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MAY 2 9 2015

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Ms. Kathryn Roberts, Director
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New Mexico Environment Department
Harold Runnels Building
1190 Saint Francis Drive, Room 4050
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Subject: Submittal of the *Waste Isolation Pilot Plant Nitrate Salt Bearing Waste Container Isolation Plan, Revision 2*

Dear Mr. Kieling and Ms. Roberts:

The purpose of this letter is to provide the information requested in your March 30, 2015 letter regarding the *Waste Isolation Pilot Plant Nitrate Salt Bearing Waste Container Isolation Plan, Revision 1*. The update to Revision 1 is enclosed as *Waste Isolation Pilot Plant Nitrate Salt Bearing Waste Container Isolation Plan, Revision 2*.

We certify under penalty of law that this document and all attachments were prepared under our direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on our inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of our knowledge and belief, true, accurate, and complete. We are aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

If you have any questions regarding this transmittal, please call Mr. George T. Basabilvazo at (575) 234-7488

Sincerely,

Original Signatures on File

Jose R. Franco, Manager
Carlsbad Field Office

Robert L. McQuinn, Project Manager
Nuclear Waste Partnership LLC

Enclosure

cc: w/enclosure

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Enclosure

Waste Isolation Pilot Plant Nitrate Salt Bearing Waste Container Isolation Plan, Revision 2

- Isolation Plan – 37 pages
- Attachment A – 11 pages
- Attachment B – 12 pages
- Attachment C – 11 pages
- Attachment D – 14 pages

85 Total Pages

Waste Isolation Pilot Plant
Nitrate Salt Bearing Waste Container Isolation Plan

Revision 2

1.0 INTRODUCTION

The *WIPP Nitrate Salt Bearing Waste Container Isolation Plan* (Isolation Plan) is required by the New Mexico Environment Department (NMED) Administrative Order 05-20001 (Order) issued on May 20, 2014, to the U.S. Department of Energy (DOE) and Nuclear Waste Partnership LLC (NWP), collectively referred to as the Permittees (NMED 2014a). The Order, at paragraph 22, requires the Permittees to submit an isolation plan for identified nitrate salt bearing waste disposed in the Waste Isolation Pilot Plant (WIPP) underground disposal facility. The Order also requests an implementation schedule for this Isolation Plan. The Order requires that the Isolation Plan include "a detailed proposal for the expedited closure of underground Hazardous Waste Disposal Unit (HWDU) Panel 6, so that a potential release from any nitrate salt bearing waste containers in Panel 6 does not pose a threat to human health or the environment." It also requires "a detailed proposal for the expedited closure of underground HWDU Panel 7, Room 7, so that a potential release from any nitrate salt bearing waste containers in Panel 7, Room 7, does not pose a threat to human health or the environment." Additionally, the Order requires information regarding the "volumetric flow rate for ventilation in the WIPP underground, a description of how the volumetric flow rate is protective of human health and the environment, and a description of how volumetric flow rate will be achieved while the WIPP Nitrate Salt Bearing Waste Container Isolation Plan is implemented."

On August 5, 2014, the NMED approved the Permittees' proposal for the initial closure of Panel 6 and the Permittees' proposal to continue to use the mine ventilation system in filtration mode to protect public health and the environment (NMED 2014b). However, the NMED provided comments and questions requiring clarification and resubmittal of the Isolation Plan. The major changes in revision 1 of the Isolation Plan include an updated description of the WIPP Facility Recovery Plan (Recovery Plan); additional detail regarding the schedule for final closure of Panel 6 and closure of Panel 7, Room 7; analysis that supports the assumptions regarding possible hazards posed by nitrate salt bearing waste in Panel 6 and Panel 7, Room 7; and additional detail regarding ventilation needs for accomplishing the work proposed in the Isolation Plan.

On March 30, 2015, the NMED provided a second letter to the Permittees which: 1) approved the proposed closure for Panel 7, Room 7; 2) specified that the permanent closure for Panel 6 is to be approved through the 40 CFR 270.42 permit modification process; and 3) requested an update to Revision 1 of the Plan (NMED 2015). Revision 2 of the plan addresses the NMED March 30, 2015 letter.

2.0 BACKGROUND

This background discussion consists of two parts. First is a description of the event and the known and expected condition of the underground facility. The second part provides a description of the Permittees proposed Recovery Plan, which includes details about the process of reestablishing the safety and habitability of the underground and returning to normal waste disposal operations. Some portions of the Recovery Plan will be important to the completion of the Isolation Plan; therefore, they are integrated into Section 3 of this Isolation Plan. The approved Recovery Plan (DOE 2014) was issued on September 30, 2014. The Recovery Plan is available from the Permittees at the following address: http://www.wipp.energy.gov/Special/WIPP%20Recovery%20Plan.pdf.

2.1 DESCRIPTION OF THE RADIOLOGICAL EVENT OF FEBRUARY 14, 2014

At 11:14 p.m. on February 14, 2014, a continuous air monitor (CAM) detected airborne radiation in the WIPP underground facility. When the CAM alarmed, underground ventilation exhaust air automatically shifted to flow through high-efficiency particulate air (HEPA) filters to remove radioactive particles. Since that time, underground exhaust air has continued to be routed through HEPA filtration. On April 11, 2014, in anticipation of investigation of the source of a radiological release from the facility, the Permittees implemented the Resource Conservation and Recovery Act (RCRA) Contingency Plan. On May 1, 2014, NWP declared a potentially inadequate safety analysis based on the possibility that a container of inadequately remediated nitrate salt bearing waste had caused the release of radioactivity in the WIPP underground. Entries into the underground to Panel 7 have confirmed one container from a nitrate salt bearing waste stream from Los Alamos National Laboratory (LANL) is breached and is the source of the radioactive particulates. Detailed investigation by the DOE Accident Investigation Board (AIB) has determined that no other containers contributed to the release (AIB 2015). Investigations by the Technical Assessment Team (TAT) have determined that the presence of incompatible materials, including nitrate salts, in an improper configuration in container LA00000068660 led to a thermal runaway. This container of waste is from waste stream LA-MIN02.001 (SRNL 2015). Shipments of waste to the WIPP facility have been suspended.

Ongoing investigations by the LANL have indicated that other waste streams may also contain nitrate salts that are incompatible and are potentially susceptible to the same chemical reactions that occurred in container LA00000068660. Disposal records indicate that containers from these waste streams are in Panels 5, 6, and 7. (See Attachment A for detailed information regarding the location of nitrate salt bearing waste covered by the order). Panels 5 and 6 are full. Explosion-isolation walls have been constructed in Panel 5. Panel 6 was in the process of being closed with a substantial barrier and bulkhead at the time of the February 14, 2014 event. This initial closure for Panel 6 has been completed. Expedited closure of Panel 6 is a subject of the Order.

The radiological release contaminated portions of the underground facility. The Permittees determined the extent of such radiological contamination and have initiated activities to remove or stabilize (referred to as fixing) the contamination so it does not become airborne when normal operations resume. Because of the radiological contamination, activities in the underground must be carefully planned and performed to ensure workers are not exposed to harmful levels of radioactivity. The planning process defines the type of protection workers must wear and the amount of time they can work while wearing protective clothing. The planning process is comprehensive; it evaluates both actual and potential conditions and job hazards in order to establish safety boundaries for work activities underground. Throughout this Isolation Plan, there is reference to numerous documentation steps associated with planning such as preparing work packages, characterizing radiation areas, and preparing and approving safety basis documents. These are important steps in ensuring the required closures in Panels 6 and 7 occur within the boundaries of safe radiological operations.

In addition to addressing radiological contamination, recovery includes mine-related activities that must be performed, including the installation of panel closures and resuming mine maintenance activities such as ground control bolting. In order to perform these activities, the Permittees must be able to provide sufficient ventilation air to the underground working areas. Sufficient ventilation air is defined by the regulations promulgated for mines such as the WIPP facility by the U.S. Department of Labor, Mine Safety and Health Administration (MSHA).

A discussion about ventilation in the WIPP underground is provided in Section 3.6 of this Isolation Plan. As described above, the mine is being ventilated in filtration mode. This means that under the current configuration, approximately 60,000 cubic feet per minute (cfm) of ventilation air is available throughout the entire underground. This air is circulated through HEPA filters before it is discharged into the ambient atmosphere. This total flow is distributed throughout the underground using bulkheads, louvers, and other flow control devices to direct ventilation air to where it is needed.

The limited amount of ventilation air dictates the types and number of activities that can be performed at any given time in the underground. Until the Permittees install additional filtration devices, the amount of air will remain limited to its current capacity. Although this limitation will not prevent the Permittees from complying with the Order, it does dictate the speed at which an expedited closure can be accomplished, particularly simultaneously in Panels 6 and 7. The Permittees have determined that certain protective measures, as described in this Isolation Plan, are possible in Panels 6 and 7 under the conditions of limited ventilation air, which will enable work crews to perform an expedited closure of Panel 6 and Panel 7, Room 7. These measures will be installed, inspected, and repaired, if accessible, until installation of the permanent closure is possible after establishing additional ventilation capacity.

As the result of the February 14, 2014, event, the DOE established an AIB under the authority of Department of Energy Order 225.1B, *Accident Investigation*. The charter of the AIB was to determine the cause of the accident and to identify any needed changes to prevent similar events from occurring in the future. In performing their work and in order to preserve potential evidence, the AIB took control of areas of the facility that may provide information needed to do their work. The AIB released the final portion of the underground, Panel 7, back to the Permittees on February 5, 2015.This means that the Permittees are free to complete assessments and recovery activities in all underground areas. Recovery activities are preceded with the preparation of the necessary safety documentation. The AIB reported its findings in two phases. Phase 1 focused on the release of radioactive material from the underground to the environment and the follow-on response to that release. The Phase 1 AIB Report was released April 24, 2014 (AIB 2014). The Phase 2 report focused on determining the direct cause of the release of the material. The Phase 2 report was released April 15, 2015 (AIB 2015).

2.2 DESCRIPTION OF THE RECOVERY PLAN

The WIPP Recovery Plan defines the DOE approach to developing and implementing activities to resume transuranic (TRU) waste disposal operations by the first Quarter of calendar year

2016 in a safe, compliant and environmentally sound manner. The conditions to safely resume operations include ensuring safety concerns are addressed in response to the February 2014 events to create an environment of robust safety awareness that complies with applicable requirements and protects the worker, public, and environment. The mine will be systematically made habitable for safe operations and protective of workers with resumption of critical mine safety and maintenance operations. Safety management programs (SMPs) will be strengthened. Actions will be taken to prevent fires at the WIPP facility, effectively respond to a fire should one occur, and safely manage a fire emergency. Ventilation will be increased for underground activities using interim and supplemental measures. This will provide the ability to commence waste emplacement operations starting with the waste derived from re-entry and recovery activities, followed by onsite stored TRU waste, and low rate emplacement of waste from generator sites. Finally, a new underground ventilation system will be constructed that will allow for a return to simultaneous mining and waste emplacement and will provide for a return to a more normal waste emplacement rate. The Recovery Plan priorities emphasizes safety, health, and environmental protection ahead of mission resumption. Key elements include the following:

- Safety
- Regulatory compliance
- Decontamination
- Ventilation
- Mine stability and underground habitability
- Workforce retraining
- Managing waste streams

In order to facilitate recovery, the Permittees have segmented the WIPP facility underground into discrete zones for the purposes of scheduling and tracking progress as areas in the underground are made available to support the restart of operations (see Figure 1). Once a zone has been characterized and underground safety established, entry teams can address equipment maintenance and habitability issues, including replacing damaged equipment, fire loading reduction, equipment and structure cleaning required as a result of the fire, and electrical system safe restart.

The Recovery Plan does not include detailed lists of activities or detailed schedules. These are incorporated into the Performance Measurement Baseline (PMB). However, the Recovery Plan includes the general path and major project activities needed to achieve the goal of resuming waste emplacement operations by the first Quarter of Calendar Year 2016.

As part of the Permittees' PMB, Table 1 has been developed as a typical list of activities required for clearing each zone. In the table, Steps 1 through 7 apply to most zones and Steps 8 through 10 apply to contaminated areas. The Panel 6 closure areas and Panel 7 were contaminated by the radiological release event. The placement of Panel 6 initial closures and Panel 7, Room 7 closures were initiated after habitability was established and mine safety activities such as roof bolting were completed.

3.0 INFORMATION REQUIRED BY THE ORDER

The following sections describe the Isolation Plan required under the Order. In formulating the schedule, some activities may be done concurrently, and some activities performed to close Panel 6 will support closure of Panel 7, Room 7. The relationship between these activities will become more obvious once prerequisite activities are completed and the schedule matures. Some of the proposed activities are already underway, such as:

- Radiological surveys
- Safety basis documentation
- Ventilation upgrades
- Work on waste hoist startup

In the following sections, the tie between the Isolation Plan and the Recovery Plan is noted. It should be noted that schedule conflicts between activities in the Isolation Plan and the Permittees' PMB are unintentional and in such cases, the Permittees' PMB will take precedence. Progress in implementing this process will be the subject of the biweekly status calls with the NMED. When the changes to the Permittees' schedules affect the Isolation Plan, the Permittees will point out such changes on the biweekly calls with the NMED. Updates to the Isolation Plan can be prepared as appropriate.

At the time of the most recent update to the Isolation Plan (Revision 2), many of the proposed Isolation Plan activities have been completed. Completed activities are noted.

3.1 Prerequisites and Key Assumptions

The Order covers underground HDWUs Panel 6 and Panel 7. Access to these units for work is dependent on completion of the following assessment activities.

- Evaluation of the cause of the release, currently narrowed to a single container in Panel 7, Room 7. (Section 2 of the Recovery Plan addresses AIB activities. The Recovery Plan commits to prepare corrective action plans to address AIB findings). (This evaluation is completed.)

- Evaluation of the extent of radiological contamination on entries leading up to Panel 6. (The Permittees' Performance Measurement Baseline addresses the details for performing this work. For example, it includes completion of Activities 3 – 7 in Table 1 for Zones 1a, 1b, 2, 3, and 4). (This evaluation is completed.)

- Evaluation of the extent of radiological contamination on equipment needed to maintain the mine entries for the units. (The Permittees' Performance Measurement Baseline addresses the details for performing this work. For example, it will include completion of Activity 3 in Table 1 in all zones containing such equipment). (This evaluation is completed.)

- Evaluation of the extent of soot on electrical equipment needed to perform work in the underground. (The Permittees' Performance Measurement Baseline addresses the details for performing this work. For example, it includes completion of Activity 7.4 in Table 1 in all zones containing such electrical equipment). (This evaluation is completed.)

- Evaluation of the extent of radiological contamination within the units. (The Permittees' Performance Measurement Baseline addresses the details for performing this work. For example, it will include completion of the following activities in Table 1: Zone 6, Activity 3 for Panel 6 and Zone 7, Activity 3 for Panel 7). (This evaluation is completed.)

- Evaluation of the ground conditions in and around the units. (The Permittees' Performance Measurement Baseline addresses the details for performing this work. For example, it includes completion of Activity 7.4 in Table 1 in all relevant zones). (This evaluation is completed.)

In addition to the ongoing assessment activities, certain additional actions are required prior to initiating work in the units. These actions include the following:

- Implementation of corrective actions identified from the investigation of the haul truck fire in the WIPP facility underground on February 5, 2014, and identification of compensatory measures necessary for those corrective actions that cannot be implemented prior to initiating closure of Panel 6. (Section 3.2.5 of the Recovery Plan states the following in response to the AIB findings: "Extra fire protection compensatory measures have been implemented (e.g., requiring fire watches) to support recovery activities in the underground while improvements to the fire protection program are being developed."). (This has been completed for Panel 6 initial closure and Panel 7, Room 7 closure.)

- Radiological posting of work areas needed to implement the Order. (The Permittees' Performance Measurement Baseline addresses the details for performing this work. As an example, it will include completion of the Activity 4 in Table 1 for all affected zones). (This activity is complete for Panel 6 initial closure and Panel 7, Room 7 closure.)

- Reconfiguration of the ventilation to support the actions required by the Order. (This activity is complete for Panel 6 initial closure and Panel 7, Room 7 closure.)

- Replacement of applicable underground filtration system filters. (This activity is complete for Panel 6 initial closure and Panel 7, Room 7 closure; however, future replacements will likely be needed as activity in the underground increases).

- Finalization and implementation of the WIPP recovery schedule. (This activity is complete, however, the schedule is subject to change as conditions change.)

- Activation of the Waste Hoist (affects Panel 7, Room 7 closure only). (The population within the mine at one time is limited due to mine safety egress requirements. Without the Waste Hoist in operation, the number that can be in the underground is limited. This constrains the amount of work that can be done simultaneously. Once the Waste Hoist is available, this number will increase significantly. Larger crews mean more work can be conducted simultaneously. In addition, the Waste Hoist is needed to lower certain materials to the underground such as the bulkheads that will be used to close Panel 7, Room 7). (This activity is complete.)

The results of the assessment activities will dictate the schedule and duration of several of the prerequisite actions. As the result, this Isolation Plan is submitted with the following assumptions:

- Assumption 1: The extent of radiological contamination is restricted to Panel 7 and the downstream areas. (This is consistent with the zone designation used for recovery as shown in Figure 1).

- Assumption 2: Safety basis documentation to protect workers is prepared and approved.

- Assumption 3: Ongoing work to radiologically clear underground areas progresses so that work areas outside Panel 7 can be established as radiological buffer areas (RBAs). An RBA is an area to which access is managed in order to protect individuals from exposure to radiation and/or radioactive materials. Radiological personal protective equipment (PPE) is not required in an RBA, optimizing worker efficiency. (This is consistent with Activity 4 in Table 1 for all zones).

- Assumption 4: Habitability of the underground is as anticipated, requiring minimal replacement of facilities and safety required equipment.

- Assumption 5: If additional filter replacement is needed after work commences, only the mod filters will require replacement.

- Assumption 6: Ground control maintenance activities underground are not extensive and can be provided on an as-needed basis during work activities.

- Assumption 7: With the exception of mining, work prerequisite to installing the permanent closure in Panel 6 can be performed with the approximately 60,000 cfm total available airflow.

- Assumption 8: Worker training to the new underground ventilation and radiological configuration and emergency drills will be completed prior to starting closure work.

- Assumption 9: Closure activities can be accomplished by reconfiguring existing ventilation bulkheads and no new ventilation structures are needed other than those that are integral to the closure itself.

- Assumption 10: No equipment filtration is needed to support closure work activities (i.e., scrubbers on diesel-fueled mining equipment such as roof bolters).

- Assumption 11: Corrective actions from the fire accident report can be completed to the extent they affect the equipment and areas needed for the closures or appropriate compensatory measures such as manual fire suppression systems and fire watches can be implemented.

- Assumption 12: Ventilation upgrades needed for permanent Panel 6 closure are accomplished as notifications of planned changes to the permitted facility and subject to NMED inspection when completed. However, a Permit modification may be needed to initiate limited waste handling operations.

The following sections address the actions that the Permittees intend to take to meet the conditions of the Order. In some cases, the activities have already been completed as indicated. In other cases, activities cannot be started until the prerequisites are completed. To the extent possible, activities will be scheduled to run concurrently. For this reason, the schedule provides duration and sequencing of activities, but no hard dates. Actual dates can be included as prerequisites are completed. Activities and durations are subject to change as field conditions change during performance of work. Actual dates will be the subject of the biweekly calls with the NMED.

3.2 Paragraph 22, Section a) i

The Order requires the Permittees to provide a detailed proposal for the expedited closure of Panel 6, so that a potential release from any nitrate salt bearing waste containers in Panel 6 does not pose a threat to human health or the environment. The Permittees have determined that this involves the following three activities:

- Continued HEPA filtration of the underground exhaust air.
- Expedited closure of Panel 6 with initial closure.
- Expedited closure of Panel 6 with the permanent closure.

The following sections include a description of the proposed activity followed by a discussion of how the activity meets the requirements of the Order to protect human health and the environment.

3.2.1 Proposed Activity: Continue HEPA Filtration of Underground Exhaust Air

Description: The design of the WIPP facility incorporates HEPA filtration as the primary method of protecting human health and the environment in the event of a radiological release in the underground. Ventilation air passes through and by waste disposal areas and is circulated through filtration units, thus ensuring that air follows the ventilation pathway and does not pass through other portions of the mine or to the surface unfiltered. The filtration system has been operating since February 14, 2014. This mitigates the public exposure hazards associated with a potential release of radioactive contaminants from waste containers in Panel 6 and provides continued protection of human health and the environment.

The filtration system consists of two banks of filters that include mod filters, high-efficiency filters, and two sets of HEPA filters. Primarily due to build-up on the mod filters, the Permittees performed a filter change-out in June, 2014, based upon the condition of each type of filter. The system is monitored continuously. Additional filter change-outs have been performed periodically as particulates build-up on the filter surfaces. Additional filter change-outs are anticipated in the future. Filter change-out is performed in a manner that minimizes the risk of an airborne release from the facility.

Two independent filter banks are in use. An upgrade to provide two more filter banks is underway. This will facilitate future change out by ensuring at least three banks continue to be in-service to filter any possible releases and ensure adequate ventilation to continue planned activities in the underground. In the underground, the current operating practice is to provide workers with PPE sufficient to mitigate potential radiological exposures. This PPE includes breathing protection, anti-contamination clothing, and administrative controls for the duration of underground activities.

The Recovery Plan commits to managing emissions from the waste disposal areas through filtration and providing a safety basis that ensures the protection of the workers entering the underground. With the limited air flow, the Permittees will control operations and plan to work on multiple shifts to support the large backlog of safety related activities.

Discussion: The Permit, Attachment A2, Section A2-2a(3) describes the filtration mode as follows:

> *In the filtration mode, the exhaust air will pass through two identical filter assemblies, with only one of the three Exhaust Filter Building filtration fans operating (all other fans are stopped). This system provides a means for removing the airborne particulates that may contain radioactive and hazardous waste contaminants in the reduced exhaust flow before they are discharged through the exhaust stack to the atmosphere. The filtration mode is activated manually or automatically if the radiation monitoring system detects abnormally high concentrations of airborne radioactive particulates (an alarm is received from the continuous air monitor in the exhaust drift of the active waste panel) or a waste handling incident with the potential for a waste container breach is observed. The filtration mode is not initiated by the release of gases such as VOCs.*

Normally, prior to the February 14, 2014, incident, filtration mode was seldom used and emissions were unfiltered because there was no detectable airborne radioactivity released from the facility. After the event, only filtered air from the waste disposal areas underground is released to the ambient atmosphere. The Recovery Plan commits to continue this practice for the foreseeable future. Filtration is designed to reduce the emission of respirable particulate by a factor of one million. Onsite and offsite monitoring for radioactive emissions in the weeks and months since the event have shown that this filtration system is effective in protecting surface workers and the public off site. Monitoring results are posted on the WIPP Recovery Web Page (http://www.wipp.energy.gov/wipprecovery/recovery.html) and are provided to the NMED. Monitoring data indicate that the ongoing filtration of underground ventilation air that passes through the disposal area has been proven to be effective in protecting human health and the environment as required by the Order. In their August 5, 2014, letter, the NMED approved the Permittees' proposed continuation of HEPA filtration of underground exhaust air to protect human health and the environment. The continuation of HEPA filtration is proposed in this Isolation Plan.

3.2.2 Proposed Activity: Expedited Closure of Panel 6 with Initial Closure

Description: This first step involves the installation of a barrier sufficient to mitigate potential releases from the nitrate salt waste in Panel 6 should an event recur, thereby being protective of workers, the public, and the environment. This barrier will be the substantial barrier and bulkhead as described in Permit Attachment N1. Construction of the substantial barrier and bulkhead structures in Panel 6 was suspended when a vehicle fire in another part of the mine required the immediate evacuation of the underground on February 5, 2014. Work on these structures had not resumed prior to the radiological release event. The substantial barrier (defined in Permit Part 1, Section 1.5.13) has been installed in Panel 6, S-2750 drift (ventilation air intake side). The salt and the chain-link and brattice cloth curtain are in place. On the S-3080 drift (ventilation air exhaust side), the chain-link and brattice cloth curtain have been dropped from the back (ceiling) and the salt (or other non-flammable material pursuant to Permit Attachment N1, Figure N1-1) has been placed against the waste. Bulkheads have been installed in each drift. The initial closure is complete with the construction of the substantial barrier and installation of the bulkheads.

Based upon a review of the information available to date regarding the release in Panel 7, Room 7, the Permittees are proposing that the substantial barrier and bulkhead will be sufficient based on the following observations regarding the release event in Panel 7:

- A chemical reaction in the involved container resulted in a thermal runaway that created sufficient pressure to breach the lid to the container and cause a release. The event did not involve an explosion, based on the observations of the AIB and the conclusions of the TAT.

- Damage to surrounding containers, backfill bags, shrink-wrap, and slip-sheets was initiated by the heat from the reaction in the drum.

- The bulkhead adjacent to the waste stack in Panel 7, Room 7 does not appear to display signs of damage from a pressure pulse.

- The risk to workers is from heat, smoke, airborne radionuclides, and pressure related to a container breach as the result of a similar heat event.

- The radiological event investigation performed by the DOE AIB is complete. The results from the investigation do not require changes to the proposed closures and schedules described in this Isolation Plan.

The following discrete steps are proposed as part of this Isolation Plan to provide the initial closure (some activities will be performed in parallel):

- Assess the physical conditions and clear the route between the shafts and the entries to Panel 6. This includes ground inspection, equipment inspections and electrical component cleaning (which applies to the removal of soot and combustion products from the February 5, 2014, haul truck fire) if needed, fixing contamination or decontamination (which applies to the removal of contamination from the radiological release on February 14, 2014) if needed, and radiological contamination assessment. This activity is to provide work crews with access to work areas and equipment, ensure safety equipment is in place, ensure the stability of the underground, and ensure the protection of work crews from exposure to radioactive contamination. (This activity is complete.)

- Establish underground areas to RBAs, such that work can be performed without the need for radiological PPE. (This activity is complete.)

- Determine the roof stability and radiological conditions in the entry drifts to Panel 6. This will influence the selection of PPE and limitations on work activity duration. Roof bolting and geotechnical work will be performed as needed as a prerequisite for entry by work crews. (This activity is complete.)

- Complete necessary work orders. Develop, review, and approve applicable safety basis documentation and other work planning documents to authorize the work and define safe working conditions. (This activity is complete.)

- Implement compensatory measures and interim actions for fire protection, emergency management and other SMPs. (This activity is complete.)

- Conduct drills, training, and mock-ups. (This activity is complete for the initial Panel 6 closure, however, drills, training and mock-ups will continue to support other underground activities.)

- Perform necessary maintenance activities on equipment that will be needed for placing the closures. (This activity is complete.)

- Return mine phones to service and verify operability. (This activity is complete.)

- Assess ventilation needs and reconfigure air flow to ensure adequate ventilation in compliance with applicable work and safety standards. (This activity is complete.)

- Stage needed materials in the underground. (This activity is complete.)

- Install the substantial barrier in the S-3080 drift. (This activity is complete.) Prepare bulkhead locations (e.g., remove loose material, terminate air monitoring tubing inside the bulkhead location, and remove tubes in the bulkhead area). (This activity is complete. Monitoring lines have been capped and monitoring terminated, it was not necessary to remove the lines in the bulkhead area since the lines do not interfere with the bulkhead and removal posed health hazards to workers.)

