine phones, possibly some strobes. Inaudible public addresses system (in some locations).	Allowed fuel for fire. No direct effect but reflects weakness in the program. Inhibited egress. Inhibited egress.	HPI: N/A ISMS: CF-2,3; GP-1,2,5,7

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
B28: Emergency Management Program	Ineffective: Lack of categorization. Plays a support role to the CMR. Failure to make some notifications. Communications (yelp, strobes, status, direction).	Lack of rigor in training. Procedures not followed. Not specific enough (notifications, tactical support to FSM, response, emergency action levels). Lack of defined roles for EOC staff. No integrated annual exercise with external agencies. Drills on schedule, typically performed on Wednesdays (Family Day) – no unannounced drills.	Ineffective command and control structure (CMR/EOC). Delayed evacuation for some personnel.	HPI: N/A ISMS: CF-2,3; GP-1,2,5,6,7
B29: Underground Escape and Evacuation Plan	Effective	Did not fail.	No affect	HPI: N/A ISMS: CF-2,3; GP-1,5,6,7

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
B30: Underground Fire Response Procedure	Ineffective: Does not include BNA requirements to use the onboard manual FSP.	BNA requirements not included in the procedure.	Worker activated the FSP only after using the portable fire extinguisher (may have extinguished fire). Workers were attempting to fight fire with the 300 lb extinguisher without sufficient hands on training.	HPI: N/A ISMS: CF-1,2,3,4; GP-1,3,5,6
B31: Training Program	Partially effective.	No hands on training (fire extinguishers, donning self-rescuers/SCSRs), drills and exercises didn't prepare UG personnel for this scenario	Some personnel did not follow procedures, drills and exercises were only partially effective, and some personnel encountered difficulties donning and wearing self-rescuers and SCSRs	HPI: IC-1,2 ISMS: CF-1, CF-4, GP-3
B32: Documented Safety Analysis Program/Technical Safety Requirements	Effective	Did not fail	Did not – accident is bounded.	HPI: N/A ISMS: GP-5

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
B33: Ventilation System Control	Ineffective: Distributed smoke throughout the UG.	Fire at this location had not been analyzed to take the appropriate ventilation control actions to minimize and/or eliminate smoke in the UG (similar to MSHA requirement for fire in an intake shaft).	Distributed smoke throughout the UG.	HPI: N/A ISMS: CF-2,3; GP-1,5,6,7
B34: Medical Response	Effective	Did not fail	Timely and efficient	HPI: N/A ISMS: N/A
B35: Contractor Assurance System	Ineffective	Does not have		HPI: N/A ISMS: CF-5; GP-1,2,3,5,7

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
B36: DOE CBFO	Partially effective	Inadequate resolution of externally identified issues Emergency mgt. assessment triennial assessment has not been performed. FR program assessment FR/SME communication Facility Representative program: Staffing (only 2 of 4 FRs) due to medical issues. In-development. No structured surveillance program.	Did not identify issues with ineffective or failed barriers identified in this analysis.	HPI: N/A ISMS: CF-5; GP-1,2,5,7
		Informal documentation and tracking of issues		

Hazard: Fire and Smoke in the Underground			Target: Workers in the Mine	
Barriers	**How did barrier perform?**	**Why did barrier fail?**	**How did barrier affect accident?**	**Context: HPI/ISMS**
B37: External Oversight (DOE HQ, EMCBC, MSHA, DNFSB, etc.)	Partially effective	Acceptance or lack of enforcement of inadequate development and/or implementation of corrective actions to issues identified by these organizations.	Allowed for long-standing deficiencies in emergency management, fire protection, oversight, etc. to remain unresolved for extended periods	HPI: N/A ISMS: CF-5; GP-1,2,5,6,7
B38: Response to external Oversight (DOE HQ, EMCBC, MSHA, DNFSB, etc.)	Ineffective	There is ineffective site (CBFO and NWP) response (corrective action) to issues identified by these organizations.	Allowed for long-standing deficiencies in emergency management, fire protection, oversight, etc. to remain unresolved for extended periods	HPI: N/A ISMS: CF-5; CP-1,2,5,6,7

Appendix C. Change Analysis

Change is anything that disturbs the "balance" of a system from operating as planned. Change is often the source of deviations in system operations. Change can be planned, anticipated, and desired, or it can be unintentional and unwanted. Change analysis examines the planned or unplanned disturbances or deviations that caused the undesired results or outcomes related to the accident. This process analyzes the difference between what is normal (or "ideal") and what actually occurred. The results of the change analysis are used to support the development of causal factors.

Table C-1: Change Analysis

Accident Situation	Prior, Ideal or Accident-Free Situation	Difference	Evaluation of Effect
Local Changes for Preventing and/or Extinguishing the Salt Haul Truck Fire			
C1: Mine atmosphere unsafe	Mine atmosphere safe	Significant smoke in the underground	Smoke inhalation, difficulty evacuating
C2: Fire and smoke in underground	No fire or smoke in underground	Significant smoke in the underground	Smoke inhalation, difficulty evacuating, soot on equipment and mine, soot on pre-filters
C3: Combustible fluid leaks on underground vehicles	No or minimal combustible fluid leaks on underground vehicles	Combustible fluids were available to combust. Maintenance program ineffective or not followed.	The combustible fluid ignited when in contact with hot surfaces of the salt haul truck
C4: The on-board fire suppression system required activation by the salt haul truck driver.	The automatic fire suppression system activates at first indication of fire.	Delay in the time for activation of the on-board fire suppression system.	Fire may have been extinguished while in the incipient stage.

Accident Situation	Prior, Ideal or Accident-Free Situation	Difference	Evaluation of Effect
Local Barriers for Ensuring the Successful Evacuation of Personnel from the Underground After the Salt Haul Truck Fire			
C5: Issues donning self-rescuers and self-contained self-rescuers (SCSR)	No issues donning self-rescuers or SCSRs	Some personnel did not wear self-rescuers. Training ineffective or inadequate.	Smoke inhalation
C6: Emergency alarm short, not heard everywhere	Emergency alarm for 5 seconds as per training and heard throughout the underground	Not all personnel were aware of the need to evacuate. CMR did not leave yelp alarm for standard 5 seconds.	Delay in evacuation
C7: Emergency strobes not turned on or not visible throughout underground	Emergency strobes turned on at same time as "yelp" (or directly thereafter), remain on, and are visible throughout the underground	Not all personnel were aware of the need to evacuate	Delay in evacuation
C8: Personnel did not don self-rescuers at first sign of smoke	Personnel don self-rescuers at first sign of smoke	Not all personnel were wearing self-rescuers as required	Potential for smoke inhalation
C9: Announcements not audible and/or clear and not heard throughout the underground	Announcements were clear and concise and were heard throughout the underground	Not all personnel were aware of the need to evacuate and/or where the fire was located. Public Address (PA) system ineffective.	Delay in evacuation and inability to plan best exit route

Accident Situation	Prior, Ideal or Accident-Free Situation	Difference	Evaluation of Effect
C10: Personnel were preparing to fight the fire wearing self-rescuers	Personnel did not wear self-rescuers to fight the fire	Personnel were preparing to fight the fire wearing only self-rescuers. Training ineffective.	Potential for smoke inhalation
C11: Decision to change to filtration during the fire made based on personal experience	Decision on changes to filtration during a fire is based on analysis and full understanding of consequences.	Significant build-up of smoke in the mine and smoke in areas personnel expected to have "good air". Experienced based decision making was inadequate.	Delay in evacuation, potential for personnel to become incapacitated during travel to the waste hoist
C12: Near-misses when driving/walking to waste hoist for evacuation	No near-misses when driving/walking to the waste hoist for evacuation	A number of near-misses (collisions) with people, carts, and/or equipment occurred. Housekeeping less than adequate. No designated travel paths. No lights/strobes, or adequate reflectors on equipment.	Potential for personnel injuries and blockages to egress
C13: Hoist not at bottom when evacuation began.	Hoist "parked" at bottom when not in use.	Hoist wasn't available to immediately evacuate personnel.	Slight delay in evacuation.
C14: Manual fire suppression system was activated late in the fire	Automatic FSS that functions as designed and extinguishes fire in the incipient state	Significant reduction in the time the suppressant was applied	Fire didn't get extinguished in the incipient state

Accident Situation	Prior, Ideal or Accident-Free Situation	Difference	Evaluation of Effect
C15: Operator called maintenance and then his Supervisor about the fire	Operator calls the CMRO to report the fire	Delay in CMRO notification	Slight delay in reporting and evacuation
C16: Operator uses portable fire extinguisher first	Operator activates FSS first then use portable fire extinguisher	Significant reduction in the time the suppressant was applied	Fire didn't get extinguished in the incipient state
C17: Combustible fluids buildup on the salt haul truck	Combustible fluid managed in accordance with the owner's manual	Combustible fluids were available to ignite	Combustible fluids ignited
C18: Pre-operational checks on salt haul truck did not identify fluid buildup	Pre-operational check identifies fluids and has them addressed	Combustible fluids were available to ignite	Combustible fluids ignited
C19: Salt dump area and travel path is adjacent to and in the primary air intake split	Salt dump area and travel path is away from the air intake split	Smoke was distributed both north and south	Impeded egress
C20: UG Services responds to fire with only their self-rescuers	Trained fire response with proper PPE and firefighting equipment or clear policy to immediately evacuate	UG Services personnel not prepared to fight fire	UG Services personnel at risk
C21: Yelp was shorter in activation than required, delay in activating strobes, inaudible in some areas	Prompt activation of yelp alarm and strobes, audible and clear communication of instructions	Confusion in identifying type of emergency (or if a drill), expected response, and egress	Impeded egress

Accident Situation	Prior, Ideal or Accident-Free Situation	Difference	Evaluation of Effect
C22: Not all personnel donned self-rescuers at first indication of fire	All personnel don self-rescuers at first sign of fire	Some personnel were in smoke without wearing self-rescuers	Smoke inhalation and inability to evacuate
C23: Some personnel couldn't open and don their self-rescuers and SCSRs	Personnel have no difficulty opening and donning their self-rescuers and SCSRs	Some personnel were exposed to greater amount of smoke	Potential smoke inhalation
C24: CMR changed the ventilation to filtration during the incident	Should have followed their procedure and not switched to filtration (or come out of filtration if in that mode)	Potentially effected the locations of good air and concentrations of CO, put smoke in areas workers have been trained and expected to have good air	Spread smoke , confused workers, delayed egress
C25: Personnel were not prepared via drills and exercises for scenario where all underground has smoke	Drills and exercises prepare personnel for a scenario where all the UG is filled with smoke	Personnel were surprised and unprepared for situation and had to develop own egress plans	Delay in egress or failure to egress
C26: Alarms and announcements not heard throughout the UG,	Alarms and communication equipment operates as expected	Personnel not aware of need to evacuate or instructions	Delay in egress or failure to egress
C27: Strobes may not have been operable or visible throughout the mine	Strobes turned on with yelp alarm and are visible throughout the UG	Personnel could not see strobes to assist in egress	Delay in egress or failure to egress

Accident Situation	Prior, Ideal or Accident-Free Situation	Difference	Evaluation of Effect
C28: Did not categorize or make notifications	EOC activation, categorization, and notifications made in accordance with DOE O 151.1C	Event not properly categorized and required notifications were not made	Didn't trigger support from DOE and external agencies.
C29: FSM controlled all actions	Crisis manager with EOC support controls all actions allowing the FSM to focus on operational response	Decisions are made with limited input and support, potential for overload of FSM	Potential for inadequate response to the accident
Systemic Changes for Ensuring the Safety of WIPP Personnel and the Environment			
C30: BNA and FHA did not address this scenario, specifically the location of the fire (didn't consider fire in the supply drifts)	Fire Protection Program is effective. BNA and FHA analyze and pre-plan for credible scenarios.	No detailed analysis and response to this scenario	FSM had to develop response (location specific) at time of crisis
C31: Salt truck had combustible buildup, alarms could not be heard or understood throughout the mine, reflectors were not able to be seen during egress.	Maintenance Program effective. Equipment is properly maintained (trucks, alarms, strobes, PA system, reflectors, mine phones and pager).	Equipment was not effective in notifying personnel UG of the fire or expected evacuation	Delay in egress or potential for failure to egress

Accident Situation	Prior, Ideal or Accident-Free Situation	Difference	Evaluation of Effect
C32: Some red tagged safety related equipment for over 7 months.	Minimal backlog of impaired/inoperable safety related equipment with short period impaired/inoperable.	There is a relatively high number of impaired/out-of-service safety related equipment that has been in that state for an extended period of time.	No direct impact on this event. None of the red tagged equipment was relative to the fire or response.
C33: Lack of an integrated emergency management system.	Emergency Management Program effective. System is integrated with offsite agencies, site complies with requirements for categorization and notification.	Plans were not followed.	Not using all resources that are available
C34: Does not consider manual only initiation of onboard fire suppression systems. Did not flow BNA requirements.	Underground Fire Response Procedure effective. Directs activation of manual fire suppression system upon discovery of vehicle fire.	Not instructed to initiate fire suppression system first.	May extinguish fire at incipient stage.
C35: A fire in the non-waste handling section of the mine adversely affected the ventilation system, including smoke and soot on the HEPA filtration system, waste handling building, and waste hoist.	Documented Safety Analysis Program/Technical Safety Requirements effective and includes evaluation of impacts of non-waste incidents, e.g., fire with a salt truck that impacts ventilation system.	Non-waste handling equipment is treated differently than waste handling equipment.	There was an impact on the HEPA filtration system from a fire involving a non-waste handling vehicle, waste handling building, and waste hoist.

