DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

August 27, 2019

The Honorable James Richard Perry
Secretary of Energy
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Secretary Perry:

The Defense Nuclear Facilities Safety Board has determined that the final design of the Waste Isolation Pilot Plant safety significant confinement ventilation system does not adequately consider design requirements for the underground safety significant continuous air monitoring system. The SSCVS relies upon a timely actuation signal from the CAM system to align into a safe configuration in the event of an underground radiological release. Inadequate performance of the CAM system can result in an atmospheric radiological release and contamination of the SSCVS salt reduction building.

The enclosure describes the Board's determination of safety items and observations developed by a staff review team. Pursuant to 42 U.S.C. §2286b(d), the Board requests a written response followed by a briefing from DOE within 90 days, outlining plans to address these concerns.

Yours truly,

Bruce Hamilton
Chairman

Enclosure

c: Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Report

June 26, 2019

Safety Issues Relating to the Waste Isolation Pilot Plant Safety Significant Confinement Ventilation System

Summary. The Defense Nuclear Facilities Safety Board (Board) is concerned that the final design of the Waste Isolation Pilot Plant (WIPP) safety significant confinement ventilation system (SSCVS) may not adequately perform its intended safety functions due to the use of potentially inadequate performance criteria for damper closure time and unspecified design requirements for the underground safety significant continuous air monitors (CAM) and related support systems. SSCVS relies upon a timely actuation signal to align into a safe configuration in the event of an underground radiological release. Inadequate system performance could result in a radiological release through the isolation dampers of the salt reduction system during normal operation and through the SSCVS filter bypass during operation in the unfiltered mode.

Background. In a March 26, 2018, letter [1], the Board expressed concern (1) "that the final design documentation for the WIPP SSCVS does not adequately address design requirements for the full integration of the underground safety significant continuous air monitoring system (CAM)" and (2) "systems, structures, and components that support the CAM system and its classification are not addressed in the final design."

In a March 29, 2018, letter [2], the Department of Energy (DOE) Deputy Assistant Secretary for Safety, Security, and Quality Assurance, Environmental Management replied that the "SSCVS Project set the boundaries of the project scope at the surface of the WIPP site and did not include any portion of the WIPP underground" and "[T]he CAMs in the WIPP underground are controlled through the currently approved documented safety analysis (DSA) and technical safety requirements (TSRs)."

On April 26, 2018, DOE's Carlsbad Field Office issued a safety evaluation report (SER) [3] approving the preliminary documented safety analysis (PDSA) with conditions of approval that included directed PDSA page changes. The SER identified conditions and established additional requirements for the underground CAMs and their support elements that had not been included in the final design that the Board's staff had previously reviewed. These new requirements include:

- Recognition that the radiation detection signal is a "key system component."
- Requirements that SSCVS performance and reliability would be assured by meeting a safety integrity level (SIL) 2 "or equivalent reliability in accordance with DOE-STD-1195-2011 [DOE Standard 1195, *Design of Safety Significant Safety Instrumented Systems Used at DOE Nonreactor Nuclear Facilities*].

- Recognition that redundant voter logic would be needed to initiate the SSCVS safety instrumented function.
- Declarations that the Radiological Protection Program would establish the location and setpoints for the radiological detection system.

Discussion. The SSCVS project is an exhaust air system that consists of a new filter building, salt reduction building, exterior ductwork, and new exhaust stack. The SSCVS is designed such that it will mitigate design basis accidents with high unmitigated dose consequences for the facility worker and co-located worker. During normal operation, the SSCVS directs exhaust air through the salt reduction building before exhausting the airflow through high efficiency particulate air (HEPA) filters. The salt reduction building contains equipment that pulls salt out of the exhaust air to reduce the load on the HEPA filters. Upon detection of an underground radiological release event, SSCVS is designed to bypass the salt reduction building to prevent an unfiltered release through the salt reduction system. SSCVS also has the capability to operate in an unfiltered mode, bypassing the HEPA filters. The unfiltered operating mode can be used during an underground fire without a radiological release. While operating in that mode, if an underground radiological release is detected, the bypass dampers automatically realign, forcing all exhaust air to exit through the HEPA filters.

The staff review team identified the following safety items.

Safety Instrumented Systems' Performance Criteria Are not Adequate—The SSCVS project established performance criteria for the ventilation dampers to ensure that they reach their fail-safe positions (salt reduction building bypassed and HEPA filters enabled) within 60 seconds of receiving an actuation signal. WIPP selected this value to prevent any unfiltered release and to prevent radiological contamination and release through the salt reduction building, while avoiding potential negative impacts to SSCVS components that might result from rapid repositioning of dampers and sudden shifts in air flow rates and paths. The Board's staff has completed an independent analysis [Appendix A] that has identified that even for a release that is immediately detected, a 60 second damper closure time may not be adequate to prevent radiological contamination releases for all potential event initiation locations.

Supply Fans Are not Interlocked with Exhaust Fans—The final SSCVS design did not establish any requirements for an interlock with supply fans as recommended by Table A-1 of DOE Guide 420.1-1A, *Nonreactor Nuclear Safety Design Guide for use with DOE O 420.1C, Facility Safety*. The non-safety utility shaft project proposes fans to supply a total of 500,000 cubic feet per minute (cfm). SSCVS has the capacity to exhaust 540,000cfm. If utility shaft fans are not automatically shut down when the SSCVS fans stop, an imbalance in the underground air flow has the potential to up-cast unfiltered air from the contaminated circuit. The DOE-EM Project Peer Review Exit Briefing also identified this item as a recommendation (R-TTQA-10), stating that "WIPP needs to ensure that provisions for such an interlock, which will be safety significant, are established in the programmable logic controller."

