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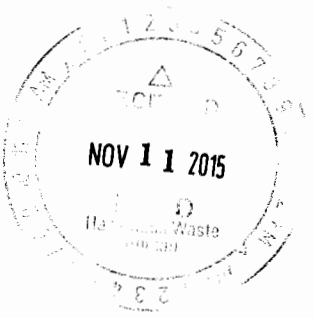

Mr. Ricardo Maestas
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

November 11, 2015

Ricardo,

I am submitting comments on the September 8, 2015 Class 2 permit modification request (**PMR**) submitted by the US Department of Energy Carlsbad Field Office and Nuclear Waste Partnership (**Permittees**) to the New Mexico Environment Department (**NMED**), proposing changes to the Waste Isolation Pilot Plant (**WIPP**) Hazardous Waste Facility Permit (**Permit**). Please consider and provide responses to my comments when you deliberate modifying the Permit as requested in the PMR.

The Permittees divided their PMR discussion into six topics, to which I will comment on four of them. These are:

- Topic 2 – Change the repository VOC monitoring locations
- Topic 4 – Change in the sampling duration for the VOC monitoring
- Topic 5 – Revise the method of determining compliance with the non-waste surface worker environmental performance standard
- Topic 6 – Remove the minimum running annual average mine ventilation exhaust rate

<u>Topic 2 – Change the repository VOC monitoring locations</u>

The Permittees adequately justify, in the context of the overall PMR and related appendices, relocating the VOC monitoring locations for the Repository VOC Monitoring Program (**RVMP**) from the underground to above ground locations, based upon updated air dispersion modeling reflecting current conditions. The maximally exposed non-waste surface workers continue to be those who are downwind of the exhaust shaft in Building 489.

1. The Permittees offer various descriptions throughout the PMR for a new VOC monitoring location (station VOC-C) near Building 489, but fail to adequately incorporate that language or description in the actual language of the permit text. Here are some examples:

- "Station VOC-C is proposed to be stationed at the west air intake of Building 489" (top of page 9)

- "...modeling indicated that the best location to monitor is the air intake to Building 489" (middle of page 9)

However, the language proposed for inclusion in the Permit Attachment N, Section N-3a(1) reads:

> *Building 489 has been identified as the location of the maximum non-waste surface worker exposure. Air samples will be collected at the air intake for Building 489 (Figure N-1) to quantify VOCs in the ambient air.*

Note that this does not state it will be at the west air intake, nor does it explicitly identify this location as station VOC-C, instead relying on a reference to a separate figure. The Permit language must be as precise as possible, and should state explicitly that station VOC-C is located at the west air intake of Building 489.

2. The situation is similar for new VOC monitoring location VOC-D. At the top of page 9, it says "Station VOC-D is proposed to be stationed at WQSP-4," whereas the language proposed for Section N-3a(1) says *Background VOCs will be measured by sampling at groundwater pad WQSP-4 (Figure N-1)* without explicitly identifying this location as station VOC-D. This text description must also be as precise as for Station VOC-C, not relying on reference to a figure.

3. Furthermore, the depiction of the VOC monitoring locations on Figure N-1 is insufficient to clearly identify them without reference back to the text. Figure N-1 should be modified to explicitly identify Building 489 with a label in the enlarged box as the location for station VOC-C, and monitoring well WQSP-4 should be identified with a label in the lower right corner as the location for station VOC-D.

Topic 4 – Change in the sampling duration for the VOC monitoring

4. The proposal to change the sampling duration for the RVMP samples from six to 24 hours is conservative and protective, in light of the modeling results provided in Appendix D, pages D-14 to D-18. Sampling over a 24-hour period eliminates the impact of a shorter duration where samples might be collected during the day when atmospheric turbulence disperses VOCs released from the repository.