- Install bulkheads in both the S-2750 drift and in the S-3080 drift. (This activity is complete.)

- Add new bulkheads to the monthly inspection schedule. (This activity is complete.)

- Install radiological monitoring equipment at the entries to S-2750 and S-3080, and ensure access is restricted. (This activity is complete.)

Discussion: Figure 2 shows the proposed initial closure for Panel 6.

In NMED, 2014b, the NMED approved the Permittees' initial closure for Panel 6, which is proposed in this Isolation Plan. The design and construction of the approved initial closure for Panel 6 has been effective in protecting human health and the environment from releases of hazardous waste in Panels 3 and 4 where these structures have served their intended purpose for more than 6 years. The isolation bulkhead portion of the initial closure also serves as the inbye bulkhead of the permanent closure. As the result, it is the subject of the thermal and pressure evaluations discussed in the next section.

3.2.3 Proposed Activity: Expedited Closure of Panel 6 with the Permanent Closure

Description: The next step to closing Panel 6 involves placing the required permanent closure. This step requires significantly more underground ventilation than placement of the initial closures and therefore will be deferred until the Permittees have established the needed supplemental ventilation to support mining activities. See Section 2.2 for a discussion of supplemental ventilation. The Permittees have made the permanent closure of Panel 6 a priority activity by focusing on improving ventilation in the underground for operational activities associated with Panel 6 permanent closure.

The following discrete steps are anticipated as part of this Isolation Plan to provide final, permanent closure of Panel 6 (some activities will be performed in parallel):

- Submit the permanent closure design for Panel 6 to the NMED for approval through the 40 CFR 270.42 permit modification process.
- Determine the roof stability and radiological conditions in Panel 6. This will influence the selection of PPE and limitations on work activity duration. Roof bolting and scaling will be performed as needed as a prerequisite for entry by work crews. (This activity is complete for the initial closures. Ground conditions in Panel 6 will be part of routine inspection of the underground and additional bolting will be performed as needed.)
- Complete necessary work orders, safety basis documentation, and other work planning documents to authorize the work and define safe working conditions.
- Perform necessary maintenance activities on equipment that will be needed for placing the closures. (This activity is complete.)
- Assess ventilation needs and reconfigure ventilation and establish supplemental ventilation for mining run-of-mine salt to ensure adequate ventilation in compliance with applicable work standards.
- Order components for the permanent closure and work to be performed in the underground.
- Stage required components and materials in the underground.
- Install the final closure as approved by the NMED.

Discussion: The design proposed to the NMED on March 18, 2013, has been evaluated to determine if it adequately addresses the potential hazards from the nitrate salt bearing waste as the permanent closure of Panel 6. The proposed permanent closure for Panel 6 is shown in Figure 3. Originally, the Permittees have evaluated the consequences of a single event similar to the one that occurred in Panel 7, Room 7 occurring in Panel 6, Room 1 to determine if the panel closure specifications proposed in the March 18, 2013, permit modification request (PMR) (DOE 2013a) are sufficient or if additional specifications are needed. The results of that evaluation are included in calculation notes attached to this Isolation Plan (Attachment C). At the request of the NMED, the Permittees performed a subsequent calculation that updated the original calculations based on the results of the TAT and that simulated an event involving three containers experiencing thermal runaway reactions simultaneously. This calculation note is also attached to this Isolation Plan (Attachment D). The calculations document that there will be no thermal impacts and the impacts of pressure will be insignificant on the outbye bulkhead portion of the closure. The performance of the inbye bulkhead portion of the permanent closure coupled with the substantial barrier has previously been evaluated in the WIPP facility DSA (DOE 2013b) to determine that it will be protective of workers. The DSA concluded that because the substantial barrier and isolation bulkhead collectively prevent waste from falling the full height of the waste stack, restrict ventilation, and prevent human entry into the waste areas, they will be protective of workers until such time the construction of the permanent closure is initiated.

The conclusions from the attached analyses are provided below. Italicized text indicates direct quotes from the analyses in Attachments B, C, and D. References to Figures and Tables and citations in the quotes can be found in the Attachments.

Conclusion Regarding the Thermal Performance of the Inbye Bulkhead Component of the Permanent Closure for Panel 6 (from Attachment B)

The impact of any temperature changes on the steel bulkheads in the typical design will be mitigated by the location of these bulkheads and its materials:

- *The steel bulkhead is about 22-feet away from the waste face for the typical design of the Initial Closure (see Figure 2). Since a row of waste in Figure 1 is approximately 3-feet wide, the 22-foot separation is equivalent to 7 rows of waste. As described in Section 3.2, thermal effects (melting polypropylene sacks) were observed up to 8 rows away from the breached drum on the downwind side. The steel bulkhead in the typical design is therefore on the boundary of the region with thermal effects, assuming a drum at the waste face has an exothermic reaction. The bulkhead would be well beyond the region with thermal effects if a drum inside the room, rather than on the waste face, has an exothermic reaction.*
- *The steel bulkhead is constructed of steel sheet, steel struts, and plastic flashing which are much more heat resistant than the thin polypropylene sacks containing MgO. The plastic flashing is 1-ply Nitril belting with a thickness of 3/64 inches (0.047 inches). It is a flame resistant material, stamped with Mine Safety and Health Administration (MSHA) approval number 28-53/10 (Zimmerly, 2014). Depending on the specific chemical composition, softening temperature can vary from 100°C for nitrile butadiene rubber (NBR) to about 150°C for highly saturated NBR (Minnesota Rubber and Plastics, 2014)*

Given the minimum bulkhead separation of 22-feet from an ignited drum and the robustness of the materials in the steel bulkhead, thermal effects on the steel bulkhead from an ignited drum should be insignificant for the typical design of the Initial Closure.

Conclusion Regarding the Pressure Performance of the Inbye Bulkhead Component of the Permanent Closure for Panel 6 (from Attachment C)

The predicted pressure changes resulting from an exothermic reaction of a single drum containing waste stream LA-MIN02-V.001 are 0.13 to 0.17 psi in Room 1 of Panel 6 and 0.07 psi to 0.09 psi in Room 7 of Panel 7. The range encompasses reactions for five nitrate salts: calcium nitrate, magnesium nitrate, potassium nitrate, iron nitrate, and sodium nitrate. The pressure changes in Room 1 of Panel 6 and Room 7 of Panel 7 differ because the free volume is greater in Room 7 than in Room 1 and because the average nitrate mass in a drum is greater in Room 7 than in Room 1.

Within each room, these results confirm that the predicted pressure change is insensitive to the composition of nitrate salts in a drum. The predicted pressure change is also insensitive to modest changes in temperature of the product gases. For example, if the temperature of the product gases increases by 50°C, from 300K to 350K, then the maximum pressure change in Room 1 of Panel 6 increases from 0.17 psi to 0.20 psi.

To put these calculated pressures in perspective, the WIPP Mine Ventilation Plan specifies that the upper operating pressure range for the surface ventilation fans is 0.47 psi for the filtration fan that is currently operating. This means that the bulkheads could be continuously subjected to pressure differential that are much greater than the transient pressures calculated in Attachment C.

Conclusion Regarding the Thermal Performance of the Run-of-Mine Salt and Outbye Bulkhead Components of the Permanent Closure for Panel 6 (from Attachment B)

Thermal effects on the permanent panel closure system will not be significant because of the location of the outbye steel bulkhead in the Permanent Closure. The Permittees do not take credit for the performance of the inbye bulkhead because creep closure of mine entries will deform the bulkhead and because the inbye bulkhead cannot be inspected after 100-feet of mined salt is installed. Thermal effects on the inbye bulkhead are not discussed further.

A thermal pulse from an exothermic reaction in a drum containing waste stream LA-MIN02-V.001 will have no significant effect on the mined salt pile because of its large mass and because halite is insensitive to small changes in temperature. A thermal pulse will also have no significant effect on the outbye bulkhead because it is located at least 132-feet from the nearest drums in Room 1 of any panel. This estimate is based on a 22-foot separation from the waste face to the isolation barrier in the Initial Closure design, 100-feet of mined salt, and an estimated gap of 10-feet from the toe of the 100-foot-long salt pile to the outbye bulkhead. As observed after the Heat Event, thermal effects were limited to 8 rows or 24-feet from the breached drum. The outbye steel bulkhead is therefore unlikely to experience any damage from the thermal effects of a reacting drum.

In summary, the location and materials in the outbye steel bulkhead and 100-foot-long salt pile indicate that temperature changes at the 100-feet of mined salt and at the outbye bulkhead of the Permanent Closure are expected to be insignificant. No performance standard is required for temperature changes from the Heat Event for the Permanent Closure.

Conclusion Regarding the Pressure Performance of the Run-of-Mine Salt and Outbye Bulkhead Components of the Permanent Closure for Panel 6 (from Attachment C)

The predicted pressure changes resulting from an exothermic reaction of a single drum containing waste stream LA-MIN02-V.001 are 0.13 to 0.17 psi in Room 1 of Panel 6 and 0.07 psi to 0.09 psi in Room 7 of Panel 7. The range encompasses reactions for five nitrate salts: calcium nitrate, magnesium nitrate, potassium nitrate, iron nitrate, and sodium nitrate. The pressure changes in Room 1 of Panel 6 and Room 7 of Panel 7 differ because the free volume is greater in Room 7 than in Room 1 and because the average nitrate mass in a drum is greater in Room 7 than in Room 1.

Within each room, these results confirm that the predicted pressure change is insensitive to the composition of nitrate salts in a drum. The predicted pressure change is also insensitive to modest changes in temperature of the product gases. For example, if the temperature of *the product gases increases by 50°C, from 300K to 350K, then the maximum pressure change in Room 1 of Panel 6 increases from 0.17 psi to 0.20 psi.*

Conclusions from the evaluation of three simultaneous thermal runaway events (from Attachment D)

A similar bounding analysis for Room 1 of Panel 6 predicts pressure changes of 0.40 to 0.54 psi. These predicted pressure changes are approximately equal to the steady–state operating pressure differential of 0.47 psi for a steel bulkhead. However, the bulkheads are still expected to remain intact because the bounding analysis overestimates the gas buildup and pressure changes by at least a factor of 5.5, as discussed in Section 3.6 of this memorandum. This factor of 5.5 can be interpreted as providing a substantial safety factor in the performance and stability of the steel bulkheads in the Closure for Panel 6. Furthermore, the steady state pressure is not a limit for bulkhead operation, simply the result of air pressure created by the ventilation system. Bulkheads are known to withstand higher transient pressures for short periods of time during ventilation adjustments and system rebalancing. In addition, once bulkheads are installed and ventilation through the disposal room is blocked, static pressure on the bulkheads is negligible. The steel bulkheads in the Closure for Panel 6 are therefore expected to remain intact, and will mitigate worker exposure to gas buildup caused by future exothermic reactions or breached drums in Room 1 of Panel 6.

Based on the analyses, no new performance specifications are needed for the permanent closure for Panel 6 and the design proposed in the March 18, 2013, Class 3 PMR will be adequate.

3.3 Paragraph 22, Section a) ii

The Order requests a schedule for the expedited closure of Panel 6. The schedule is presented in three broad categories: prerequisite actions, installation of initial closures in Panel 6, and installation of permanent closures in Panel 6. The schedules are based on the understanding of the current underground conditions and they will be updated as conditions are better understood.

3.3.1 Proposed Activity: Prerequisite Actions

These activities must be completed prior to initiating panel closure activities to ensure safety of personnel and in order to resume operating the needed equipment.

- Perform underground radiological surveys to determine the extent of contamination. The surveys performed to date have been focused on re-entry needs for the purposes of investigations. This must be expanded to include areas where personnel will be working and to gain access to the required equipment. (This activity is complete.)

- Establish underground habitability to meet applicable worker safety and health standards. Activities required for personnel hygiene and safety (e.g., portable toilets replacement, eyewash stations inspections, and fire suppression equipment inspections) must be completed to re-establish personnel habitability. (This activity is complete.)

- Evaluate and update work packages, procedures, and health and safety plans to address current conditions, workability, adequacy and flow-down of necessary manufacturers' recommendations, and work in minimally ventilated areas and in potentially contaminated areas. Conduct personnel training to these documents and activities. (This activity is complete.)

- Perform electrical equipment safety inspections and maintenance. Due to the underground fire, some electrical equipment may have carbon buildup. These inspections and maintenance activities may need to be completed for the required equipment in order to prevent the potential for electrical arcing. (This activity is complete.)

- Perform maintenance, cleaning, and inspections on the salt haulage vehicles and scissor lifts to ensure safe operability. (This activity is complete.)

- Complete corrective actions and/or implement compensatory measures for inadequacies noted in the fire protection and emergency management SMPs. (This activity is complete.)

- Establish required ventilation. Minimum ventilation must be established pursuant to MSHA requirements in order to operate the salt haulage vehicles and other necessary equipment. (This activity is complete.)

- Prepare, approve, and implement safety basis documentation. (This activity is complete.)

These prerequisite activities are addressed in the schedule below. Durations are work days and are based on five-day work weeks, one entry per shift per day.

Prerequisite Actions for Panel 6 Closure

Activity	Duration
Perform underground radiological surveys	40 days
Establish underground habitability.	20 days
Evaluate, update, prepare, and train to work packages, procedures, and health and safety plans.	20 days
Perform electrical equipment safety inspections and maintenance for required equipment.	20 days
Perform vehicle inspections and maintenance including compensatory measures.	15 days
Delineate ventilation requirements and establish required ventilation.	10 days
Prepare, approve, and implement safety basis documentation.	75 days

3.3.2 Proposed Activity: Initial Panel 6 Closure Activities

The following activities have been identified for the initial closures for Panel 6:

- Remove volatile organic compound (VOC) and hydrogen/methane monitoring lines in S-2750. (This activity is complete. Monitoring lines have been capped and monitoring terminated, it was not necessary to remove the lines in the bulkhead area since the lines do not interfere with the bulkhead and removal posed health hazards to workers.)

- Erect bulkhead in S-2750. (This activity is complete.)

- Anchor chain-link and brattice curtain and place run-of-mine salt against waste in S-3080. (This activity is complete.)

- Remove VOC and hydrogen/methane monitoring lines in S-3080. (This activity is complete. Monitoring lines have been capped and monitoring terminated, it was not necessary to remove the lines in the bulkhead area since the lines do not interfere with the bulkhead and removal posed health hazards to workers.)

- Erect bulkhead in S-3080. (This activity is complete.)

- Install radiological monitors for Panel 6. (This activity is complete.)

Activities for Panel 6 Initial Closure

Activity	**Duration**
Remove VOC and hydrogen/methane monitoring lines in S-2750.	1 day
Erect bulkhead in S-2750.	7 days
Anchor chain-link and brattice curtain and place run-of-mine salt against waste in S-3080.	8 days
Remove VOC and hydrogen/methane monitoring lines in S-3080.	1 day
Erect bulkhead in S-3080.	7 days
Install radiological monitors for Panel 6.	5 days

3.3.3 Proposed Activity: Permanent Panel 6 Closure Activities

The following activities have been identified for the permanent closures for Panel 6. Installation will be performed after supplemental ventilation is established:

- Select closure design and submit to NMED through the 40 CFR 270.42 permit modification process.

- NMED evaluation and approval period.

- Install closure in Panel 6.

- Send notifications of final closure.

Activities for Panel 6 Permanent Closure

Activity **(these activities are in series)**	**Duration**
Select closure design and submit to NMED.	90 days
NMED evaluation and approval period.	60 days
Install closure in Panel 6.	180 days

Activities for Panel 6 Permanent Closure

Activity (these activities are in series)	Duration
Send notifications of final closure.	60 days

3.4 Paragraph 22, Section a) iii

The Order requires a detailed proposal for the expedited closure of Panel 7, Room 7, so that a potential release from any nitrate salt bearing waste containers in Panel 7, Room 7, does not pose a threat to human health or the environment. This consists of the following activities:

- Continue HEPA filtration of the Underground Exhaust Air.
- Closure of Panel 7, Room 7.

The following sections include a description of the proposed activity followed by a discussion of how the activity meets the requirements of the Order to protect human health and the environment.

3.4.1 Proposed Activity: Continue HEPA Filtration of Underground Exhaust Air

Description: The design of the WIPP facility incorporates HEPA filtration as the primary method of protecting human health and the environment in the event of a radiological release in the underground. The filtration system has been continuously operating since February 14, 2014. This mitigates the public and environmental exposure hazards associated with a potential release of nitrate bearing salts from waste containers in Room 7 of Panel 7 and provides continued protection to human health and the environment. The filtration system consists of two banks of filters that include mod filters, high-efficiency filters, and two sets of HEPA filters. Due primarily to build-up on the mod filters, the Permittees performed a filter change-out in June 2014. Additional filter change-outs have been performed periodically as particulates build up on the filter surfaces. Additional filter change-outs are anticipated in the future.

The system is continuously monitored and the Permittees plan to change out filters due to particulate build-up on filter media in order to ensure effective filtration. Filter change-out is performed in a manner that minimizes the risk of an airborne release from the facility. Two independent filter banks are currently and an upgrade to provide two additional filter banks is underway. This will facilitate future change-out by ensuring that at least three banks continue to be in-service to filter any possible releases and ensure adequate ventilation for planned activities in the underground.

Discussion: The Permit, Attachment A2, Section A2-2a(3) describes the filtration mode as follows:

> *In the filtration mode, the exhaust air will pass through two identical filter assemblies, with only one of the three Exhaust Filter Building filtration fans operating (all other fans are stopped). This system provides a means for removing the airborne particulates that may contain radioactive and hazardous waste contaminants in the*

reduced exhaust flow before they are discharged through the exhaust stack to the atmosphere. The filtration mode is activated manually or automatically if the radiation monitoring system detects abnormally high concentrations of airborne radioactive particulates (an alarm is received from the continuous air monitor in the exhaust drift of the active waste panel) or a waste handling incident with the potential for a waste container breach is observed. The filtration mode is not initiated by the release of gases such as VOCs.

Normally, prior to the February 14, 2014, incident, filtration mode was seldom used and emissions were unfiltered because there was no detectable airborne radioactivity released from the facility. After the event, only filtered air is released to the ambient atmosphere. The Recovery Plan commits to continue this practice for the foreseeable future. Filtration is designed to reduce the emission of respirable particulates by a factor of one million. Onsite and offsite monitoring or radioactive emissions in the weeks and months since the event have shown that this filtration is effective in protecting surface workers and the public offsite. Monitoring results are posted on the WIPP Recovery Web Page (http://www.wipp.energy.gov/wipprecovery/recovery.html) and are provided to the NMED in the monthly report. Monitoring data indicate that the ongoing filtration of underground ventilation air that passes through the disposal area is effective in protecting human health and the environment as required by the Order. In their NMED, 2014b, the NMED approved the Permittees' proposed continuation of HEPA filtration of underground exhaust air to protect human health and the environment. The continuation of HEPA filtration is proposed in this Isolation Plan.

In the underground, the current operating practice is to provide workers with PPE sufficient to mitigate potential releases. This PPE includes breathing protection, anti-contamination clothing, and administrative controls for the duration of underground activities. Ultimately, protection from waste disposed in Panel 7 will be provided by the Room 7 closures described in the subsequent section.

3.4.2 Proposed Activity: Closure of Panel 7, Room 7

Description: The situations with Panel 7, Room 7 and Panel 6 are significantly different and therefore are addressed with different closure approaches. Panel 6 is a filled panel and is ready for final closure because no further waste will be emplaced and because an exothermic reaction did not occur in Panel 6. Panel 6 closure activities were underway when the incident of February 2014 resulted in suspension of closure activities. The Isolation Plan picks up where that activity left off. The analyses attached to this Isolation Plan demonstrate that Panel 6 closures will prevent the release of hazardous waste or hazardous waste constituents in excess of those allowed by the Permit should an event three times the event similar to what occurred in Panel 7, Room 7 occur in Panel 6.

Panel 7, however, is not ready for final closure since the Permittees intend to emplace more TRU mixed waste in the panel once it is radiologically safe to do so. Therefore, the Isolation Plan does not describe the final closure for Panel 7. Instead, the Permittees have proposed a closure to effectively isolate Panel 7, Room 7 so that a recurrence of an event three times the event of February 14, 2014, will not subject workers to harmful levels of hazardous waste or hazardous waste constituents. The following discrete steps are planned to be performed as part of this Isolation Plan to provide the closure for Panel 7, Room 7 (some activities may be performed in parallel):

- Complete entries into Panel 7 to determine the cause of the February 14, 2014, radiological event (closure of Panel 7 Room 7 is subject to release of the location by the DOE AIB). This is an ongoing investigation and results may require changes to the proposed closures and schedules described in this Isolation Plan. The NMED will be notified of any required changes. (This activity is complete.)

- Perform additional assessments of the physical conditions along the route between the shafts and the entries to Panel 7. This includes ground inspection, equipment inspection and decontamination if needed, and radiological assessment. This activity is to provide work crews with safe access to work areas and equipment, ensure safety equipment is in place, ensure the stability of the underground, and ensure the protection of work crews from exposure to radioactive contamination. (This activity is complete.)

- Determine the roof stability and radiological conditions in Panel 7. This will influence the selection of PPE and limitations on work activity duration. Roof bolting will be performed as needed as a prerequisite for entry by work crews. (This activity is complete.)

- Complete necessary work orders, safety basis documentation, and work planning documents to authorize the work and define safe working conditions. (This activity is complete.)

- Implement compensatory measures and interim actions for fire protection and emergency management SMPs (This activity is complete.).

- Conduct drills, training, and mock-ups. (This activity is complete for the closure of Panel 7, Room 7, however, drills, training and mock-ups will continue to support other underground activities.)

- Perform necessary maintenance activities on equipment that will be needed for placing the closures. (This activity is complete.)

- Assess ventilation needs and reconfigure ventilation to ensure adequate ventilation in compliance with applicable work standards. (This activity is complete.)

- Stage needed materials in the underground. (This activity is complete.)

- Prepare and move equipment contaminated by the radiological release event that cannot be decontaminated nor operated safely in a contaminated condition into Panel 7, Room 7 for disposal. This disposal is allowed under the provisions of the RCRA Contingency Plan, Permit Part D, Section D-4d(6). (This activity is complete.)

- Prepare bulkhead locations (e.g., remove loose material, terminate air monitoring tubing inside bulkhead location and remove tubes in bulkhead area, apply fixatives or other decontamination methods to deal with radiological conditions). (This activity is complete. Monitoring lines have been capped and monitoring terminated, it was not necessary to remove the lines in the bulkhead area since the lines do not interfere with the bulkhead and removal posed health hazards to workers.)

- Install a steel bulkhead in S-2520 between Panel 7, Room7 and Panel 7, Room 6. (This activity is complete.)

- Seal the slider in the bulkhead ventilation regulator in Panel 7, Room 7 in S-2180. (This activity is complete.)

- Install a steel bulkhead in S-2180 between Panel 7, Room7 and Panel 7, Room 6. (This activity is complete.)

- Add new bulkheads to the monthly inspection schedule (for as long as they are accessible). (This activity is complete.)

- Install radiological monitoring equipment, as appropriate, and ensure access is restricted. (This activity is complete.)

Discussion: The minimum requirements in the Permit for this isolation are the chain-link and brattice cloth curtain or a standard bulkhead to block the ventilation from entering the room. In addition, the Permittees will also have to address radiation protection requirements which may be more stringent than those anticipated for protection from non-radiological releases. An explosion-isolation wall will not be needed for Panel 7, Room 7 due to the minimal potential to generate sufficient hydrogen or methane over a time period that would pose a threat to workers. Data collected for filled Room 7 of Panel 4 show that it would take more than 100 years to reach one tenth of the lower explosive limit for hydrogen (DOE 2013a). Panel 7, Room 7 only has a fraction of the waste that is in Room 7 of Panel 4 and significantly more void volume. Both of these factors will further delay the accumulation of hydrogen. However, radiological monitoring (e.g., CAM) is being evaluated to provide early indication of a potential radiological release.

The candidate design for the initial closure in Room 7 of Panel 7 consists of the chain-link and brattice cloth curtain and a steel bulkhead that is installed in the air intake and two steel bulkheads that is installed on the air exhaust entries of Room 7 (see Figure 4). On the air intake side (S-2520), the chain-link and brattice cloth curtain will be dropped and attached to the ribs and floor, and a steel bulkhead will be installed close to the chain-link and brattice cloth curtain. These components are more than 400-feet away from the closest waste drums. On the air exhaust side (S-2180), the chain-link and brattice cloth curtain is inaccessible due to its location between the waste and the ventilation flow regulator bulkhead, therefore, as part of closure, the existing regulator bulkhead will remain in place, the ventilation sliders will be closed and sealed, and a new steel bulkhead will be installed. The new steel bulkhead is approximately 13-feet from the waste face.

Calculation notes are attached to this Isolation Plan (Attachments B, C, and D) analyzing the response of the Panel 7, Room 7 closure caused by an event three times the February 14, 2014 event. The effects of temperature changes are identical to the closure for Panel 6, and the pressure changes are insignificant in Panel 7, Room 7 because a large volume will remain unfilled with waste. Similarly, the analyses demonstrate that particulate releases will not pose a threat for two reasons: ongoing HEPA filtration and the low ventilation flow as the result of the closures. Therefore, the proposed closures will be protective of workers placing waste in Room 6 and human health and the environment in general.

The conclusions from the attached analyses are provided below. Italicized text are direct quotes from the analyses in Attachments B, C, and D.

Conclusion Regarding the Thermal Performance of Closure for Panel 7, Room 7 (from Attachment B)

For the Initial Closure of Room 7 in Panel 7, any thermal effects at the steel bulkhead are mitigated by the presence of the room (air) regulator bulkhead between it and the waste face and by the 11-foot separation of the bulkhead from the waste face. In effect, there are two steel bulkheads for the Initial Closure on the air exhaust side of Room 7, and the dual bulkheads will provide added mitigation of any thermal effects. On the air intake side of Room 7, the steel bulkhead is more than 400-feet away from the nearest waste containers, and any thermal effects will be mitigated by the large separation.

Given the presence of double steel bulkheads on the air exhaust side of Room 7 and the large separation of the bulkhead from the waste on the air intake side of Room 7, thermal effects from a Heat Event on the steel bulkhead for the initial panel closures in Room 7 of Panel 7 should be insignificant. No performance standard is required for temperature changes from the Heat Event for the Initial Closure designs.

Conclusion Regarding the Pressure Performance of the Closure for Panel 7, Room 7 (from Attachment C)

The predicted pressure changes resulting from an exothermic reaction of a single drum containing waste stream LA-MIN02-V.001 are 0.13 to 0.17 psi in Room 1 of Panel 6 and 0.07 psi to 0.09 psi in Room 7 of Panel 7. The range encompasses reactions for five nitrate salts: calcium nitrate, magnesium nitrate, potassium nitrate, iron nitrate, and sodium nitrate. The pressure changes in Room 1 of Panel 6 and Room 7 of Panel 7 differ because the free volume is greater in Room 7 than in Room 1 and because the average nitrate mass in a drum is greater in Room 7 than in Room 1.

Within each room, these results confirm that the predicted pressure change is insensitive to the composition of nitrate salts in a drum. The predicted pressure change is also insensitive to modest changes in temperature of the product gases. For example, if the temperature of the product gases increases by 50°C, from 300K to 350K, then the maximum pressure change in Room 1 of Panel 6 increases from 0.17 psi to 0.20 psi.