The Radiological Protection Program Establishes CAM Locations and Setpoints—WIPP currently uses CAMs as part of an occupational radiological protection program under Title 10, Code of Federal Regulations, Part 835 (10 CFR 835), *Occupational Radiation Protection Program*. This regulation requires monitoring of the concentrations of radioactive material in the air but does not discuss the application of instrumentation setpoints for initiating an automatic action (e.g., alarm) based on instrumentation performance criteria. The use of CAMs as a hazard control require they meet requirements under 10 CFR 830, *Nuclear Safety Management*. The CAMs WIPP uses to initiate SSCVS are safety significant components. The SSCVS project has identified DOE Standard 1195, *Design of Safety Significant Safety Instrumented Systems Used at DOE Nonreactor Nuclear Facilities*, as the method to assure sufficient reliability of the safety significant instrumentation. DOE Standard 1195 requires that setpoint development follow the requirements of American National Standards Institute (ANSI)/International Society for Automation (ISA) standard ANSI/ISA 67.04.01, *Setpoints for Nuclear Safety-Related Instrumentation*. This setpoint methodology assures that SSCVS complies with analytical limits and, in conjunction with CAM placement, ensures that SSCVS properly performs its safety function for all hazards it is designed to prevent or mitigate. A radiological protection program established under 10 CFR 835 does not establish equivalent setpoints to ensure 10 CFR 830 requirements are met. This safety item results from the failure to properly consider the CAMs during the SSCVS design.

The staff review team identified the following observations.

WIPP Does Not Specify CAM Performance Criteria—WIPP must consider the long term effect of the underground salt environment on CAM performance, as well as the effects of a smoke environment that may co-exist with a radiological release event. Any impacts on CAM performance that result in a delay in the detection and signaling that a radiological release has occurred could affect the overall SSCVS performance and may prevent SSCVS from meeting its safety function. Many factors affect the total time from event initiation to completion of SSCVS response, including the location of the CAMs, the magnitude of the release event, and all performance factors that affect the ability of the CAM to detect the release.

Redundancy Objectives Are Unclear—The SER indicated that the radiation detection "instrument system will be connected to a PLC [programmable logic controller] with redundant voter logic to initiate alarm signals to the CMS [central monitoring system]." It is not clear if this redundant voter logic will be designed to maximize the probability of detection (e.g., one out of two logic), to minimize the probability of a false or spurious actuation (e.g., two out of two logic), or to use some type of an optimization scheme (e.g., two out of three logic). The selected design approach will affect actuation time as well as the calculated safety integrity level specified by DOE Standard 1195.

Conclusion. WIPP does not completely specify and analyze design and performance criteria, which makes it difficult to ensure that the final SSCVS design meets its functional safety requirements. The lack of proper integration between the surface portions of SSCVS with the underground safety system increases the risk that the final system design will not meet all safety requirements. In addition to releasing unfiltered radiological contamination, a release could contaminate the salt reduction system and impact operations of the WIPP facility as a whole.

References

[1] Bruce Hamilton, Acting Chairman of the Defense Nuclear Facilities Safety Board, letter to Honorable James Richard Perry, Secretary of Energy, March 26, 2018.

[2] James A. Hutton, Department of Energy Deputy Assistant Secretary for Safety, Security, and Quality Assurance, Environmental Management, letter to Steven A. Stokes, Technical Director, Defense Nuclear Facilities Safety Board, March 29, 2018.

[3] Department of Energy, *Safety Evaluation Report for Approval of the Waste Isolation Pilot Plant Safety Significant Confinement Ventilation System Project, Preliminary Documented Safety Analysis, 500655-416-BD-SE-00306, Revision 0*, DOE/WIPP 18-3602, Revision 0, U.S. Department of Energy, Carlsbad Field Office, April 2018.

Appendix A: WIPP Underground Transport Calculation

1. Background and Objective

Figures A-1 and A-2 illustrate the configuration of the existing Waste Isolation Pilot Plant (WIPP) Facilities. The WIPP safety significant confinement ventilation system (SSCVS) preliminary documented safety analysis (PDSA) [1] requires:

- *SSCVS shall ensure that all flow from the disposal air circuit is filtered prior to release to the environment unless manually bypassed for life safety.*

- *SSCVS ductwork is provided with bypass/isolation dampers which permit the filtration assemblies or SRS [salt reduction system] to be bypassed. The SRS inlet and outlet dampers are double isolation dampers. The nominal closure time for the isolation dampers is 60 seconds. The closure time must be rapid enough, relative to the transport time of the release to reach the surface, to prevent significant radiological consequences to the co-located worker (CW). Analysis must also show that the closure time is not too rapid so as to result in a transient condition that can damage the SSCVS or UG [underground] bulkheads, regulators, etc.*

In addition to the disposal circuit, the WIPP documented safety analysis (DSA) [2] requires that air from the waste shaft station be filtered to mitigate any potential radiological releases while waste is downloaded and transported in the underground. The WIPP DSA identifies the waste shaft, waste shaft station, transport path, and disposal areas as hazardous zones. The WIPP DSA defines the following functional requirements when waste is downloaded with the waste shaft conveyance:

- *During downloading of Waste Containers with the Waste Shaft Conveyance, the SSCVS shall ensure that airflow from the Waste Shaft Station is filtered prior to release to the environment.*

The targeted volumetric flow rate through the waste shaft station is between 20,000 and 25,000 cubic feet per minute (cfm). WIPP recommends this flow rate to maintain the required differential pressure across bulkhead (BH) 308 [3] and to ensure air from the waste shaft station is filtered and air is flowing from the non-contaminated to the potentially contaminated areas. WIPP defines the waste shaft station as the underground area between the waste shaft and the intersection between S-400 and the E-140 drift, which can been seen in Figure A-3 [2].