Accident Situation	Prior, Ideal or Accident-Free Situation	Difference	Evaluation of Effect
C36: Some ventilation doors were chained open and a regulator was not operating properly. In filtration mode, there is one door that must be manually positioned.	Ventilation System Control effective All ventilation doors and regulators can be operated automatically or remotely.	Limits options for automatically or remotely controlling ventilation flow paths.	Inability to control the flow of smoke and cannot recover from filtration mode.
C37: Fire protection, emergency management, and CBFO oversight issues identified by DOE and external agencies have not been addressed and/or resolved in a timely manner	Complete and prompt response and resolution of issues identified by DOE and external agencies.	Could have had a fully compliant and effective fire protection, emergency management, and CBFO oversight program.	May have identified precursors to this incident.
C38: FR program is currently understaffed, no schedule for surveillances, issues are not documented and tracked through closure	DOE CBFO oversight (SME, FRs) is structured, fully staffed, and effective.	Could have identified conditions or inadequacies that caused this event.	Did not identify precursors to this incident.
C39: Contractor Assurance System did not identify conditions or precursors to this event.	Contractor Assurance System is effective – staffed, self-assessment and oversight is performed, issues are addressed, trending is performed	Could have identified conditions or inadequacies that caused this event	Did not identify precursors to this incident.

Appendix D. Causal Factors and Related Conditions

Table D-1: Causal Factors and Related Conditions

Causal Factor	Related Conditions
C1: The preventative and corrective maintenance program did not prevent or correct the buildup of combustible fluids on the salt truck.	Buildup of combustibles on the salt haul truck. Vehicle washing station was removed from service. Vehicle service manual requires washing every 100 hours of operation or every two weeks. Difference in expectations for waste-handling vs non-waste-handling vehicles. Unclear if compensatory measures for impaired safety related equipment have been identified or are in-place. (CONOPS) Numerous mine phones were inoperable (run to battery failure). Twelve of the 40 tested were non-functional. PA announcements were difficult to hear or understand. Salt haul trucks are designed and built to use fire resistant hydraulic fluid, but it is not used in these vehicles. Ability to change ventilation configuration remotely to control smoke is hampered by chained doors and a regulator in need of repair. Expectations for clearing red tags on critical safety equipment, e.g., fans, fire suppression system, CAMs. No method to readily understand status of impaired safety related equipment. (CONOPS)

Causal Factor	Related Conditions
C2: Fire protection program less than adequate.	The BNA requirement for use of manual onboard FSS before use of portable fire extinguisher not included in U/G fire response procedure and therefore the onboard FSS was not activated first. Decision to disable the automatic fire suppression system due to inadvertent actuation (engineering). BNA has long-standing open issues, e.g., evaluation of the needs for U/G firefighting activities. The U/G fire response procedure requires the CMRO to direct U/G Services to respond and evaluate fires after decision to evacuate the mine. FHA did not consider the impact of a vehicle fire in this location. MSHA requires evaluation and control of fires at a wooden shaft, this event simulates a fire at a wooden shaft and no evaluation has been performed or controls have been specified. No direct relationship between the Fire Hazard Analysis (FHA) and this event. Conditions in the U/G exceeded combustible loading limits during the event.
C3: CMR response (evaluation and protective actions) was less than adequate.	Did not sound emergency evacuation alarm for the full 5 seconds as required by procedure. Did not immediately activate emergency strobe lights until notified by personnel U/G (~ 4 – 5 minute delay). Unreasonable expectations and uncertain capabilities of the FSM to directly manage all aspects of an emergency abnormal event. Alarm and communication system (control box) is not user friendly, e.g., strobes must be activated independent of the alarms and independent of the PA. There is no longer a training week built into the CMR rotation schedule.

Causal Factor	Related Conditions
C4: Training and qualification of the CMR operator was inadequate to ensure proper response to a vehicle fire.	Did not sound emergency evacuation alarm for the full 5 seconds as required by procedure. Did not immediately activate emergency strobe lights until notified by personnel U/G (~ 4 – 5 minute delay). Unreasonable expectations and uncertain capabilities of the FSM to directly manage all aspects of an emergency abnormal event. Alarm and communication system (control box) is not user friendly, e.g., strobes must be activated independent of the alarms and independent of the PA. There is no longer a training week built into the CMR rotation schedule.
C5: Elements of the emergency management/preparedness and response program were ineffective.	Buildup of debris on reflectors, covered reflectors, blocked reflectors, irregular spacing of reflectors compounded the difficulty in egress due to the heavy smoke. There were equipment and materials in the drifts that also made egress difficult and resulted in near-misses (collisions with people and equipment) in the heavy smoke. Inconsistency between site EM program and DOE O 151.1C with regard to activation of the EOC. Failure to classify and categorize. Failure to make required notifications and reports. No integrated emergency management program (notification, classification, and categorization). No implementation of the ICS system between the scene of the accident, the EOC, and DOE HQ. The EOC does not play a leadership role, the CMR maintains command of the event. Incident command structure is not fully developed or implemented. Some FSMs do not have the ICS series training. No training for specific EOC position roles.

Causal Factor	Related Conditions
	No unannounced drills (on schedule, usually on Family Day) No fully integrated exercises where personnel are fully evacuated and offsite agencies respond, e.g., MSHA, other than notifications. A triennial emergency management self-assessment has not been conducted since 2008 and maybe not at all. Effectiveness of training in donning and use of self-rescuers and SCSRs (many had trouble with one or both). Annual refresher is a video with no donning and therefore no evaluation of competency. Rigor of training for salt truck drivers (used portable first instead of FSS). Not all personnel receive hands on training on portable fire extinguisher use. There are currently over 500 personnel granted unescorted access to the U/G. Many of these individuals have little familiarity with the U/G or evacuation expectations.
C6: Nuclear versus mine culture.	Different treatment of waste vs non-waste handling equipment, e.g., combustible buildup, manual vs. automatic FSS, fire resistant hydraulic oil, etc. DSA/TSR LCO 3.3.7 allowed this truck in this condition to be at the waste face. There is a difference in the level of oversight and attention on WH vs non-WH equipment.
C7: There are elements of the Conduct of Operations program that demonstrate a lack of rigor and discipline commensurate with the operation of a Hazard Category 2 Facility.	Maintenance Procedure PM074080, EMCO Haul Truck 74-U-006A/B, does not refer to the CHAMPS Preventative Maintenance process, nor include performance requirements from manufacturer's instructions. While "Various O&M Manuals" are listed as a reference in the procedure, there are no steps in the procedure that direct the user to refer to the manufacturer's instructions and validate performance criteria. Operator's Checklists are not completely filled

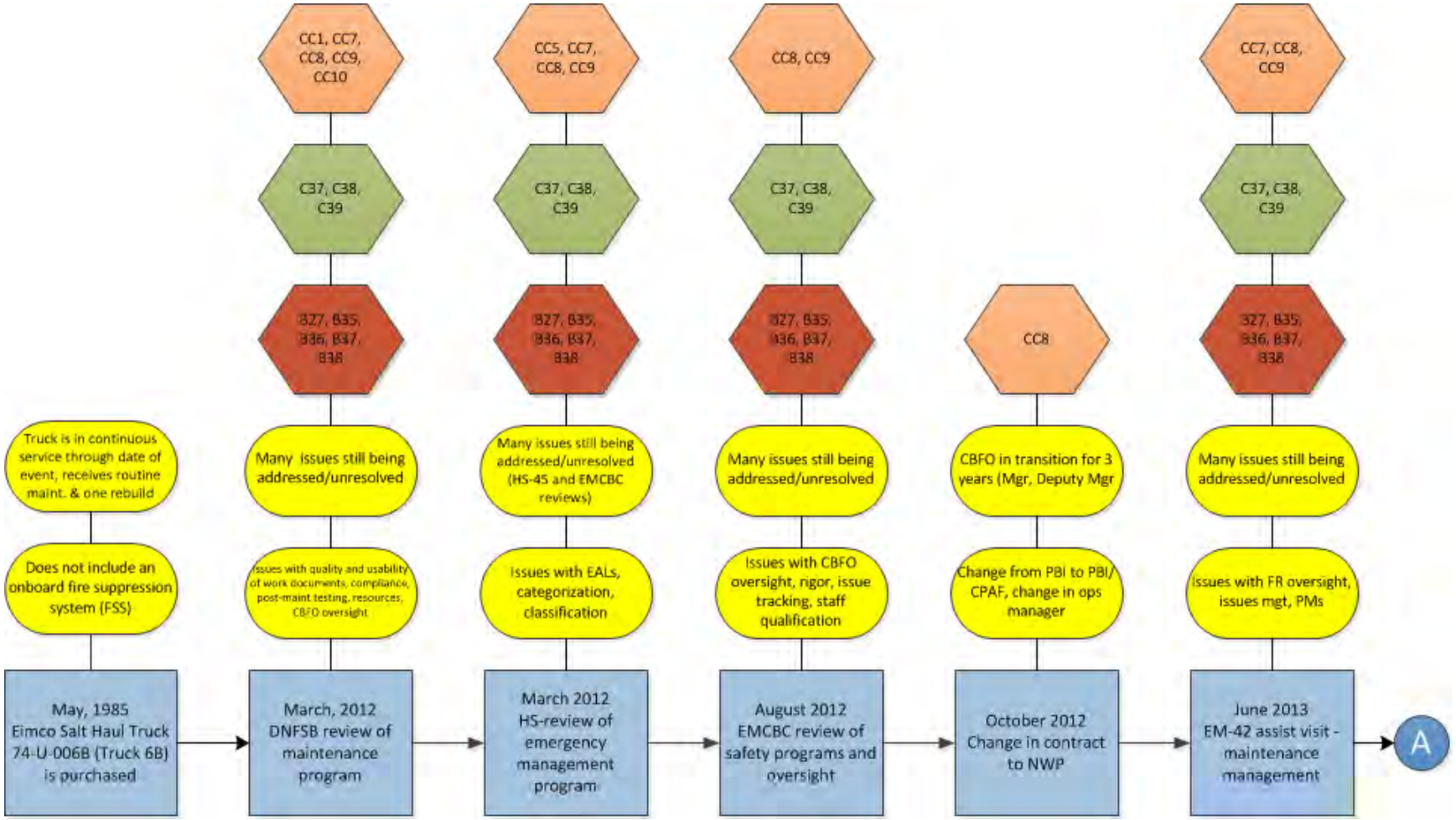
Causal Factor	Related Conditions
	out. On several occasions, the initial and/or final meter reading was not filled out, and the machine (Haul Truck) is not marked as safe to use. The emergency response procedures did not clearly identify points when U/G ventilation should be secured and/or changed, egress methods for conditions when multiple people are in the U/G, or when to activate the EOC. The BNA requirement for use of the manual onboard FSS before use of a portable fire extinguisher was not included in the U/G fire response procedure. The U/G fire response procedure required the CMRO to direct U/G Services to respond and evaluate fires after a decision was already made to evacuate the mine. As identified in training and written in procedures, the haul truck operator did not notify the CMR of the fire after the portable fire extinguisher and manual FSS failed. The operator contacted the maintenance department. Although required by the evacuation procedure, the CMR did not sound the evacuation alarm for a full 5 seconds and illuminate the emergency strobe lights. Many U/G personnel were unable to don SRs and/or SCSRs. Critical safety equipment had red tags in which NWP employees via interviews did not fully understand the status of the impaired safety related equipment. Safety equipment included fans, FSS, and CAM. The U/G vehicle operator did not receive hands-on training on the use of portable fire extinguishers.
C8: NWP Contractor Assurance System (CAS) was ineffective.	Did not identify precursors through self-assessment or independent oversight. Did not identify and disseminate pertinent lessons learned. Ineffective corrective action to externally