Conclusions from the evaluation of three simultaneous thermal runaway events (from Attachment D)

The predicted pressure changes from the bounding analysis are 0.22 to 0.29 psi in Room 7 of Panel 7. The Closure for Room 7 of Panel 7 includes steel bulkheads with flexible plastic flashing that is anchored to the sides and roof of the entries to Room 7. The WIPP Mine Ventilation Plan specifies that the bulkhead's upper operating pressure range is 0.47 psi (13.0 in. water gauge) with the filtration fan that is currently operating (NWP, 2015, Table 1). This upper limit (0.47 psi) is greater than the transient pressure changes predicted by the bounding analysis for Room 7. The steel bulkheads in the Room 7 Closure are therefore expected to remain intact, and the intact bulkheads will mitigate worker exposure to any gas buildup caused by future exothermic reactions or breached drums in Room 7 of Panel 7.

After the completion of recovery activities, waste disposal may resume in Panel 7, Room 6. Workers in Room 6 will be further protected during day-to-day activities as the result of the disposal room VOC monitoring program and ongoing air sampling as described in Permit

Attachment H, Section H-1, implementing the air monitoring requirements of MSHA, which states:

> *These rules require that underground mines monitor air quality to assure good breathing air whenever personnel are underground and that mine operators provide safe ground conditions for personnel in areas that require access. Routine monitoring of the openings in the access ways to panels will be continued and these openings will be maintained for as long as access into them is needed. This includes continued reading of installed geomechanical instrumentation, sounding the areas, visual inspection and maintenance activities such as scaling, mining, or bolting as required and as described in Permit Attachment A2. In addition, all areas in the underground that are occupied by personnel are checked prior to each day's work activities for accumulations of harmful gases, including methane.*

3.5 Paragraph 22, Section a) iv

The Order requests a schedule for expedited closure of Panel 7, Room 7, that takes into account all factors related to the ongoing recovery efforts being undertaken at WIPP and that will be implemented following completion of the investigation in the underground related to the cause of the radiological release in Panel 7, Room 7. The schedule is presented in two broad categories: prerequisite actions, and closure of Panel 7, Room 7.

3.5.1 Proposed Activity: Prerequisite Actions

These actions must be completed prior to initiating closure activities to ensure safety of personnel and in order to resume operating the equipment that is needed.

- Perform underground radiological surveys to determine the extent of contamination. The surveys performed to date have been focused on re-entry needs for the purposes of investigating the cause of the heat event in Panel 7, Room 7. This must be expanded to include areas where personnel will be working and to gain access to the required equipment. The assumption is that decontamination activities will be the minimal amount needed to support bulkhead installation for Room 7 closure. (This activity is complete.)

- Establish underground habitability for activity in Panel 7 to meet applicable worker safety and health standards. Activities required for personnel hygiene and safety (e.g., eyewash stations inspections and fire suppression equipment inspections) must be performed to re-establish personnel habitability. (This activity is complete.)

- Evaluate and update work packages, procedures, and health and safety plans to address current conditions, workability, adequacy and flow down of necessary manufacturers' recommendations, and work in minimally ventilated areas and in potentially contaminated areas. Conduct personnel training to these documents and activities. (This activity is complete.)

- Perform electrical equipment safety inspections and maintenance. Due to the underground fire, some electrical equipment may have carbon buildup. These inspections may need to be completed for the required equipment in order to prevent electrical arcing. (This activity is complete.)

- Prepare an area in Panel 7 in order to conduct maintenance activities on contaminated equipment. (This activity is complete.)

- Conduct maintenance on forklifts and scissor lifts to ensure safe operability. (This activity is complete.)

- Establish required ventilation. Minimum ventilation must be established pursuant to MSHA requirements in order to operate the salt haulage vehicles and other necessary equipment. (This activity is complete.)

- Prepare, approve, and implement safety basis documentation. (This activity is complete.)

- Build new bulkheads. (This activity is complete.)

- Complete underground investigations of the radiological release event in Panel 7, Room 7. (This activity is complete.)

These prerequisite activities are addressed in the schedule below.

Prerequisite Activities for Panel 7, Room 7 Closure

Activity	**Duration**
Perform underground radiation surveys and decontaminate/fix contamination as needed.	60 days
Establish underground habitability.	20 days
Evaluate, update, prepare and train to work packages, procedures, and health and safety plans.	20 days
Perform electrical equipment safety inspections and maintenance for the required equipment.	20 days
Perform vehicle inspections and maintenance.	20 days
Delineate ventilation requirements and establish required ventilation.	10 days
Prepare, approve, and implement safety basis documentation.	10 days
Fabricate new bulkheads.	10 days
Complete underground investigations.	Ongoing

3.5.2 Proposed Activity: Panel 7, Room 7 Closure Activities

The following activities have been identified for the closures of Panel 7, Room 7:

- Identify contaminated equipment to be disposed of in Panel 7, Room 7. (This activity is complete.)

- Prepare and move equipment out of Panel 7, Room 7. There is equipment in Panel 7, Room 7 that the Permittees intend to remediate for use in Panel 7 waste management activities when they resume. This equipment will be moved from Room 7. (This activity is complete.)

- Remove monitoring lines to Room 7. (This activity is complete. Monitoring lines have been capped and monitoring of Room 7 terminated, it was not necessary to remove the lines in the bulkhead area since the lines do not interfere with the bulkhead and removal posed health hazards to workers.) Drop and anchor the chain-link and brattice cloth curtain in S-2520. (This activity is complete.)

- Erect bulkhead in S-2520. (This activity is complete.)

- Seal sliders on bulkhead in S-2180. (This activity is complete.)

- Erect bulkhead in S-2180. (This activity is complete.)

Panel 7, Room 7 Closure Activities

Activity	Duration
Identify contaminated equipment to be disposed of in Panel 7, Room 7.	14 days
Prepare and move contaminated equipment and materials into and out of Panel 7, Room 7.	20 days
Remove monitoring lines to Room 7.	1 day
Drop and anchor the chain-link and brattice cloth curtain in S-2520.	3 days
Erect bulkhead in S-2520.	7 days
Seal sliders on bulkhead in S-2180.	1 day
Erect bulkhead in S-2180.	7 days

3.6 Paragraph 22, Section a) v

The Order requests a description of how the volumetric flow rate is protective of human health and the environment, and a description of how volumetric flow rate will be achieved while the Isolation Plan is implemented.

The design of the WIPP facility incorporates HEPA filtration as the primary method of protecting human health and the environment in the event of a radiological release in the underground. Ventilation air passes through and by waste disposal areas and is circulated through filtration units, thus ensuring that air follows the ventilation pathway and does not flow into other portions of the mine or to the surface unfiltered. The filtration system has been operating since February 14, 2014 and will continue to do so for the foreseeable future. This mitigates the public exposure hazards associated with a potential release of radioactive contaminants from waste containers in Panel 6 and provides continued protection to human health and the environment.

The ventilation system for the underground facility at WIPP is designed with four main ventilation paths having a common exhaust. One flow path supports the underground mining activities, a second path supports the north area activities, and a third path supports activities in the disposal panels. The fourth path provides ventilation to the Waste Shaft Station. The mining and waste disposal circuits share a common exhaust downstream of the active disposal area. This concept results in a design where waste disposal areas are separated from the mining and experimental area. The underground ventilation configuration is designed such that air leakage is from the mining and north areas into the waste disposal area. Bulkheads and their associated doors and flow regulators are used throughout the underground facility to direct the underground air flow as required. Pressure differentials are maintained between flow paths to ensure that air leakage is always from areas of lower to higher contamination potential. In filtration mode, the main purpose of the ventilation is to maintain the negative pressures required to assure leakage is into the disposal circuit and to route air into the HEPA filters. Other circuits receive only minimal to no ventilation unless needed for recovery activities.

Protection of human health and the environment is accomplished by continuing to operate the ventilation fans in order to maintain underground airflow through the surface filter system. Air flow through the Air Intake, Waste, and Salt Handling Shafts will be maintained to allow down casting. The alignment of the underground bulkheads will be configured to provide adequate ventilation flows to select work areas and direct the flow to the exhaust path. The basic criteria is to maintain the Waste Handling Tower differential pressure negative (from the Waste Shaft Station towards the E-300 drift); keep the differential pressure negative across the bulkheads located between the mining circuit and the waste handling circuit (from mining to waste handling); and maintain the exhaust flow direction from the disposal panels to the E-300 exhaust drift and subsequently up the Exhaust Shaft through the filter bank.

The underground is currently operating in filtration mode, which means that approximately 60,000 cfm of air is being circulated through the underground. The priority use for this air is to ensure that any radioactive particulate that may become airborne will be routed through the HEPA filtration system. In order to perform work in the underground, areas will have to be adequately ventilated. Adequate ventilation is as defined in the regulations promulgated by MSHA (30 CFR 57 Subpart G) to protect underground workers and is related to the type and number of internal combustion engines being used for work activities. Sufficient air will have to be diverted, using currently installed bulkheads, brattice cloth curtains, and ducting to ensure workers are protected when performing work. Air requirements for each piece of equipment that will be used for implementing the Order are listed in Table 2, which is extracted from the WIPP Mine Ventilation Plan.

Installing the initial Panel 6 closure and the Panel 7, Room 7 closure can be performed with the existing ventilation configuration on the surface (i.e., filtration mode with approximately 60,000 cfm). The permanent closure for Panel 6 will require modification of these ventilation requirements for the run-of-mine salt component of the closure. Providing this increased ventilation is part of the WIPP facility recovery schedule. Use of the diesel equipment and salt handling may accelerate particulate loading on the underground filtration system resulting in additional filter change-outs and potentially impacting the schedules.

3.7 Paragraph 23

The Order requests that the Permittees provide daily updates on the implementation of the Isolation Plan during prescheduled technical calls with NMED, and that such updates are memorialized in daily written submissions to NMED until NMED indicates otherwise. These calls began on October 7, 2014, at 3:00 p.m. daily except for weekends and holidays. Subsequently, the NMED agreed to biweekly calls, on Tuesday and Thursdays, at 3:00 pm.

3.8 Paragraph 24

The Order requires the Permittees to post submissions to NMED related to this Order in the Information Repository within five working days of submission to NMED. The Permittees have created a folder in the Information repository entitled, “Responses to the Administrative Order.” The Permittees post submissions to the NMED related to this Order to the Information Repository within five working days.

References

Accident Investigation Board, 2014, Radiological Release Event at the Waste Isolation Pilot Plant. U.S. Department of Energy, Office of Environmental Management, Washington, D.C. Accident Investigation Report, Phase 2. April 24, 2014.

Accident Investigation Board, 2015, Radiological Release Event at the Waste Isolation Pilot Plant. U.S. Department of Energy, Office of Environmental Management, Washington, D.C. Accident Investigation Report, Phase 2. April 15, 2015.

AIB see Accident Investigation Board

DOE see U. S. Department of Energy

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Nuclear Waste Partnership LLC, RE: WIPP Nitrate Salt Bearing Waste Container Isolation Plan, Revision 1, Waste Isolation Pilot Plant, EPA I.D. Number NM4890139088. State of New Mexico, Environment Department, Santa Fe, New Mexico. March 30, 2015.

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Savannah River National Laboratory (SRNL), 2015. Waste Isolation Pilot Plant Technical Assessment Team Report. SRNL-RP-2014-01198, Revision 0. Savannah River National Laboratory, Aiken, South Carolina. March 17, 2015.

SRNL see Savannah River National Laboratory

U.S. Department of Energy, 2013a, PMR Notification of a Class 3 Permit Modification to the Hazardous Waste Facility Permit, Permit Number: NM4890139088•TSDF (Panel Closure Redesign; Repository Reconfiguration; Volatile Organic Compound Monitoring Program Changes) Jose R. Franco/CBFO MF Sharif/NWP LLC dated March 18, 2013

U.S. Department of Energy, 2013b, Waste Isolation Pilot Plant Documented Safety Analysis, Section 2.4.4.6, DOE/WIPP 07-3372, Rev. 4, Nuclear Waste Partnership LLC, November 2013.

U.S. Department of Energy, 2014, Waste Isolation Pilot Plant Nitrate Salt Bearing Waste Container Isolation Plan. Revision 1. U.S. Department of Energy and Nuclear Waste Partnership LLC, Carlsbad, New Mexico. September 30, 2014.

Tables

Table 1. Typical Work Activities for Zones Cleanup

Activities for all work areas

1 Update evaluation of the safety of the situation (ESS) for work in cleared zones
2 Establish survey zones
3 Survey/characterize contamination within zone
4 Establish zone as radiological buffer area (RBA) or contaminated
5 If required, place CAMs and establish connectivity with surface monitoring
6 Place barriers for demarking confirmed clean areas
7 Release RBA areas for other work
   - 7.1 Identify equipment to be used
   - 7.2 Initiate equipment maintenance evaluation
   - 7.3 Prepare work packages as required
   - 7.4 Conduct operations in RBA zones as scheduled (complete actions zone by zone)
     - Conduct mine stability inspections
     - Inspect zone electrical system and clean soot as required
     - Conduct basic housekeeping activities
     - Remove trash to the surface
     - Assess smoke/fire damage
     - Clean components as required
     - Remove permanently damaged materials/equipment to the surface
     - Validate maintenance of equipment in zone
     - Schedule maintenance for equipment
     - Conduct maintenance of equipment

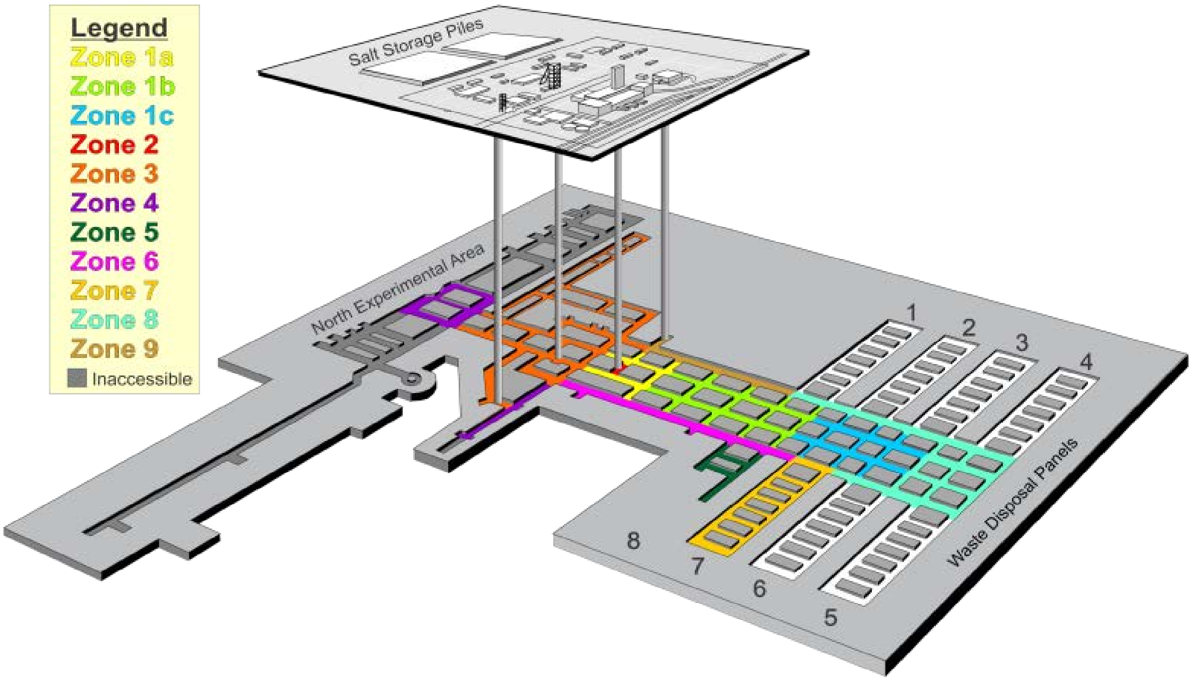
Activities for radiologically contaminated work areas

8 Prepare contaminated zones to release for work
   - 8.1 Prepare radiation work permit (RWP) for the zone
   - 8.2 Ensure boundaries are appropriately marked
   - 8.3 If not already prepared, establish change room facility
   - 8.4 If required, establish monitoring/counting station
   - 8.5 Establish contaminated clothing bins
   - 8.6 Establish transition (survey) zone for moving items from contaminated to non-contaminated areas
   - 8.7 Establish procedure for bagging items for movement from one contaminated zone to another
   - 8.8 Train workers to RWP and radiological worker requirements
   - 8.9 Train workers in donning and doffing techniques
9 Establish hot maintenance shop
   - 9.1 Identify area
   - 9.2 Create tool storage (tool crib) area
   - 9.3 Collect and inventory tools
   - 9.4 Validate calibration of tools and instruments
   - 9.5 Establish process for organizing, segregating and maintaining tools
10 Release contaminated areas for other work
   - 10.1 Identify equipment to be used
   - 10.2 Initiate equipment maintenance evaluation
   - 10.3 Prepare work packages as required
   - 10.4 Conduct operations in contaminated zone as scheduled
     - Conduct mine inspections
     - Inspect zone electrical system & clean soot if needed
     - Conduct basic housekeeping activities
     - Collect trash in central location for survey and disposal
     - Assess smoke/fire damage
     - Clean or remove components as required
     - Conduct maintenance of equipment

Table 2 Ventilation Requirements for Diesel Powered Mining Equipment to be used for Closure of Panel 6 and Panel 7, Room 7

Equipment	MSHA air requirements (cfm)	Use	Where needed	Duration
Roof bolter	6,500	Install roof bolts	Main access and cross drifts, Panel 6 entries, Panel 7 entries and Room 7	Intermittent as needed
Scissor lift	1,000 (hybrid) and 7,500 (diesel)	Install bulkheads	Panel 6 entries, Panel 7 Room 7	Intermittent during bulkhead installation
Fork lift	6,500	Move, erect bulkheads	Panel 6 entries, Panel 7 Room 7	Intermittent
Load-Haul-Dump loader	12,000	Transport salt backfill	Panel 6 S-3080 entry	Intermittent
Haul truck	7,500	Transport salt backfill	Panel 6 S-3080 entry	Intermittent

Figures



Zone	Description	Radiological Contamination
Zone 1a	Drift W30 from S90 to S700, Drift E140 from S700 to S90	Uncontaminated
Zone 1b	Drift W30 from S700 to S1950, Drift E140 from S1950 to S700, and cross drifts at S1000, S1300, S1600 and S1950.	Uncontaminated
Zone 1c	Drift W30 from S1950 to S3080, Drift E140 from S3080 to S1950, and cross drifts at S2180, S2520, S2750 and S3080.	Contaminated
Zone 2	Area around the waste shaft station including sumps	Uncontaminated
Zone 3	Drifts from S-400 to N-1100 including maintenance area	Uncontaminated
Zone 4	Experimental areas including NEXA, EXO, SDI	Uncontaminated
Zone 5	Panel 8	Uncontaminated
Zone 6	Other uncontaminated areas (e.g., panel entry drifts)	Uncontaminated
Zone 7	Panel 7 including rooms 1 to 7 and the exhaust drifts	Contaminated
Zone 8	Contaminated areas at the south end of the mine with boundaries defined by characterization	Contaminated
Zone 9	The exhaust drift and exhaust shaft	Contaminated

Figure 1 Proposed Zone Layout of the WIPP Underground for Implementing Recovery

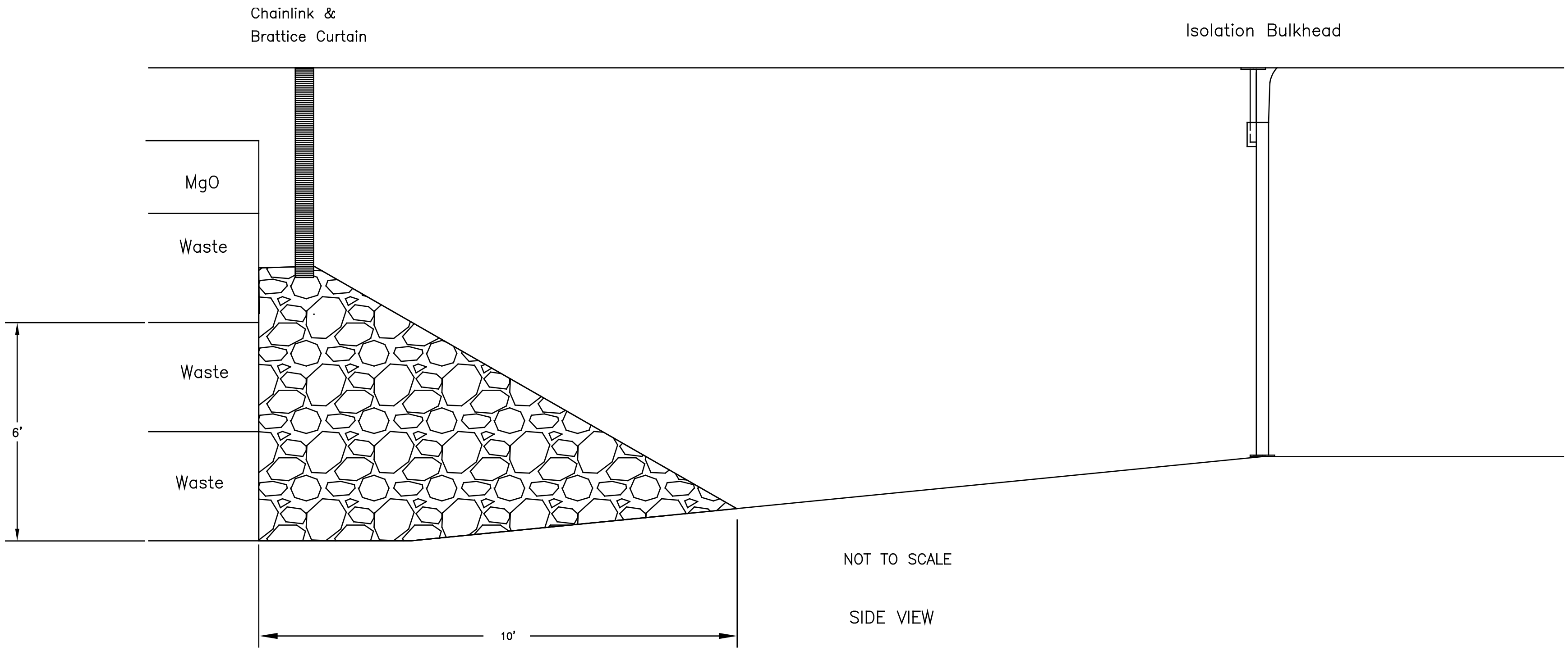
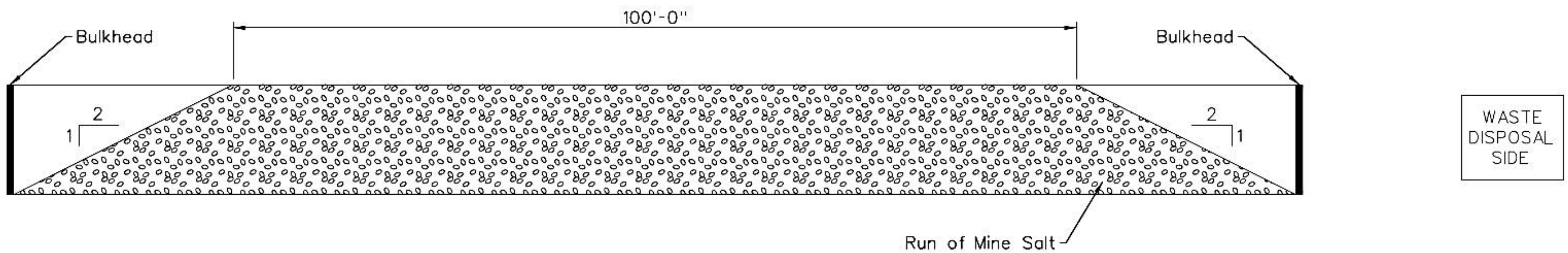


Figure 2 Typical Layout for the Initial Closure in Panel 6



1. Salt Zone 100'-0" minimum length.
2. Salt layers can be inclined within specifications.
3. Detailed design drawings are presented in Appendix D.
4. The ROM salt shall be placed to fill up to the back.
5. ROM salt is a porous salt in the loose state derived from underground mining operations at WIPP.