SRK Consulting performed a transient time analysis [4] to calculate the time required for the transport of air from Panel 9B to the exhaust shaft collar, assuming that the existing drift and areas from panel 1 to 8 are sealed. This analysis estimated that air would take 5 minutes 29 seconds to travel from Panel 9B to the exhaust shaft collar for the case when the proposed utility shaft is operating and 5 minutes 8 seconds for the case when the utility shaft is not operating. These times are based on using volumetric flow rates through the exhaust shaft of

270,000cfm and 385,000cfm, respectively. The utility shaft project, previously known as the exhaust shaft project, proposes construction of a new shaft with two fans at the top of the shaft. Each fan would have the capacity to provide 500,000cfm (WIPP engineers have indicated the fans are not intended to be run simultaneously), which is comparable to the total nominal capacity of 540,000cfm for SSCVS. DOE is scheduled to approve the final utility shaft project design in 2019. The utility shaft project is not considered any further in this calculation.

The transient time analysis assumes a radiological release from Panel 9 or 10. These two panels do not currently exist in the WIPP underground. WIPP is emplacing waste in panel 7 and mining in panel 8. The Board's staff team considers that the assumptions and conditions used to calculate the transport time from panels 9 and 10 might be similar to those that could be used for calculations assuming that the release originated from the existing panels 7 and 8. However, the Board's staff team considers that the assumptions and scenarios are not conservative in either case. In addition, SSCVS could be completed and running before panels 9 and 10 are built and ready to emplace waste.