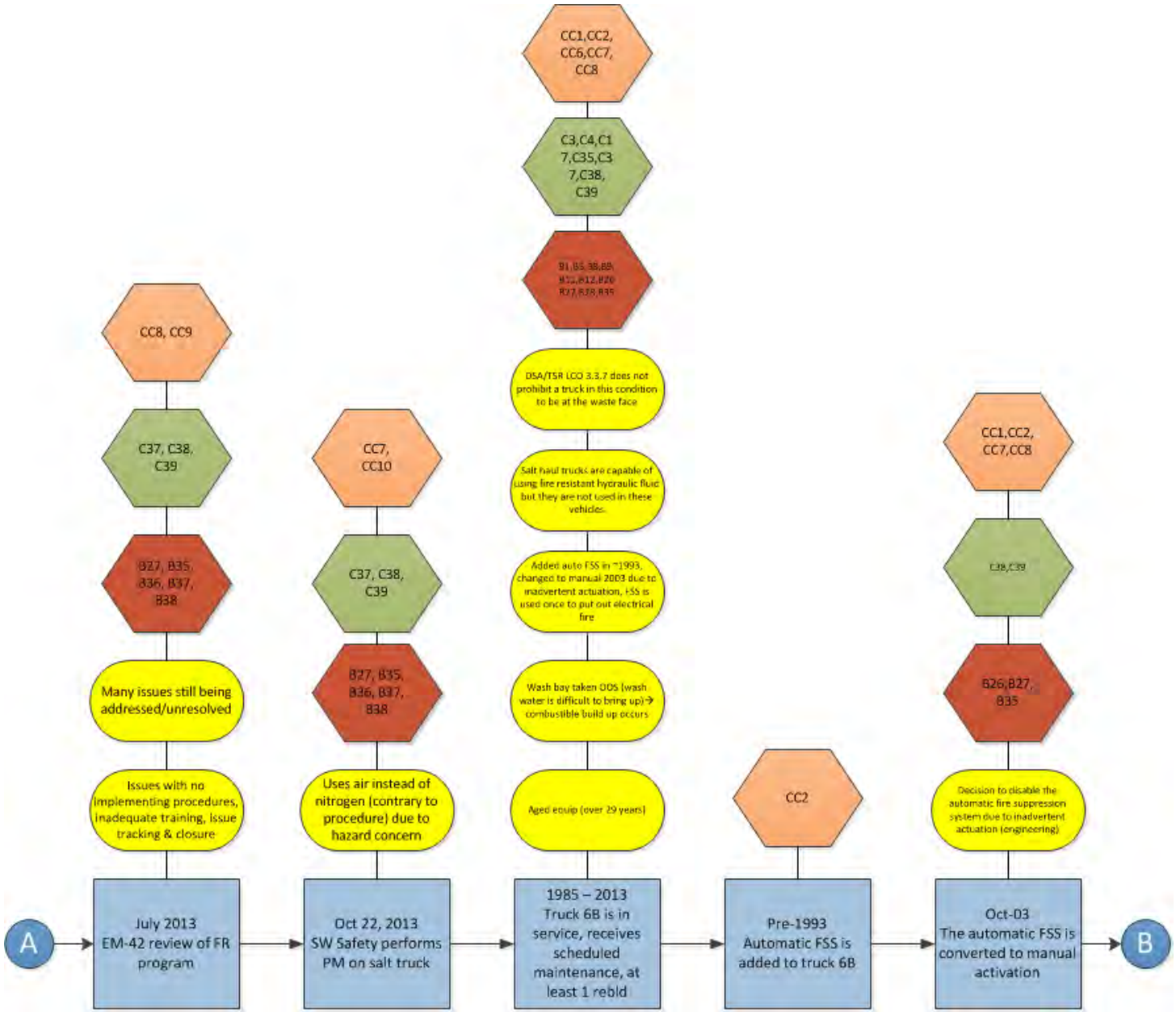
Causal Factor	Related Conditions
	identified issues. Management walkdowns of the U/G (if/when performed) did not identify conditions causal to the fire, housekeeping, combustible loading, mine phone inoperability, etc. External organizations identify issues not pre-identified through NWP self-assessment and/or oversight
C9: CBFO oversight was ineffective.	Did not identify precursors through oversight, i.e., Facility Representative program or oversight. Inadequate management attention, tracking and trending, and execution of the WIPP corrective action program. Lost opportunities to utilize MSHA inspections and assist visits required by public law and the MOU. Facility Representative program is ineffective: • Procedures incomplete • Staffing does not meet staffing analysis • No structured surveillance program. Inadequate communication of issues to DOE and contractor management. FR/SME communications/barriers.
C10: Repeat deficiencies were identified in DOE and external agency assessments, e.g., DNFSB emergency management, fire protection, maintenance, CBFO oversight, and work planning and control, but allowed to remain unresolved for extended periods of time without ensuring effective site response.	There are numerous issues from DOE HQ, EMCBC, and the DNFSB which remain unresolved and have been so for extended periods of time.

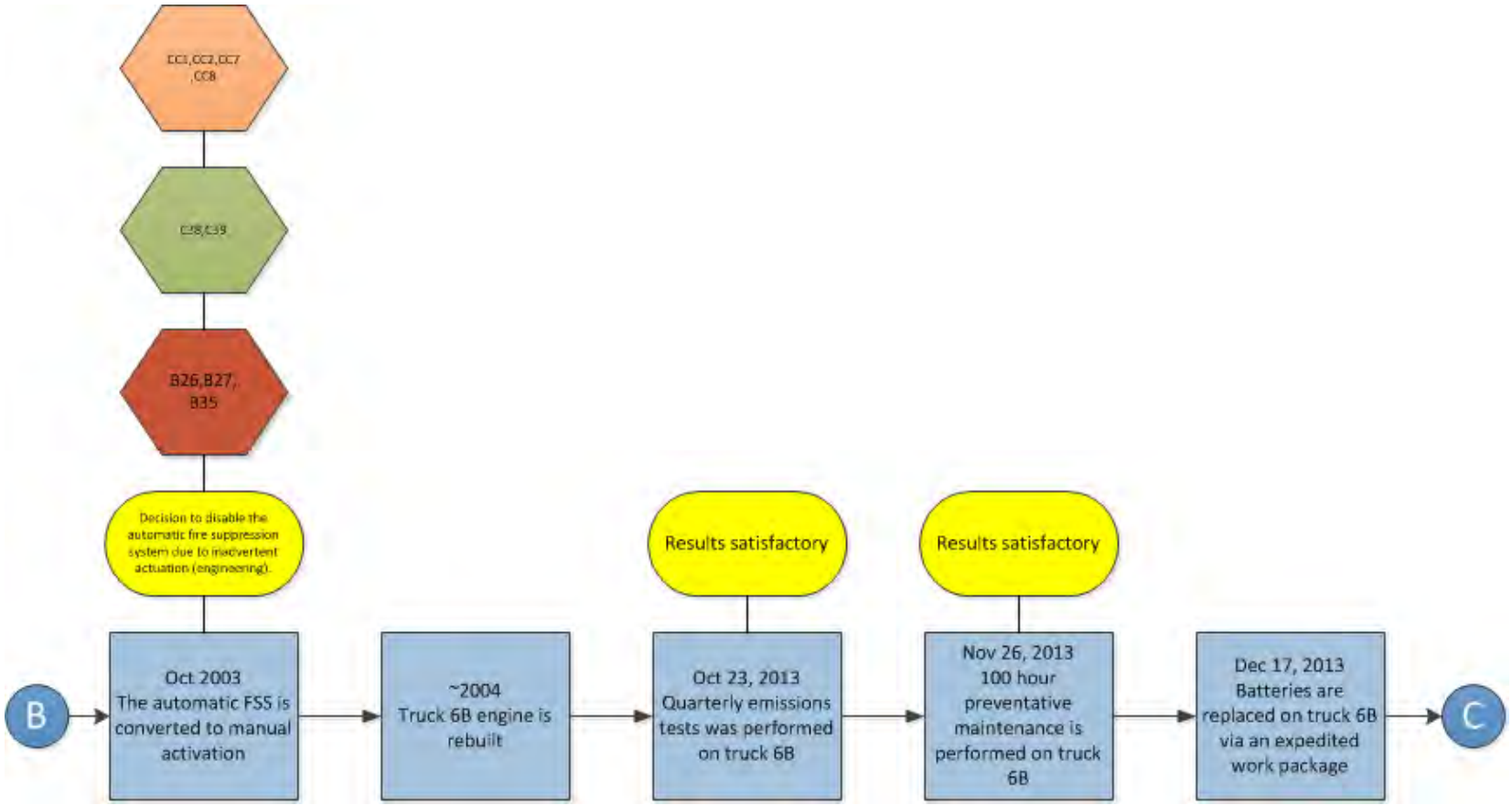
Appendix E. Event and Causal Factor Analysis