Figure 3 Permanent Closure Proposed for Panel 6

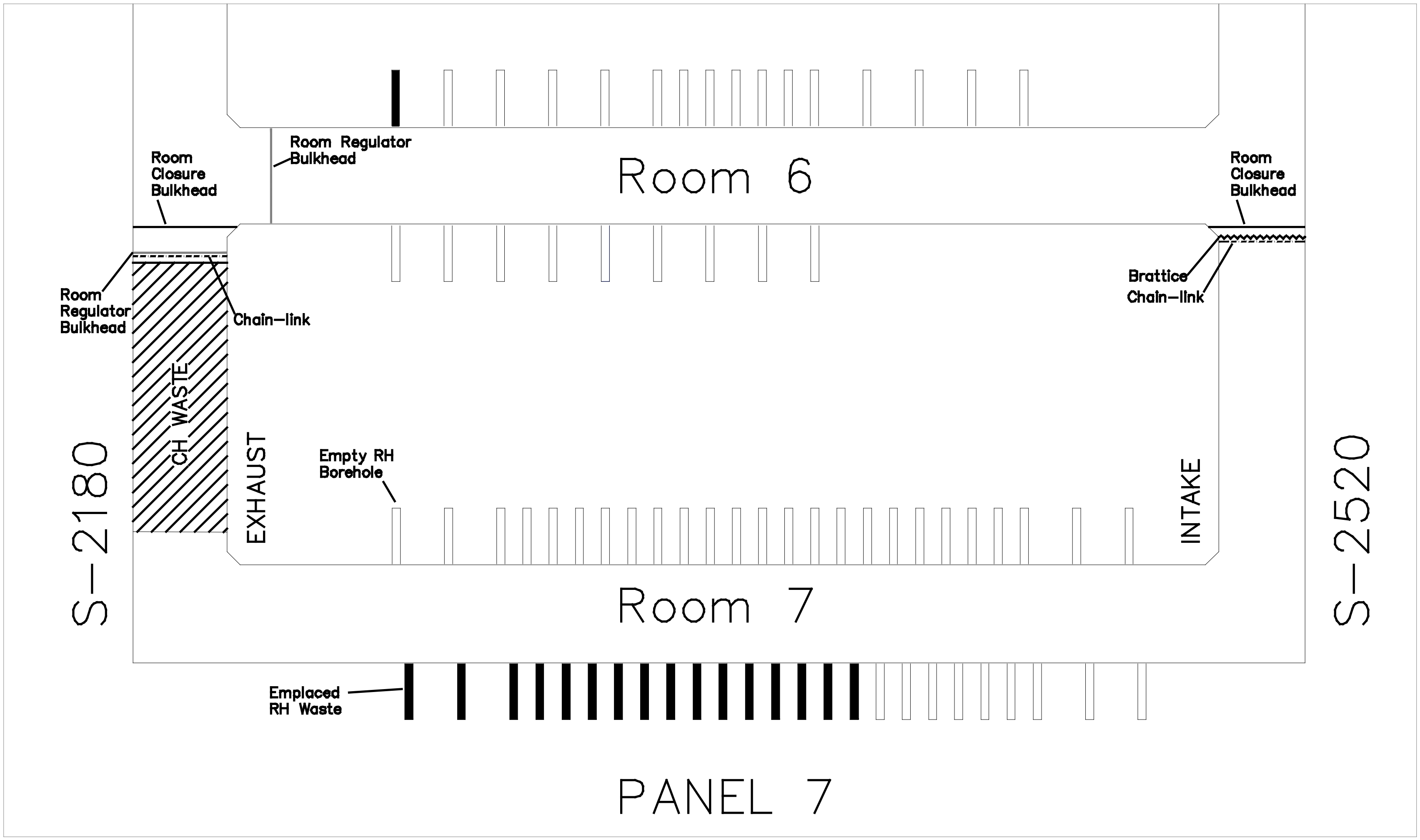


Figure 4 Proposed Location for Bulkheads that will Close Panel 7, Room 7

Attachment A
Location of Nitrate Salt Bearing Waste in Panels 5, 6 and 7

May 8, 2015

ATTACHMENT A

Container Number	Emplacement Date	Waste Stream	Emplacement Location				
			Panel	Room	Row	Column	Height
LA00000088327	5-May-11	LA-MHD01.001	5	1	5	3	T
LA00000087822	16-May-11	LA-MHD01.001	5	1	29	1	B
LA00000089308	16-Dec-11	LA-MHD01.001	6	6	53	1	T
LA00000089309	11-Jan-12	LA-MHD01.001	6	6	74	4	T
LA00000090315	19-May-12	LA-MHD01.001	6	5	35	1	B
LA00000087824	6-Oct-12	LA-MIN04-S.001	6	4	48	4	B
LA00000090801	9-Dec-12	LA-MHD01.001	6	4	125	3	T
LA00000090840	9-Dec-12	LA-MHD01.001	6	4	125	3	T
LA00000090845	9-Dec-12	LA-MHD01.001	6	4	125	3	T
LA00000090814	9-Dec-12	LA-MHD01.001	6	4	126	2	B
LA00000091006	9-Dec-12	LA-MHD01.001	6	4	126	2	B
LA00000090999	9-Dec-12	LA-MHD01.001	6	4	126	2	T
LA00000090712	12-Jan-13	LA-MHD01.001	6	3	18	6	B
LA00000090715	16-Jan-13	LA-MHD01.001	6	3	24	6	B
LA00000092461	15-Mar-13	LA-MHD01.001	6	3	31	5	B
LA00000092147	17-Mar-13	LA-MHD01.001	6	3	32	4	B
LA00000092158	17-Mar-13	LA-MHD01.001	6	3	32	4	B
LA00000092192	17-Mar-13	LA-MHD01.001	6	3	32	4	B
LA00000092197	17-Mar-13	LA-MHD01.001	6	3	32	4	B
LA00000092202	31-Mar-13	LA-MHD01.001	6	3	49	3	B
LA00000092351	31-Mar-13	LA-MHD01.001	6	3	49	3	B
LA00000092481	31-Mar-13	LA-MHD01.001	6	3	49	3	B
LA00000092343	2-Apr-13	LA-MHD01.001	6	3	51	3	M
LA00000092349	2-Apr-13	LA-MHD01.001	6	3	51	3	M
LA00000092494	17-Apr-13	LA-MHD01.001	6	3	67	3	M
LA00000092154	18-Apr-13	LA-MHD01.001	6	3	68	6	M
LA00000092166	18-Apr-13	LA-MHD01.001	6	3	68	6	M
LA00000092181	18-Apr-13	LA-MHD01.001	6	3	68	6	M
LA00000092355	18-Apr-13	LA-MHD01.001	6	3	68	6	M
LA00000092466	18-Apr-13	LA-MHD01.001	6	3	68	6	M
LA00000092468	18-Apr-13	LA-MHD01.001	6	3	69	5	T
LA00000092139	19-Apr-13	LA-MHD01.001	6	3	70	6	M
LA00000092341	21-Apr-13	LA-MHD01.001	6	3	75	1	T
LA00000092364	21-Apr-13	LA-MHD01.001	6	3	75	1	T
LA00000092376	21-Apr-13	LA-MHD01.001	6	3	75	3	T
LA00000092463	21-Apr-13	LA-MHD01.001	6	3	75	3	T
LA00000092479	4-May-13	LA-MHD01.001	6	3	90	4	T
LA00000092476	5-May-13	LA-MHD01.001	6	3	92	4	B
LA00000092188	16-May-13	LA-MHD01.001	6	3	104	2	B
LA00000092204	16-May-13	LA-MHD01.001	6	3	104	2	B
LA00000092486	16-May-13	LA-MHD01.001	6	3	104	2	B

ATTACHMENT A

Container Number	Emplacement Date	Waste Stream	Emplacement Location				
			Panel	Room	Row	Column	Height
LA00000092339	16-May-13	LA-MHD01.001	6	3	105	1	M
LA00000092484	16-May-13	LA-MHD01.001	6	3	105	1	M
LA00000092183	24-May-13	LA-MHD01.001	6	3	115	1	B
LA00000092378	24-May-13	LA-MHD01.001	6	3	115	1	B
LA00000092492	24-May-13	LA-MHD01.001	6	3	115	1	B
LA00000090883	31-May-13	LA-MIN04-S.001	6	3	119	3	T
LA00000090931	31-May-13	LA-MIN04-S.001	6	3	119	3	T
LA00000092488	4-Jun-13	LA-MHD01.001	6	3	125	3	B
LA00000092190	9-Jun-13	LA-MHD01.001	6	3	130	2	M
LA00000092144	14-Jun-13	LA-MHD01.001	6	3	137	1	T
LA00000092124	18-Jun-13	LA-MHD01.001	6	3	141	1	M
LA00000092150	18-Jun-13	LA-MHD01.001	6	3	141	1	M
LA00000092206	28-Jun-13	LA-MHD01.001	6	2	7	3	B
LA00000090835	2-Jul-13	LA-MHD01.001	6	2	12	4	B
LA00000090752	2-Jul-13	LA-MHD01.001	6	2	13	5	B
LA00000092616	3-Jul-13	LA-MHD01.001	6	2	14	6	T
LA00000092131	5-Jul-13	LA-MHD01.001	6	2	15	5	T
LA00000092142	5-Jul-13	LA-MHD01.001	6	2	15	5	T
LA00000092169	5-Jul-13	LA-MHD01.001	6	2	15	5	T
LA00000092160	6-Jul-13	LA-MHD01.001	6	2	17	1	B
LA00000092164	6-Jul-13	LA-MHD01.001	6	2	17	1	B
LA00000092129	7-Jul-13	LA-MHD01.001	6	2	18	6	B
LA00000091768	7-Jul-13	LA-MIN04-S.001	6	2	18	6	T
LA00000091769	12-Jul-13	LA-MIN04-S.001	6	2	24	2	B
LA00000092184	14-Jul-13	LA-MHD01.001	6	2	28	2	B
LA00000092618	18-Jul-13	LA-MHD01.001	6	2	30	6	M
LA00000092561	2-Aug-13	LA-MHD01.001	6	2	50	2	T
LA00000092186	3-Aug-13	LA-MHD01.001	6	2	51	1	T
LA00000092195	4-Aug-13	LA-MHD01.001	6	2	53	1	B
LA00000092175	8-Aug-13	LA-MHD01.001	6	2	58	4	T
LA00000092671	14-Aug-13	LA-MHD01.001	6	2	68	2	B
LA00000092563	15-Aug-13	LA-MHD01.001	6	2	68	4	B
LA00000092894	15-Aug-13	LA-MHD01.001	6	2	68	4	B
LA00000092559	15-Aug-13	LA-MHD01.001	6	2	68	6	T
LA00000093153	15-Aug-13	LA-MHD01.001	6	2	68	6	T
LA00000092217	30-Aug-13	LA-MIN02-V.001	6	2	88	2	T
LA00000092237	30-Aug-13	LA-MIN02-V.001	6	2	88	2	T
LA00000092347	30-Aug-13	LA-MIN02-V.001	6	2	88	2	T
LA00000093588	30-Aug-13	LA-MIN02-V.001	6	2	88	2	T
LA00000092555	31-Aug-13	LA-MIN02-V.001	6	2	88	6	T
LA00000093589	31-Aug-13	LA-MIN02-V.001	6	2	88	6	T

ATTACHMENT A

Container Number	Emplacement Date	Waste Stream	Emplacement Location				
			Panel	Room	Row	Column	Height
LA00000092140	10-Sep-13	LA-MIN02-V.001	6	2	89	5	M
LA00000092495	10-Sep-13	LA-MIN02-V.001	6	2	89	5	M
LA00000092235	10-Sep-13	LA-MIN02-V.001	6	2	89	5	T
LA00000092211	10-Sep-13	LA-MIN02-V.001	6	2	90	2	T
LA00000092249	10-Sep-13	LA-MIN02-V.001	6	2	90	4	B
LA00000092252	10-Sep-13	LA-MIN02-V.001	6	2	90	4	B
LA00000093593	10-Sep-13	LA-MIN02-V.001	6	2	90	4	B
LA00000093598	10-Sep-13	LA-MIN02-V.001	6	2	90	4	M
LA00000092220	10-Sep-13	LA-MIN02-V.001	6	2	90	4	T
LA00000092145	11-Sep-13	LA-MIN02-V.001	6	2	91	3	B
LA00000092134	11-Sep-13	LA-MIN02-V.001	6	2	91	3	M
LA00000092496	11-Sep-13	LA-MIN02-V.001	6	2	91	3	M
LA00000092246	11-Sep-13	LA-MIN02-V.001	6	2	91	3	T
LA00000092239	11-Sep-13	LA-MIN02-V.001	6	2	91	5	B
LA00000092251	11-Sep-13	LA-MIN02-V.001	6	2	91	5	B
LA00000092219	11-Sep-13	LA-MIN02-V.001	6	2	91	5	T
LA00000093597	11-Sep-13	LA-MIN02-V.001	6	2	91	5	T
LA00000092152	14-Sep-13	LA-MIN02-V.001	6	2	96	2	B
LA00000092136	14-Sep-13	LA-MIN02-V.001	6	2	96	2	M
LA00000092557	17-Sep-13	LA-MIN02-V.001	6	2	97	1	B
LA00000092684	17-Sep-13	LA-MIN02-V.001	6	2	97	1	B
LA00000092156	17-Sep-13	LA-MIN02-V.001	6	2	97	1	M
LA00000092572	17-Sep-13	LA-MIN02-V.001	6	2	97	1	M
LA00000092905	17-Sep-13	LA-MIN02-V.001	6	2	97	1	M
LA00000092907	17-Sep-13	LA-MIN02-V.001	6	2	97	1	M
LA00000092173	17-Sep-13	LA-MIN02-V.001	6	2	97	1	T
LA00000092565	17-Sep-13	LA-MIN02-V.001	6	2	97	1	T
LA00000092888	17-Sep-13	LA-MIN02-V.001	6	2	97	1	T
LA00000092902	17-Sep-13	LA-MIN02-V.001	6	2	97	1	T
LA00000092540	17-Sep-13	LA-MIN02-V.001	6	2	97	3	B
LA00000092570	17-Sep-13	LA-MIN02-V.001	6	2	97	3	B
LA00000092213	17-Sep-13	LA-MIN02-V.001	6	2	97	3	T
LA00000092122	17-Sep-13	LA-MIN02-V.001	6	2	97	5	B
LA00000092470	17-Sep-13	LA-MIN02-V.001	6	2	97	5	B
LA00000092477	17-Sep-13	LA-MIN02-V.001	6	2	97	5	B
LA00000092482	17-Sep-13	LA-MIN02-V.001	6	2	97	5	B
LA00000092937	17-Sep-13	LA-MIN02-V.001	6	2	97	5	B
LA00000092938	17-Sep-13	LA-MIN02-V.001	6	2	97	5	B
LA00000092940	17-Sep-13	LA-MIN02-V.001	6	2	97	5	B
LA00000092171	17-Sep-13	LA-MIN02-V.001	6	2	97	5	T
LA00000092215	17-Sep-13	LA-MIN02-V.001	6	2	97	5	T

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Container Number	Emplacement Date	Waste Stream	Emplacement Location				
			Panel	Room	Row	Column	Height
LA00000092216	17-Sep-13	LA-MIN02-V.001	6	2	97	5	T
LA00000092682	18-Sep-13	LA-MIN02-V.001	6	2	98	2	T
LA00000092890	18-Sep-13	LA-MIN02-V.001	6	2	98	2	T
LA00000092917	18-Sep-13	LA-MIN02-V.001	6	2	98	2	T
LA00000092921	18-Sep-13	LA-MIN02-V.001	6	2	98	2	T
LA00000092892	20-Sep-13	LA-MIN02-V.001	6	2	98	4	T
LA00000092898	20-Sep-13	LA-MIN02-V.001	6	2	98	4	T
LA00000092913	20-Sep-13	LA-MIN02-V.001	6	2	98	4	T
LA00000092915	20-Sep-13	LA-MIN02-V.001	6	2	98	4	T
LA00000092580	20-Sep-13	LA-MIN02-V.001	6	2	98	6	T
LA00000092674	20-Sep-13	LA-MIN02-V.001	6	2	98	6	T
LA00000092909	20-Sep-13	LA-MIN02-V.001	6	2	98	6	T
LA00000092933	20-Sep-13	LA-MIN02-V.001	6	2	98	6	T
LA00000092578	25-Sep-13	LA-MIN02-V.001	6	2	104	2	T
LA00000092574	26-Sep-13	LA-MIN02-V.001	6	2	105	5	T
LA00000092576	26-Sep-13	LA-MIN02-V.001	6	2	105	5	T
LA00000092932	26-Sep-13	LA-MIN02-V.001	6	2	105	5	T
LA00000093442	27-Sep-13	LA-MHD01.001	6	2	106	6	T
LA00000093465	27-Sep-13	LA-MHD01.001	6	2	106	6	T
LA00000092676	8-Oct-13	LA-MIN02-V.001	6	2	120	2	T
LA00000093516	8-Oct-13	LA-MIN02-V.001	6	2	120	2	T
LA00000093487	8-Oct-13	LA-MIN02-V.001	6	2	121	1	T
LA00000093577	8-Oct-13	LA-MIN02-V.001	6	2	121	1	T
LA00000092678	8-Oct-13	LA-MIN02-V.001	6	2	121	3	T
LA00000092896	8-Oct-13	LA-MIN02-V.001	6	2	121	3	T
LA00000092212	10-Oct-13	LA-MIN02-V.001	6	2	124	4	T
LA00000093568	10-Oct-13	LA-MIN02-V.001	6	2	124	4	T
LA00000093515	13-Oct-13	LA-MIN02-V.001	6	2	127	3	T
LA00000093609	13-Oct-13	LA-MIN02-V.001	6	2	127	3	T
LA00000092680	13-Oct-13	LA-MIN02-V.001	6	2	127	5	T
LA00000093576	13-Oct-13	LA-MIN02-V.001	6	2	127	5	T
LA00000092919	18-Oct-13	LA-MIN02-V.001	6	1	4	2	B
LA00000093571	18-Oct-13	LA-MIN02-V.001	6	1	4	2	B
LA00000093610	18-Oct-13	LA-MIN02-V.001	6	1	4	2	B
LA00000093601	18-Oct-13	LA-MIN02-V.001	6	1	4	2	M
LA00000093581	18-Oct-13	LA-MIN02-V.001	6	1	4	4	B
LA00000093603	18-Oct-13	LA-MIN02-V.001	6	1	4	4	B
LA00000093572	18-Oct-13	LA-MIN02-V.001	6	1	4	4	M
LA00000093573	18-Oct-13	LA-MIN02-V.001	6	1	4	4	M
LA00000093155	19-Oct-13	LA-MIN02-V.001	6	1	5	5	B
LA00000093602	19-Oct-13	LA-MIN02-V.001	6	1	5	5	B

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Container Number	Emplacement Date	Waste Stream	Emplacement Location				
			Panel	Room	Row	Column	Height
LA00000093606	19-Oct-13	LA-MIN02-V.001	6	1	5	5	B
LA00000093086	19-Oct-13	LA-MIN02-V.001	6	1	5	5	M
LA00000093574	19-Oct-13	LA-MIN02-V.001	6	1	5	5	M
LA00000093590	19-Oct-13	LA-MIN02-V.001	6	1	5	5	M
LA00000093595	19-Oct-13	LA-MIN02-V.001	6	1	5	5	M
LA00000092127	25-Oct-13	LA-MIN02-V.001	6	1	10	6	B
LA00000092934	25-Oct-13	LA-MIN02-V.001	6	1	10	6	B
LA00000092935	25-Oct-13	LA-MIN02-V.001	6	1	10	6	B
LA00000093083	25-Oct-13	LA-MIN02-V.001	6	1	10	6	B
LA00000093084	25-Oct-13	LA-MIN02-V.001	6	1	10	6	B
LA00000093088	25-Oct-13	LA-MIN02-V.001	6	1	10	6	B
LA00000093154	25-Oct-13	LA-MIN02-V.001	6	1	10	6	B
LA00000093082	25-Oct-13	LA-MIN02-V.001	6	1	10	6	M
LA00000093089	25-Oct-13	LA-MIN02-V.001	6	1	10	6	M
LA00000093599	25-Oct-13	LA-MIN02-V.001	6	1	10	6	M
LA00000092233	1-Nov-13	LA-MIN02-V.001	6	1	22	2	T
LA00000068316	3-Nov-13	LA-MIN02-V.001	6	1	23	1	T
LA00000092162	3-Nov-13	LA-MIN02-V.001	6	1	23	1	T
LA00000092210	3-Nov-13	LA-MIN02-V.001	6	1	23	1	T
LA00000092245	3-Nov-13	LA-MIN02-V.001	6	1	23	1	T
LA00000068309	3-Nov-13	LA-MIN02-V.001	6	1	23	3	T
LA00000068372	3-Nov-13	LA-MIN02-V.001	6	1	23	3	T
LA00000093156	3-Nov-13	LA-MIN02-V.001	6	1	24	2	M
LA00000068310	7-Nov-13	LA-MIN02-V.001	6	1	29	3	T
LA00000092294	7-Nov-13	LA-MIN02-V.001	6	1	29	3	T
LA00000092296	7-Nov-13	LA-MIN02-V.001	6	1	29	3	T
LA00000092366	7-Nov-13	LA-MIN02-V.001	6	1	29	3	T
LA00000092489	8-Nov-13	LA-MIN02-V.001	6	1	31	5	B
LA00000092936	8-Nov-13	LA-MIN02-V.001	6	1	31	5	B
LA00000092939	8-Nov-13	LA-MIN02-V.001	6	1	31	5	M
LA00000068312	10-Nov-13	LA-MIN02-V.001	6	1	33	1	B
LA00000092360	10-Nov-13	LA-MIN02-V.001	6	1	33	1	B
LA00000092345	10-Nov-13	LA-MIN02-V.001	6	1	34	4	T
LA00000092665	10-Nov-13	LA-MIN02-V.001	6	1	34	4	T
LA00000092911	10-Nov-13	LA-MIN02-V.001	6	1	34	4	T
LA00000093150	10-Nov-13	LA-MIN02-V.001	6	1	34	4	T
LA00000093085	17-Nov-13	LA-MIN02-V.001	6	1	39	3	M
LA00000068381	17-Nov-13	LA-MIN02-V.001	6	1	39	3	T
LA00000068448	17-Nov-13	LA-MIN02-V.001	6	1	39	3	T
LA00000093594	17-Nov-13	LA-MIN02-V.001	6	1	39	3	T
LA00000092148	17-Nov-13	LA-MIN02-V.001	6	1	39	5	M

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Container Number	Emplacement Date	Waste Stream	Emplacement Location				
			Panel	Room	Row	Column	Height
LA00000092357	17-Nov-13	LA-MIN02-V.001	6	1	39	5	M
LA00000092362	17-Nov-13	LA-MIN02-V.001	6	1	39	5	M
LA00000092227	17-Nov-13	LA-MIN02-V.001	6	1	39	5	T
LA00000092292	17-Nov-13	LA-MIN02-V.001	6	1	39	5	T
LA00000092567	17-Nov-13	LA-MIN02-V.001	6	1	39	5	T
LA00000068332	17-Nov-13	LA-MIN02-V.001	6	1	40	2	B
LA00000068379	17-Nov-13	LA-MIN02-V.001	6	1	40	2	B
LA00000068383	17-Nov-13	LA-MIN02-V.001	6	1	40	2	B
LA00000068410	17-Nov-13	LA-MIN02-V.001	6	1	40	2	B
LA00000068335	19-Nov-13	LA-MIN02-V.001	6	1	40	6	T
LA00000068417	19-Nov-13	LA-MIN02-V.001	6	1	40	6	T
LA00000092221	19-Nov-13	LA-MIN02-V.001	6	1	40	6	T
LA00000068375	20-Nov-13	LA-MIN02-V.001	6	1	41	1	T
LA00000068376	20-Nov-13	LA-MIN02-V.001	6	1	41	1	T
LA00000068385	20-Nov-13	LA-MIN02-V.001	6	1	41	1	T
LA00000068411	20-Nov-13	LA-MIN02-V.001	6	1	41	1	T
LA00000092248	22-Nov-13	LA-MIN02-V.001	6	1	44	4	B
LA00000092290	22-Nov-13	LA-MIN02-V.001	6	1	44	4	B
LA00000068374	23-Nov-13	LA-MIN02-V.001	6	1	45	1	T
LA00000068413	23-Nov-13	LA-MIN02-V.001	6	1	45	1	T
LA00000092231	23-Nov-13	LA-MIN02-V.001	6	1	45	1	T
LA00000068300	23-Nov-13	LA-MIN02-V.001	6	1	45	5	B
LA00000068416	23-Nov-13	LA-MIN02-V.001	6	1	45	5	B
LA00000092229	23-Nov-13	LA-MIN02-V.001	6	1	45	5	B
LA00000092241	23-Nov-13	LA-MIN02-V.001	6	1	45	5	B
LA00000068446	26-Nov-13	LA-MIN02-V.001	6	1	49	3	B
LA00000068447	26-Nov-13	LA-MIN02-V.001	6	1	49	3	B
LA00000092374	26-Nov-13	LA-MIN02-V.001	6	1	49	3	B
LA00000094148	26-Nov-13	LA-MIN02-V.001	6	1	49	3	B
LA00000068451	26-Nov-13	LA-MIN02-V.001	6	1	49	3	M
LA00000094149	26-Nov-13	LA-MIN02-V.001	6	1	49	3	M
LA00000094151	26-Nov-13	LA-MIN02-V.001	6	1	49	3	M
LA00000068373	26-Nov-13	LA-MIN02-V.001	6	1	49	3	T
LA00000068453	26-Nov-13	LA-MIN02-V.001	6	1	49	3	T
LA00000068455	26-Nov-13	LA-MIN02-V.001	6	1	49	3	T
LA00000068462	26-Nov-13	LA-MIN02-V.001	6	1	49	3	T
LA00000068466	26-Nov-13	LA-MIN02-V.001	6	1	49	3	T
LA00000068484	26-Nov-13	LA-MIN02-V.001	6	1	50	2	B
LA00000068498	26-Nov-13	LA-MIN02-V.001	6	1	50	2	B
LA00000068502	26-Nov-13	LA-MIN02-V.001	6	1	50	2	B
LA00000068504	26-Nov-13	LA-MIN02-V.001	6	1	50	2	B

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Container Number	Emplacement Date	Waste Stream	Emplacement Location				
			Panel	Room	Row	Column	Height
LA00000092380	26-Nov-13	LA-MIN02-V.001	6	1	50	2	B
LA00000068337	26-Nov-13	LA-MIN02-V.001	6	1	50	2	M
LA00000068479	26-Nov-13	LA-MIN02-V.001	6	1	50	2	M
LA00000068496	26-Nov-13	LA-MIN02-V.001	6	1	50	2	M
LA00000090872	26-Nov-13	LA-MIN04-S.001	6	1	50	2	M
LA00000068318	30-Nov-13	LA-MIN02-V.001	6	1	50	2	T
LA00000068404	30-Nov-13	LA-MIN02-V.001	6	1	50	2	T
LA00000068458	30-Nov-13	LA-MIN02-V.001	6	1	50	2	T
LA00000068467	30-Nov-13	LA-MIN02-V.001	6	1	50	2	T
LA00000093611	30-Nov-13	LA-MIN02-V.001	6	1	50	2	T
LA00000068317	30-Nov-13	LA-MIN02-V.001	6	1	50	4	T
LA00000068327	30-Nov-13	LA-MIN02-V.001	6	1	50	4	T
LA00000068407	30-Nov-13	LA-MIN02-V.001	6	1	50	4	T
LA00000068378	30-Nov-13	LA-MIN02-V.001	6	1	50	6	T
LA00000068382	30-Nov-13	LA-MIN02-V.001	6	1	50	6	T
LA00000068409	30-Nov-13	LA-MIN02-V.001	6	1	50	6	T
LA00000068483	30-Nov-13	LA-MIN02-V.001	6	1	50	6	T
LA00000068503	30-Nov-13	LA-MIN02-V.001	6	1	50	6	T
LA00000068336	1-Dec-13	LA-MIN02-V.001	6	1	51	3	T
LA00000068387	1-Dec-13	LA-MIN02-V.001	6	1	51	3	T
LA00000068465	1-Dec-13	LA-MIN02-V.001	6	1	51	3	T
LA00000068468	1-Dec-13	LA-MIN02-V.001	6	1	51	3	T
LA00000068499	1-Dec-13	LA-MIN02-V.001	6	1	51	3	T
LA00000068461	1-Dec-13	LA-MIN02-V.001	6	1	52	2	B
LA00000068329	1-Dec-13	LA-MIN02-V.001	6	1	52	2	T
LA00000068454	4-Dec-13	LA-MIN02-V.001	6	1	54	4	B
LA00000068324	7-Dec-13	LA-MIN02-V.001	6	1	55	5	B
LA00000068346	7-Dec-13	LA-MIN02-V.001	6	1	55	5	B
LA00000092672	7-Dec-13	LA-MIN02-V.001	6	1	55	5	B
LA00000093607	7-Dec-13	LA-MIN02-V.001	6	1	55	5	B
LA00000093087	7-Dec-13	LA-MIN02-V.001	6	1	55	5	M
LA00000068330	7-Dec-13	LA-MIN02-V.001	6	1	55	5	T
LA00000068338	7-Dec-13	LA-MIN02-V.001	6	1	55	5	T
LA00000068452	7-Dec-13	LA-MIN02-V.001	6	1	55	5	T
LA00000068463	7-Dec-13	LA-MIN02-V.001	6	1	55	5	T
LA00000068386	7-Dec-13	LA-MIN02-V.001	6	1	56	2	T
LA00000068473	7-Dec-13	LA-MIN02-V.001	6	1	56	2	T
LA00000068536	7-Dec-13	LA-MIN02-V.001	6	1	56	2	T
LA00000068544	7-Dec-13	LA-MIN02-V.001	6	1	56	2	T
LA00000068556	7-Dec-13	LA-MIN02-V.001	6	1	56	2	T
LA00000068321	10-Dec-13	LA-MIN02-V.001	6	1	59	1	B