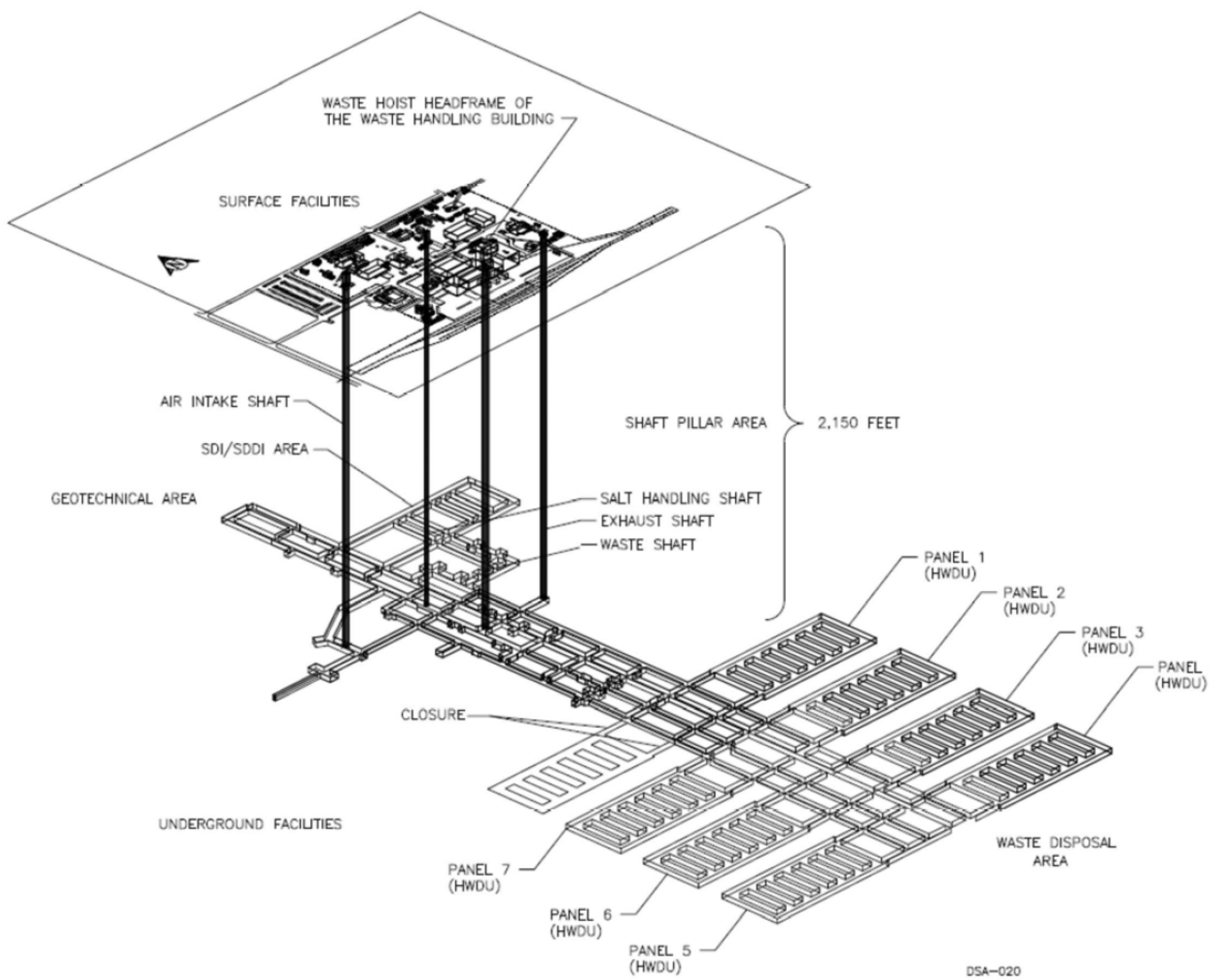

Figure A-1. *Three dimensional rendition of existing WIPP Facilities*

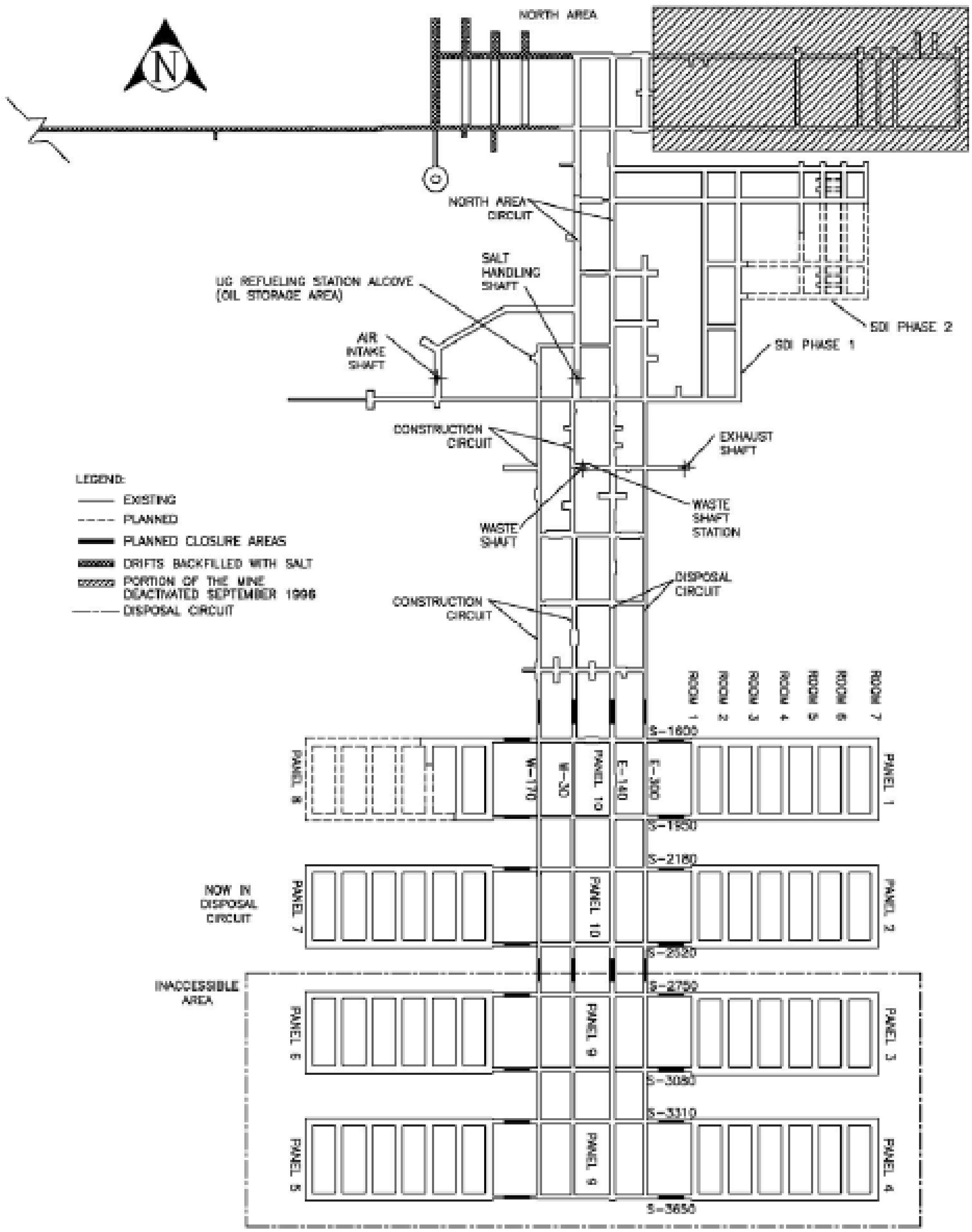

Figure A-2. *Existing WIPP underground layout*

The Board's staff team documented the following staff safety item in an information paper related to the final design review of the Waste Isolation Pilot Plant (WIPP) safety significant confinement ventilation system (SSCVS).

> *After the review, NWP [Nuclear Waste Partnership] personnel provided a preliminary calculation for a situation in which the transport of radiological contamination from the underground would reach the surface after the SRS isolation dampers were completely closed. However, the values used to calculate the transport of contaminants from the underground to the surface are not bounding values. Bounding values would include: the maximum PVS [primary ventilation system] airflow, the shortest distance from underground to the surface, and a calculated velocity using the most restrictive nominal cross-sectional areas.*
>
> *The Board's staff notes that NWP personnel [plan] to evaluate the HEPA filters' performance criteria and [are] currently evaluating the transport time for radiological contamination from the underground to reach the surface. The Board's staff understands that NWP personnel will use the transport time to evaluate the closure time of the SRS isolation dampers to avoid release of contamination to the environment. These are important factors affecting safety that should be understood and adequately integrated into the design. The staff classifies this as a Case 2 Staff Safety Item pending the outcome of NWP personnel's on-going work. The Board's staff anticipates resolution of this safety item prior to DOE's planned approval of CD-2/3 in March 2018.*

On March 26, 2018, the Board sent a letter to DOE [5] identifying concerns with the final design of the WIPP SSCVS. The WIPP SSCVS PDSA did not adequately include requirements for the integration of the underground safety significant continuous air monitoring (CAM) system. These requirements are necessary to actuate the safety significant isolation dampers of SSCVS upon detection of an underground radiological release. In a March 29, 2018, letter, DOE responded that the scope of the SSCVS project did not include any portions of the WIPP underground, including any potential upgrades to the CAM system. DOE's response stated that the design of the CAM system will be handled separately.