Topic 5 – Revise the method of determining compliance with the non-waste surface worker environmental performance standard

In Topic 5, the Permittees discuss revising the methodology for demonstrating compliance with the non-waste surface worker environmental performance standards. The historic approach implemented in the Permit relies upon not exceeding VOC-specific concentrations of concern (**COCs**) in the active panel that were calculated to result in an acceptable risk to surface receptors. The proposed approach relies on the determination of the actual risk to the receptor from the target VOCs that will be directly measured at a point

of compliance. COCs are an indirect method of determining risk, whereas measurement of VOC concentrations allows a direct calculation of risk.

5. On page 12 of the PMR, the Permittees identify the process to calculate risk. After determining the concentration of target VOCs based on measurements at surface monitoring stations, the process is to "Subtract the results of background Station VOC-D from the results at Station VOC-C."

However, subtraction of background is not included in the language proposed in Permit Attachment N, Section N-3e(1), thus creating a discrepancy. Instead, $Conc_{VOC}$ is defined as the concentration of the target VOC at the receptor, apparently without any subtraction. If this is the case, the Permittees should not be allowed to reduce the concentration measured at VOC-C by subtracting the background concentration measured at VOC-D. In any case, the Permit should be consistent and explicit in identifying what concentration is used to calculate risk due to exposure to each target VOC.

6. On page 14 of the PMR, the Permittees identify four advantages to the approach of calculating risk directly. In part, they state:

> *Third, reporting will be greatly simplified since a single exceedance of a COC by any particular compound will no longer have to be reported unless it is high enough to cause the overall risk or HI to exceed the action levels. Fourth, the methodology provides a more comprehensive assessment of health impacts since it considers both the carcinogenic and non-carcinogenic effects of compounds, making the risk calculations more protective of human health than the use of the COCs.*

While it is clear that reporting will be greatly simplified, it could be argued that the new risk calculations are not necessarily more protective of human health, since the COC method triggered remedial action when the running annual average for any VOC exceeded its COC, providing an early warning of potential risk from either carcinogenic or non-carcinogenic VOCs.

7. Also on page 14 of the PMR, the Permittees propose to allow "alternative remedial actions" (subject to approval by the NMED Secretary) in lieu of closing active disposal rooms or panels. The specific language proposed for inclusion is in Permit Condition 4.6.2.4, Remedial Action.

The language as proposed is overly broad and unnecessary, particularly with the use of the phrase, "prior to reaching the action level." The two examples of alternative remedial actions" offered on page 14 of the PMR (move affected employees so that excessive chronic exposure does not occur, remediate the emissions by managing waste emplacement activities) are actions currently allowed under the Permit without prior approval by the Secretary.

It appears the intent of the language proposed in Permit Condition 4.6.2.4 is to avoid closing active disposal rooms or panels in the event of excess risk. The Permittees should

be motivated to proactively and aggressively manage their operations to preclude these occurrences, not seek an "escape clause" for failing due diligence after the fact. I strongly recommend that the sentences proposed for insertion at the end of the first two paragraphs in Permit Condition 4.6.2.4 be excluded from the final Permit.

8. In order to encourage the Permittees to manage their operations to preclude these occurrences, NMED should impose a requirement under Permit Condition 4.6.2.2, Reporting Requirements, for the Permittees to report, on a quarterly basis, the most recent and the historic maximum running annual average (including measurement dates) for both carcinogenic and non-carcinogenic VOCs on a link the WIPP Home Page. This would allow the public to determine whether there are any observable potential health risks to non-waste surface workers at WIPP.

Topic 6 – Remove the minimum running annual average mine ventilation exhaust rate