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Container Number	Emplacement Date	Waste Stream	Emplacement Location				
			Panel	Room	Row	Column	Height
LA00000068340	10-Dec-13	LA-MIN02-V.001	6	1	59	1	B
LA00000068349	10-Dec-13	LA-MIN02-V.001	6	1	59	1	B
LA00000068391	10-Dec-13	LA-MIN02-V.001	6	1	59	1	B
LA00000068399	10-Dec-13	LA-MIN02-V.001	6	1	59	1	B
LA00000068323	10-Dec-13	LA-MIN02-V.001	6	1	59	1	M
LA00000068339	10-Dec-13	LA-MIN02-V.001	6	1	59	1	M
LA00000068348	10-Dec-13	LA-MIN02-V.001	6	1	59	1	M
LA00000068393	10-Dec-13	LA-MIN02-V.001	6	1	59	1	M
LA00000092469	10-Dec-13	LA-MIN02-V.001	6	1	59	1	M
LA00000068334	10-Dec-13	LA-MIN02-V.001	6	1	59	3	T
LA00000068377	10-Dec-13	LA-MIN02-V.001	6	1	59	3	T
LA00000068450	10-Dec-13	LA-MIN02-V.001	6	1	59	3	T
LA00000068493	10-Dec-13	LA-MIN02-V.001	6	1	59	3	T
LA00000068469	10-Dec-13	LA-MIN02-V.001	6	1	59	5	T
LA00000068475	10-Dec-13	LA-MIN02-V.001	6	1	59	5	T
LA00000068539	10-Dec-13	LA-MIN02-V.001	6	1	59	5	T
LA00000068542	10-Dec-13	LA-MIN02-V.001	6	1	59	5	T
LA00000068550	10-Dec-13	LA-MIN02-V.001	6	1	59	5	T
LA00000068304	14-Dec-13	LA-MIN02-V.001	6	1	61	3	T
LA00000068497	14-Dec-13	LA-MIN02-V.001	6	1	61	3	T
LA00000068470	18-Dec-13	LA-MIN02-V.001	6	1	66	2	T
LA00000068500	18-Dec-13	LA-MIN02-V.001	6	1	66	2	T
LA00000068566	18-Dec-13	LA-MIN02-V.001	6	1	66	2	T
LA00000068575	18-Dec-13	LA-MIN02-V.001	6	1	66	2	T
LA00000093582	18-Dec-13	LA-MIN02-V.001	6	1	66	2	T
LA00000068412	19-Dec-13	LA-MIN02-V.001	6	1	66	4	T
LA00000068457	19-Dec-13	LA-MIN02-V.001	6	1	66	4	T
LA00000068495	19-Dec-13	LA-MIN02-V.001	6	1	66	4	T
LA00000068564	19-Dec-13	LA-MIN02-V.001	6	1	66	4	T
LA00000068322	19-Dec-13	LA-MIN02-V.001	6	1	67	1	T
LA00000068415	19-Dec-13	LA-MIN02-V.001	6	1	67	1	T
LA00000068474	19-Dec-13	LA-MIN02-V.001	6	1	67	1	T
LA00000068572	19-Dec-13	LA-MIN02-V.001	6	1	67	1	T
LA00000068579	19-Dec-13	LA-MIN02-V.001	6	1	67	1	T
LA00000068482	21-Dec-13	LA-MIN02-V.001	6	1	68	4	T
LA00000068537	21-Dec-13	LA-MIN02-V.001	6	1	68	4	T
LA00000068558	21-Dec-13	LA-MIN02-V.001	6	1	68	4	T
LA00000068562	21-Dec-13	LA-MIN02-V.001	6	1	68	4	T
LA00000068384	21-Dec-13	LA-MIN02-V.001	6	1	69	3	T
LA00000068456	21-Dec-13	LA-MIN02-V.001	6	1	69	3	T
LA00000068569	21-Dec-13	LA-MIN02-V.001	6	1	69	3	T

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Container Number	Emplacement Date	Waste Stream	Emplacement Location				
			Panel	Room	Row	Column	Height
LA00000092667	21-Dec-13	LA-MIN02-V.001	6	1	69	3	T
LA00000068611	28-Dec-13	LA-MIN02-V.001	6	1	72	6	T
LA00000068612	28-Dec-13	LA-MIN02-V.001	6	1	72	6	T
LA00000068637	28-Dec-13	LA-MIN02-V.001	6	1	72	6	T
LA00000068380	28-Dec-13	LA-MIN02-V.001	6	1	73	1	B
LA00000068480	28-Dec-13	LA-MIN02-V.001	6	1	73	1	B
LA00000068563	28-Dec-13	LA-MIN02-V.001	6	1	73	1	B
LA00000068568	28-Dec-13	LA-MIN02-V.001	6	1	73	1	B
LA00000068570	28-Dec-13	LA-MIN02-V.001	6	1	73	1	B
LA00000068560	28-Dec-13	LA-MIN02-V.001	6	1	73	1	M
LA00000068565	28-Dec-13	LA-MIN02-V.001	6	1	73	1	M
LA00000068634	28-Dec-13	LA-MIN02-V.001	6	1	73	1	M
LA00000068561	29-Dec-13	LA-MIN02-V.001	6	1	73	5	T
LA00000068613	29-Dec-13	LA-MIN02-V.001	6	1	73	5	T
LA00000068633	29-Dec-13	LA-MIN02-V.001	6	1	73	5	T
LA00000068414	16-Jan-14	LA-MIN02-V.001	6	1	88	2	T
LA00000068549	16-Jan-14	LA-MIN02-V.001	6	1	88	2	T
LA00000068559	16-Jan-14	LA-MIN02-V.001	6	1	88	2	T
LA00000068574	16-Jan-14	LA-MIN02-V.001	6	1	88	2	T
LA00000068610	16-Jan-14	LA-MIN02-V.001	6	1	88	2	T
LA00000068547	18-Jan-14	LA-MIN02-V.001	6	1	92	2	B
LA00000068557	18-Jan-14	LA-MIN02-V.001	6	1	92	2	B
LA00000068608	18-Jan-14	LA-MIN02-V.001	6	1	92	2	B
LA00000068651	18-Jan-14	LA-MIN02-V.001	6	1	92	2	B
LA00000068551	18-Jan-14	LA-MIN02-V.001	6	1	92	2	M
LA00000068552	18-Jan-14	LA-MIN02-V.001	6	1	92	2	M
LA00000068606	18-Jan-14	LA-MIN02-V.001	6	1	92	2	M
LA00000068344	18-Jan-14	LA-MIN02-V.001	6	1	92	6	B
LA00000068389	18-Jan-14	LA-MIN02-V.001	6	1	92	6	B
LA00000068390	18-Jan-14	LA-MIN02-V.001	6	1	92	6	B
LA00000068392	18-Jan-14	LA-MIN02-V.001	6	1	92	6	B
LA00000068398	18-Jan-14	LA-MIN02-V.001	6	1	92	6	B
LA00000068400	18-Jan-14	LA-MIN02-V.001	6	1	92	6	B
LA00000068436	18-Jan-14	LA-MIN02-V.001	6	1	92	6	B
LA00000068343	18-Jan-14	LA-MIN02-V.001	6	1	92	6	M
LA00000068345	18-Jan-14	LA-MIN02-V.001	6	1	92	6	M
LA00000068397	18-Jan-14	LA-MIN02-V.001	6	1	92	6	M
LA00000068427	18-Jan-14	LA-MIN02-V.001	6	1	92	6	M
LA00000068435	18-Jan-14	LA-MIN02-V.001	6	1	92	6	M
LA00000068554	18-Jan-14	LA-MIN02-V.001	6	1	93	3	T
LA00000068615	18-Jan-14	LA-MIN02-V.001	6	1	93	3	T

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Container Number	Emplacement Date	Waste Stream	Emplacement Location				
			Panel	Room	Row	Column	Height
LA00000068650	18-Jan-14	LA-MIN02-V.001	6	1	93	3	T
LA00000068494	24-Jan-14	LA-MIN02-V.001	7	7	2	6	T
LA00000068652	24-Jan-14	LA-MIN02-V.001	7	7	2	6	T
LA00000068614	24-Jan-14	LA-MIN02-V.001	7	7	3	1	T
LA00000068623	24-Jan-14	LA-MIN02-V.001	7	7	3	1	T
LA00000068671	24-Jan-14	LA-MIN02-V.001	7	7	3	1	T
LA00000068571	24-Jan-14	LA-MIN02-V.001	7	7	3	3	T
LA00000068635	24-Jan-14	LA-MIN02-V.001	7	7	3	3	T
LA00000068636	24-Jan-14	LA-MIN02-V.001	7	7	3	3	T
LA00000068672	24-Jan-14	LA-MIN02-V.001	7	7	3	3	T
LA00000068541	25-Jan-14	LA-MIN02-V.001	7	7	5	1	T
LA00000068605	25-Jan-14	LA-MIN02-V.001	7	7	5	1	T
LA00000068629	25-Jan-14	LA-MIN02-V.001	7	7	5	1	T
LA00000068654	25-Jan-14	LA-MIN02-V.001	7	7	5	1	T
LA00000068655	25-Jan-14	LA-MIN02-V.001	7	7	5	1	T
LA00000068501	28-Jan-14	LA-MIN02-V.001	7	7	10	2	T
LA00000068669	28-Jan-14	LA-MIN02-V.001	7	7	10	2	T
LA00000068680	28-Jan-14	LA-MIN02-V.001	7	7	10	2	T
LA00000068573	28-Jan-14	LA-MIN02-V.001	7	7	10	4	T
LA00000068578	28-Jan-14	LA-MIN02-V.001	7	7	10	4	T
LA00000068647	28-Jan-14	LA-MIN02-V.001	7	7	10	4	T
LA00000068422	28-Jan-14	LA-MIN02-V.001	7	7	10	6	B
LA00000068423	28-Jan-14	LA-MIN02-V.001	7	7	10	6	B
LA00000068424	28-Jan-14	LA-MIN02-V.001	7	7	10	6	B
LA00000068512	28-Jan-14	LA-MIN02-V.001	7	7	10	6	B
LA00000068577	28-Jan-14	LA-MIN02-V.001	7	7	10	6	B
LA00000068582	28-Jan-14	LA-MIN02-V.001	7	7	10	6	B
LA00000068618	28-Jan-14	LA-MIN02-V.001	7	7	10	6	B
LA00000068394	28-Jan-14	LA-MIN02-V.001	7	7	10	6	M
LA00000068395	28-Jan-14	LA-MIN02-V.001	7	7	10	6	M
LA00000068510	28-Jan-14	LA-MIN02-V.001	7	7	10	6	M
LA00000068511	28-Jan-14	LA-MIN02-V.001	7	7	10	6	M
LA00000068513	28-Jan-14	LA-MIN02-V.001	7	7	10	6	M
LA00000068616	29-Jan-14	LA-MIN02-V.001	7	7	12	6	T
LA00000068545	29-Jan-14	LA-MIN02-V.001	7	7	13	3	B
LA00000068548	29-Jan-14	LA-MIN02-V.001	7	7	13	3	B
LA00000068576	29-Jan-14	LA-MIN02-V.001	7	7	13	3	B
LA00000068609	29-Jan-14	LA-MIN02-V.001	7	7	13	3	B
LA00000068659	29-Jan-14	LA-MIN02-V.001	7	7	13	3	B
LA00000068581	29-Jan-14	LA-MIN02-V.001	7	7	13	3	M
LA00000068626	29-Jan-14	LA-MIN02-V.001	7	7	13	3	M

ATTACHMENT A

Container Number	Emplacement Date	Waste Stream	Emplacement Location				
			Panel	Room	Row	Column	Height
LA00000068653	29-Jan-14	LA-MIN02-V.001	7	7	13	3	M
LA00000068666	29-Jan-14	LA-MIN02-V.001	7	7	13	3	M
LA00000068459	31-Jan-14	LA-MIN02-V.001	7	7	15	5	B
LA00000068667	31-Jan-14	LA-MIN02-V.001	7	7	15	5	B
LA00000068668	31-Jan-14	LA-MIN02-V.001	7	7	15	5	B
LA00000068687	31-Jan-14	LA-MIN02-V.001	7	7	15	5	B
LA00000094152	31-Jan-14	LA-MIN02-V.001	7	7	15	5	B
LA00000068328	31-Jan-14	LA-MIN02-V.001	7	7	15	5	M
LA00000068555	31-Jan-14	LA-MIN02-V.001	7	7	15	5	M
LA00000068649	31-Jan-14	LA-MIN02-V.001	7	7	15	5	M
LA00000068333	31-Jan-14	LA-MIN02-V.001	7	7	16	4	T
LA00000068607	31-Jan-14	LA-MIN02-V.001	7	7	16	4	T
LA00000068630	31-Jan-14	LA-MIN02-V.001	7	7	16	4	T
LA00000068660	31-Jan-14	LA-MIN02-V.001	7	7	16	4	T
LA00000068670	31-Jan-14	LA-MIN02-V.001	7	7	16	4	T

Attachment B
Evaluation of Thermal Effects on Panel Closures from the "Heat Event" That Occurred in Room 7 of Panel 7 on February 14, 2014
September 29, 2014

Date: September 29, 2014

To: Rick Chavez

From: Michael Gross

Subject: Evaluation of Thermal Effects on Panel Closures from the "Heat Event" That Occurred in Room 7 of Panel 7 On February 14, 2014

Summary

On February 14, 2014, a drum containing waste stream LA-MIN02-V.001 had an exothermic reaction in Room 7 of Panel 7. This calculation provides an evaluation of thermal effects from this exothermic reaction and from a hypothetical future exothermic reaction in Panel 6 or in Room 7 of Panel 7. The exothermic reaction and its consequences are referred to as a "Heat Event" in this document.

Based on observations and photographic evidence collected by the reentry teams, the exothermic reaction produced high temperature in the immediate area around the breached drum. The observations indicate that only a single drum, LA00000068660 (#68660), containing waste stream LA-MIN02-V.001 experienced a strong exothermic reaction in Room 7. This conclusion is supported by a comparison of the total energy released by drum #68660 to the energy required to melt a polypropylene sack for magnesium oxide or a polyethylene slipsheet. This comparison shows that the energy required to melt a sack is less than 0.3% of the energy released by drum #68660 or the energy to melt a slipsheet is less than 0.8% of the energy released by drum #68660. This comparison indicates that the thermal energy released by the chemical reaction in a single drum is sufficient to explain the observed thermal damage in Room 7 of Panel 7.

Smaller temperature changes extended up to 8 rows downwind of the breached drum, judging by the presence of melted polypropylene sacks and missing polyethylene reinforcement sheets on top of waste stacks. The exposed sides and tabs of the polyethylene slipsheets in a waste stack were also observed to have melted in this region.

The design of the Initial Closure for Room 1 of Panel 6 (the "typical" design) has two barriers: a substantial barrier and a bulkhead. The substantial barrier consists of chainlink and brattice cloth curtains that are installed close to the waste face, and a pile of mined salt that is pushed up against the waste face. The bulkhead is made of steel and has plastic flexible flashing that is bolted to the walls of the entry. The steel bulkhead will be about 22-feet from the waste face. Given the minimum bulkhead separation of 22-feet from a hypothetical future Heat Event and the robustness of the steel bulkhead compared to polypropylene sacks and polyethylene sheets, thermal effects from an ignited drum on the steel bulkhead of the Initial Closure should be insignificant.

The design of the Initial Closure for Room 7 of Panel 7 is different from the typical design outlined above. Two significant changes are being made: (1) the existing room (air) regulator bulkhead on the air exhaust side of Room 7 will remain in place, and (2) mined salt will not be

pushed against the waste face. These changes will minimize the risk to workers from hazardous waste/hazardous waste constituents and from radiation exposure during construction. Given the presence of two steel bulkheads on the air exhaust side of Room 7 and the fact that the steel bulkhead on the air intake side will be located more than 400-feet away from the nearest waste in Room 7, thermal effects on the bulkheads from a hypothetical future Heat Event in Room 7 of Panel 7 are predicted to be insignificant.

The proposed design for the permanent panel closures consists of 100-foot of mined salt, with isolation barriers on the inbye and outbye sides of the salt. The isolation barriers are steel bulkheads with flexible flashing that is bolted to the walls of the entry. The mined salt will be generated by mining operations, without grading or compaction or addition of moisture. Thermal effects on the 100-foot of mined salt and on the outbye steel bulkhead will not be significant because the mined rock will not be affected by the thermal pulse and because the outbye bulkhead is located more than 100-feet from the nearest nitrate-salt-bearing waste containers. The Permittees do not take credit for the performance of the inbye bulkhead because creep closure of mine entries will deform the bulkhead and because the inbye bulkhead cannot be inspected after 100-feet of mined salt is installed.

Given these results, no panel closure performance standard is required for temperature changes from the Heat Event for the Initial Closure or the Permanent Closure in Panel 6 or the room closure in Panel 7, Room 7.

1. Introduction

On February 14, 2014, a drum containing waste from waste stream LA-MIN02-V.001 had an exothermic reaction in Room 7 of Panel 7. Room 7 was the active room for contact-handled (CH) waste emplacement at the time of the incident. After ignition, a portion of the lid separated from the drum, resulting in a release of radioactive particulates into the ventilation air stream. The exothermic reaction in drum #68660 and its consequences are referred to as the "Heat Event" in this document.

After this event, the New Mexico Environment Department (NMED) issued an administrative order requiring the WIPP Permittees to prepare a *WIPP Nitrate Salt Bearing Waste Isolation Plan* with a detailed proposal for the expedited closure of Panel 6 and of Room 7 in Panel 7 (NMED 2014, Section 22a, items i and iii). The expedited closures are intended to provide additional isolation of drums containing waste stream LA-MIN02-V.001 until Permanent Closures can be installed in Panel 6 and Panel 7. Panel 6 is a concern to NMED because it has 313 drums containing waste stream LA-MIN02-V.001. These expedited closures are called Initial Closures in this document to distinguish them from the longer-term Permanent Closures for each waste-filled panel.

This document presents a description of the Heat Event, provides an estimate of the energy released from the exothermic reaction in the drum in Room 7 of Panel 7, reviews observations from photographs taken by the reentry teams after the incident, and provides an evaluation of the magnitude of the thermal effects on the Initial and Permanent Closures if a second hypothetical Heat Event were to occur in a drum containing waste stream LA-MIN02-V.001.

2. Description of the Heat Event

On February 14, 2014, a single drum (#68660) containing nitrate-salt-bearing waste from waste stream LA-MIN02-V.001 had an exothermic reaction in Room 7 of Panel 7. After ignition, the reaction products increased the internal pressure in the drum until a portion of the lid separated from the drum, resulting in a release of radioactive particulates into the ventilation air stream. After an underground Continuous Air Monitor (CAM) detected the presence of radioactivity in the air flow, the ventilation system shifted from normal mode to filtration mode. In filtration mode, ventilation air passes through HEPA filters before being released to the atmosphere. The WIPP ventilation system has remained in filtration mode since the Heat Event.

2.1 Heat of Combustion for the Heat Event

The drum (#68660) that ignited in Room 7 contained nitrate-salt-bearing waste that was mixed with a desiccant called Swheat Scoop, a wheat-based organic kitty litter. For the purposes of this evaluation, the exothermic reaction in drum #68660 is assumed to follow a simple reaction chemistry, with the nitrate salts acting as an oxidizer and the Swheat Scoop providing the organic fuel. Physically, the nitrate salts and Swheat Scoop in a drum may not react completely because the mass of desiccant added to each drum is unlikely to be in stoichiometric balance for complete reaction with the mass of nitrate salts in the drum. Given this fact, an upper bound for the heat of combustion of this waste stream has been estimated from the heat of combustion of potassium nitrate and charcoal, 0.72 – 0.75 kcal/g (CRC 1958, page 1917).

2.2 Total Energy Released from Drum #68660

With a value for the heat of combustion, the total energy released during a Heat Event is a function of the mass of nitrate salts and organic desiccant in a drum. Drums containing waste stream LA-MIN02-V.001 have been emplaced in Rooms 1 and 2 of Panel 6 and in Room 7 of Panel 7. In the WIPP underground layout, Room 1 is closest to the exhaust main and is the last room in a panel to be filled with waste; Room 7 is farthest from the exhaust main and is the first room to be filled with waste.

Table 1 summarizes statistical data for drums containing LA-MIN02-V.001 (Pearcy, 2014 and Walentine, 2014). The Waste Mass is the approximate total mass in a container and the Nitrate Mass is the approximate mass of solidified nitrate salts, including any desiccant or absorbent that was added. Table 1 presents average, minimum, and maximum values of these parameters for the drums with waste stream LA-MIN02-V.001. The average values in the highlighted boxes are used to estimate the total energy released by the exothermic reaction.

Table 1. Data for drums containing waste stream LA-MIN02-V.001

Location	No. of Drums	Waste Mass (kg)			Nitrate Mass (kg)			Fill Factor (%)		
		Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Room 1 of Panel 6	222	86.9	2.3	206.1	74.9	0.0	194.0	74.6	20	100
Room 2 of Panel 6	91	67.6	1.8	155.1	50.6	0.0	143.1	69.9	15	95
Total in Panel 6	313	81.3	1.8	206.1	67.9	0.0	194.0	73.3	15	100
Room 7 of Panel 7	55	96.0	9.4	197.6	84.5	7.2	165.6	74.3	20	100
Total in Panel 7	55	96.0	9.4	197.6	84.5	7.2	165.6	74.3	20	100

Sources: (Pearcy, 2014) and (Walentine, 2014)

The Nitrate Mass is the basis for estimating the total energy release from a drum. The Nitrate Mass is appropriate because it represents the combined mass of oxidizer and fuel in the drum. The Heat Event in Room 7 of Panel 7 occurred in drum #68660, which had a Nitrate Mass of 71.6 kg (WDS, 2014, Page 6, Material Parameters, Solidified Inorganic Material). The total energy released is then estimated as (71,600 g)(0.75 kcal/g) = 54,000 kcal for drum #68860.

An alternate approach is to use the average Nitrate Mass in a Room. This approach is consistent with calculations in the WIPP Hazardous Waste Permit, which are often based on average values. Using an average Nitrate Mass of 74.9 kg in Room 1 of Panel 6 and of 84.5 kg in Room 7 of Panel 7 (see the shaded cells in Table 1), the total energy release is calculated as:

a. (74,900 g)(0.75 kcal/g) = 56,000 kcal for a drum in Room 1 of Panel 6; and
b. (84,500 g)(0.75 kcal/g) = 63,000 kcal for a drum in Room 7 of Panel 7.

These energy releases are similar to the value of 54,000 kcal for drum #68660.

2.3 Comparison of Energy Release to Melt Energy for Sacks and Slipsheets

These energy releases are much larger than the energy required to melt polypropylene sacks of MgO. The energy required to melt a single sack can be calculated from the mass of the sack and from the specific heat and melting temperature of polypropylene:

$$\begin{aligned} E &= C_p M \Delta T, \\ &= C_p M (T_{melt} - T_{amb}), \end{aligned} \quad (1)$$

where C_p is the specific heat of polypropylene [kcal/kg/C], M is the mass of a sack [kg], and ΔT is the temperature change [C], defined as the melting temperature of polypropylene, T_{melt}, minus the ambient temperature, T_{amb}, in the WIPP repository.

The polypropylene cloth for the sacks holding magnesium oxide (MgO) has a minimum weight of 8 ounces per square yard (WTS 2009, Section 3.3.2.A). The sack is hexagonal in shape, with nominal dimensions of 61 inches across the flats and 25.5 inches in height (WTS, 2009, Section 3.3.2.B). The surface areas of the top, bottom, and sides of the sack are 3,220 in^2, 5,390 in^2, and 3,220 in^2, for a total surface area of 11,800 in^2 (9.13 yd^2). The weight/mass of a sack is then (0.5 lbs/yd^2)(9.13 yd^2) = 4.57 lbs (2.07 kg).

The values of the parameters in Equation (1) for polypropylene are as follows:

- C_p is 1800 Joules/kg/K (0.430 kcal/kg/C) (Goodfellow, 2014);
- M is 2.07 kg;
- T_{melt} is 175°C (Avallone et al., 2007, Table 6.12.1, page 6-201, maximum value for unfilled homopolymer or unfilled copolymer); and
- T_{amb} is 27°C at the WIPP repository horizon.

The energy required to melt a single polypropylene sack is then:

$$\begin{aligned} E &= C_p M (T_{melt} - T_{amb}), \\ &= (0.430\, kcal/kg/C)(2.07\, kg)(175C - 27C), \\ &= 132\, kcal. \end{aligned} \qquad (2)$$

The energy required to melt a single sack, 132 kcal, is less than 0.3% of the thermal energy released by drum #68660, estimated (above) as 54,000 kcal.

It is possible that a flame front propagated outward from the breached drum and ignited adjacent sacks. Based on current observations, a flame front appears less likely than melting because the back (roof) above the breached drum does not show significant flame-induced blackening. However, in the event that the sacks ignited and burned, they are a source of thermal energy rather than a sink for thermal energy, as implied by melting. In either situation (source or sink), an exothermic reaction in a single drum is sufficient to explain the observed response of the polypropylene sacks in Room 7 to a Heat Event.

A similar calculation for a high density polyethylene (HDPE) slipsheet shows that 420 kcal is required to melt a single slipsheet. The increased energy is due to the increased weight of a slipsheet, which is about 19.5 lbs (McInroy, 2014), versus the weight of a sack, which is 4.57 lbs. The energy to melt a slipsheet is less than 0.8% of the energy released by drum #68660. Ignition and burning of slipsheets seems less likely than for the MgO sacks because the slipsheets are about 0.15-inches thick. These results support the conclusion that an exothermic reaction in drum #68660 (alone) is sufficient to explain the observed response of the HDPE slipsheets in Room 7.

3. Observations of Thermal Effects from the Heat Event

The Heat Event involves a complex sequence of processes in the drum: (1) ignition of waste and pressure build-up in the drum, (2) drum failure (perhaps by lid separation) due to internal pressurization, (3) release and mixing of the hot reaction gases with the cooler air in the room, (4) continued burning until the fuel (i.e., the organic material in Swheat Scoop) or the oxidant is depleted; (5) hot ash and hot cinders may be released from the drum as burning continues, and drums may outgas if gaskets are degraded by the heat; and (6) heat transfer via thermal radiation and convection from the hot reaction gases to the cooler surroundings. These surroundings include adjacent drums, slipsheets used for drum handling, MgO on top of waste stacks, and the halite surrounding the room. A detailed analysis of this process is quite complex; however, observations after the event in Room 7 indicate that high temperatures are confined to the area immediately surrounding the breached drum.