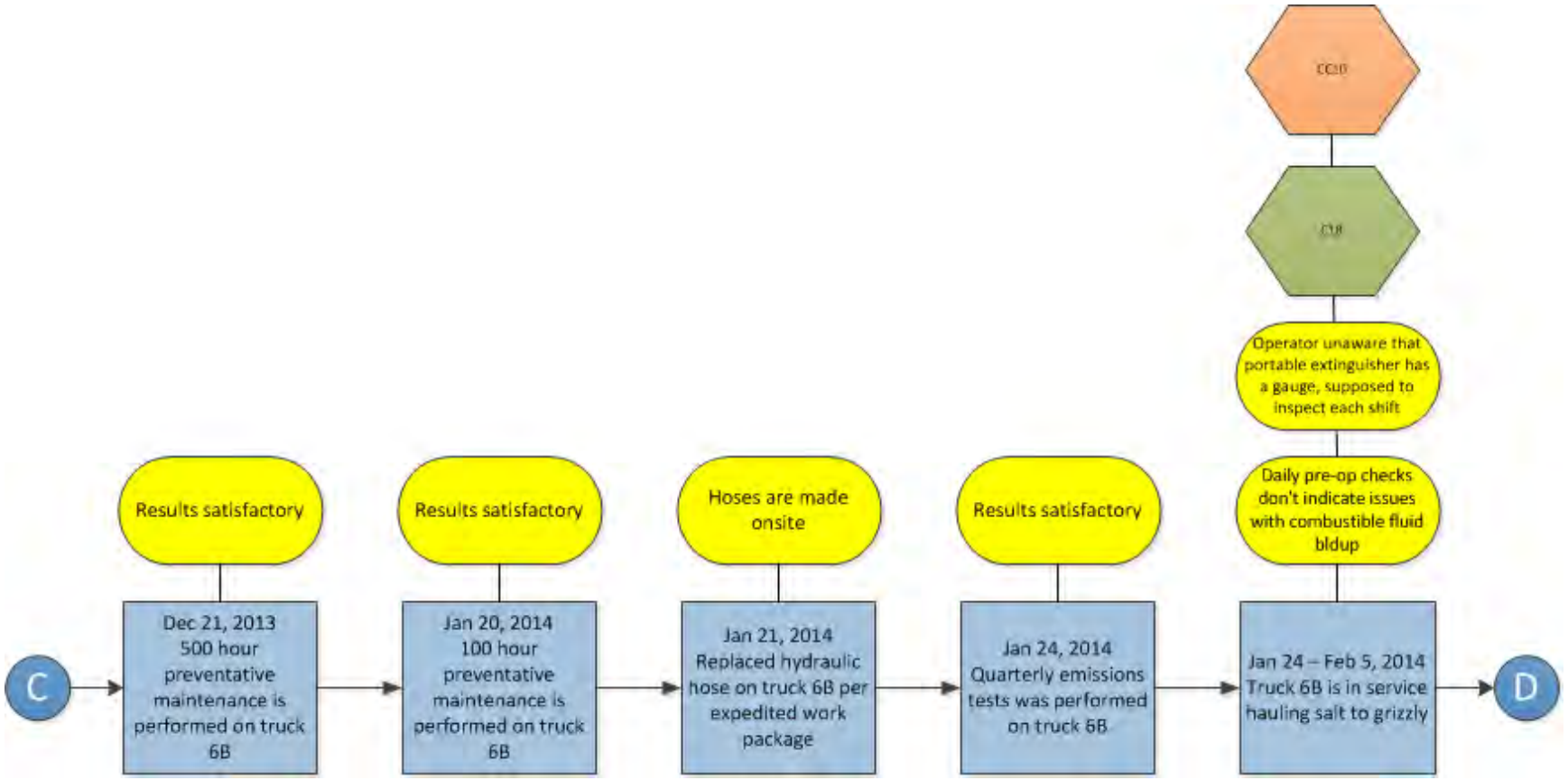
An events and causal factors analysis was performed in accordance with the DOE Workbook, Conducting Accident Investigations. The events and causal factors analysis requires deductive reasoning to determine those events and/or conditions that contributed to the accident. Causal factors are the events or conditions that produced or contributed to the accident, and they consist of direct, contributing, and root causes. The direct cause is the immediate event(s) or condition(s) that caused the accident. The contributing causes are the events or conditions that, collectively with the other causes, increased the likelihood of the accident, but which did not solely cause the accident. Root causes are the events or conditions that, if corrected, would prevent recurrence of this and similar accidents. The causal factors are identified in Figure D-1: Events and Causal Factors Analysis.

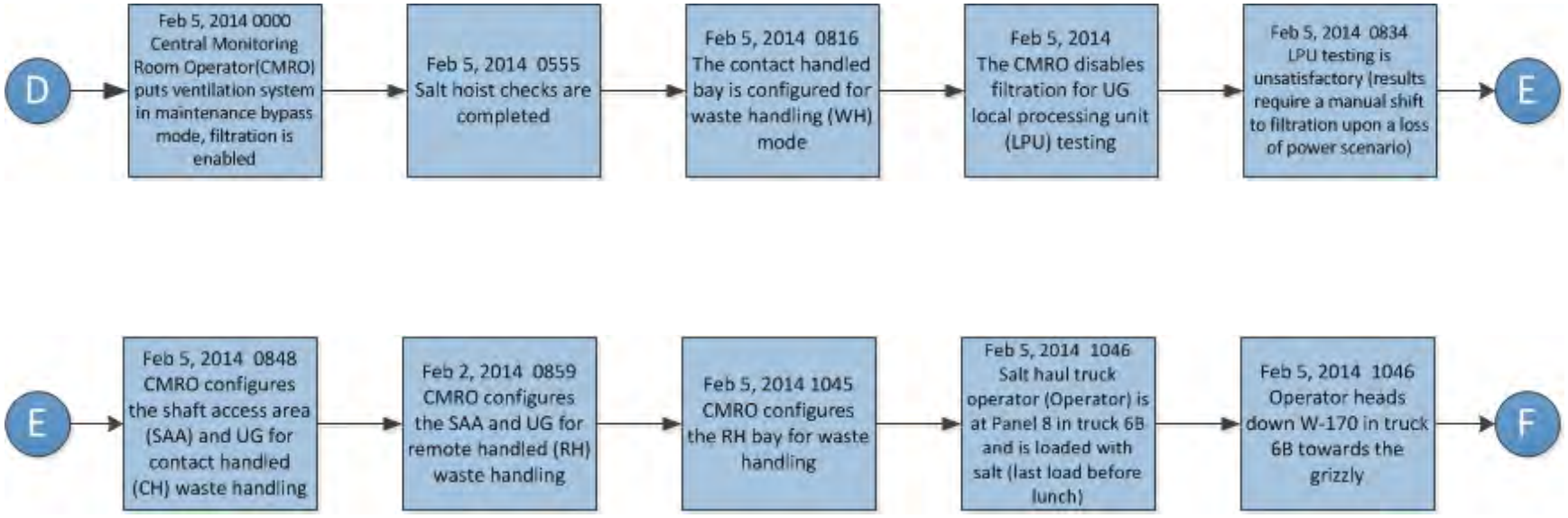
Table D-1: Event and Causal Factors Analysis

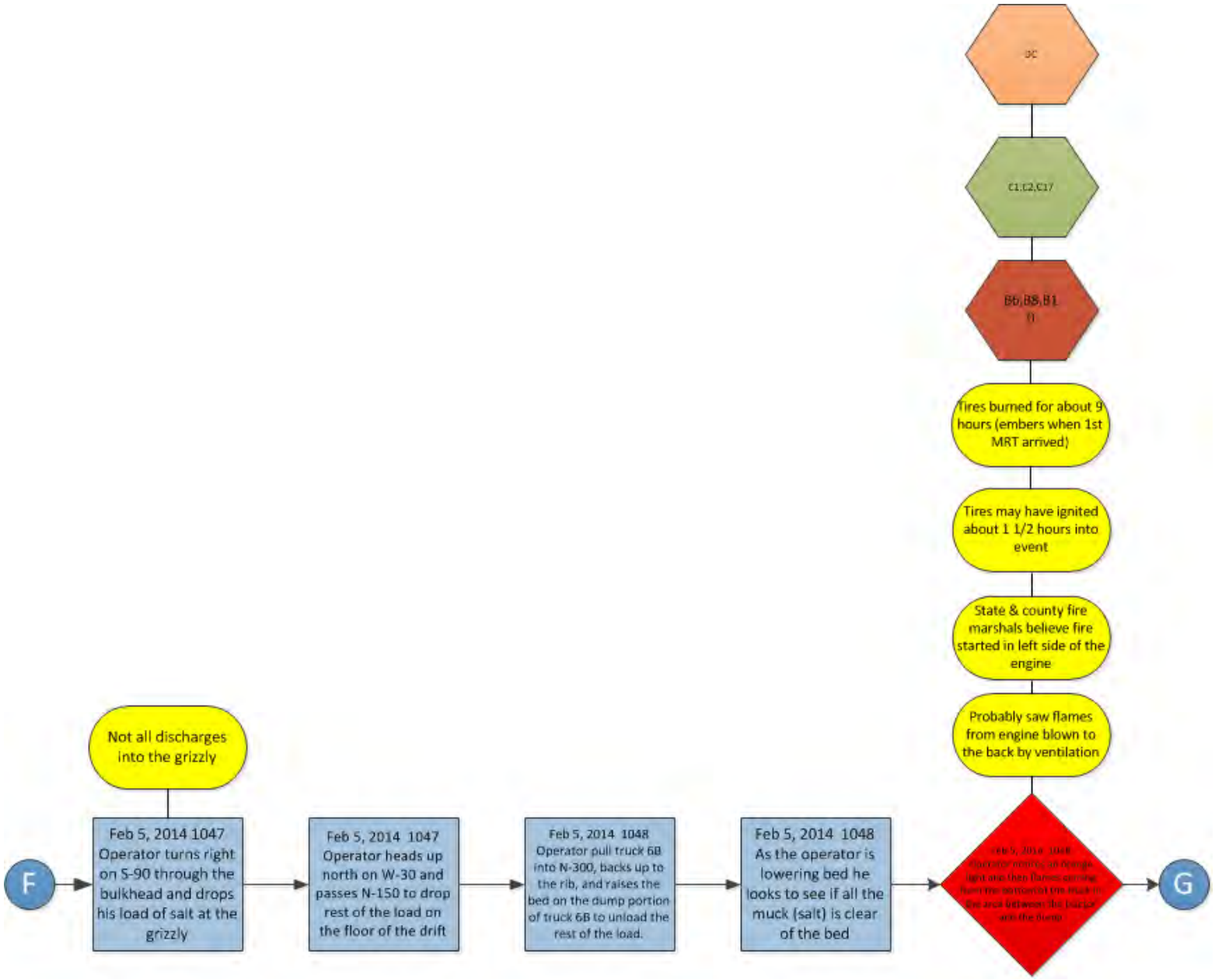

May, 1985
Eimco Salt Haul Truck 74-U-006B (Truck 6B) is purchased
Truck is in continuous service through date of event, receives routine maint. & one rebuild
Does not include an onboard fire suppression system (FSS)
March, 2012
DNFSB review of maintenance program
Many issues still being addressed/unresolved
Issues with quality and usability of work documents, compliance, post-maint testing, resources, CBFO oversight
CC1, CC7, CC8, CC9, CC10
C37, C38, C39
B27, B35, B36, B37, B38
March 2012
HS-review of emergency management program
Many issues still being addressed/unresolved (HS-45 and EMCBC reviews)
Issues with EALs, categorization, classification
CC5, CC7, CC8, CC9
C37, C38, C39
B27, B35, B36, B37, B38
August 2012
EMCBC review of safety programs and oversight
Many issues still being addressed/unresolved
Issues with CBFO oversight, rigor, issue tracking, staff qualification
CC8, CC9
C37, C38, C39
B27, B35, B36, B37, B38
October 2012
Change in contract to NWP
CBFO in transition for 3 years (Mgr, Deputy Mgr
Change from PBI to PBI/ CPAF, change in ops manager
CC8
B27, B35, B36, B37, B38
June 2013
EM-42 assist visit - maintenance management
Many issues still being addressed/unresolved
Issues with FR oversight, issues mgt, PMs
CC7, CC8, CC9
C37, C38, C39
B27, B35, B36, B37, B38
A