9. The Permittees' discussion under Topic 6 contains some incorrect information. It states

> *The model started with the VOC concentration that resulted in an acceptable risk to the non-waste surface worker and applied an air dispersion factor to calculate the concentration at the top of the Exhaust Shaft. A corresponding concentration was calculated at the bottom the Exhaust Shaft by assuming a repository ventilation flow rate of 425,000 scfm. Because the measurement point, known as Station VOC-A is some 1,300 feet south of the base of the Exhaust Shaft, a corresponding concentration was calculated assuming a disposal circuit ventilation rate of 130,000 scfm. The resulting concentrations became the COCs for each compound. The values in Table 4.6.2.3 are the acceptable concentrations if the repository and disposal circuit ventilation rates are 425,000 and 130,000 scfm, respectively.*
>
> *In 2006, the Permittees modified the Permit to change the manner in which compliance with the COCs in Table 4.4.1 is demonstrated. In lieu of individual headspace gas measurements on each container and specification of the container filter vent characteristics, direct measurement of filled disposal room concentrations was instituted. This action broke the tie between disposal room concentrations and concentrations at Station VOC-A since compliance with one can now be managed independently of the other and the numerical model simulating the flow from the container to the monitoring station is no longer relevant. Since this model, including its assumptions regarding minimum flow rates is no longer needed, the minimum repository ventilation flow rate of 260,000 scfm is likewise no longer necessary to protect human health or the environment.* (emphasis mine)

Actually, the COCs were calculated assuming a mine ventilation exhaust rate of 260,000 scfm, hence the imposition of this value as the minimum running annual average mine ventilation rate in Permit Condition 4.5.3.2, Ventilation (see attached spreadsheet "VOC Releases.xls" [tabs "sur-fnl-5" and forward] and the November 19, 1998 memorandum, pages 7-8, referenced in footnote 13 of the PMR). Changes implemented in 2006 by which compliance with the COCs in Table 4.4.1 was demonstrated did not "break" the tie between

COCs and concentrations at Station VOC-A, nor they did render the numerical modeling "no longer relevant." COCs were calculated the same way in 2006 and again in 2010 during the first renewal of the WIPP Permit as they had been in 1998. The only reason the minimum repository ventilation flow rate of 260,000 scfm is now no longer necessary is because the Permittees are proposing to measure VOC concentrations at the point of compliance at newly designated Station VOC-C and directly calculate the resultant risk. I support removal of the minimum running annual average mine ventilation exhaust rate from Permit Condition 4.5.3.2.

Conclusion

I support the overall approach to managing risk from VOCs to receptors on the surface as proposed in the PMR. It is made possible primarily by the significantly improved maximum method reporting limits (**MRLs**) imposed in Permit Attachment N, Table N-2 for surface monitoring samples. This, coupled with refined air dispersion modeling at lower exhaust ventilation rates confirming Building 489 as the location of maximum impact from VOC releases, should ensure a technically defensible monitoring program for protecting human health at WIPP. I believe incorporation of my comments strengthen the program by reducing ambiguity and providing public access to relevant information.

Please feel free to contact me if you have any questions about my comments.

Sincerely,

Steve Zappe

MEMORANDUM

TO: File

FROM: Steve Zappe

DATE: November 19, 1998

SUBJECT: NMED calculations for VOC concentrations in WIPP Underground HWDUs

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In response to comments received from the DOE and WID regarding unreasonably low limits on volatile organic compounds in the repository (Comments 1.1.5 and 94), NMED proceeded to document its process for determining VOC limits for Underground HWDUs.

The first step was to develop a spreadsheet capable of reproducing the results presented by the Permittees in their permit application. Relevant information was submitted to NMED in Appendix D9 of the permit application (*Exposure Assessment for Protection of the Atmosphere*) and Chapter 5 of the No-Migration Variance Petition (*Environmental Impact Analysis*). Information concerning calculations of concentrations of concern for the VOC monitoring program described in Appendix D20 of the permit application (*Confirmatory Volatile Organic Compound Monitoring Plan*) was obtained during a telephone conversation with WID (J.R. Stroble and Bob Kehrman) sometime in 1996 or 1997.

Initially each scenario was developed in a separate file, but I finally put everything into one Excel '97 workbook so I could quickly switch between different scenarios. Attached are pages printed from the master workbook (VOC Releases.xls) used to calculate VOC concentrations. Following is a description of each sheet along with relevant assumptions and observations:

res-avg - Exposure to Resident at WIPP LWA Boundary, Average VOC Headspace Concentrations - DOE Calculations. Agrees with results in Tables D9-3 and D9-4.