In April 2018, DOE's Carlsbad Field Office (CBFO) and DOE's Office of Environmental Management approved the final SSCVS design documented in the PDSA. In the safety evaluation report (SER) [6] the CBFO safety basis review team indicated that the transient time analysis [4] supports the conclusion that the 60 second closure time of the SSCVS isolation dampers ensures that the SSCVS performance criterion (avoid a radiological release) is met.

The objective of this simple calculation is to independently estimate the transport time of airborne contaminants using conservative assumptions for three scenarios. The results are used to determine if the credited PDSA controls are adequate to maintain confinement following a radiological release. The scenario and assumptions are described in the next section.

2. Assumptions and Input Parameters

This analysis evaluates three cases. The radiological releases of the three scenarios evaluated take place in the underground waste shaft station located between the waste shaft and exhaust shaft. The Board's staff team selected this area due to the proximity of the waste shaft station to the bottom of the exhaust shaft. The three cases evaluate the following anticipated events at the waste shaft station and transport path: fire, deflagration/over pressurization, impact, and spontaneous combustion (e.g., CH/RH-UG-02-001a, CH/RH-UG-02-002a2, CH/RH-UG-02-002a3, CH-UG-01-001a2, CH-UG-06-001a, CH/RH-UG-10-003a, CH/RH-UG-01-005a1, CH/RH-UG-10-005a), when the underground ventilation system is credited as a mitigative control. The main differences between the three cases is the magnitude of the event and the location of the CAMs (see Figure A-3).

The most important parameters affecting the transport time are the air stream velocities, the location of the CAM, and the distance between the first SSCVS isolation damper and the CAM. These analyses use the nominal SSCVS exhaust volumetric flow rate of 540,000cfm [1] and 25,000cfm through BH-308.

The air stream velocity is inversely proportional to the cross-sectional area of the drift. The area of the drift is irregular along the drift. The Board's staff team used the cross-sectional area of BH-308 as an approximation of the cross-sectional area of drift S-400 for the purpose of this calculation. Due to the natural tendency of the mine to close and rock to periodically fall, this area could be smaller. This area also could be reduced by equipment located in the drift and vehicles transiting. The locations of the CAMs have not been identified in the SSCVS PDSA. The locations of the CAMs are important to detect a radiological release promptly and to ensure that the automatic actuation to close the isolation dampers occurs before contaminated air reaches the surface.

First Case—In the first case, the Board's staff team assumed that the anticipated event would be an explosion or high energy event of sufficient magnitude to push radiological contamination from the waste shaft station toward the exhaust shaft. The magnitude of this anticipated event would be similar to the design basis accidents (DBA), which contemplate a fuel operated vehicle and/or a vehicle carrying waste dropping from the waste shaft collar (i.e., CH/RH-UG-01-005a1 and CH/RH-UG-10-005a). This scenario assumed that CAMs would still work during and after the explosion and that any CAM located between the waste shaft and BH-308 would detect airborne contamination and send the signal to automatically start closing the isolation dampers. As illustrated in Figure A-3, BH-308 is located between the waste shaft and the exhaust shaft. However, BH-308 is not a safety component and for that reason it cannot be credited during these events. For this reason the Board's staff team also assumed that BH-308 is nonexistent and contamination is pushed almost instantaneously to the bottom of the exhaust shaft during this scenario. Thus there is no practical difference between detection times for any of the three potential CAM locations.