3.1 Observations Close to the Breached Drum

The observations from the Heat Event in Room 7 of Panel 7 that are relevant to the thermal response close to the breached drum are as follows:

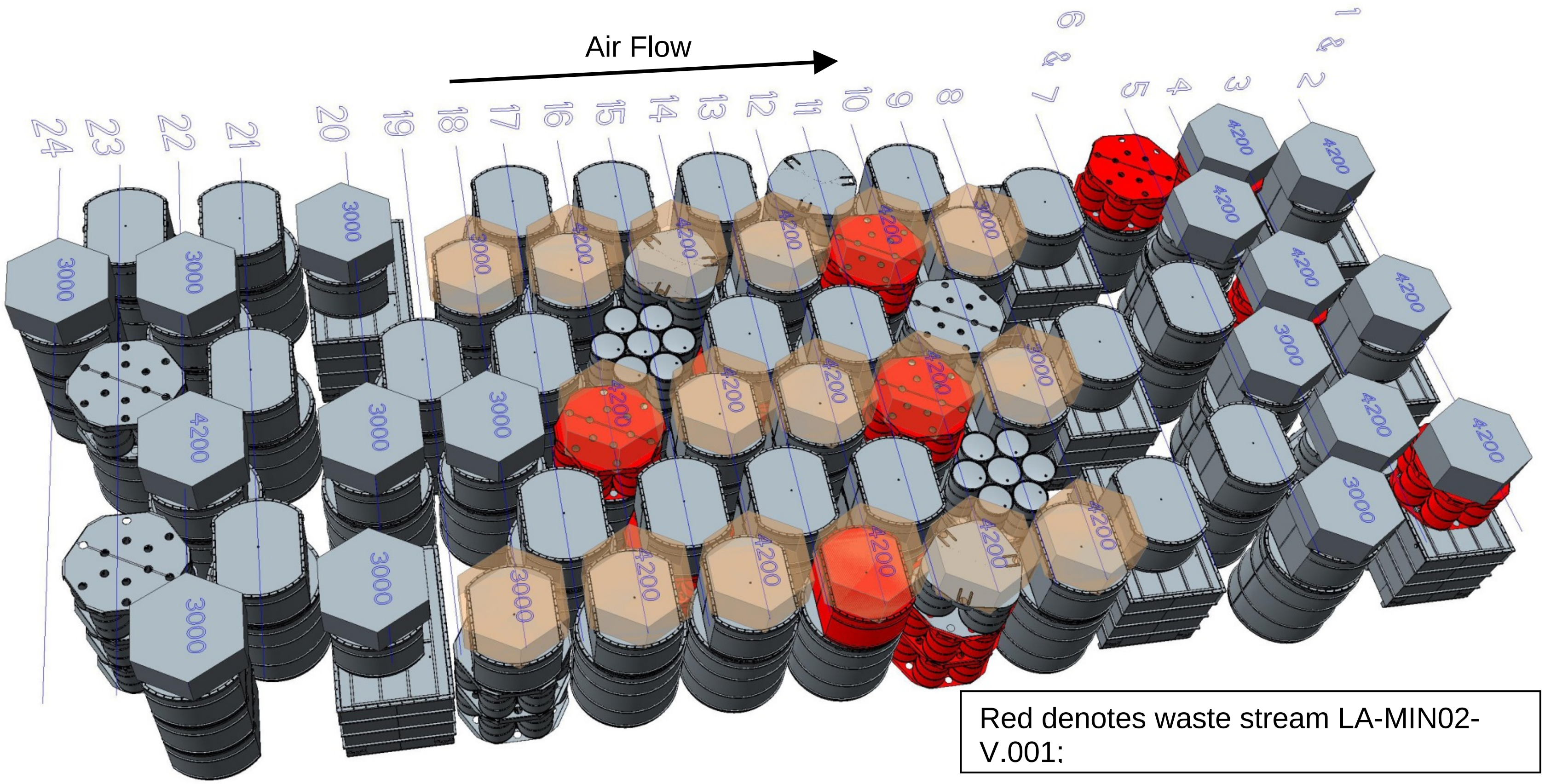
- A single drum (#68660) containing waste stream LA-MIN02-V.001 ignited in Room 7.
- A portion of the lid on this drum separated, most likely because the exothermic reaction increased the internal gas pressure in the drum.
- The contents of this breached drum would continue to react after the lid separated, although the time required for completion of the reaction is uncertain.
- A small area of the breached drum experienced temperatures in the range of 310°C to 400°C, based on photographic evidence for the bluish discoloration of the drum's outer surface (NWP, 2014, pages 2 and 3).
- The immediately adjacent drums do not show signs of radiant heat damage in excess of 246°C, the ignition temperature of paper (Cafe, 2014).
- A waste stack directly adjacent to drum #68660 has a 7-pack of drums containing LA-MIN02-V.001. The outer surface of the drum closest to drum #68660 is not discolored in the photographs, indicating it did not have a strong exothermic reaction.

These observations and estimates confirm that high temperatures are confined to the area immediately surrounding the breached drum, and that only a single drum containing waste stream LA-MIN02-V.001 had a significant exothermic reaction during the Heat Event.

3.2 Observations in the Area Downwind from the Breached Drum

Melting of the polypropylene sacks of MgO, missing HDPE reinforcement sheets, and melting of HDPE slipsheets occurs in an area downwind from the breached drum (see Figure 1). Downwind refers to the direction of ventilation air flow. Polypropylene homopolymer (unfilled) melts at 160°C to 175°C and HDPE homopolymer melts at 130°C to 137°C, (Avallone et al., 2007, Table 6.12.1, pages 6-201 and 6-200, resp.). The polypropylene sack material is approximately 0.017-inches thick (Batchelder, 2014) and the HDPE slipsheets are 0.15-inches thick (McInroy, 2014). It is not surprising that melting of polypropylene sacks and HDPE slipsheets is observed over a larger area given the low melting temperatures, the thinness of these materials, and the potential for releasing a large amount of thermal energy from a breached drum.

The polypropylene MgO sacks are observed to melt for 1 row upwind and 8 rows downwind from the breached drum, as shown in Figure 1. The polypropylene sacks in Rows 8 through 18 (see Figure 1) may have melted from contact with hot combustion gases that were released from the breached drum. Alternately, hot ash or hot cinders could have been released from the breached drum and settled onto the polypropylene sacks. Finally, a flame front could have propagated between adjacent sacks or outgassing and ignition of flammable volatile organic compounds (VOCs) could have contributed to melting the polypropylene. The polypropylene sacks in Rows 2 through 4 remain intact (see Figure 1).



NOTES: (1) Drums with waste stream LA-MIN02-V.001 are shown in red. The breached drum is located at Row 16, Position 4. It is in the top 7-pack in this waste stack, at approximately 4:00 o'clock.

(2) The adjacent waste stack at Row 15, Position 5, has a 7-pack of LA-MIN02-V.001 beneath a standard waste box. The drum in this 7-pack that is nearest to drum #68660 (the breached drum) does not show evidence of a strong exothermic reaction because its white paint is not discolored.

(3) Waste stacks that have lost the polypropylene sacks for MgO are indicated by a light tan color. These locations are generally downwind from the breached drum (i.e., generally to the right of the breached drum at Row 16, Position 4; ventilation air flows from left to right in this figure).

(4) The waste stack at Row 18, Position 4 is directly adjacent to and upwind from the breached drum. This MgO sack showed slight blackening, but remained intact. However, the MgO sacks in Row 18 at Positions 2 and 6 have melted.

(5) The MgO sacks in Rows 2 through 4 are intact. The reinforcement sheets at Row 11, Position 1 and Row 9, Position 3 are intact, but the sheet at Row 9, Position 5 is missing and may have melted.

Figure 1. View of waste containers and MgO sacks in Room 7 of Panel 7

Similar mechanisms could cause melting of the reinforcement sheets in the downwind area. The reinforcement sheets at Row 11, Position 1 and Row 9, Position 3 are intact, but the reinforcement sheet at Row 9, Position 5 is missing. This behavior is consistent with the observation that the larger area with thermal effects on the MgO sacks and HDPE extends approximately 8 rows downwind from the breached drum.

The reentry teams also observed melting on the exposed edges and tabs of the HDPE slipsheets in the downwind area. It appears that the portion of the slipsheet beneath most drums is not melted, but this is difficult to verify because the drums obscure the slipsheets in the photographs. In summary, current observations indicate that a single drum (#68660) containing waste stream LA-MIN02-V.001 experienced an exothermic reaction and breached in Room 7 of Panel 7. High temperature was confined to the immediate area around the breached drum. Smaller temperature changes extended up to 8 rows downwind of the breached drum, judging by the presence of melted polypropylene sacks and missing HDPE reinforcement sheets up to 8 rows downwind of the breached drum.

4. Thermal Effects on Panel Closures

The potential for an exothermic reaction in a drum containing waste stream LA-MIN02-V.001 to impact the performance of initial and permanent panel closures is a function of their location relative to the waste emplacement areas and of their construction materials. As noted in Section 3, high temperature was confined to the immediate area around the breached drum, and lower temperature changes extended up to 8 rows downwind of the breached drum, judging by the presence of melted polypropylene sacks and missing HDPE reinforcement sheets.

4.1 Designs for the Initial Panel Closures

The proposed design for the Initial Closure in Panel 6 has two barriers: a substantial barrier and a barrier bulkhead, as shown in Figure 2. The substantial barrier consists of chainlink and brattice cloth curtains and a salt pile that are installed close to the waste face. The bulkhead will be constructed of steel and has a flexible plastic flashing that is bolted to the walls and roof of the entry. Collectively, the substantial barrier and bulkhead are referred to as the initial Panel 6 closure.

The design for Panel 6 (the “typical” design) includes a pile of mined salt from mining operations, as shown in Figure 2. The pile of mined salt will be pushed against the waste to at least the height of the bottom of the top row of waste, and the chainlink and brattice cloth curtains will be anchored in the salt pile. The salt pile will be at its natural angle of repose, and will be about 10-feet long at its base. The steel bulkhead will then be installed approximately 10-feet away from the toe of the run-of-mine (ROM) salt. The steel bulkhead will be a total of about 22-feet from the waste face, based on a 2-foot gap between the waste face and chainlink curtain, a 10-foot-long salt pile, and a 10-foot gap from the toe of the pile to the steel bulkhead. These dimensions are nominal; the final placement of the bulkhead will be determined by mine operations.

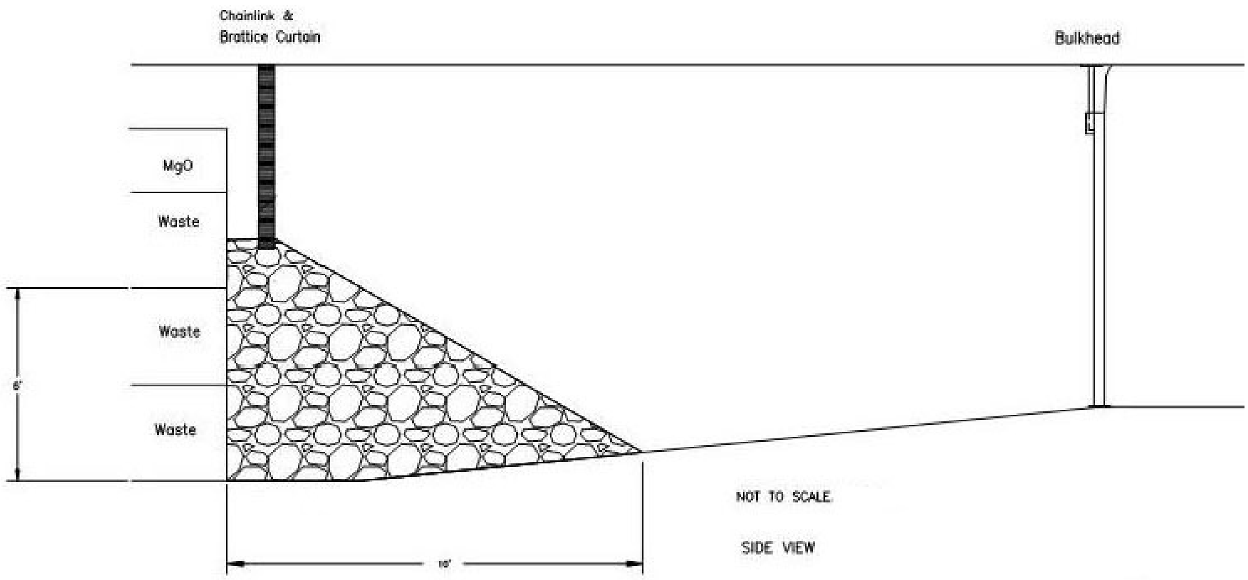


Figure 2. Schematic of the typical design for the initial panel closure system

The design in Figure 2 will not be used for Room 7 of Panel 7. The Permittees believe that it is critical to protect workers from exposure to any contamination that resulted from the Heat Event in Room 7 of Panel 7. The design of the Initial Closure has therefore been simplified for Room 7 of Panel 7. In particular, the salt pile will not be installed and the existing room (air) regulator bulkhead on the air exhaust side of Room 7 will not be removed in order to minimize risk to underground construction workers. There will then be two steel bulkheads on the air exhaust side of Room 7.

On the air intake side of Room 7, at South-2520, a steel bulkhead will be installed approximately 4 feet away from chainlink and brattice cloth curtains. This bulkhead is more than 400-feet away from the nearest waste containers because Room 7 is only partly filled with waste. On the air exhaust side of Room 7, at South-2180, the room regulator bulkhead will be left in place, and a (new) steel bulkhead will be installed approximately 8-feet from the regulator bulkhead. The (new) steel bulkhead will be a total of 11-feet from the waste face, based on a 2-foot gap between the waste face and chainlink curtain, a 1-foot gap between the curtain and the regulator bulkhead, and an 8-foot gap between the regulator and the steel bulkhead. These dimensions are nominal.

4.2 Thermal Effects on the Initial Panel Closures

The impact of any temperature changes on the steel bulkheads in the typical design will be mitigated by the location of these bulkheads and its materials:

- The steel bulkhead is about 22-feet away from the waste face for the typical design of the Initial Closure (see Figure 2). Since a row of waste in Figure 1 is approximately 3-feet wide, the 22-foot separation is equivalent to 7 rows of waste. As described in Section 3.2, thermal effects (melting polypropylene sacks) were observed up to 8 rows away from the breached drum on the downwind side. The steel bulkhead in the typical design is therefore on the boundary of the region with thermal effects, assuming a drum at the waste face has an exothermic reaction. The bulkhead would be well beyond the region with thermal effects if a drum inside the room, rather than on the waste face, has an exothermic reaction.

- The steel bulkhead is constructed of steel sheet, steel struts, and plastic flashing which are much more heat resistant than the thin polypropylene sacks containing MgO. The plastic flashing is 1-ply Nitril belting with a thickness of 3/64 inches (0.047 inches). It is a flame resistant material, stamped with Mine Safety and Health Administration (MSHA) approval number 28-53/10 (Zimmerly, 2014). Depending on the specific chemical composition, softening temperature can vary from 100°C for nitrile butadiene rubber (NBR) to about 150°C for highly saturated NBR (Minnesota Rubber and Plastics, 2014).

Given the minimum bulkhead separation of 22-feet from an ignited drum and the robustness of the materials in the steel bulkhead, thermal effects on the steel bulkhead from an ignited drum should be insignificant for the typical design of the Initial Closure.

For the Initial Closure of Room 7 in Panel 7, any thermal effects at the steel bulkhead are mitigated by the presence of the room (air) regulator bulkhead between it and the waste face and by the 11-foot separation of the bulkhead from the waste face. In effect, there are two steel bulkheads for the Initial Closure on the air exhaust side of Room 7, and the dual bulkheads will provide added mitigation of any thermal effects. On the air intake side of Room 7, the steel bulkhead is more than 400-feet away from the nearest waste containers, and any thermal effects will be mitigated by the large separation.

Given the presence of double steel bulkheads on the air exhaust side of Room 7 and the large separation of the bulkhead from the waste on the air intake side of Room 7, thermal effects from a Heat Event on the steel bulkhead for the initial panel closures in Room 7 of Panel 7 should be insignificant. No performance standard is required for temperature changes from the Heat Event for the Initial Closure designs.

4.3 Design for the Permanent Panel Closures

The proposed design for the permanent panel closures consists of 100-foot of mined salt, with bulkheads on the inbye and outbye sides of the salt (see Figure 3). The bulkheads are steel bulkheads with flexible flashing that is attached to the host rock. The mined salt will be generated by mining operations, without grading or compaction or addition of moisture. The mined salt will be pushed up to the back (roof) of the drift using standard mining equipment. Two Permanent Closures will be installed in each panel, one in the air intake drift and a second in the air exhaust drift. Collectively, the 100-feet of mined salt and the bulkheads are referred to as the permanent panel closure system.

4.4 Thermal Effects on the Permanent Panel Closures

Thermal effects on the permanent panel closure system will not be significant because of the location of the outbye steel bulkhead in the Permanent Closure. The Permittees do not take credit for the performance of the inbye bulkhead because creep closure of mine entries will deform the bulkhead and because the inbye bulkhead cannot be inspected after 100-feet of mined salt is installed. Thermal effects on the inbye bulkhead are not discussed further.

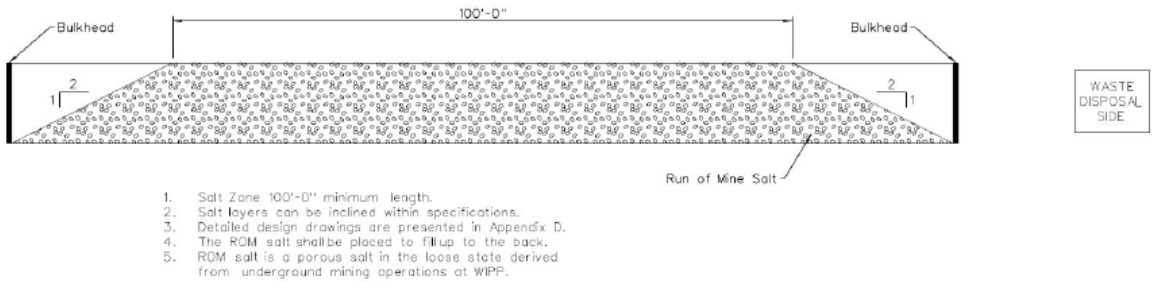


Figure 3. Schematic diagram of the permanent panel closure with 100-feet of mined salt between steel bulkheads on the inbye and outbye sides of the salt

A thermal pulse from an exothermic reaction in a drum containing waste stream LA-MIN02-V.001 will have no significant effect on the mined salt pile because of its large mass and because halite is insensitive to small changes in temperature. A thermal pulse will also have no significant effect on the outbye bulkhead because it is located at least 132-feet from the nearest drums in Room 1 of any panel. This estimate is based on a 22-foot separation from the waste face to the isolation barrier in the Initial Closure design, 100-feet of mined salt, and an estimated gap of 10-feet from the toe of the 100-foot-long salt pile to the outbye bulkhead. As observed after the Heat Event, thermal effects were limited to 8 rows or 24-feet from the breached drum. The outbye steel bulkhead is therefore unlikely to experience any damage from the thermal effects of a reacting drum.

In summary, the location and materials in the outbye steel bulkhead and 100-foot-long salt pile indicate that temperature changes at the 100-feet of mined salt and at the outbye bulkhead of the Permanent Closure are expected to be insignificant. No performance standard is required for temperature changes from the Heat Event for the Permanent Closure.

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Attachment C
Evaluation of Pressure Effects on Steel Bulkheads from a Future "Heat Event" in Room 1 of Panel 6 or Room 7 of Panel 7
September 29, 2014

Date: September 29, 2014

To: Rick Chavez

From: Michael Gross

Subject: Evaluation of Pressure Effects on Steel Bulkheads from a Future "Heat Event" in Room 1 of Panel 6 or Room 7 of Panel 7

Summary

On February 14, 2014, a drum containing waste stream LA-MIN02-V.001 had an exothermic reaction in Room 7 of Panel 7. An exothermic reaction can increase the pressure in a room by adding product gases to the existing air in a room and by increasing the gas temperature as the hot product gases mix with the cooler air at ambient temperature. This calculation provides an analysis of the pressure changes from an exothermic reaction in a single drum containing waste stream LA-MIN02-V.001 in Room 1 of Panel 6 or Room 7 of Panel 7.

The predicted pressure changes resulting from an exothermic reaction of a single drum containing waste stream LA-MIN02-V.001 are 0.13 to 0.17 psi in Room 1 of Panel 6 and 0.07 psi to 0.09 psi in Room 7 of Panel 7. The range encompasses reactions for five nitrate salts: calcium nitrate, magnesium nitrate, potassium nitrate, iron nitrate, and sodium nitrate. The pressure changes in Room 1 of Panel 6 and Room 7 of Panel 7 differ because the free volume is greater in Room 7 than in Room 1 and because the average nitrate mass in a drum is greater in Room 7 than in Room 1.

Within each room, these results confirm that the predicted pressure change is insensitive to the composition of nitrate salts in a drum. The predicted pressure change is also insensitive to modest changes in temperature of the product gases. For example, if the temperature of the product gases increases by 50°C, from 300K to 350K, then the maximum pressure change in Room 1 of Panel 6 increases from 0.17 psi to 0.20 psi.

The analysis makes three assumptions which tend to overestimate the pressure: (1) the potential for product gases to leak around the steel bulkheads at the ends of Room 1 of Panel 6 and of Room 7 of Panel 7 is ignored, meaning leakage is not taken into account as a means of relieving the pressure; (2) the Nitrate Mass in a drum reacts completely which maximizes the amount of gas produced. This assumption is made even though the masses of nitrate salts and desiccant may not be in the proper stoichiometric balance for a complete reaction; and (3) the Nitrate Mass in a drum reacts instantaneously which maximizes the time-related effect of the pressure. It is not possible to quantify the degree of conservatism in these assumptions, but they do provide a bounding calculation for the predicted pressure changes due to a single drum of waste.

1. Introduction

On February 14, 2014, a single drum, LA00000068660 (#68660), containing nitrate-salt-bearing waste from waste stream LA-MIN02-V.001 had an exothermic reaction in Room 7 of Panel 7. After ignition, the reaction products increased the internal pressure in the drum until a portion of the lid separated from the drum, resulting in a release of radioactive particulates into the ventilation air stream. After an underground Continuous Air Monitor (CAM) detected the presence of radioactivity in the air flow, the ventilation system shifted from normal mode to filtration mode. In filtration mode, ventilation air passes through HEPA filters before being released to the atmosphere. The WIPP ventilation system has remained in filtration mode since the radiation release. The exothermic reaction in drum #68660 and its consequences are referred to as the “Heat Event” in this document.

After this event, the New Mexico Environment Department (NMED) issued an administrative order requiring the WIPP Permittees to prepare a *WIPP Nitrate Salt Bearing Waste Isolation Plan* with a detailed proposal for the expedited closure of Panel 6 and of Room 7 in Panel 7 (NMED 2014, Section 22a, items i and iii). The expedited closures are intended to provide additional isolation of drums containing waste stream LA-MIN02-V.001 until Permanent Closures can be installed in Panel 6 and Panel 7. Panel 6 is a concern to NMED because it has 313 drums containing waste stream LA-MIN02-V.001. These expedited closures are called Initial Closures in this document to distinguish them from the longer-term Permanent Closures for each waste-filled panel.

This document presents a description of the “Heat Event” and provides an evaluation of the magnitude of the pressure change on the steel bulkheads in the Initial and Permanent Closures if a second “Heat Event” were caused by a single drum containing waste stream LA-MIN02-V.001. This analysis considers an exothermic reaction in a single drum because observations and analysis of the “Heat Event” in Room 7 of Panel 7 indicate that the region with high temperature changes is centered on a single drum which could have caused the observed thermal damage in Room 7 (NWP, 2014, Section 3.1).

2. Chemistry of the LA-MIN02-V.001 Waste Stream

2.1 Reaction of Waste Stream LA-MIN02-V.001

The drum (#68660) that ignited in Room 7 contained nitrate-salt-bearing waste that was mixed with a desiccant called Swheat Scoop, a wheat-based organic kitty litter. The exothermic reaction in drum #68660 is assumed to follow a simple reaction chemistry, with the nitrate salts acting as an oxidizer and the Swheat Scoop providing the fuel for the reaction. The organic fuel is represented as cellulose, with a generic formula of $C_6H_{10}O_5$, in the chemical reactions with nitrate salts.

The composition of the nitrate salts is estimated from laboratory analysis of lean residues of nitrate salts from evaporator bottoms for two relevant LANL waste streams. Calcium and magnesium nitrate salts have the greatest cation concentrations (61 g/l and 58.7 g/l, respectively) by mass or by moles (Veazey et al., 1996, Appendix 1). The potassium, iron, and sodium nitrate salts are also included in this analysis because they have cation concentrations significantly above trace levels (17.6 g/l, 17.0 g/l, and 7.4 g/l, respectively). The nitrate salts present in the lean residues provide a good basis for this analysis because the reaction of nitrates with cellulose/starch in the desiccant doesn't vary significantly with the individual nitrate salt and because the cellulose/starch, rather than the nitrate salt, provides most of the energy released in the reactions.

2.2 Nitrate Mass in Drums Containing Waste Stream LA-MIN02-V.001

Drums containing waste stream LA-MIN02-V.001 have been emplaced in Rooms 1 and 2 of Panel 6 and in Room 7 of Panel 7. In the WIPP underground layout, Room 1 is closest to the exhaust main and is the last room in a panel to be filled with waste; Room 7 is farthest from the exhaust main and is the first room to be filled with waste.

Table 1 summarizes statistical data for drums containing LA-MIN02-V.001 (Pearcy, 2014) (Walentine, 2014). The Waste Mass is the total mass in a container and the Nitrate Mass is the mass of solidified nitrate salts, including any desiccant or absorbent that was added. Table 1 presents average, minimum, and maximum values of these parameters for the drums with waste stream LA-MIN02-V.001.

Table 2. Data for drums containing waste stream LA-MIN02-V.001

Location	No. of Drums	Waste Mass (kg)			Nitrate Mass (kg)			Fill Factor (%)		
		Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Room 1 of Panel 6	222	86.9	2.3	206.1	74.9	0.0	194.0	74.6	20	100
Room 2 of Panel 6	91	67.6	1.8	155.1	50.6	0.0	143.1	69.9	15	95
Total in Panel 6	313	81.3	1.8	206.1	67.9	0.0	194.0	73.3	15	100
Room 7 of Panel 7	55	96.0	9.4	197.6	84.5	7.2	165.6	74.3	20	100
Total in Panel 7	55	96.0	9.4	197.6	84.5	7.2	165.6	74.3	20	100

Sources: (Pearcy, 2014) and (Walentine, 2014)

The average Nitrate Mass is the basis for estimating the mass of combustion gases produced by reaction of waste stream LA-MIN02-V.001 in a single drum. The Nitrate Mass is appropriate because it represents the combined mass of oxidizer and fuel in the drum. This approach is consistent with calculations in the WIPP Hazardous Waste Permit, which are often based on average values. The values in the highlighted cells in Table 1 have been used to estimate gas production in Room 1 of Panel 6 and in Room 7 of Panel 7.

3. Pressure Change from Ignition of a Single Drum Containing Waste Stream LA-MIN02-V.001

An exothermic reaction can increase the pressure in a room by adding product gases to the existing air in a room and by increasing the gas temperature as the hot product gases mix with the cooler air at ambient temperature. This latter effect is not expected to be significant because the product gases represent a small fraction of the existing moles of air in a room and because the pressure change is insensitive to temperature changes. These features of the system are demonstrated in Section 3.3 for sodium nitrate and in Section 3.4 for the other nitrate salts.

The calculated pressure increase ignores the potential flow of product gases through the chainlink and brattice cloth curtains and isolation (steel) bulkheads for the Initial Closure design. The calculation also assumes complete and instantaneous reaction of the total Nitrate Mass in a drum. These are reasonable assumptions because they maximize the pressure increase from the product gases.