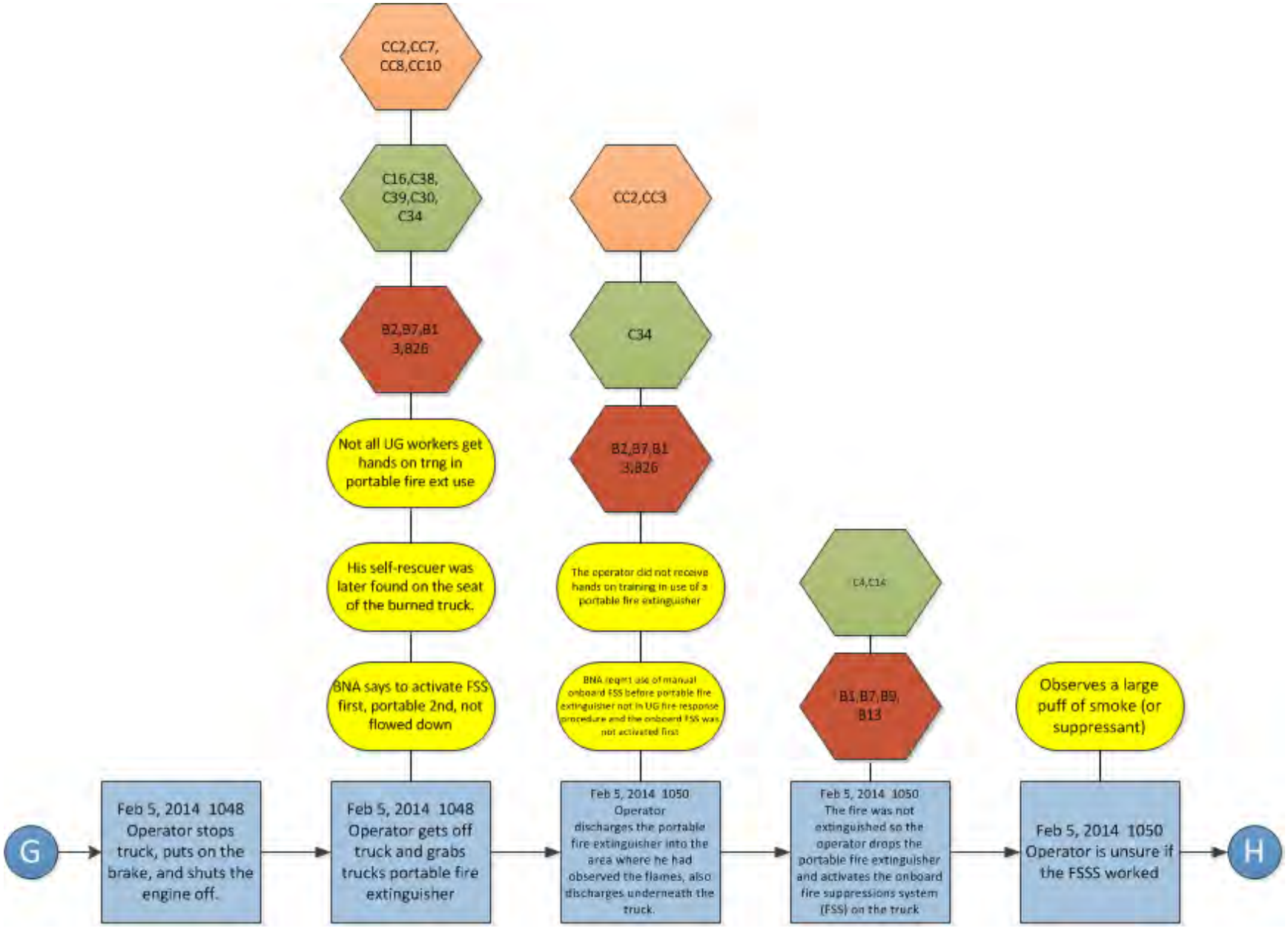

A
July 2013
EM-42 review of FR program
CC8, CC9
C37, C38, C39
B27, B35, B36, B37, B38
Many issues still being addressed/unresolved
Issues with no implementing procedures, inadequate training, issue tracking & closure
Oct 22, 2013
SW Safety performs PM on salt truck
CC7, CC10
C37, C38, C39
B27, B35, B36, B37, B38
Uses air instead of nitrogen (contrary to procedure) due to hazard concern
1985 – 2013
Truck 6B is in service, receives scheduled maintenance, at least 1 rebld
CC1,CC2, CC6,CC7, CC8
C3,C4,C17,C35,C37,C38, C39
B1,B5,B8,B9,B12,B20,B27,B38,B39
DSA/TSR LCO 3.3.7 does not prohibit a truck in this condition to be at the waste face
Salt haul trucks are capable of using fire resistant hydraulic fluid but they are not used in these vehicles.
Added auto FSS in ~1993, changed to manual 2003 due to inadvertent actuation, FSS is used once to put out electrical fire
Wash bay taken OOS (wash water is difficult to bring up)→ combustible build up occurs
Aged equip (over 29 years)
Pre-1993
Automatic FSS is added to truck 6B
CC2
Oct-03
The automatic FSS is converted to manual activation
CC1,CC2, CC7,CC8
C38,C39
B26,B27, B35
Decision to disable the automatic fire suppression system due to inadvertent actuation (engineering)
B

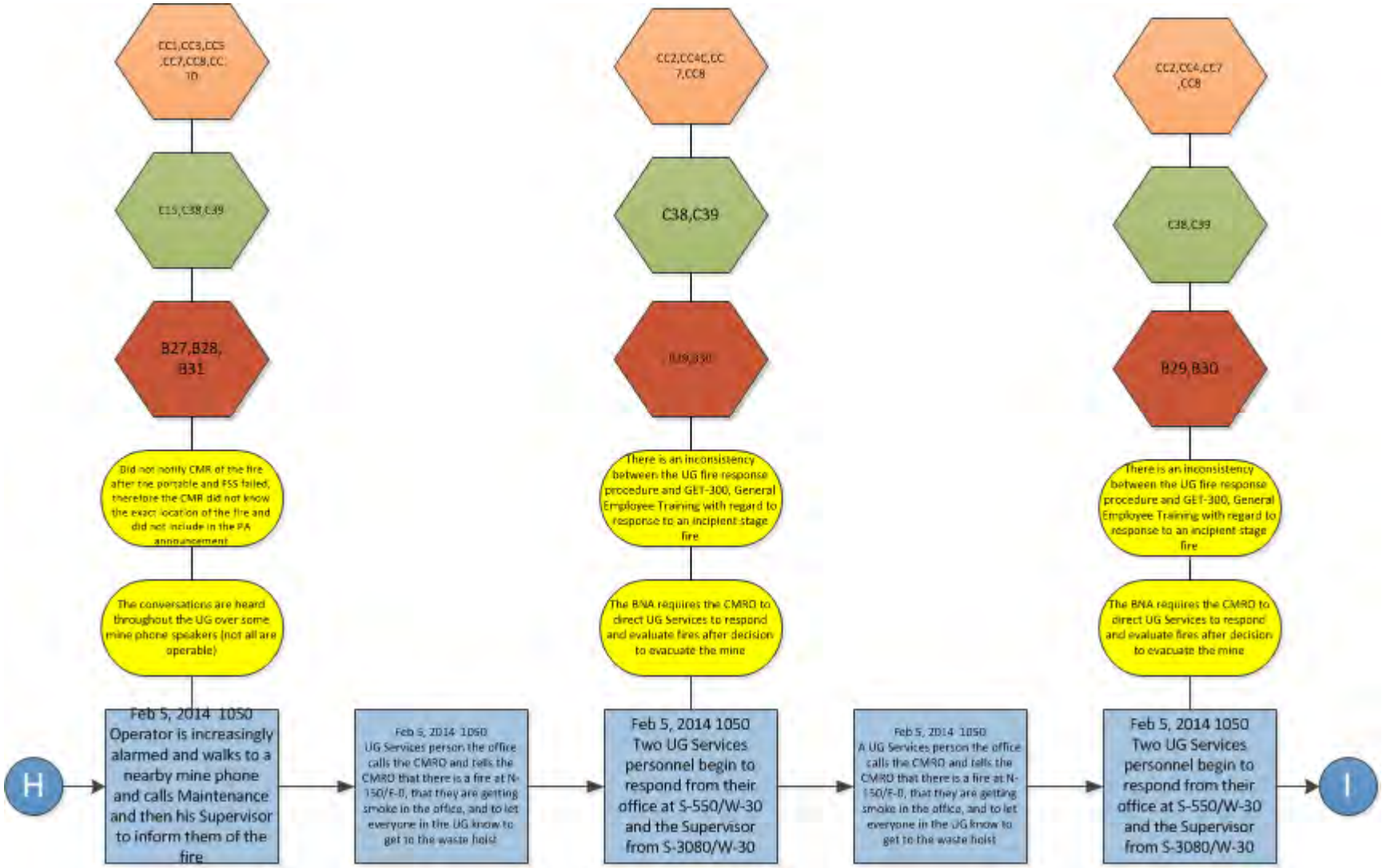

CC1,CC2,CC7
,CC8
C38,C39
B26,B27,
B35
Decision to disable the automatic fire suppression system due to inadvertent actuation (engineering).
Results satisfactory
Results satisfactory
B
Oct 2003
The automatic FSS is converted to manual activation
~2004
Truck 6B engine is rebuilt
Oct 23, 2013
Quarterly emissions tests was performed on truck 6B
Nov 26, 2013
100 hour preventative maintenance is performed on truck 6B
Dec 17, 2013
Batteries are replaced on truck 6B via an expedited work package
C

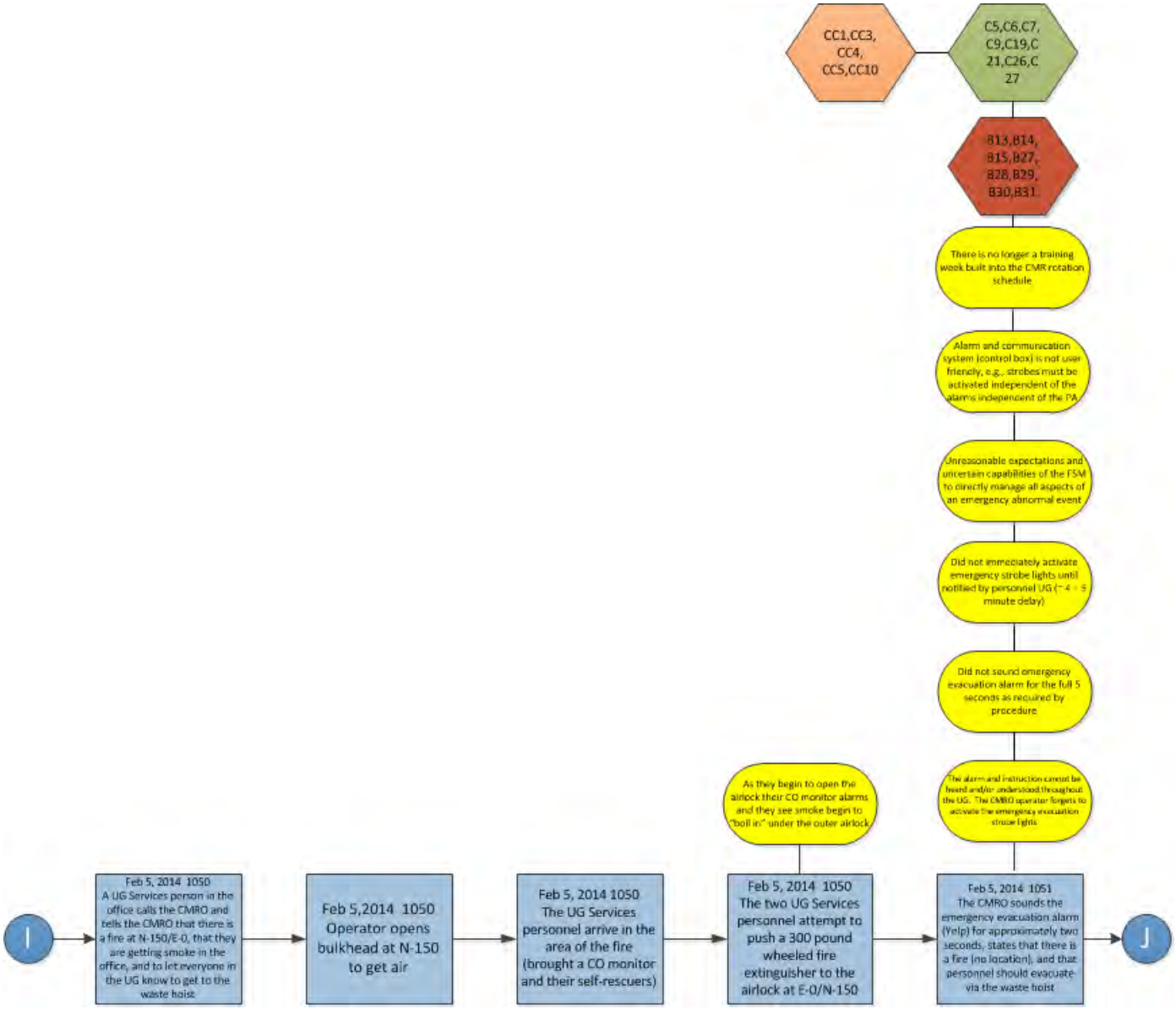

CC10
CC8
Operator unaware that portable extinguisher has a gauge, supposed to inspect each shift
Daily pre-op checks don't indicate issues with combustible fluid bldup
Results satisfactory
Results satisfactory
Hoses are made onsite
Results satisfactory
C
Dec 21, 2013 500 hour preventative maintenance is performed on truck 6B
Jan 20, 2014 100 hour preventative maintenance is performed on truck 6B
Jan 21, 2014 Replaced hydraulic hose on truck 6B per expedited work package
Jan 24, 2014 Quarterly emissions tests was performed on truck 6B
Jan 24 – Feb 5, 2014 Truck 6B is in service hauling salt to grizzly
D