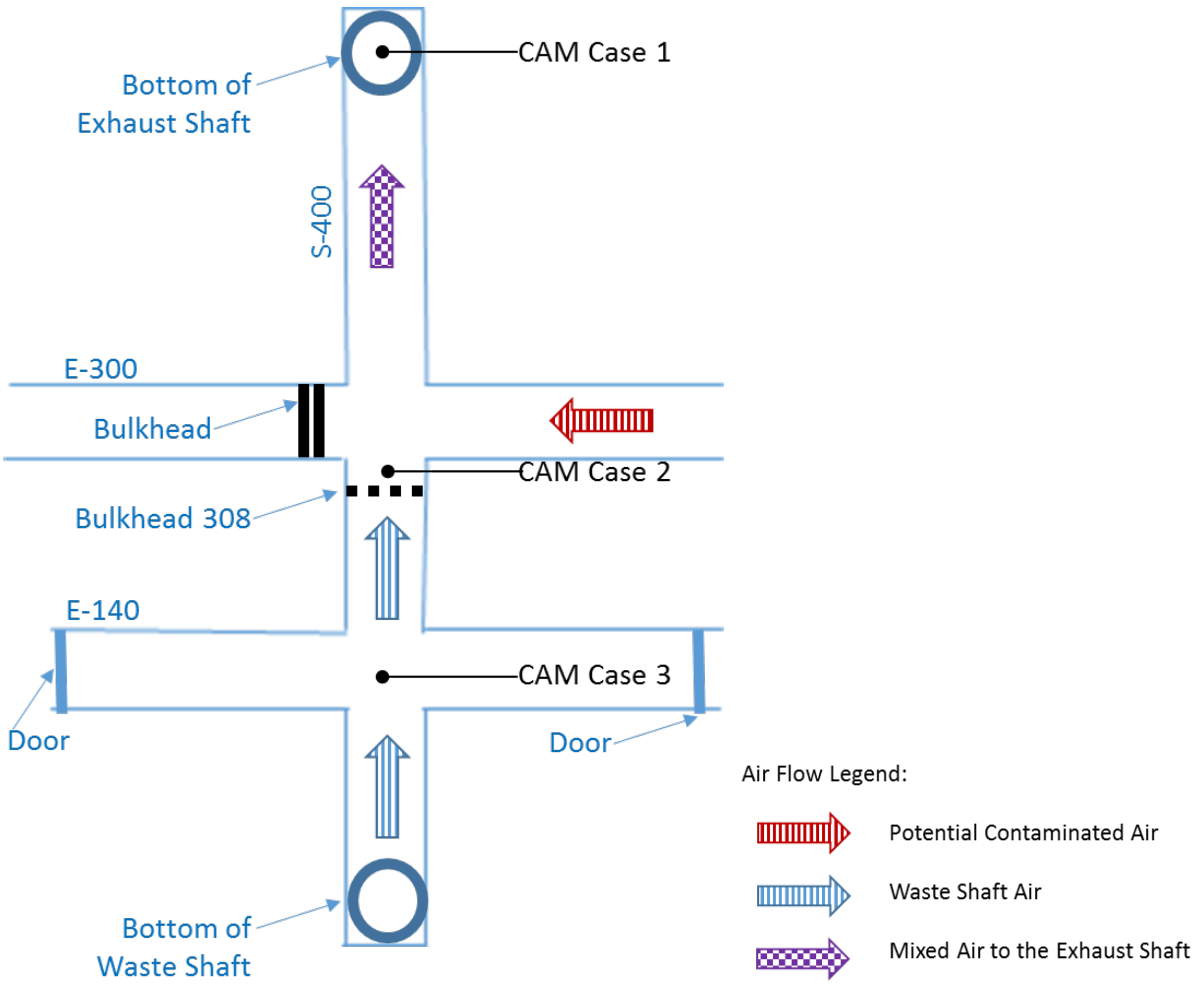

Figure A-3. *Simplified diagram with potential CAM locations for the three cases evaluated.*

The second and third cases contemplate medium to low energy events without the potential to instantaneously push contamination to the bottom of the exhaust shaft. Instead, the contamination is detected at two different locations in the waste shaft station as described in the second and third cases.

Second Case—The second case assumed detection by a CAM located next to BH-308 and takes into consideration the distance between BH-308 and the bottom of the exhaust shaft. The cross-sectional area of the S-400 drift and maximum SSCVS volumetric flow rate are used to calculate the air stream velocity; factoring in the travel distance yields the transport time. This volumetric flow rate is used due to the short distance between BH-308 and drift E-300 (see Figure A-3). The Board's staff team assumed that any radiological release detected in the vicinity of BH-308 accelerates almost immediately to the air stream velocity of the E-300 drift in the direction toward the exhaust shaft.

***Third Case*—**The third case assumed detection by a CAM located at the intersection of the S-400 and E-140 drifts. This case takes into consideration the additional distance between the intersection and BH-308. Once again the air stream velocity is inversely proportional to the cross-sectional area of the flow path. In the third case, the smallest area and higher velocity is at the BH-308 dampers. The cross-sectional area at BH-308 also could fluctuate based on the damper free area[1].

In this case, two main cross-sectional areas are used to calculate two different transport times. One area calculation uses the S-400 drift cross-sectional area and the second calculation uses the BH-308 damper cross-sectional area. The Board's staff team used the area of BH-308 as an approximation of S-400 drift cross-sectional area (Figure A-4). The dimensions of this area are 19'6" by 13'9" for an area of 268.13ft^2 [7]. Each BH-308 damper has dimensions of 5' by 6' for an area of 30ft^2 for a single damper and 60ft^2 for two dampers. However, assuming the damper blades occupied 50 percent of the area, the damper free area for the two dampers would be 30ft^2. The volumetric flow rate of 25,000cfm, used between the intersection and BH-308 for this calculation, is the approximate target volumetric flow rate used to keep the differential pressure across BH-308 and the same flow rate used in the SRK transient time analysis [4] when BH-308 dampers are mostly open.

The air stream velocity in the exhaust shaft for these three cases is calculated by dividing the maximum volumetric flow of SSCVS by the corresponding cross sectional areas. The transport time is then calculated by dividing the exhaust shaft length by the air stream velocity. Maximum air volumetric rates were also calculated under Case 3 conditions to evaluate the volumetric flow rate that would cause airborne contamination to reach the first SRS isolation damper just before it is fully closed.

[1] The damper free area is the face area of the open portion of the damper through which air flows.