3.1 Reaction Chemistry of Nitrate Salts and Organic Desiccant

The reaction of sodium nitrate with cellulose has been postulated to follow a one-to-one carbon-to-nitrogen molar ratio (Smith et al., 1999):

$$6NaNO_3 + C_6H_{10}O_5 \rightarrow 3Na_2CO_3 + 3CO_2 + 5H_2O + 2N_2 + N_2O + O_2. \qquad (1)$$

The principal product gases were confirmed by experimental work at Pacific Northwest National Laboratory (PNNL) (Scheele et al., 2007, Section 3.4). The residual gas in the PNNL testing contained 49.8 mol% nitrogen, 44.4 mol% carbon dioxide, 5.5 mol% N_2O, and traces of other gases (Scheele et al., 2007, Table 3.5). These data confirm the presence of the principal product gases in Equation (1), although the mole percentages are different. For example, the PNNL data show a 10:1 ratio of nitrogen to nitrous oxide, but Equation (1) predicts a 2:1 ratio of N_2:N_2O (or a 4:1 ratio for N:N_2O). Equation (1) has been used to estimate gas production because it includes the principal product gases and because it represents current understanding of the stoichiometry.

3.2 Free Volume for Combustion Gases

The reaction product gases will expand and mix with the cooler air in the free volume in a room. The free volumes in Room 1 of Panel 6 and in Room 7 of Panel 7 are calculated as the difference between total room volume and the combined volumes of all contact-handled (CH) waste containers and all sacks of magnesium oxide (MgO) in the room. Remote-handled (RH) waste containers are not included in this calculation because RH waste containers were emplaced in the walls and do not affect the free volume within the room.

Room 1 of Panel 6 is 111.56-m (366-ft) long, 10.06-m (33-ft) wide, and 3.96-m (13-ft) high (SNL 1992, Figure 3.1-3), for a total room volume of (111.56 m)(10.06 m)(3.96 m) = 4,444 m^3. Room 1 is smaller than Rooms 2 through 7 because it does not include space for waste emplacement in the access drifts between rooms. There are a total of 2,436 CH waste containers in Room 1 with a total external volume of 1,115 m^3, based on a query of the WIPP Data System (WDS) on August 27, 2014 (Offner, 2014).

There are a total of 142 3,000-lb sacks of MgO and 22 4,200-lb sacks of MgO in Room 1 of Panel 6, based on the same WDS query. The MgO sacks have a total volume of 47.6 ft^3 (1.35 m^3) (WTS, 2009, Section 3.3.2.B). Assuming that 4,200-lbs of MgO fills a sack and that 3,000 lbs of MgO fills (3,000)/(4,200) = 0.714 = 71.4% of the sack, the total volume of MgO sacks is calculated as 142(0.714)(1.35 m^3) + 22(1.0)(1.35 m^3) = 167 m^3.
The free volume in Room 1 of Panel 6 is then calculated as:

$V_{free,\ R1P6}$ = 4,444 m^3 – 1,115 m^3 – 167 m^3, (2)
= 3,162 m^3
~ 3,160 m^3.

The free volume in Room 1 is approximately 71% of the total volume of Room 1.

The total volume of Room 7 of Panel 7 has two components: the main room volume plus the volumes of the two access drifts between Room 7 and Room 6. The main room volume is given by Equation (2). Each access drift is 30.5-m (100-ft) long between main rooms, 10.06-m (33-ft) wide, and 3.96-m (13-ft) high (SNL, 1992, Figures 3.1-2 and 3.1-3). The volume in the two access drifts is then 2(30.5 m)(10.06 m)(3.96 m) = 2,430 m^3. The total room volume for Room 7 of Panel 7 is then 4,444 m3 + 2,430 m3 = 6,874 m^3.

There are a total of 639 CH waste containers in Room 7 with a total external volume of 268 m^3, based on the recent WDS query (Offner, 2014). There are a total of 13 3,000-lb sacks of MgO and 21 4,200-lb sacks of MgO in Room 1 of Panel 6, with a volume of 13(0.714)(1.35 m^3) + 21(1.0)(1.35 m^3) = 40.9 m^3. The free volume in Room 7 of Panel 7 is then calculated as:

$V_{free,\ R7P7}$ = 6,874 m^3 – 268 m^3 – 40.9 m^3, (3)
= 6,565 m^3,
~ 6,570 m^3.

The free volume in Room 7 of Panel 7 is approximately 96% of the total volume in this room. This high percentage is consistent with the fact that waste in Room 7 has only been emplaced in the access drift on the exhaust side of the room.

3.3 Detailed Pressure Calculations for Reaction of One Drum Containing Sodium Nitrate and Cellulose

The reaction of sodium nitrate with cellulose is postulated to follow a one-to-one carbon-to-nitrogen molar ratio, as explained in Section 3.1:

$$6NaNO_3 + C_6H_{10}O_5 \rightarrow 3Na_2CO_3 + 3CO_2 + 5H_2O + 2N_2 + N_2O + O_2. \quad (1)$$

The stoichiometric reaction parameters for Equation (1) are summarized in Table 2. In Table 2, “Mass” refers to the total mass of an individual reactant or product, and “Mass Balance” compares the total mass on both sides of the reaction. The exact values of physical constants were used for the calculations in this section, based on handbooks and other sources. The input values (such as the molecular weights in Table 2), intermediate results, and final results have been rounded to three or four significant digits for presentation purposes. Any small discrepancies in the Tables are due to this round off process.

Table 3. Reaction parameters for sodium nitrate with cellulose in Room 1, Panel 6

	$6NaNO_3$	+	$C_6H_{10}O_5$	→	$3Na_2CO_3$	+	$3CO_2$	+	$5H_2O$	+	$2N_2$	+	N_2O	+	O_2
Mol. Wt.*	84.99		162.1		106.0		44.01		18.02		28.01		44.01		32.00
Mass (g)	509.9	+	162.1	→	318.0	+	132.0	+	90.08	+	56.03	+	44.01	+	32
Mass Balance	672.1				672.1										
Reaction Multiplier	Ratio of Average Nitrate Mass in a Drum to the Mass of Reactants in Eqn. (1) = (74,900 g)/(672.1 g) = 111.4														

*CRC, 1983. Molecular weights have been rounded to 4 significant digits for this table. Calculations were performed with the exact values from the handbook, and rounded for presentation purposes.

The average nitrate mass of a 55-gallon drum loaded with waste stream LA-MIN02-V.001 is 74.9 kg (74,900 g) in Room 1 of Panel 6 (see first shaded cell in Table 1). Since the total mass on each side of Equation (1) is 672.1 g (see Table 2), the "reaction multiplier" on Equation (1) that corresponds to the average Nitrate Mass of 1 drum in Room 1 is (74,900 g)/(672.1 g) = 111.4. The complete reaction of 1 drum of waste stream LA-MIN02-V.001 with the average Nitrate Mass produces (111.4 × 3) = 334 moles of CO_2, (111.4 × 5) = 557 moles of water vapor, (111.4 × 2) = 223 moles of N_2, (111.4 × 1) = 111.4 moles N_2O, and (111.4 × 1) = 111.4 moles O_2. The total moles of product gases is (334+557+223+111.4+111.4)) ~ 1,340 moles. The total moles of product gases could be significant less than this value if some Nitrate Mass remains unreacted. Each of the product gases will mix with the air and expand into the free volume in Room 1. The free volume in Room 1 is 3,160 m^3, based on Equation (2). The temperature of the expanded product gases from Equation (1) is assumed to be the ambient temperature of the host rock in the underground facility, 27°C (300K). This is a reasonable assumption because the product gases are a small mass fraction of the ambient air in the free volume, as shown next.

The moles of air in the free volume of Room 1, $n_{air,R1P6}$, are calculated from the ideal gas law:

$$\begin{aligned} n_{air,R1P6} &= \frac{PV}{RT}, \\ &= \frac{(101{,}300\,Pa)(3{,}160\,m^3)}{(8.315\,j/mol/K)(300\,K)}, \qquad (4) \\ &= 128{,}000\,mol. \end{aligned}$$

The reaction of 1 drum containing the average mass of sodium nitrate salts and desiccant produces 1,340 moles of combustion gases, assuming complete oxidation. The product gases are then (1,340 moles/128,000 moles) ~ 1 mol% of the moles of air in a room. The combustion gases will have a minor impact on temperature and pressure in a room.

The partial pressures from the individual product gases in Equation (1) for Room 1 of Panel 6 are calculated from the ideal gas law:

$$P = \frac{nRT}{V},$$
$$P_{CO2} = \frac{n_{CO2}(8.315\ j/mol/K)(300K)}{(3160m^3)} = \frac{(334mol)(8.315\ j/mol/K)(300K)}{(3160m^3)} = 264Pa,$$
$$P_{H2O} = \frac{n_{H2O}(8.315\ j/mol/K)(300K)}{(3160m^3)} = \frac{(557mol)(8.315\ j/mol/K)(300K)}{(3160m^3)} = 440Pa,$$
$$P_{N2} = \frac{n_{N2}(8.315\ j/mol/K)(300K)}{(3160m^3)} = \frac{(223mol)(8.315\ j/mol/K)(300K)}{(3160m^3)} = 176Pa, \quad (5)$$
$$P_{N2O} = \frac{n_{N2}(8.315\ j/mol/K)(300K)}{(3160m^3)} = \frac{(111.4mol)(8.315\ j/mol/K)(300K)}{(3160m^3)} = 88Pa,$$
$$P_{O2} = \frac{n_{N2}(8.315\ j/mol/K)(300K)}{(3160m^3)} = \frac{(111.4mol)(8.315\ j/mol/K)(300K)}{(3160m^3)} = 88Pa.$$

The increase in pressure, ΔP, from the product gases is the sum of their partial pressures:

$$\begin{aligned} \Delta P &= P_{CO2} + P_{H2O} + P_{N2} + P_{N2O} + P_{O2}, \\ &= 264Pa + 440Pa + 176Pa + 88Pa + 88Pa, \\ &\sim 1{,}060\ Pa, \\ &= 0.15\ psi. \end{aligned} \quad (6)$$

Complete reaction of 1 drum containing the average loading of sodium nitrate salt and cellulose results in a pressure increase of 0.15 psi above the ambient air pressure in Room 1 of Panel 6. Water vapor from the reaction products could potentially condense as it expands and cools to 300K. Liquid water can remain condensed if the partial pressure of water vapor from the product gases is greater than the equilibrium vapor pressure above the liquid at 27°C (300K). The partial pressure of water vapor from Equation (5) is 440 Pa, which is less than the equilibrium vapor pressure above liquid water at 27°C, 3,565 Pa (CRC, 1983). In this situation, condensation of water vapor will not reduce the partial pressure of the product gases.

The calculation of the individual pressure increases in Equation (5) is insensitive to changes in the final temperature of the product gases. For example, if the temperature of the product gases increases by 50°C, from 300K to 350K, then the pressure changes in Equation (5) increase by a factor of (350K/300K), or 16.7%. The total pressure change in Equation (6) increases from 0.15 psi to 0.18 psi. This result confirms that modest changes in the temperature of the expanded product gases have a minor impact on the predicted pressure change.

3.4 Detailed Pressure Calculations for Reaction of One Drum Containing Other Nitrate Salts and Cellulose

The analogs of Equation (1) for calcium nitrate, magnesium nitrate, potassium nitrate, and iron nitrate salts are as follows:

$$3Ca(NO_3)_2 + C_6H_{10}O_5 \rightarrow 3CaCO_3 + 3CO_2 + 5H_2O + 2N_2 + N_2O + O_2, \quad (7)$$

$$3Mg(NO_3)_2 + C_6H_{10}O_5 \rightarrow 3MgCO_3 + 3CO_2 + 5H_2O + 2N_2 + N_2O + O_2, \quad (8)$$

$$6KNO_3 + C_6H_{10}O_5 \rightarrow 3K_2CO_3 + 3CO_2 + 5H_2O + 2N_2 + N_2O + O_2, \quad (9)$$

and $$3Fe(NO_3)_2 + C_6H_{10}O_5 \rightarrow 3FeCO_3 + 3CO_2 + 5H_2O + 2N_2 + N_2O + O_2. \quad (10)$$

Table 3 summarizes the key stoichiometric parameters, partial pressures, and total pressure for reaction of the various nitrate salts and cellulose, as defined by Equation (1) and by Equations (7) through (10). The methodology for these calculations is identical to the approach in Section 3.3. Pressure of individual gases is calculated with the ideal gas law and total pressure is based on the sum of the partial pressures. The total pressure change for the five nitrates lies within a narrow range of 0.13 psi to 0.17 psi. Table 3 includes the results for sodium nitrate for completeness.

Table 4. Stoichiometric parameters, partial pressures, and total pressure change for product gases from the reaction of one drum of nitrate salts in Room 1 of Panel 6

Nitrate Salt	Mass of Reactants (g)	Reaction Multiplier (-)	Pressure CO_2 (Pa)	Pressure H_2O (Pa)	Pressure N_2 (Pa)	Pressure N_2O (Pa)	Pressure O_2 (Pa)	Total Pressure Change (Pa)	(psi)
$Ca(NO_3)_2$	654.4	114.5	271	452	181	90	90	1,084	0.16
$Mg(NO_3)_2$	607.1	123.4	292	487	195	97	97	1,168	0.17
KNO_3	768.8	97.4	231	384	154	77	77	922	0.13
$Fe(NO_3)_2$	701.7	106.7	253	421	168	84	84	1,011	0.15
$NaNO_3$	672.1	111.4	264	440	176	88	88	1,055	0.15

Table 4 summarizes the predicted pressure increases and moles of product gases for the reactions of the five nitrate salts and cellulose. The product gases account for between 0.9 mol% and 1.2 mol% of the total moles of air in a room. The product gases are a small fraction of the air mass in a room and will not significantly raise the temperature in the room, as stated previously.

Table 5. Pressure change and moles of product gases from the reaction of one drum of nitrate salts in Room 1 of Panel 6

Nitrate Salt	Pressure Change		Product Gases	Product Gases : Air
	(Pascals)	(psi)	(Moles)	(Mol%)
$Ca(NO_3)_2$	1,084	0.16	1,370	1.1%
$Mg(NO_3)_2$	1,168	0.17	1,480	1.2%
KNO_3	922	0.13	1,170	0.9%
$Fe(NO_3)_2$	1,011	0.15	1,280	1.0%
$NaNO_3$	1,055	0.15	1,340	1.0%

The results in Table 4 confirm that the pressure change is insensitive to the composition of nitrate salts in a drum, as stated previously. The calculated pressure changes are also insensitive to changes in temperature of the product gases. For example, if the temperature of the product gases increases by 50°C, from 300K to 350K, then the pressure changes in Table 4 increase by a factor of (350K/300K), resulting in a maximum value of 0.20 psi. This result confirms that modest temperature increases in the reaction product gases have only a minor impact on the analysis.

The ambient pressure in the underground facility will be slightly greater than atmospheric pressure at the surface because of the downcast ventilation flow in the air intake shaft. This difference is not significant for these calculations because it is the changes in pressure due to the product gases that are important for determining mechanical loads on the steel bulkheads.

Room 7 of Panel 7 will have a different pressure increase because of two factors: (1) the average Nitrate Mass in Room 7 is 84.5 kg, which is greater than the average Nitrate Mass in Room 1 of Panel 6, 74.9 kg (see shaded cells in Table 1); and (2) the free volume in Room 7 is 6,570 m^3, which is greater than the free volume in Room 1 of Panel 6, 3,160 m^3 (compare Equations (2) and (3)). The first factor will increase the pressure of product gases, while the second factor will reduce the pressure of the product gases. The net change in pressure for Equations (5) and (6) is defined by the product of the ratios of these changes:

$$\begin{aligned} \Delta P_{R7P7} &= \left(\frac{84.5\,kg}{74.9\,kg}\right)\left(\frac{3{,}160\,m^3}{6{,}570\,m^3}\right)\Delta P_{R1P6}, \\ &= 0.543\,\Delta P_{R1P6}. \end{aligned} \qquad (11)$$

Correcting the values in the second and third columns of Table 4 for the scaling factor of 0.543, the pressure increases in Room 7 of Panel 7 are presented in Table 5. The last two columns in Table 5 are computed using the same methodology as in Section 3.3.

The total pressure increase above ambient pressure is between 0.07 to 0.09 psi, with the assumption that no product gas leaks out of the Initial Closures in Room 7 of Panel 7.

Table 6. Pressure Change and Moles of Product Gases Generated by the Reaction of Various Nitrate Salts in One Drum in Room 7 of Panel 7

Nitrate Salt	Pressure Change		Product Gases (Moles)	Product Gases : Air (Mol%)
	(Pascals)	(psi)		
$Ca(NO_3)_2$	589	0.09	1,550	0.6%
$Mg(NO_3)_2$	635	0.09	1,670	0.6%
KNO_3	501	0.07	1,320	0.5%
$Fe(NO_3)_2$	549	0.08	1,450	0.5%
$NaNO_3$	573	0.08	1,510	0.6%

4. Conservatisms in the Analysis

The analysis of pressure changes from the exothermic reaction of waste stream LA-MIN 02-V.001 in a single drum has three conservative assumptions:

- The analysis assumes that all the Nitrate Mass in the drum reacts according to Equation (1). However, it is likely that some Nitrate Mass remains unreacted because the initial mass ratio of nitrate salts to cellulose may not be in the proper balance for a complete stoichiometric reaction or because the coarse particles of the desiccant (Swheat Scoop) may not react completely.
- The potential for gas to leak around the steel bulkheads at the ends of Room 1 of Panel 6 and of Room 7 of Panel 7 is ignored in the analysis because of the assumption that the reaction is instantaneous.

- The analysis assumes that the reaction in Equation (1) occurs instantaneously. In reality, it is likely that the reaction continues for perhaps several minutes after initiation because the coarse particles of desiccant (Swheat Scoop) have a limited surface area and cannot react instantaneously. A longer duration for the reaction enhances the potential for gas to leak around the steel bulkheads.

Each of these assumptions could reduce the total moles of product gases or the predicted pressure change. It is not possible to quantify the degree of conservatism in these bounding assumptions.

5. References

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Attachment D

Mitigation of Gas Buildup from a "Heat Event" in Room 7 of Panel 7 or near Room 1 of Panel 6
May 11, 2015

Date: May 11, 2015

To: Rick Chavez

From: Michael Gross

Subject: Mitigation of Gas Buildup for Workers near Room 7 of Panel 7 or near Room 1 of Panel 6

Summary

On February 14, 2014, a drum containing waste stream LA-MIN02-V.001 had a runaway thermal reaction in Room 7 of Panel 7. This exothermic reaction converted a portion of the waste into various gases that were released into Room 7 when the drum lid breached (opened) due to high internal gas pressure. An analysis of the resulting pressure changes in Room 7 was submitted to the New Mexico Environment Department (NMED) as part of the Waste Isolation Pilot Plant Nitrate Salt Bearing Waste Container Isolation Plan (DOE and NWP, 2014, Attachment C). Revision 1 of this Plan was submitted to the NMED by "the Permittees" (U.S. Department of Energy and Nuclear Waste Partnership LLC) on September 30, 2014. The NMED approved Revision 1 of the Plan, with the exception of the proposed activities for the permanent closure of Panel 6, in a letter dated March 30, 2015 (NMED 2015). In this letter, the NMED directed the Permittees to update Revision 1 of the Plan to include "*an expanded discussion on how gas buildup in Panel 7, Room 7 will be mitigated while workers are in Panel 7, Room 6.*"

This memorandum provides the expanded discussion required by the NMED, based on a bounding analysis for gas buildup. The bounding analysis assumes that the Nitrate Mass in three drums reacts simultaneously and completely. The results and conclusions from the Technical Assessment Team (SRNL 2015) and the Accident Investigation Board (DOE 2015) have been used to quantify the conservatisms in the bounding analysis. Although the NMED did not request a similar analysis for Room 1 of Panel 6, it is also provided in this memorandum.

The predicted pressure changes from the bounding analysis are 0.22 to 0.29 psi in Room 7 of Panel 7. The Closure for Room 7 of Panel 7 includes steel bulkheads with flexible plastic flashing that is anchored to the sides and roof of the entries to Room 7. The WIPP Mine Ventilation Plan specifies that the bulkhead's upper operating pressure range is 0.47 psi (13.0 in. water gauge) with the filtration fan that is currently operating (NWP, 2015, Table 1). This upper limit (0.47 psi) is greater than the transient pressure changes predicted by the bounding analysis for Room 7. The steel bulkheads in the Room 7 Closure are therefore expected to remain intact, and the intact bulkheads will mitigate worker exposure to any gas buildup caused by future exothermic reactions or breached drums in Room 7 of Panel 7.

A similar bounding analysis for Room 1 of Panel 6 predicts pressure changes of 0.40 to 0.54 psi. These predicted pressure changes are approximately equal to the steady–state operating pressure differential of 0.47 psi for a steel bulkhead. However, the bulkheads are still expected to remain

intact because the bounding analysis overestimates the gas buildup and pressure changes by at least a factor of 5.5, as discussed in Section 3.6 of this memorandum. This factor of 5.5 can be interpreted as providing a substantial safety factor in the performance and stability of the steel bulkheads in the Closure for Panel 6. Furthermore, the steady state pressure is not a limit for bulkhead operation, simply the result of air pressure created by the ventilation system. Bulkheads are known to withstand higher transient pressures for short periods of time during ventilation adjustments and system rebalancing. In addition, once bulkheads are installed and ventilation through the disposal room is blocked, static pressure on the bulkheads is negligible. The steel bulkheads in the Closure for Panel 6 are therefore expected to remain intact, and will mitigate worker exposure to gas buildup caused by future exothermic reactions or breached drums in Room 1 of Panel 6.

Installation of the Closure for Panel 6 was completed on May 8, 2015, providing added assurance for the protection of workers and the public in the event that a runaway thermal reaction occurs in another drum containing the LA-MIN02-V.001 waste stream.

1. Introduction

On February 14, 2014, a single drum, LA00000068660 (#68660), containing nitrate-salt-bearing waste from the LA-MIN02-V.001 waste stream had an exothermic reaction in Room 7 of Panel 7. After ignition, the reaction products increased the internal pressure in the drum until a portion of the lid separated from the drum, resulting in a release of hot combustion gases and radioactive particulates into the ventilation air stream. The Technical Assessment Team report characterizes this reaction as a “runaway thermal reaction” that was initiated internally and not caused by phenomena outside Drum #68660 (SRNL 2015, page 13 and Sections 4.2 and 4.4).

After this event, the NMED issued an administrative order requiring the Permittees to prepare a *WIPP Nitrate Salt Bearing Waste Isolation Plan* with a detailed proposal for the expedited closure of Panel 6 and of Room 7 in Panel 7 (NMED, 2014, Section 22a, items i and iii). The expedited closures, called “Closures” in this document, are intended to provide additional isolation of these drums until Permanent Closures can be installed in Panel 6 and Panel 7.

Section 2 of this document describes the reactive components of the LA-MIN02-V.001 waste stream and the assumptions for the bounding analysis of gas buildup. Section 3 describes the reaction chemistry and the calculations of gas buildup and pressure change for Room 7 of Panel 7 and for Room 1 of Panel 6. Section 4 describes the Closures and how they will mitigate the effects of gas buildup for workers in Room 6 of Panel 7 or near Room 1 of Panel 6.

2. Chemistry of the LA-MIN02-V.001 Waste Stream

2.1 Reaction of the MIN02 Waste Stream

The drum (#68660) that had a runaway thermal reaction in Room 7 contained metal-nitrate-salt-bearing waste, a desiccant called Swheat Scoop, which is a wheat-based organic kitty litter, a neutralization reagent (KolorSafe®), and other waste items, including plastic bags and a glove-box glove (SRNL, 2015, Section 4.1 and Figure 4-1). The exothermic reaction in drum #68660 is based on the metal nitrate salts acting as an oxidizer and the Swheat Scoop providing the fuel for the reaction. Swheat Scoop is 65-70% starch by dry weight (SRNL, 2015, page 26), and is represented by a generic formula for starch, $C_6H_{10}O_5$, in the chemical reactions for LA-MIN02-V.001 waste.

The composition of the metal nitrate salts is estimated from laboratory analysis of lean residues of nitrate salts from evaporator bottoms for two relevant LANL waste streams. Calcium and magnesium nitrate salts have the greatest cation concentrations (61 g/l and 58.7 g/l, respectively) by mass or by moles (Veazey et al., 1996, Appendix 1). The potassium, iron, and sodium nitrate salts are also included in this analysis because they have cation concentrations significantly above trace levels (17.6 g/l, 17.0 g/l, and 7.4 g/l, respectively).

2.2 Definition of the Bounding Analysis

Table 1 summarizes inventory data for drums containing LA-MIN02-V.001 waste in Panels 6 and 7 (Pearcy, 2014) (Walentine, 2014). The Waste Mass is the total mass in a container and the Nitrate Mass is the mass of solidified nitrate salts, including any desiccant or absorbent that was added. Nitrate Mass was estimated based on data from the characterization process and on the empty and full weights of individual drums (Pearcy, 2015). Table 1 presents average, minimum, and maximum masses in each room. The bounding analyses are based on the average Nitrate Mass for Room 7 of Panel 7 or for Room 1 of Panel 6 (see colored cells in Table 1).

Table 7. Data for drums containing waste stream LA-MIN02-V.001

Location	No. of Drums	Waste Mass (kg)			Nitrate Mass (kg)			Fill Factor (%)		
		Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Room 1 of Panel 6	222	86.9	2.3	206.1	74.9	0.0	194.0	74.6	20	100
Room 2 of Panel 6	91	67.6	1.8	155.1	50.6	0.0	143.1	69.9	15	95
Total in Panel 6	313	81.3	1.8	206.1	67.9	0.0	194.0	73.3	15	100
Room 7 of Panel 7	55	96.0	9.4	197.6	84.5	7.2	165.6	74.3	20	100
Total in Panel 7	55	96.0	9.4	197.6	84.5	7.2	165.6	74.3	20	100

Sources: (Pearcy, 2014) and (Walentine, 2014)

The bounding analysis assumes that three drums containing the average nitrate mass per drum react simultaneously and completely. With this assumption, the total reactive Nitrate Mass in Room 7 of Panel 7 is 3×84.5 kg = 253.5 kg. This total reactive mass is 53% greater than the maximum Nitrate Mass in a single drum in Room 7, which is 165.6 kg. The total reactive Nitrate Mass in Room 1 of Panel 6 is 3×74.9 = 224.7 kg. This reactive mass is 16% greater than the maximum Nitrate Mass in a single drum in Room 1 of Panel 6 and 57% greater than the maximum Nitrate Mass in a single drum in Room 2 of Panel 6. Room 1 of Panel 6 is more relevant for gas buildup calculations than Room 2 because Room 1 is closer to any personnel who might be performing closure or maintenance activities in the access drifts to Panel 6.

3. Gas Buildup and Pressure Change from Ignition of Three Drums in Room 7, Panel 7

A runaway thermal reaction can increase the pressure in a closed room by adding product gases to the existing air in a room at a rate that exceeds any leakage from the room and by increasing the overall gas temperature as the hot product gases mix with the cooler air at ambient temperature. This latter effect is not expected to be significant because the product gases represent a small fraction of the existing moles of air in a room, as shown in Section 3.3 for sodium nitrate and in Section 3.4 for the other metal nitrate salts.