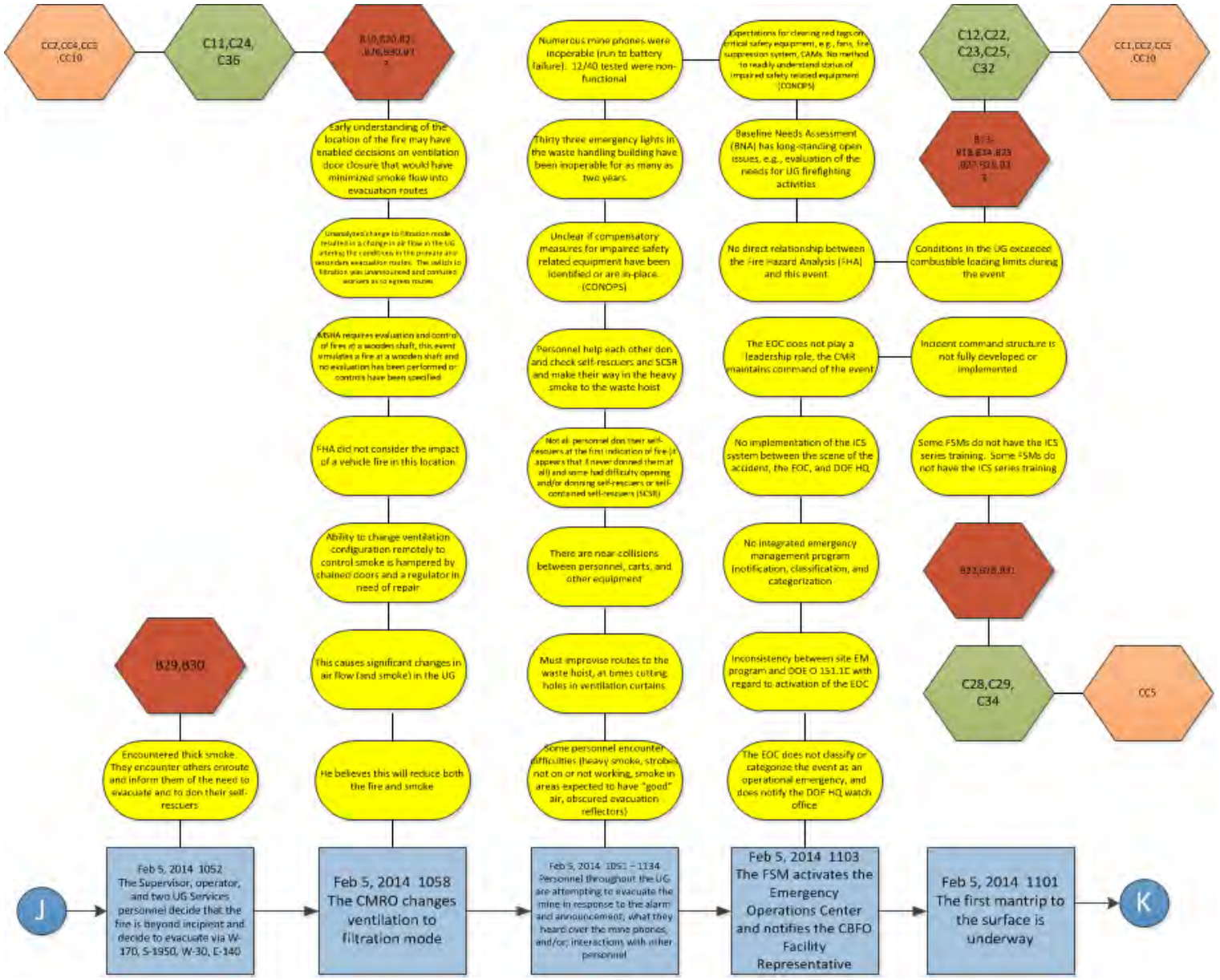

D
Feb 5, 2014 0000 Central Monitoring Room Operator(CMRO) puts ventilation system in maintenance bypass mode, filtration is enabled
Feb 5, 2014 0555 Salt hoist checks are completed
Feb 5, 2014 0816 The contact handled bay is configured for waste handling (WH) mode
Feb 5, 2014 The CMRO disables filtration for UG local processing unit (LPU) testing
Feb 5, 2014 0834 LPU testing is unsatisfactory (results require a manual shift to filtration upon a loss of power scenario)
E
E
Feb 5, 2014 0848 CMRO configures the shaft access area (SAA) and UG for contact handled (CH) waste handling
Feb 2, 2014 0859 CMRO configures the SAA and UG for remote handled (RH) waste handling
Feb 5, 2014 1045 CMRO configures the RH bay for waste handling
Feb 5, 2014 1046 Salt haul truck operator (Operator) is at Panel 8 in truck 6B and is loaded with salt (last load before lunch)
Feb 5, 2014 1046 Operator heads down W-170 in truck 6B towards the grizzly
F

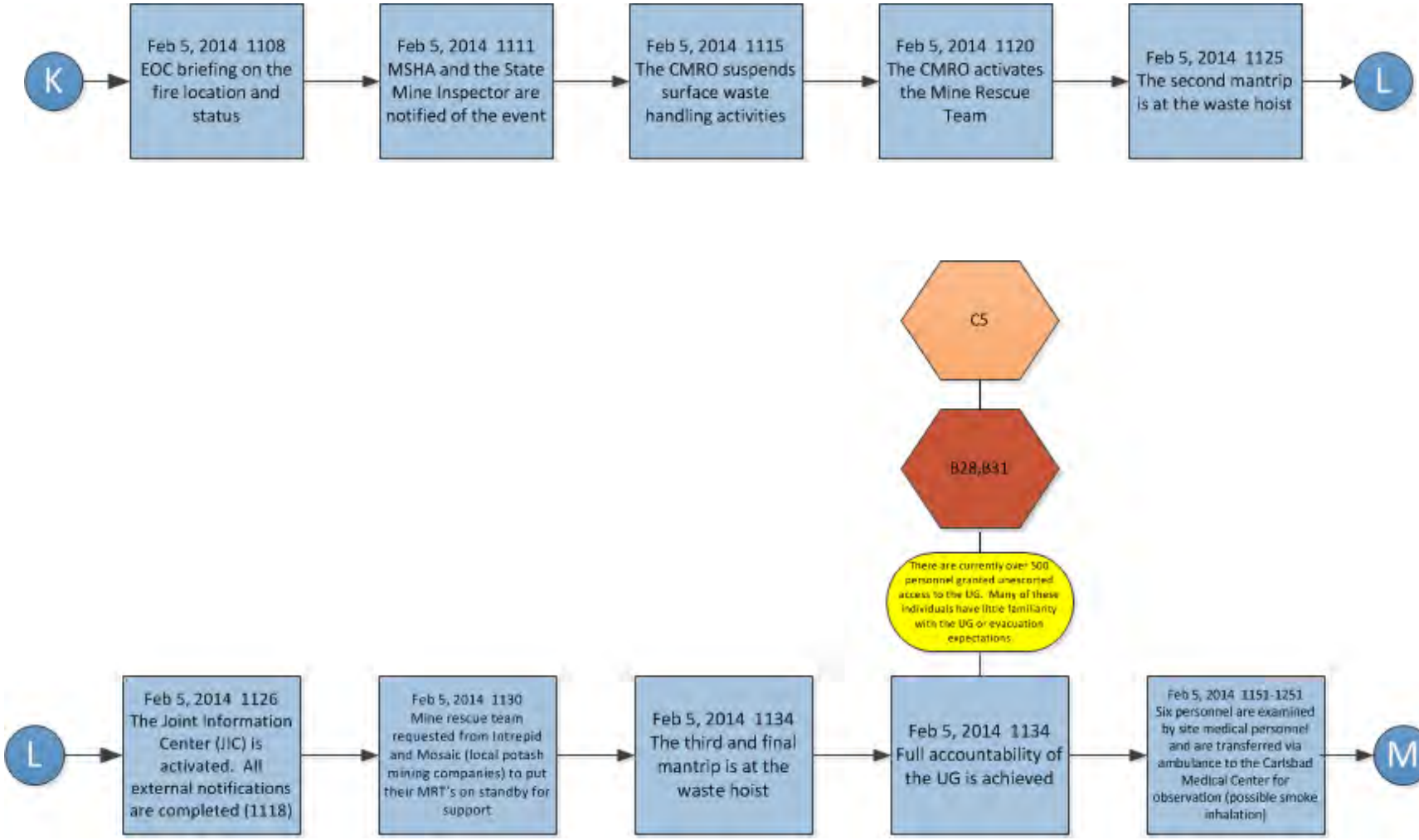

F
Not all discharges into the grizzly
Feb 5, 2014 1047 Operator turns right on S-90 through the bulkhead and drops his load of salt at the grizzly
Feb 5, 2014 1047 Operator heads up north on W-30 and passes N-150 to drop rest of the load on the floor of the drift
Feb 5, 2014 1048 Operator pull truck 6B into N-300, backs up to the rib, and raises the bed on the dump portion of truck 6B to unload the rest of the load.
Feb 5, 2014 1048 As the operator is lowering bed he looks to see if all the muck (salt) is clear of the bed
Probably saw flames from engine blown to the back by ventilation
State & county fire marshals believe fire started in left side of the engine
Tires may have ignited about 1 1/2 hours into event
Tires burned for about 9 hours (embers when 1st MRT arrived)
B6,B8,B1
C1,C2,C17
G