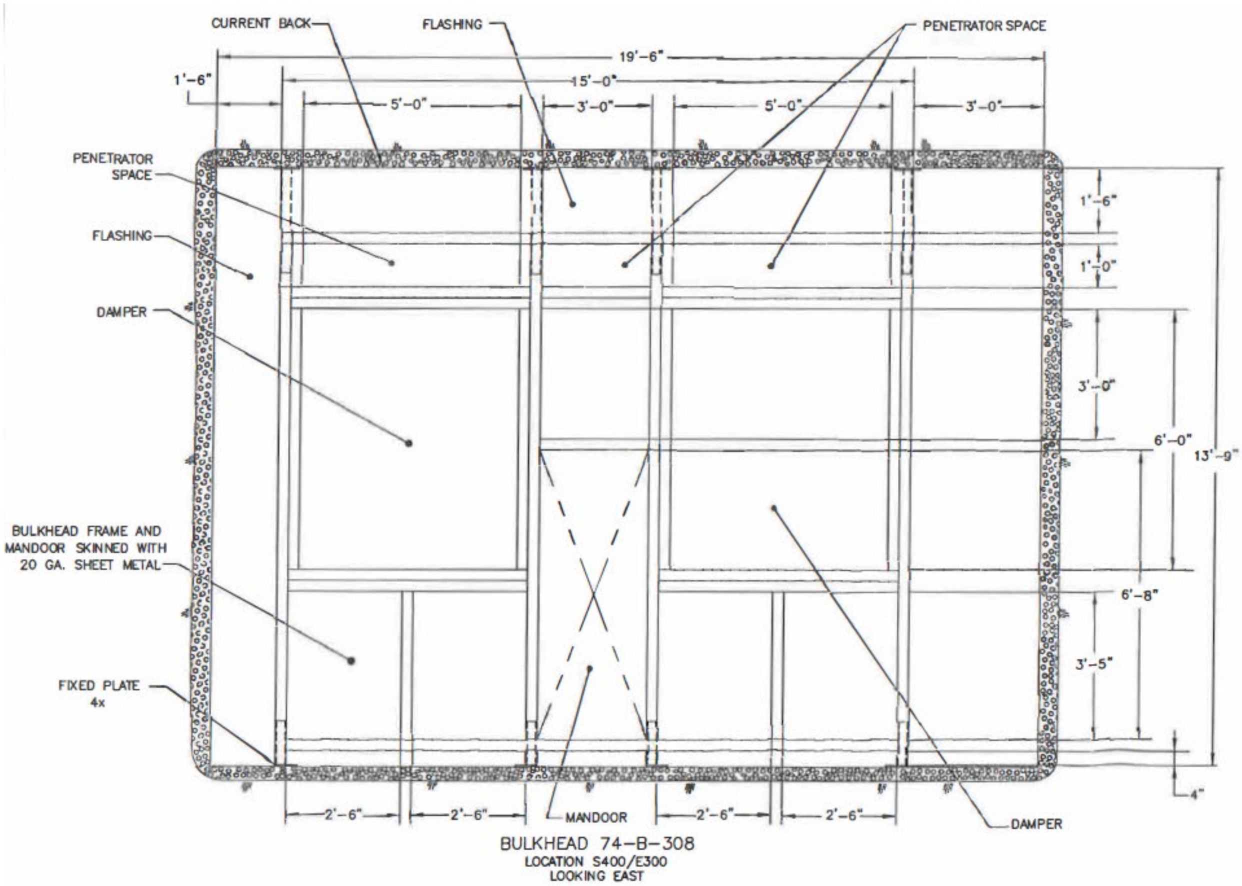

Figure A-4. *Bulkhead 308 Front View*

3. Analytical Methods, Calculations, and Results

Table A-1 summarizes the inputs used to calculate the transport time for Case 1.

Table A-1. *Summary of Inputs for Case 1*

Maximum air volumetric flow	**Collar Shaft Diameter** [8]	**Collar Shaft to 1st Damper** [9], [10]	**UG Exhaust Shaft Depth**	**Total Length**
cfm	inches	ft	ft	ft
540,000	168.5	225	2,150	2,375

Collar shaft area (A):

$$A = \frac{\pi \times D^2}{4} = \frac{\pi \times (168.5in\left(\frac{1ft}{12\ in.}\right))^2}{4} = 154.85\ ft^2$$

where D is shaft diameter.

Maximum Velocity (V):

$$V = \frac{Q}{A} = \frac{540{,}000\ \frac{ft^3}{min}\left(\frac{1min}{60\ s}\right)}{154.85\ ft^2} = 58.12\ \frac{ft}{s}$$

where Q is volumetric flow.

Transport from the bottom of the exhaust shaft to the first SRS isolation damper (t):

$$t = \frac{L}{V} = \frac{2{,}375\ ft}{58.12\ \frac{ft}{s}} = 41\ seconds$$

where L is the total length.

Based on the assumptions for Case 1, it takes 41 seconds for any airborne contamination at the bottom of the exhaust shaft to reach the first isolation damper. Given the damper will take 60 seconds to close, this means there is clearly a potential for release of contaminated air into the salt reduction building (SRB). SRB is not a safety significant confinement boundary component and for that reason it cannot be used as a credited boundary under this scenario.

Table A-2 summarizes the inputs and results for the calculation of transport time for Case 2. The cross-sectional area used to calculate the air flow velocity in the underground corresponds to drift S-400 [7].

Table A-2. *Summary of Inputs and Results for Case 2*

Maximum air volumetric flow	BH-308 to Exhaust Shaft-bottom	Drift cross-sectional area	Maximum Velocity	Time to reach the bottom of the shaft	Time to reach 1st SRS isolation damper
cfm	ft	ft^2	ft/s	seconds	seconds
540,000	192	268.13	33.57	5.72	47

Table A-3 summarizes the inputs and results for the calculation of the transport time for Case 3. The volumetric flow rate of 25,000cfm and the cross-sectional area of drift S-400 [7] are used to calculate the additional transport time from the S-400/E-140 intersection to BH-308. A second velocity was calculated using the cross-sectional area of the two BH-308 dampers. However, the actual velocity could fluctuates at drift S-400 before reaching BH-308 due to the damper free area. For that reason a third velocity was calculated using the 50 percent damper free area of BH-308. For this analysis, the velocity at drift S-400 is the lower bounding value (less conservative) and the velocity at BH-308 with 50 percent damper free area is the upper bounding value (more conservative).