This spreadsheet sets up the basic framework for all subsequent calculations, using the Permittees' assumptions for all parameters. The headspace gas concentrations used here are based upon data accumulated and presented in Appendix C2 of the permit application. Appendix C2 also provides the justification for the use of weighted averages based upon expected proportions of different types of wastes and headspace gas measurements taken from 900 drums of TRU mixed waste prior to September 29, 1995.

Initial assumptions which were later changed based upon additional information provided by the Permittees included the mine ventilation exhaust rate. The Permittees assumed, for modeling purposes, that the

mine ventilation exhaust rate was 425,000 ft^3/min over the exposure duration period (35 years in this instance). Also, the exhaust shaft concentration assumed a full repository (9 closed and 1 open panel equivalents) with no ventilation barriers, a relatively conservative assumption.

The Permittees never asked that these modeled headspace gas concentrations be imposed by the Permit. This calculation was an attempt by the Permittees to demonstrate that, if the actual waste disposed at WIPP did not exceed these limits, the overall risk to a receptor living at the WIPP LWA Boundary would be one to two orders of magnitude below acceptable risk levels. This spreadsheet confirms this conclusion.

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antelope - Exposure to Antelope Ridge Rancher within WIPP LWA Boundary, Average VOC Headspace Concentrations - DOE Calculations. Agrees with results in Tables D9-5 and D9-6.

livridge - Exposure to Livingstone Ridge Rancher within WIPP LWA Boundary, Average VOC Headspace Concentrations - DOE Calculations. Agrees with results in Tables D9-5 and D9-6.

These two scenarios assume an occupational exposure to a hypothetical rancher working within one of two grazing allotments within the WIPP LWA Boundary. The only differences between these two spreadsheets depicting risks to ranchers and the spreadsheet depicting risk to a resident at the WIPP LWA Boundary are as follows:

- Exposure frequency (EF) reflects an occupational exposure for the ranchers (8 hours/day, 5 days/week for 35 years) rather than a residential exposure (continuous for 35 years); and
- Air Dispersion Factor (ADF) is determined by averaging over the appropriate grazing allotment rather than a stationary settlement on the WIPP LWA Boundary at the point of least dispersion.

Not surprisingly, these two spreadsheets also indicate the overall risk to a rancher working within the WIPP LWA Boundary would be one to two orders of magnitude below acceptable risk levels.

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res-max - Exposure to Resident at WIPP LWA Boundary, Maximum VOC Headspace Concentrations - DOE Calculations. Calculations not actually performed by the Permittees, but "back-calculated" numbers provided by the Permittees were plugged into the first sheet.

The Permittees documented their assumption for establishing headspace concentration limits (maximum headspace concentrations) in Revision 5.2 of the permit application, using the following equation:

$$HSCL_{voc} = \left(\frac{acceptable\ level\ of\ risk}{calculated\ risk} \right) \times headspace\ concentration$$

where for carcinogens,

$HSCL_{VOC}$ = headspace concentration limit for each VOC, ppmv
acceptable level of risk = 1E-06 for Class B, 1E-05 for Class C
calculated risk = based upon weighted average concentrations
headspace concentration = weighted average, ppmv

and for non-carcinogens,

acceptable level of risk = Hazard Quotient of 1.0
calculated risk = based upon weighted average concentrations
headspace concentration = weighted average, ppmv

The Permittees derived the headspace concentration limits based upon calculated risk in Revision 5.2. However, there are numerous differences in headspace concentration limits presented in Tables D9-11 and D9-12 of Revision 5.2 from those presented in Table D9-7 of Revision 6 which the Permittees never documented or justified. The calculations in this spreadsheet used the headspace concentration limits specified in Revision 6.