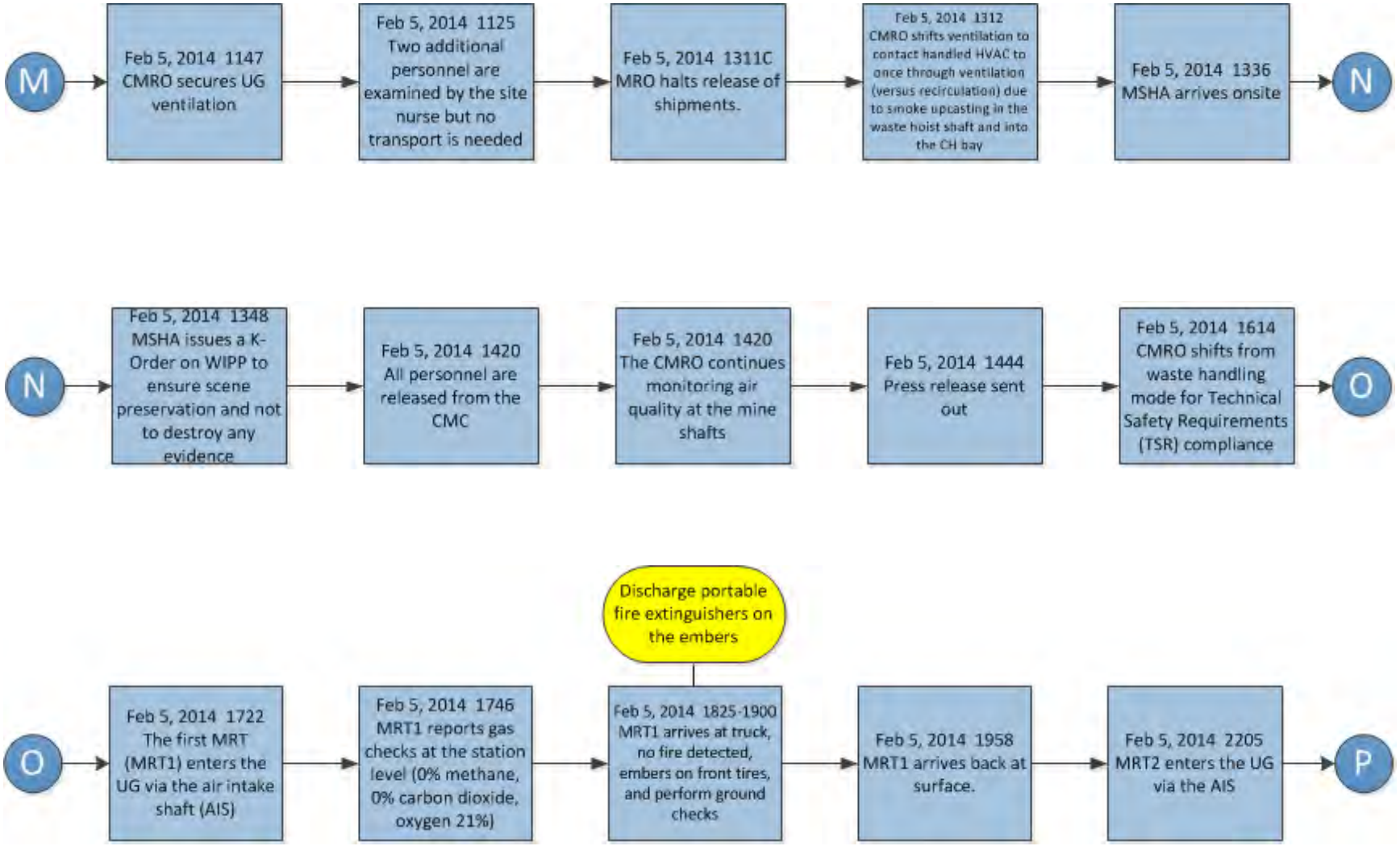

G
Feb 5, 2014 1048 Operator stops truck, puts on the brake, and shuts the engine off.
Feb 5, 2014 1048 Operator gets off truck and grabs trucks portable fire extinguisher
BNA says to activate FSS first, portable 2nd, not flowed down
His self-rescuer was later found on the seat of the burned truck.
Not all UG workers get hands on trng in portable fire ext use
B2,B7,B13,B26
C16,C38,C39,C30,C34
CC2,CC7,CC8,CC10
Feb 5, 2014 1050 Operator discharges the portable fire extinguisher into the area where he had observed the flames, also discharges underneath the truck.
BNA reqmt use of manual onboard FSS before portable fire extinguisher not in UG fire response procedure and the onboard FSS was not activated first
The operator did not receive hands on training in use of a portable fire extinguisher
B2,B7,B13,B26
C34
CC2,CC3
Feb 5, 2014 1050 The fire was not extinguished so the operator drops the portable fire extinguisher and activates the onboard fire suppressions system (FSS) on the truck
B1,B7,B9,B13
C4,C14
Feb 5, 2014 1050 Operator is unsure if the FSSS worked
Observes a large puff of smoke (or suppressant)
H

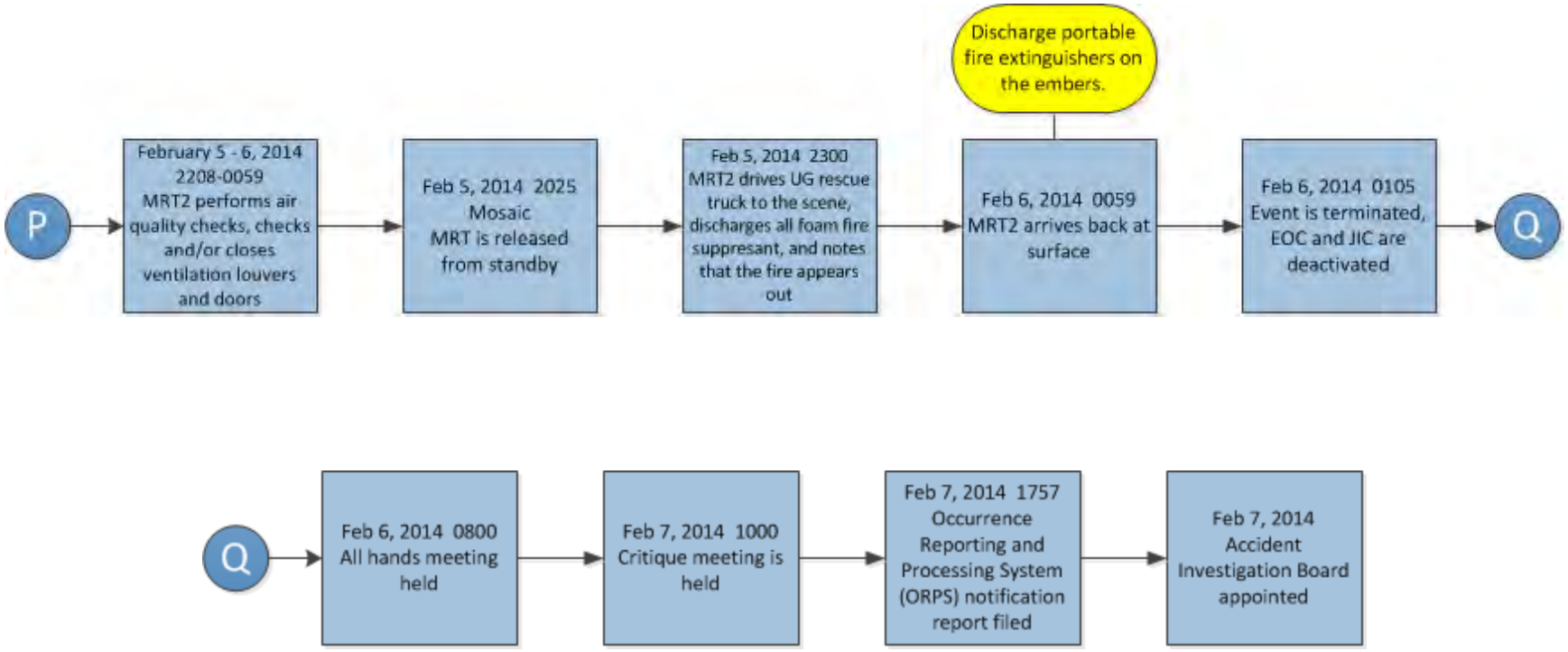

CC1,CC3,CC5,CC7,CC8,CC10
C15,C38,C39
B27,B28,B31
Did not notify CMR of the fire after the portable and FSS failed, therefore the CMR did not know the exact location of the fire and did not include in the PA announcement
The conversations are heard throughout the UG over some mine phone speakers (not all are operable)
H
Feb 5, 2014 1050 Operator is increasingly alarmed and walks to a nearby mine phone and calls Maintenance and then his Supervisor to inform them of the fire
Feb 5, 2014 1050 UG Services person the office calls the CMRO and tells the CMRO that there is a fire at N-150/F-0, that they are getting smoke in the office, and to let everyone in the UG know to get to the waste hoist
CC2,CC4C,CC7,CC8
C38,C39
B29,B30
There is an inconsistency between the UG fire response procedure and GET-300, General Employee Training with regard to response to an incipient stage fire
The BNA requires the CMRO to direct UG Services to respond and evaluate fires after decision to evacuate the mine
Feb 5, 2014 1050 Two UG Services personnel begin to respond from their office at S-550/W-30 and the Supervisor from S-3080/W-30
Feb 5, 2014 1050 A UG Services person the office calls the CMRO and tells the CMRO that there is a fire at N-150/F-0, that they are getting smoke in the office, and to let everyone in the UG know to get to the waste hoist
CC2,CC4,CC7,CC8
C38,C39
B29,B30
There is an inconsistency between the UG fire response procedure and GET-300, General Employee Training with regard to response to an incipient stage fire
The BNA requires the CMRO to direct UG Services to respond and evaluate fires after decision to evacuate the mine
Feb 5, 2014 1050 Two UG Services personnel begin to respond from their office at S-550/W-30 and the Supervisor from S-3080/W-30
I


CC1,CC3, CC4, CC5,CC10
C5,C6,C7, C9,C19,C 21,C26,C 27
B13,B14, B15,B27, B28,B29, B30,B31
There is no longer a training week built into the CMR rotation schedule
Alarm and communication system (control box) is not user friendly, e.g., strobes must be activated independent of the alarms independent of the PA
Unreasonable expectations and uncertain capabilities of the FSM to directly manage all aspects of an emergency abnormal event
Did not immediately activate emergency strobe lights until notified by personnel UG (~ 4 - 5 minute delay)
Did not sound emergency evacuation alarm for the full 5 seconds as required by procedure
The alarm and instruction cannot be heard and/or understood throughout the UG. The CMRO operator forgets to activate the emergency evacuation strobe lights
As they begin to open the airlock their CO monitor alarms and they see smoke begin to "boil in" under the outer airlock
I
Feb 5, 2014 1050 A UG Services person in the office calls the CMRO and tells the CMRO that there is a fire at N-150/E-0, that they are getting smoke in the office, and to let everyone in the UG know to get to the waste hoist
Feb 5,2014 1050 Operator opens bulkhead at N-150 to get air
Feb 5, 2014 1050 The UG Services personnel arrive in the area of the fire (brought a CO monitor and their self-rescuers)
Feb 5, 2014 1050 The two UG Services personnel attempt to push a 300 pound wheeled fire extinguisher to the airlock at E-0/N-150
Feb 5, 2014 1051 The CMRO sounds the emergency evacuation alarm (Yelp) for approximately two seconds, states that there is a fire (no location), and that personnel should evacuate via the waste hoist
J


CC2,CC4,CC5 ,CC10
C11,C24, C36
Early understanding of the location of the fire may have enabled decisions on ventilation door closure that would have minimized smoke flow into evacuation routes
Unanalyzed change to filtration mode resulted in a change in air flow in the UG altering the conditions in the primary and secondary evacuation routes. The switch to filtration was unannounced and confused workers as to egress routes
MSHA requires evaluation and control of fires at a wooden shaft, this event simulates a fire at a wooden shaft and no evaluation has been performed or controls have been specified
FHA did not consider the impact of a vehicle fire in this location
Ability to change ventilation configuration remotely to control smoke is hampered by chained doors and a regulator in need of repair
This causes significant changes in air flow (and smoke) in the UG
He believes this will reduce both the fire and smoke
Feb 5, 2014 1058 The CMRO changes ventilation to filtration mode
Numerous mine phones were inoperable (run to battery failure): 12/40 tested were non-functional
Thirty three emergency lights in the waste handling building have been inoperable for as many as two years
Unclear if compensatory measures for impaired safety related equipment have been identified or are in-place. (CONOPS)
Personnel help each other don and check self-rescuers and SCSR and make their way in the heavy smoke to the waste hoist
Not all personnel don their self-rescuers at the first indication of fire (it appears that it never donned them at all) and some had difficulty opening and/or donning self-rescuers or self-contained self-rescuers (SCSR)
There are near-collisions between personnel, carts, and other equipment
Must improvise routes to the waste hoist, at times cutting holes in ventilation curtains
Some personnel encounter difficulties (heavy smoke, strobes not on or not working, smoke in areas expected to have "good" air, obscured evacuation reflectors)
Feb 5, 2014 1051 – 1134 Personnel throughout the UG are attempting to evacuate the mine in response to the alarm and announcement; what they heard over the mine phones, and/or; interactions with other personnel
Expectations for clearing red tags on critical safety equipment, e.g., fans, fire suppression system, CAMs. No method to readily understand status of impaired safety related equipment (CONOPS)
Baseline Needs Assessment (BNA) has long-standing open issues, e.g., evaluation of the needs for UG firefighting activities
No direct relationship between the Fire Hazard Analysis (FHA) and this event
The EOC does not play a leadership role, the CMR maintains command of the event
No implementation of the ICS system between the scene of the accident, the EOC, and DOF HQ
No integrated emergency management program (notification, classification, and categorization
Inconsistency between site EM program and DOE O 151.1C with regard to activation of the EOC
The EOC does not classify or categorize the event as an operational emergency, and does notify the DOF HQ watch office
Feb 5, 2014 1103 The FSM activates the Emergency Operations Center and notifies the CBFO Facility Representative
C12,C22, C23,C25, C32
CC1,CC2,CC5 ,CC10
Conditions in the UG exceeded combustible loading limits during the event
Incident command structure is not fully developed or implemented
Some FSMs do not have the ICS series training. Some FSMs do not have the ICS series training
C28,C29, C34
CC5
Feb 5, 2014 1101 The first mantrip to the surface is underway
K
B29,B30
Encountered thick smoke. They encounter others enroute and inform them of the need to evacuate and to don their self-rescuers
Feb 5, 2014 1052 The Supervisor, operator, and two UG Services personnel decide that the fire is beyond incipient and decide to evacuate via W-170, S-1950, W-30, E-140
J