Table A-3. *Summary of Inputs and Results for Case 3*

Case 3A: Release at the S-400/E-140 intersection - Drift S-400 cross-sectional area

Maximum air volumetric flow per Calculation	S-400/E-140 intersection to BH-308	Drift cross-sectional area	Maximum Velocity	Time from intersection to BH-308	Time to reach 1st SRS isolation damper
cfm	ft	ft^2	ft/s	seconds	seconds
25,000	129	268.13	1.55	83.01	130

Case 3B: Occurrence at the intersection – BH-308 dampers cross sectional area

BH-308 Damper cross-sectional area	Maximum Velocity	Time from intersection to BH-308	Time to reach 1st SRS isolation damper
ft^2	ft/s	seconds	seconds
60.00	6.94	18.58	65

Case3C: Occurrence at the intersection – 50 percent BH-308 dampers cross sectional area

BH-308 Damper with 50% cross-sectional area	Maximum Velocity	Time from intersection to BH-308	Time to reach 1st SRS isolation damper
ft^2	ft/s	seconds	seconds
30.00	13.89	9.29	56

For cases 1, 2, and 3C, the transport time calculated is 41, 47, and 56 seconds, respectively. If the PDSA allows 60 seconds from detection to full closure of the SSCVS isolation dampers, the alignment of the ventilation system to a safe configuration that could filter the underground air will not happen on time and contaminated air could be released to the environment.

The maximum volumetric flow rates under Case 3 conditions were also calculated given the time that is required before the isolation dampers are fully closed. Three flow rates were calculated. The first two calculations used the S-400 drift and BH-308 damper cross sectional areas to determine the maximum air flow rate that would allow airborne contamination to reach the isolation dampers in a 60 second time frame. The calculation of the third flow rate uses 50 percent of the BH-308 damper free area. Table A-4 summarizes the inputs and the results of these three calculations.

Table A-4. *Drift S-400 Maximum Allowed Volumetric Flow Rates given 60 second Transport Time*

Drift S-400 cross-sectional area

S-400/E-140 intersection to BH-308	Time left to reach 60 seconds	Maximum Velocity to reach 60 seconds	Drift cross-sectional area	Drift S-400 Maximum Allowed Volumetric Flow
ft	s	ft/s	ft^2	cfm
129	13.42	9.62	268.125	150,000

BH-308 dampers cross sectional area

BH-308 Damper cross-sectional area	Drift S-400 Maximum Allowed Volumetric Flow
ft^2	cfm
60	35,000

Sensitivity analysis for 50% BH-308 dampers cross sectional area

BH-308 Damper cross-sectional area	**Drift S-400 Maximum Allowed Volumetric Flow**
ft^2	cfm
30	17,000

The maximum allowed volumetric air flow rate calculated for a 50 percent damper's cross sectional area is 17,000cfm, which is below the recommended 25,000cfm to maintain the required differential pressure at BH-308. Any flow rate above that value would increase the likelihood of contaminated air reaching the isolation damper before it is completely closed. This would cause a potential release of contaminated air to the environment.

4. Conclusions

Based on this calculation, during explosion/deflagration or high energy anticipated events at the waste shaft station, radiological contamination could reach the first SRS isolation damper in approximately 41 seconds. The WIPP SSCVC PDSA allows 60 seconds for the isolation dampers to fully close. Based on this calculation, and assuming the radiological detection system survives the DBA, airborne radiological contamination has the potential to reach the surface and first SRS isolation damper before it is fully closed during this DBA. This could cause a release of contaminated air into the environment.

A radiological release detected at BH-308 or at the intersection of E-140 and S-400 has the potential to reach the first SRS isolation damper before it is completely closed. This could potentially cause a release of unfiltered radiologically contaminated air into the SRS building. The SRS building is not part of the safety significant confinement boundary, which increases the likelihood of leaking potentially contaminated air into the environment.

In addition to the damper closure times, the locations of CAMs, underground volumetric flow rates and air stream velocities, and the ability of CAMs to detect a radiological release promptly are key parameters to ensure airborne radiological contamination is not released to the environment. The sensitivity analysis of volumetric flow rates demonstrates the importance of accurately determining the design parameters (e.g., BH-308 dampers cross sectional area) that could impact the transport time of contaminated air.

5. Calculation References

[1] Nuclear Waste Partnership, LLC, *Waste Isolation Pilot Plant Permanent Ventilation System Project Preliminary Documented Safety Analysis*, 500655-416-BD-SE-00306, Rev. 0, May 8, 2017.

[2] Nuclear Waste Partnership, LLC, *Waste Isolation Pilot Plant, Documented Safety Analysis,* DOE/WIPP 07-3372, Rev. 5b, April 2016.

[3] SRK Consulting (U.S.), Inc., *2017 SVS Test and Balance*, DN-486300.050-2, December 2017.

[4] SRK Consulting (U.S.), Inc., *Technical Memorandum: PVS Panel 9B Transient Time Analysis,* DN-486300.030-09, August 22, 2017.

[5] Defense Nuclear Facilities Safety Board, *Letter from B. Hamilton to Honorable R. Perry,* March 26, 2018.

[6] U.S. Department of Energy, Carlsbad Field Office, *Safety Evaluation Report for Approval of the Waste Isolation Pilot Plant Safety Significant Confinement Ventilation System Project Preliminary Documented Safety Analysis, 500655-416-BD-SE-00306,* DOE/WIPP 18-3602, Revision 0, April 2018.

[7] Nuclear Waste Partnership, LLC, *U/G Mine Plan Bulkhead, Locations and Numbers,*DWG. NO. 74-B-LOC, January 27, 2004.

[8] Nuclear Waste Partnership LLC, *Duct Elbow Detail,* DWG. NO 416-B-013-W1, Carlsbad, NM, February 17, 2017.

[9] Nuclear Waste Partnership, LLC, *PVS Duct Supports Partial Plan-Mine Shaft to SRB/SRB to NFB,* DWG. NO. 416-B-020-W1, February 17, 2017.

[10] Nuclear Waste Partnership, LLC, *PVS Duct Support Partial Plan-Salt Removal Building,* DWG. NO. 417-B-020-W7, February 17, 2017.