In Comment 94 on the Draft Permit, the Permittees stated the following:

"The Permit Application correctly identifies EPA's health-based risk assessment limits and the OSHA time weighted average exposure limits as the appropriate regulatory standards to use in determining whether operation, maintenance, and closure of the miscellaneous unit will be protective of human health and the environment. The Permittees' proposed VOC monitoring approach is valid for two reasons[1]:

(1) *"It is consistent with environmental limits imposed by the EPA. Using the EPA risk assessment methods, the Permit Application demonstrated that the proposed VOC concentration limits for both carcinogens and non-carcinogens are protective of human health and the environment. The analysis in Appendix D9 of the Permit Application first identified the type of human receptors that are theoretically able to receive the largest chronic dose. This was determined to be a hypothetical resident who constructs and occupies a house on the WIPP site boundary. There are no such individuals and the analysis reflects a worst-case scenario, because the construction of residences closer than the boundary is prohibited under the WIPP Land Withdrawal Act and the DOE's management of the land. Maximum average container headspace concentrations were then determined and maximum permissible exposures were calculated in accordance with EPA's public health risk policy (e.g., a one in one million chance of developing cancer for exposure to carcinogenic materials and a hazard index of less than one for non-carcinogens). This analysis showed that, in all cases, exposures would be well below acceptable levels."*

Unfortunately, the Permittees failed to include this analysis in the permit application. Further, as will be shown later, the "*hypothetical*

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[1] *The second reason stated that the Permittees had demonstrated that the concentrations will meet all applicable worker safety requirements, but this is not relevant to discussions concerning risk to non-workers.*

resident who constructs and occupies a house on the WIPP site boundary" is not the human receptor that is theoretically able to receive the largest chronic dose under the conditions specified in the permit application.

This spreadsheet provides NMED's analysis consistent with what the Permittees intended to include in the permit application. Note that while the risk to a receptor to individual carcinogens are within acceptable levels, the additive excess cancer risk from all carcinogens is 1.7E-05, or 17 times greater than an acceptable risk of 1E-06. This demonstrates that a resident is at an elevated risk of developing cancer if the concentrations proposed by the Permittees in their application were approved and is not, as the Permittees assert, an exposure that is "*well below acceptable levels.*"

Several of the Permittees' proposed concentrations are also unacceptable because they exceed the Lower Explosive Limit (**LEL**) for chlorobenzene, toluene, and 1,1,1-trichloroethane specified on the table on Page 10. Although VOC concentrations would not reach equilibrium in an open room due to ventilation, they would reach equilibrium in a closed room. NMED will not approve concentrations which could result in exceeding the LEL.

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sur-max - Exposure to Surface Worker within WIPP PPA, Maximum VOC Headspace Concentrations - DOE Calculations. Using concentrations from Table D9-7, results agree with Tables D9-8 and D9-9 for surface worker.

This scenario assumed a non-waste worker at the surface stationed adjacent to the exhaust shaft. Additional assumptions made on this spreadsheet which differ from previous ones are:

- Exposure frequency (EF) reflects an occupational exposure for the surface worker(8 hours/day, 5 days/week, 48 weeks/year for 10 years);
- Air Dispersion Factor (ADF) is the maximum identified within the Property Protection area, near the exhaust fans;
- Ventilation barriers are used, such that the maximum releases from an open panel occur when 6 rooms have been filled and ventilation barriers are erected, and the last room is filled; and
- Maximum average headspace concentrations (from Table D9-7) are used

One interesting effect is noticed when comparing the actual exhaust shaft concentrations (**ECS act**) calculated in the previous scenario with this one. The simple act of implementing room ventilation barriers reduces concentrations to approximately 25% of the levels obtained when no ventilation barriers are used.

While the risk to a receptor to most individual carcinogens are within acceptable levels, both 1,2-dichloroethane and 1,1,1-trichloroethane exceed their respective acceptable excess cancer risk levels for the surface worker. Furthermore, the additive excess cancer risk from all carcinogens is 2.6E-05, which is more than twice the acceptable excess

cancer risk level of 1E-05[2]. This demonstrates that a surface worker is at an elevated risk of developing cancer if the concentrations proposed by the Permittees in their application were approved and is not, as the Permittees assert, an exposure that is "*well below acceptable levels.*" NMED has identified the surface worker as the human receptor that is theoretically able to receive the largest chronic dose under the conditions specified in the permit application.