K
Feb 5, 2014 1108
EOC briefing on the fire location and status
Feb 5, 2014 1111
MSHA and the State Mine Inspector are notified of the event
Feb 5, 2014 1115
The CMRO suspends surface waste handling activities
Feb 5, 2014 1120
The CMRO activates the Mine Rescue Team
Feb 5, 2014 1125
The second mantrip is at the waste hoist
L
C5
B28,B31
There are currently over 500 personnel granted unescorted access to the UG. Many of these individuals have little familiarity with the UG or evacuation expectations
L
Feb 5, 2014 1126
The Joint Information Center (JIC) is activated. All external notifications are completed (1118)
Feb 5, 2014 1130
Mine rescue team requested from Intrepid and Mosaic (local potash mining companies) to put their MRT's on standby for support
Feb 5, 2014 1134
The third and final mantrip is at the waste hoist
Feb 5, 2014 1134
Full accountability of the UG is achieved
Feb 5, 2014 1151-1251
Six personnel are examined by site medical personnel and are transferred via ambulance to the Carlsbad Medical Center for observation (possible smoke inhalation)
M


M
Feb 5, 2014 1147 CMRO secures UG ventilation
Feb 5, 2014 1125 Two additional personnel are examined by the site nurse but no transport is needed
Feb 5, 2014 1311C MRO halts release of shipments.
Feb 5, 2014 1312 CMRO shifts ventilation to contact handled HVAC to once through ventilation (versus recirculation) due to smoke upcasting in the waste hoist shaft and into the CH bay
Feb 5, 2014 1336 MSHA arrives onsite
N
N
Feb 5, 2014 1348 MSHA issues a K-Order on WIPP to ensure scene preservation and not to destroy any evidence
Feb 5, 2014 1420 All personnel are released from the CMC
Feb 5, 2014 1420 The CMRO continues monitoring air quality at the mine shafts
Feb 5, 2014 1444 Press release sent out
Feb 5, 2014 1614 CMRO shifts from waste handling mode for Technical Safety Requirements (TSR) compliance
O
O
Feb 5, 2014 1722 The first MRT (MRT1) enters the UG via the air intake shaft (AIS)
Feb 5, 2014 1746 MRT1 reports gas checks at the station level (0% methane, 0% carbon dioxide, oxygen 21%)
Discharge portable fire extinguishers on the embers
Feb 5, 2014 1825-1900 MRT1 arrives at truck, no fire detected, embers on front tires, and perform ground checks
Feb 5, 2014 1958 MRT1 arrives back at surface.
Feb 5, 2014 2205 MRT2 enters the UG via the AIS
P


P
February 5 - 6, 2014
2208-0059
MRT2 performs air quality checks, checks and/or closes ventilation louvers and doors
Feb 5, 2014 2025
Mosaic
MRT is released from standby
Feb 5, 2014 2300
MRT2 drives UG rescue truck to the scene, discharges all foam fire suppresant, and notes that the fire appears out
Discharge portable fire extinguishers on the embers.
Feb 6, 2014 0059
MRT2 arrives back at surface
Feb 6, 2014 0105
Event is terminated, EOC and JIC are deactivated
Q
Q
Feb 6, 2014 0800
All hands meeting held
Feb 7, 2014 1000
Critique meeting is held
Feb 7, 2014 1757
Occurrence Reporting and Processing System (ORPS) notification report filed
Feb 7, 2014
Accident Investigation Board appointed

Appendix F. **Report from Fire Investigators**

Fire Investigation Report
Waste Isolation Pilot Project
Investigator: Robert Brader

This report is written as a supplemental report for the investigation team that is reviewing a fire that occurred on February 5, 2014 underground at the Waste Isolation Pilot Project (WIPP). On February 19, 2014 I, along with William Farmer of the New Mexico State Fire Marshal's Office, met with representatives from the Department of Energy (DOE), the URS Corporation, and the Defense Nuclear Safety Board (DNFSB) at the DOE Carlsbad Field Office aka the Skeen Whitlock Building. The purpose of the meeting was to review photos, drawings, and information provided from team members to assist in identifying the origin and cause of the fire. Due to other complications the fire scene could not be directly accessed.

Vehicle Description:

This fire occurred in a mining vehicle identified as an Eimco 895D T15 Haul Truck. Photos of the truck show it to be an industrial mining truck with a dump bed to the rear, an open cab operator section in the center and the engine compartment to the front. The vehicle has four tires. The rear two are located under the center of the dump bed and the front two are located behind the operators section placing them behind the operator section and the engine compartment. The vehicle has a diesel motor, hydraulic over mechanical brakes, hydraulic dump systems, various electrical systems, and an onboard manually activated dry chemical fire fighting system. Ignitable liquids include Diesel fuel, Hydraulic Fluid, Engine Oil, and lubricating Grease. Major fuel packages include ignitable liquids, tires, and the seat cushion. Readily identifiable potential ignition sources include hot surfaces especially engine exhaust components, electrical wiring, and friction heat from mechanical component failure.

Location of the Fire:

This fire occurred underground at a "T" intersection of three tunnels. Photographs drawings and team description of the location were reviewed. This intersection is created where a major ventilation tunnel coming from the air intake shaft intersects what I will term as the "uphill" tunnel, leading to the salt handling shaft, where the haul truck was dumping salt and the "downhill" tunnel leading to the mining area, near the exhaust shaft ,where the truck was bringing salt from.

Airflow:

It is my impression that airflow played a significant role in fire propagation. Based on information provided by the team it appears that in unobstructed flow air moves through the ventilation tunnel from the intake shaft and then diverges in opposite directions following both the "uphill" and "downhill" tunnels. Airflow at this point during normal ventilation was described as over 400,000 CFM in the "downhill" tunnel and over 100,000 CFM in the "uphill". They also stated that during the fire the airflow flow was reduced to the 60,000 CFM range.

History of the Fire:

The vehicle was reported to have been in use for approximately 29 years at this location. On the day of the fire the vehicle is reported to have been in continuous use for approximately 4 hours. The operator described the incident as follows. He was dumping a load of salt in the "uphill" tunnel when he noticed a glow reflecting off the bottom of the raised dump bed. He then lowered the bed and drove forward to the intersection of the tunnels and exited the vehicle to identify the glow he had seen. He parked the vehicle in the intersection with the front toward the "downhill" tunnel, the rear toward the "uphill tunnel, the right hand side toward the ventilation tunnel, and the left hand side toward the salt rib. He

located a hole in the frame of the vehicle near the mid-point of the right hand side of the vehicle. He discharged a hand held dry-chemical extinguisher into this hole. When this did not extinguish what he had determined to be a fire he activated the onboard dry chemical extinguisher which did not extinguish the fire. He then abandoned the vehicle and evacuated. The vehicle was allowed to burn unimpeded for several hours before rescue crews re-entered the mine and extinguished the then smoldering fire.

Movement and Intensity Indicators:

From a broad overview photographs show a large truncated cone pattern on the salt rib starting near the engine compartment and extending up and out toward the “downhill” shaft. This pattern is leaned over from the vertical toward the “downhill” horizontal. This is consistent with an air driven fire coming from the front portion of the vehicle and being pushed in the “downhill” direction and back against the opposing rib. This pattern would have been created during the time of high airflow and as such occurred early in the fire prior to the change in ventilation. Also seen from broad overview photos is that the damage clearly is more severe in the front of the vehicle and progresses to relatively undamaged at the rear of the vehicle. The rear tires are intact; the front tires are burned away. This is consistent with a fire moving from the front of the vehicle to the rear of the vehicle. Close up photos show movement and intensity patterns and degree of damage leading from the rear of the truck back toward the engine compartment. This is consistent with the operator discovering the fire below and forward of the operators area. A hydraulic accumulator that was located in the operator’s area on the floor was found by the team to have BELVED. Since this was not described by the operator and would have clearly impacted him had it occurred during operation this is consistent with having occurred later in the fire. This would have added well heated ignitable liquids to the operator’s area aiding in fire propagation to that area. Photos of the hole where the operator discharged the hand extinguisher show burn marks around the hole that appear to be air driven toward the rear of the vehicle. This is consistent with the theory of fire propagation offered later in this report and is not primarily indicative of the area of origin. Photos of the exterior and interior of the engine compartment continue to support the fire originating in the engine compartment. Here degree of damage and movement patterns support the fire having started on the left side of the engine compartment down low and wrapping up and over the engine and to the right side. A classic “V” pattern on the front of the truck leads to a point low down near the base of the engine compartment and appears to wrap around from the left side. Photos of the left side of the vehicle and left interior engine compartment were not available due to safety concerns about potential collapse of the heat impacted salt rib.

Theory of Materials First Ignited, Area of Origin, and Fire Propagation:

It is impossible to be dogmatic about the origin and cause of this fire given the limitations of evidence, my inability to directly examine the vehicle, and the inability of those team members who had accessed the vehicle to fully examine and photograph it. That being said it is possible to make reasonable inferences and develop a most likely scenario of fire propagation.

The evidence clearly supports this fire starting low down on the driver’s side of the vehicle. The major fuel package in this area would be the ignitable liquids.

While any of the ignitable liquids could have been the material first ignited, including an accumulated mixture in the belly pan, I believe the most plausible would be discharge of hydraulic fluid under pressure on to exhaust components. It should be noted that the exhaust transits the area of origin to the catalytic converter located just on the outside of the engine compartment. Anecdotal evidence from a brief internet search of known failures of this type of equipment and brief interviews with local acquaintances who have operated or repaired similar mining equipment indicates that hydraulic failure is not uncommon and hydraulic fluid contacting a hot surface may be a leading cause of these types of

fires in local mines. I was told that any such fire lasting less than 30 minutes would not be reported to MSHA and thus account for limited published data on this type of fire.

I believe that this fire ignited during the normal operation of the truck. The fire ignited and then continued burning low down in the belly pan and was eventually being fed by one or several ignitable liquids as other lines in the area failed. The glow seen by the operator was the fire being reflected down the belly pan and up on to the bottom of the dump bed. The location where this happened would have been up the “uphill” shaft with the vehicle pointed back towards the intersection. This would have had the ventilation air blowing directly in to the front of the truck. This airflow would have been enhanced by both the engine cooling fan forcing air from the front of the vehicle toward the rear and the forward motion of the vehicle. This would account for the fire being briefly pushed toward the rear and out the hole in the right side. This would produce the patterns previously discussed and further support the finding that this fire started in the forward part of the engine compartment.

When the operator lowered the bed and moved forward he did not experience any recognizable equipment failure. This helps preclude an electrical short, mechanical heating of a failed component such as wheel bearings, and catastrophic engine or transmission failure. It would be expected that the hydraulic system would continue to work even in the face of a leak for some period of time until the fluid reservoir ran low.

Once the driver moved the vehicle the airflow would dramatically change. As the truck entered the intersection the flow would change from what can be described as a head wind to a right front angled side wind, to a broad side wind to a right rear angled side wind and eventually to a tail wind. In the location where the truck was stopped it appears it would have had a right rear angled side wind. This is consistent with the movement and intensity patterns seen. In this location the airflow would have pushed the fire into the left front of the engine compartment and held it away from spreading to the rest of the truck. Furthermore once the vehicle was shut off the cooling fan would no longer be pushing airflow to the rear of the vehicle. The onboard fire suppression system appears to be designed and intended to discharge into the engine compartment, Photos of the engine compartment do not show significant amounts of extinguisher powder leading to the apparent conclusion that the system did not perform as designed. Witness information from outside the mine indicates that the smoke column exiting the exhaust shaft changed to a heavy black smoke that smelled like burning rubber after the air flow was reduced. This is consistent with the fire no longer being air driven to the front of the vehicle and propagating toward the rear of the vehicle and thus igniting the front tires. The heat from the tires burning impacting the diesel and hydraulic tanks near the operator’s area accounts for any remaining fluids that had not leaked into the engine compartment being vaporized.

Conclusion:

In conclusion this was most likely an accidental fire resulting from an unidentified failure that allowed ignition of ignitable fluids in the front right engine compartment that the progressed rearward to the operator’s area and the front tires.