3.1 Reaction Chemistry of Nitrate Salts and Organic Desiccant

The reaction of sodium nitrate with starch has been postulated to follow Equation (1) for a one-to-one carbon-to-nitrogen molar ratio (Smith et al., 1999):

$$6NaNO_3 + C_6H_{10}O_5 \rightarrow 3Na_2CO_3 + 3CO_2 + 5H_2O + 2N_2 + N_2O + O_2. \qquad (1)$$

The principal product gases were confirmed by experimental work at Pacific Northwest National Laboratory (PNNL) (Scheele et al., 2007, Section 3.4). The residual gas in the PNNL testing contained 49.8 mol% nitrogen, 44.4 mol% carbon dioxide, 5.5 mol% N_2O, and traces of other gases (Scheele et al., 2007, Table 3.5). These data confirm the presence of the principal product gases in Equation (1), although the mole percentages are different than Equation (1). Equation (1) has been used to estimate gas production because it includes the principal product gases and because it is based on experimental data.

3.2 Free Volume for Reaction Product Gases

The free volumes in Room 1 of Panel 6 and in Room 7 of Panel 7 are calculated as the difference between excavated room volume and the combined volumes of all contact-handled (CH) waste containers and all sacks of magnesium oxide (MgO) in the room. Remote-handled (RH) waste containers are not included in this calculation because RH waste containers were emplaced in the walls and do not affect the free volume within the room. The porosity of the MgO pellets within each sack also provides some free volume, but this small correction is ignored in this analysis.

Room 1 of Panel 6 is 111.56-m (366-ft) long, 10.06-m (33-ft) wide, and 3.96-m (13-ft) high (SNL 1992, Figure 3.1-3), for an excavated volume of (111.56 m)×(10.06 m)×(3.96 m) = 4,444 m^3. Room 1 is smaller than Rooms 2 through 7 because it does not include space for waste emplacement in the access drifts between rooms. There are a total of 2,436 CH waste containers in Room 1 with a total external volume of 1,115 m^3, based on a query of the WIPP Data System (WDS) on August 27, 2014 (Offner, 2014).

There are a total of 142 3,000-pound sacks of MgO and 22 4,200-pound sacks of MgO in Room 1 of Panel 6, based on the same WDS query. Each MgO sack has a maximum volume of 47.6 ft^3 (1.35 m^3) (WTS, 2009, Section 3.3.2.B). Assuming that 4,200-lbs of MgO fills a sack and that

3,000 pounds of MgO fills (3,000)/(4,200) = 0.714 = 71.4% of the sack, the total volume of MgO sacks is calculated as 142(0.714)(1.35 m^3) + 22(1.0)(1.35 m^3) = 167 m^3.

The free volume in Room 1 of Panel 6 is then calculated as the excavated volume minus the volumes of the CH waste containers and the MgO sacks:

$$\begin{aligned} V_{Free,\,R1P6} &= 4{,}444\ m^3 - 1{,}115\ m^3 - 167\ m^3, \\ &= 3{,}162\ m^3 \\ &\sim 3{,}160\ m^3. \end{aligned} \tag{2}$$

The free volume in Room 1 is 71% of the excavated volume of Room 1 in Panel 6.

The excavated volume for Room 7 of Panel 7 has two components: the main room volume plus the volumes of the two access drifts between Room 7 and Room 6. The main room volume is 4,444 m^3, as calculated above. Each access drift is 30.5-m (100-ft), 10.06-m (33-ft) wide, and 3.96-m (13-ft) high (SNL, 1992, Figures 3.1-2 and 3.1-3). The volume in the two access drifts is 2(30.5 m)(10.06 m)(3.96 m) = 2,430 m^3. The excavated volume for Room 7 of Panel 7 is then 4,444 m^3 + 2,430 m^3 = 6,874 m^3.

There are a total of 639 CH waste containers in Room 7 with a total external volume of 268 m^3 (Offner, 2014). There are a total of 13 3,000-lb sacks of MgO and 21 4,200-lb sacks of MgO in Room 7 of Panel 7, with a total volume of 13(0.714)(1.35 m^3) + 21(1.0)(1.35 m^3) = 40.9 m^3. The free volume in Room 7 of Panel 7 is then calculated as the excavated room volume minus the volumes of CH waste containers and MgO sacks:

$$\begin{aligned} V_{Free,\,R7P7} &= 6{,}874\ m^3 - 268\ m^3 - 40.9\ m^3, \\ &= 6{,}565\ m^3, \\ &\sim 6{,}570\ m^3. \end{aligned} \tag{3}$$

The free volume in Room 7 of Panel 7 is 96% of the excavated volume in this room. This high percentage is consistent with the fact that Room 7 is largely empty, and only has waste emplaced in the access drift on the air exhaust side of the room.

3.3 Detailed Pressure Calculations for Simultaneous Reaction of Three Drums Containing Sodium Nitrate and Starch in Room 7 of Panel 7

The reaction of sodium nitrate with starch is postulated to follow Equation (1):

$$6NaNO_3 + C_6H_{10}O_5 \rightarrow 3Na_2CO_3 + 3CO_2 + 5H_2O + 2N_2 + N_2O + O_2. \tag{1}$$

The stoichiometric reaction parameters for Equation (1) are summarized in Table 2. In Table 2, “Mass” refers to the total mass of an individual reactant or product, and “Mass Balance” compares the total mass on each side of the reaction. Exact values of physical constants were used for the calculations, based on handbooks and other sources; input values (such as the molecular weights in Table 2), intermediate results, and final results have been rounded to three or four significant digits for presentation purposes. Any small discrepancies in the Table are due to this round off process.

The reactive mass in Room 7 is: 3×84.5 kg = 253.5 kg (for three drums that react simultaneously and completely). Since the total mass on each side of Equation (1) is 672.1 g (see Table 2), the "reaction multiplier" that corresponds to the bounding case for Equation (1) is (253,500 g)/(672.1 g) = 377.2. Using this multiplier on the product gases in Equation (1), the complete reaction of 3 drums produces (377.2 × 3) = 1132 moles of CO_2, (377.2 × 5) = 1886 moles of water vapor, (377.2 × 2) = 754 moles of N_2, (377.2 × 1) = 377 moles N_2O, and (377.2 × 1) = 377 moles O_2. The total moles of product gases is (1132+1886+754+377+377) = 4,526 moles. The total moles of product gases will be significantly less if some Nitrate Mass remains unreacted.

Table 8. Reaction parameters for sodium nitrate with starch in Room 1, Panel 6

	$6NaNO_3$	+	$C_6H_{10}O_5$	→	$3Na_2CO_3$	+	$3CO_2$	+	$5H_2O$	+	$2N_2$	+	N_2O	+	O_2
Mol. Wt.*	84.99		162.1		106.0		44.01		18.02		28.01		44.01		32.0
Mass (g)	509.9	+	162.1	→	318.0	+	132.0	+	90.08	+	56.03	+	44.01	+	32.0
Mass Balance (g)	672.1				672.1										
Reaction Multiplier	Ratio of Nitrate Mass in 3 Drums to the Mass of Reactants in Eqn. (1) = (253,500 g)/(672.1 g) = 377.19														

*CRC, 1983. Molecular weights have been rounded to 4 significant digits for this table. Calculations were performed with the exact values from the handbook, and rounded for presentation purposes. Units of molecular weight are g/mole.

Each of the product gases will mix with the air and expand into the free volume in Room 7. The free volume in Room 7 is 6,570 m^3, based on Equation (3). The temperature of the expanded product gases from Equation (1) is assumed to be at the ambient temperature of the host rock in the underground facility, 27°C (300K). This is a reasonable assumption because the product gases are a small mole fraction of the moles of ambient air in the free volume, as shown next, and because the rock mass provides a large thermal sink at its ambient temperature.

The moles of air in the free volume of Room 7, $n_{air,R7P7}$, are calculated from the ideal gas law:

$$\begin{aligned} n_{air,R7P7} &= \frac{PV}{RT}, \\ &= \frac{(101{,}300\ Pa)(6{,}570\ m^3)}{(8.315\ j/mol/K)(300\ K)}, \\ &= 267{,}000\ mol. \end{aligned} \qquad (4)$$

Based on Equation (1), complete reaction of 3 drums produces 4,526 moles of product gases (see top of this page). The moles of product gases are then (4,526 moles/267,000 moles) ~ 0.017 = 1.7% of the moles of air in a room. The product gases represent a small fraction of the moles of air. The inert or combustible product gases will therefore have a minor impact on average gas temperature in a room.

The partial pressures of the individual product gases in Equation (1) for Room 7 of Panel 7 are calculated from the ideal gas law. These calculations assume that there is negligible gas leakage through a Closure, maximizing the calculated pressure change.

$$
\begin{aligned}
&P = \frac{nRT}{V}, \\
&P_{CO2} = \frac{n_{CO2}(8.315\ j/mol/K)(300\ K)}{6570\, m^3} = \frac{(1132\, mol)(8.315\ j/mol/K)(300\ K)}{6570\, m^3} = 430\ Pa, \\
&P_{H2O} = \frac{n_{H2O}(8.315\ j/mol/K)(300\ K)}{6570\, m^3} = \frac{(1886\, mol)(8.315\ j/mol/K)(300\ K)}{6570\, m^3} = 717\ Pa, \\
&P_{N2} = \frac{n_{N2}(8.315\ j/mol/K)(300\ K)}{6570\, m^3} = \frac{(754\, mol)(8.315\ j/mol/K)(300\ K)}{6570\, m^3} = 287\ Pa, \\
&P_{N2O} = \frac{n_{N2}(8.315\ j/mol/K)(300\ K)}{6570\, m^3} = \frac{(377\, mol)(8.315\ j/mol/K)(300\ K)}{6570\, m^3} = 143\, Pa, \\
&P_{O2} = \frac{n_{N2}(8.315\ j/mol/K)(300\ K)}{6570\, m^3} = \frac{(377\, mol)(8.315\ j/mol/K)(300\ K)}{6570\, m^3} = 143\, Pa.
\end{aligned}
\tag{5}
$$

The partial pressures in Equation (5) (the values on the right-hand side of each equation) are based on calculations with exact handbook values and exact volumes. The individual parameter values in the ideal gas law have been rounded to three or four significant digits for presentation purposes. Any small discrepancies in Equation (5) are due to this rounding process.

The increase in pressure, ΔP, from the product gases is the sum of their partial pressures:

$$
\begin{aligned}
\Delta P &= P_{CO2} + P_{H2O} + P_{N2} + P_{N2O} + P_{O2}, \\
&= 430\ Pa + 717\ Pa + 287\ Pa + 143\, Pa + 143\, Pa, \\
&= 1{,}720\ \ Pa, \\
&= 0.25\ psi.
\end{aligned}
\tag{6}
$$

Complete and simultaneous reaction of the Nitrate Mass in 3 drums, each of which contains the average Nitrate Mass in Room 7 of Panel 7, results in a pressure increase of 0.25 psi above the ambient air pressure.

Water vapor from the reaction products could potentially condense as it expands and cools to 300K. Liquid water will condense if the partial pressure of water vapor is greater than the equilibrium vapor pressure above liquid water at 27°C (300K). The partial pressure of water vapor from Equation (5) is 717 Pa, which is less than the equilibrium vapor pressure above liquid water at 27°C, 26.739 mm Hg (3,565 Pa) (CRC, 1983, page D-193). In this situation, condensation of water vapor will not occur.

The calculation of the individual pressure increases in Equation (6) is insensitive to changes in the final temperature of the product gases. For example, if the temperature of the product gases increases by 50°C, from 300K to 350K, then the pressure changes in Equation (5) increase by a factor of (350K/300K), or 16.7%. The total pressure change in Equation (6) also increases by 16.7%, from 0.25 psi to 0.29 psi, for a final temperature of 350K. This result confirms that modest changes in the average temperature of the expanded product gases have a minor impact on the predicted pressure change.

3.4 Detailed Pressure Calculations for Simultaneous Reaction of Three Drums Containing Other Nitrate Salts and Starch in Room 7 of Panel 7

The analogs of Equation (1) for calcium nitrate, magnesium nitrate, potassium nitrate, and iron nitrate salts are as follows:

$$3Ca(NO_3)_2 + C_6H_{10}O_5 \rightarrow 3CaCO_3 + 3CO_2 + 5H_2O + 2N_2 + N_2O + O_2, \quad (7)$$
$$3Mg(NO_3)_2 + C_6H_{10}O_5 \rightarrow 3MgCO_3 + 3CO_2 + 5H_2O + 2N_2 + N_2O + O_2, \quad (8)$$
$$6KNO_3 + C_6H_{10}O_5 \rightarrow 3K_2CO_3 + 3CO_2 + 5H_2O + 2N_2 + N_2O + O_2, \quad (9)$$

and

$$4Fe(NO_3)_3 + 2C_6H_{10}O_5 \rightarrow 4FeCO_3 + 8CO_2 + 10H_2O + 4N_2 + 2N_2O + 3O_2. \quad (10)$$

Table 3 summarizes the key stoichiometric parameters, partial pressures, and total pressure change for reaction of the various nitrate salts and starch, as defined by these equations. The methodology for these calculations is identical to the approach in Section 3.3. Pressure of individual gases is calculated with the ideal gas law and total pressure is based on the sum of the partial pressures. The total pressure change for the five nitrate salts lies within a narrow range of 0.22 psi to 0.29 psi. Table 3 also includes the results for sodium nitrate for completeness.

Table 9. Stoichiometric parameters, partial pressures, and total pressure change for product gases from the complete reaction of three drums containing nitrate salts in Room 7 of Panel 7

Nitrate Salt	Mass of Reactants (g)	Reaction Multiplier (-)	Pressure CO_2 (Pa)	Pressure H_2O (Pa)	Pressure N_2 (Pa)	Pressure N_2O (Pa)	Pressure O_2 (Pa)	Total Pressure Change (Pa)	(psi)
$Ca(NO_3)_2$	654.4	387.4	442	736	294	147	147	1,767	0.26
$Mg(NO_3)_2$	607.1	417.6	476	794	317	159	159	1,905	0.28
KNO_3	768.8	329.7	376	627	251	125	125	1,504	0.22
$Fe(NO_3)_3$	1,291.7	196.3	597	746	298	149	224	2,014	0.29
$NaNO_3$	672.1	377.2	430	717	287	143	143	1,720	0.25

Table 4 summarizes the predicted pressure increases and total moles of product gases for the reactions of the five nitrate salts and starch. The total moles of product gases represent 1.4% to 1.9% of the total moles of air in a room. The product gases are a small fraction of the air mass in a room and will not significantly raise the average temperature in the room, as stated previously.

Table 10. Pressure change and moles of product gases from the simultaneous and complete reaction of three drums containing nitrate salts in Room 7 of Panel 7

	Pressure Change	Product Gases	Product Gases : Air

Nitrate Salt	(Pascals)	(psi)	(Moles)	(Mol%)
$Ca(NO_3)_2$	1,767	0.26	4,648	1.7%
$Mg(NO_3)_2$	1,905	0.28	5,011	1.9%
KNO_3	1,504	0.22	3,957	1.5%
$Fe(NO_3)_3$	2,014	0.29	5,299	1.6 %
$NaNO_3$	1,720	0.25	4,526	1.7%

The results in Tables 3 and 4 confirm that the pressure change is insensitive to the composition of nitrate salts. The calculated pressure changes are also insensitive to changes in temperature of the product gases. For example, if the temperature of the product gases increases by 50°C, from 300K to 350K, then the pressure changes in Table 4 increase by a factor of (350K/300K), resulting in a maximum pressure change of 0.34 psi. This result confirms that modest temperature increases in the product gases have only a minor impact on the predicted pressure change.

The ambient pressure in the underground facility will be slightly greater than atmospheric pressure at the surface because of the downcast ventilation flow in the air intake shaft. This difference is not significant for these calculations because it is the changes in pressure due to the gas buildup that are important for determining mechanical loads on the steel bulkheads.

3.5 Detailed Pressure Calculations for Simultaneous Reaction of Three Drums Containing Nitrate Salts and Starch in Room 1 of Panel 6

The pressure increase in Room 1 of Panel 6 will be different than Room 7 of Panel 7 because (1) the average Nitrate Mass in a drum in Room 1 is 74.9 kg, which is less than the average Nitrate Mass in Room 7 of Panel 7, 84.5 kg (see shaded cells in Table 1); and (2) the free volume in Room 1 of Panel 6, 3,160 m^3, is less than the free volume in Room 7 of Panel 7, 6,570 m^3 (see Equations (2) and (3)). The first factor will decrease the pressure of the product gases, while the second factor will increase the pressure of the product gases. The net change in pressure for Equations (5) and (6) is defined by the product of the ratios of these changes:

$$\begin{aligned} \Delta P_{R1P6} &= \left(\frac{74.9\,kg}{84.5\,kg}\right)\left(\frac{6{,}570\,m^3}{3{,}160\,m^3}\right)\Delta P_{R7P7}\,, \\ &= 1.843\,\Delta P_{R7P7}\,. \end{aligned} \tag{11}$$

In other words, pressure changes in Room 1 of Panel 6 will be 84% greater than the corresponding change in Room 7 of Panel 7, all other factors being equal. Correcting the values in the second and third columns of Table 4 for the scaling factor of 1.843, the pressure increases in Room 1 of Panel 6 are presented in Table 5. The resulting pressure changes for the nitrate salts lies within a range of 0.40 psi to 0.54 psi for Room 1 of Panel 6. The last two columns in Table 5 are computed using the same methodology as in Section 3.3.

Table 11. Pressure change and moles of product gases from the simultaneous and complete reaction of three drums containing nitrate salts in Room 1 of Panel 6

Nitrate Salt	Pressure Change (Pascals)	Pressure Change (psi)	Product Gases (Moles)	Product Gases : Air (Mol%)
$Ca(NO_3)_2$	3,251	0.47	4,120	3.2%
$Mg(NO_3)_2$	3,504	0.51	4,441	3.5%
KNO_3	2,767	0.40	3,507	2.7%
$Fe(NO_3)_3$	3,706	0.54	4,697	3.7%
$NaNO_3$	3,165	0.46	4,012	3.1%

3.6 Quantifying Conservatisms in the Bounding Analysis of Gas Buildup

The bounding analysis for pressure changes from a simultaneous thermal runaway reaction in three drums containing waste stream LA-MIN02-V.001 has conservative assumptions that overestimate the pressure changes from a runaway thermal reaction. The degree of conservatism in these assumptions is identified and evaluated in this section:

- **Three drums are assumed to experience a runaway thermal reaction simultaneously.** However, the runaway thermal reaction in Drum #68660 did not induce similar runaway reactions in any other drum in Room 7, including those drums directly adjacent to Drum #68660. The analysis by the Technical Assessment Team confirmed that initiation of the thermal runaway reaction in Drum #68660 was due to internal processes associated with the packaging and contents of the container and not caused by phenomena outside this drum (SRNL, 2015, Section 4.4). A similar statement should be applicable to future thermal runaway reactions in other drums containing LA-MIN02-V.001 waste. This means that runaway thermal reaction in 3 drums simultaneously is extremely unlikely, if not impossible, because the reaction is caused by internal conditions within the drum, and because no three drums are identical in their content, waste processing, and packaging.
  Degree of Conservatism: The assumption of simultaneous reactions in 3 drums increases the mass of product gases by a factor of 3 and the predicted pressure change by a factor of 3.

- **The analysis assumes that all the Nitrate Mass in each of the 3 drums reacts completely.** However, it is likely that some Nitrate Mass remains unreacted. The analysis by the Technical Assessment Team estimated that 3.4 kg out of a total Nitrate Mass of 71.3 kg reacted internally within Drum #68660 (SNRL, 2015, page 31). This estimate is based on a thermochemical model for a single internal hot spot within the Nitrate-Salt Admixture Layer (SNRL, 2015, Figure 4-2 on page 25 and Figure 4-3 on page 29). Once released, hot waste particulates and flammable product gases are likely to continue to react/burn, and may cause melting or secondary fires in plastic materials in the repository (DOE, 2015, Section 6.1).

  The mass of flammable material that is ejected and consumed is difficult to quantify because of the wide range of materials in each waste container; instead, a bounding estimate can be defined by assuming that all the Nitrate Mass surrounding the internal hot spot reacts completely. Applied to Drum #68660, this means that the entire Nitrate-Salt Admixture Layer reacts completely. This Layer consists of 13.2 kg of Swheat scoop and 26.0 kg of nitrate salts, for a total Nitrate Mass of 39.2 kg (SRNL, 2015, Figure 4-2 on page 25). This means that (39.2 kg / 71.3 kg) = 0.55 = 55 percent of the Nitrate Mass in each drum would react, as opposed to 100 percent for the bounding case.

Degree of Conservatism: The assumption of complete reaction of all Nitrate Mass increases the mass of product gases by a factor of 1/0.55 = 1.82 relative to the alternate estimate.

Collectively, the assumptions of simultaneous reactions in 3 drums and complete reaction of the total Nitrate Mass overestimate gas production by a factor of 3×1.82 = 5.5, and therefore overestimate pressure changes by a factor of 5.5. Alternately, this factor of 5.5 can be interpreted as providing a substantial safety factor in the expected performance and stability of the steel bulkhead for mitigating the effects from gas buildup on workers.

The factor of 1.82 is likely to be greater because: (1) the nitrate salts and organic desiccant may not be in the proper mass balance for complete stoichiometric reaction, (2) coarser particles of the desiccant (Swheat Scoop) have a limited surface area and may not react quickly enough to be fully consumed during or just after in the thermal runaway reaction, and (3) 34 55-gallon drums containing waste stream LA-MIN02-V.001 are in 15 Standard Waste Boxes (SWBs). The SWBs provide added containment of gases released from breached drums, thereby further reducing or slowing the buildup of pressure in the room.

4. Mitigation of Gas Buildup for WIPP Personnel

4.1 Mitigation by the Closure for Room 7 of Panel 7

On the air exhaust side of Room 7, at South-2180, the existing air regulator bulkhead will not be removed to minimize risk to underground construction workers. A new steel bulkhead with flexible plastic flashing that is bolted to the walls and roof of the entry will be installed approximately 8 feet downstream of the existing air regulator bulkhead (DOE and NWP, 2014, Figure 4). There will then be two steel bulkheads on the air exhaust side of Room 7, with about 8-feet of open space between them. A salt muck pile will not be pushed against the existing brattice cloth/chain link barriers on the air exhaust side to minimize the potential for worker exposure.

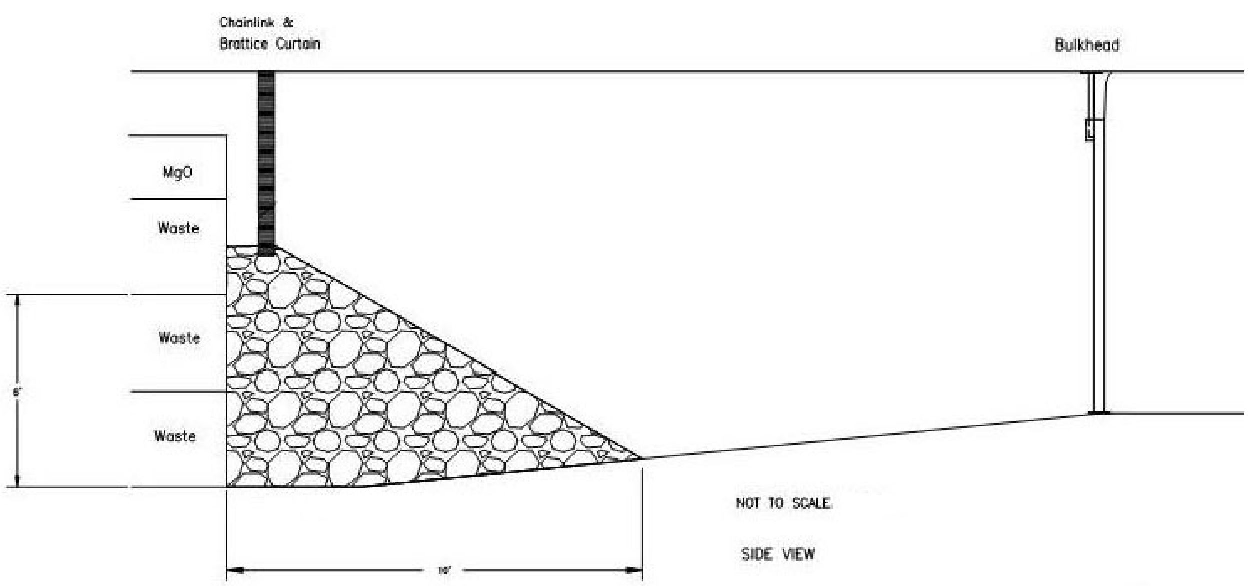
On the air intake side of Room 7, at South-2520, a new steel bulkhead will be installed a few feet away from chain link and brattice cloth curtains (DOE and NWP, 2014, Figure 4). This new bulkhead is more than 400-feet away from the nearest waste containers because Room 7 is only partly filled with waste (DOE and NWP, 2014, Figure 4).

The WIPP Mine Ventilation Plan specifies that the upper steady-state operating pressure differential is 0.47 psi across a steel bulkhead with the filtration fan that is currently operating

((NWP, 2015, Table 1). The bounding analysis for simultaneous thermal runaway reactions in 3 drums predicts pressure changes of 0.22 psi to 0.29 psi in Room 7 of Panel 7. These bounding values are less than the steady–state operating pressure differential of 0.47 psi for the steel bulkhead. The steel bulkheads in the Closure for Room 7 are therefore expected to remain intact, mitigating worker exposure to gas buildup caused by future exothermic reactions/breached drums in Room 7 of Panel 7.

4.2 Mitigation by the Closure for Room 1 of Panel 6

The design for the Closure in Panel 6 has two barriers: a substantial barrier and a barrier bulkhead, as shown in Figure 1. The substantial barrier consists of chain link and brattice cloth curtains and a salt pile that are installed close to the waste face. The pile of mined salt will be pushed against the waste to at least the height of the bottom of the top row of waste, and the chain link and brattice cloth curtains will be anchored in the salt pile. A new steel bulkhead with flexible plastic flashing that is bolted to the walls and roof of the entry will be installed approximately 10-feet away from the toe of the run-of-mine (ROM) salt. Installation of the Closure for Panel 6 was completed on May 8, 2015.



SOURCE: (DOE and NWP, 2014, Figure 2)

Figure 4. Schematic of the typical closure installation in Panel 6

As noted in Section 4.1, the upper steady-state operating pressure differential is 0.47 psi across a steel bulkhead. The bounding analysis for simultaneous thermal runaway reactions in 3 drums predicts pressure changes of 0.40 psi to 0.54 psi in Room 1 of Panel 6 (see Table 5). These bounding values are approximately equal to the steady–state operating pressure differential of 0.47 psi. However, the assumptions for the bounding analysis overestimate the gas buildup and pressure changes by a factor of 5.5, as discussed in the Section 3.6. In this situation, there is a substantial safety factor for the structural stability of the steel bulkhead. The steel bulkheads in the Closure for Panel 6 are therefore expected to remain intact, thereby mitigating worker exposure to gas buildup caused by future exothermic reactions/breached drums in Room 1 of Panel 6. Furthermore, the steady state pressure is not a limit for bulkhead operation, simply the result of air pressure created by the ventilation system. Bulkheads are known to withstand higher transient pressures for short periods of time during ventilation adjustments and system balancing. Once bulkheads are constructed, and ventilation through the disposal room blocked, static pressures on the bulkheads are negligible.

WIPP personnel have completed installation of the Closures for Panel 6. Each Closure includes the chain link and brattice cloth curtains, the 10-foot wide salt pile, and the steel bulkhead, as shown in Figure 1.

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