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coc-doe - DOE COC Calculation, Based Upon Exposure to Surface Worker within WIPP PPA, Maximum VOC Headspace Concentrations. Although the Permittees never provided their method for determining VOC Concentrations of Concern (**COCs**) in their application, NMED identified the method through direct discussions with the Permittees. Following is a description of the method:

$$COC_{VOC} = \left(\frac{HBL}{ADF}\right) \times \left(\frac{V_{exhaust}}{V_{panel}}\right)$$

where,

COC_{VOC} = concentration of concern for each VOC, ug/m^3
HBL = Health-base level for each VOC, ug/m^3
(Eqn 5-1 for carcinogens, Eqn 5-9 for non-carcinogens, from Chapter 5 of the No-Migration Variance Petition)
ADF = Air dispersion factor, unitless
$V_{exhaust}$ = mine ventilation exhaust rate, standard ft^3/min
V_{panel} = mine ventilation panel rate, standard ft^3/min

The calculations for COC are specific to a receptor, which means that the health-based level for a resident at the WIPP LWA Boundary cannot be combined with the air dispersion factor for the surface worker. It appears, based upon examination of the COCs presented in Table 3.1 in Appendix D20, that the Permittees calculated the COCs for the surface worker scenario.

The results agree with the values presented in Table 3.1 in Appendix D20, with the following exceptions. The Permittees incorrectly assumed an Averaging Time (**AT**) of 70 years instead of 10 years in determining non-carcinogenic HBLs for both chlorobenzene and 1,1,1-trichloroethane. This resulted in COCs for these two constituents 7 times greater than is appropriate. Furthermore, the Permittees apparently used the non-carcinogenic Reference Dose (**RfD**) for 1,1,2-trichloroethane instead of the correct RfD for 1,1,1-trichloroethane. This error, compounded by using the wrong AT, resulted in the Permittees requesting a COC nearly 2400 times greater than is appropriate. If NMED had allowed the Permittees to use these incorrectly calculated COCs, the threshold for identifying unsafe concentrations of these VOC would not have been protective of human health.

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[2] NMED has set the acceptable excess cancer risk level for a resident at the WIPP LWA Boundary at 1E-06, while setting the acceptable excess cancer risk level to a surface worker at 1E-05. This was done in recognition that the Permittees exert some level of control over exposure to their own workers, and thus a higher level of acceptable risk was warranted.

This is the only spreadsheet which calculates COCs using the health-based limit divided by the air dispersion factor. NMED has determined a better method for determining COCs is as follows:

$$COC_{VOC} = ECS_{ACT} \times \left(\frac{V_{exhaust}}{V_{panel}} \right)$$

where,

COC_{VOC} = concentration of concern for each VOC, ug/m^3
ECS_{ACT} = actual exhaust shaft concentration for VOC, ug/m^3
$V_{exhaust}$ = mine ventilation exhaust rate, standard ft^3/min
V_{panel} = mine ventilation panel rate, standard ft^3/min

All other sheets use the actual exhaust shaft concentration instead of the ratio of HBL to air dispersion factor, and the final COCs specified in the Draft Permit are based upon this equation. One benefit to this method is that it establishes a direct relationship between the expected concentration of VOCs in the exhaust shaft to what is measured in the confirmatory monitoring plan. Thus, both the validity of modeling assumptions used to predict releases from the repository (based upon headspace gas concentrations) and the actual releases from the repository (as actual exhaust shaft concentrations) can be confirmed by monitoring emissions from the panels.

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open-doe - Open Room Scenario with Room Vent Rate @ 35,000 ft^3/min using DOE Maximum VOC Concentrations. This is a spreadsheet developed by TechLaw Inc. to confirm the Permittees' calculations for underground waste worker exposure in the event of a roof fall as provided on Table D9-ATT 1-2 of the permit application. This scenario assumes that an underground waste worker who is upwind of the waste stack will be exposed to the VOCs from 21 drums which, in response to a roof fall, will fall from the top row and breach.

For this scenario, the spreadsheet calculated concentrations in the room air immediately after a roof fall approximately twice as high as the concentrations reported by the Permittees on Table D9-ATT 1-2. However, NMED believes the higher concentrations are correct, since the concentrations for the 8-hour time-weighted averages match the Permittees's values on Table D9-ATT 1-2.

The Permittees did not calculate concentrations in the air for four constituents (chlorobenzene, 1,1,2,2-tetrachloroethane, toluene, and 1,1,1-trichloroethane) because they failed to update Table D9-ATT 1-2 from Revision 5.2 of the permit application. This table incorrectly states that no VOC headspace concentration limits were imposed on Table C5, but Revision 6 did include limits for these VOCs. Thus, there are no comparisons on this spreadsheet for these four constituents.

This spreadsheet indicates that an underground waste worker in an open room could inhale 1,2-dichloroethane and 1,1,1-trichloroethane in concentrations exceeding Immediate Danger to Life and Health (**IDLH**) limits in the event of a roof fall. Thus, the VOC limits proposed by the Permittees are not protective of the health of an underground worker in the event of a roof fall in an open room.

closed-doe - Closed Room Scenario with Room Vent Rate @ 35,000 ft^3/min using DOE Maximum VOC Concentrations. This is a spreadsheet developed by TechLaw Inc. to confirm the Permittees' calculations for underground waste worker exposure in the event of a roof fall on Table D9-ATT 1-4. This scenario assumes that an underground waste worker who is downwind of a full room with ventilation barriers in place will be exposed to VOCs expelled following a roof fall in that closed, full room.

For this scenario, the spreadsheet calculated concentrations in the room air immediately after a roof fall that were approximately 70% of the concentrations reported by the Permittees on Table D9-ATT 1-4. However, NMED believes these concentrations are correct, since the concentrations for the 8-hour time-weighted averages match the Permittees's values on Table D9-ATT 1-4.

The Permittees did not calculate concentrations in the air for four constituents (chlorobenzene, 1,1,2,2-tetrachloroethane, toluene, and 1,1,1-trichloroethane) because they failed to update Table D9-ATT 1-4 to include VOC limits specified on Table C-5 in Revision 6. Even so, Table D9-ATT 1-4 showed that the VOC limit for 1,2-dichloroethane proposed by the Permittees exceeded the IDLH limit. This spreadsheet confirms this exceedance, and also identifies three additional constituents which the Permittees failed to consider (1,1,2,2-tetrachloroethane, toluene, and 1,1,1-trichloroethane) that exceed their respective IDLH limits in the event of a roof fall. Thus, the VOC limits proposed by the Permittees are not protective of the health of an underground worker in the event of a roof fall in a closed room.

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closed-idlh - Closed Room Scenario with Room Vent Rate @ 35,000 ft^3/min, Maximum VOC Concentrations Not To Exceed IDLH Limit. Comparison between the open room and closed room scenarios indicate the closed room scenario presents greater risk to an underground worker, primarily because the worker is downwind of the release. NMED used the previous spreadsheet to back-calculate VOC limits which would not exceed the IDLH limit for the closed room scenario. These are depicted on the spreadsheet and provide on the table on Page 10 in the column titled *Closed Room Maximum VOC Not to Exceed IDLH, ppmv*.

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sur-fnl-5 - Exposure to Surface Worker within WIPP PPA, VOCs Not Exceeding 1E-05 Additive Excess Risk for Cancer, 1.0 for HI. These are the numbers imposed in the revised Draft Permit for room-based limits and COCs.

The previous Draft Permit required the Permittees to maintain a minimum mine ventilation exhaust rate of 425,000 standard ft^3/min and a minimum active room ventilation rate of 35,000 standard ft^3/min. The Permittees, in their Comment 99 on the Draft Permit, requested flexibility in mine ventilation operation. As a result of this comment, the revised Draft Permit was modified to require a minimum mine ventilation exhaust rate of 260,000 standard ft^3/min (or 60,000 standard ft^3/min in filtration mode).

However, the mine ventilation exhaust rate ($V_{exhaust}$) has a direct impact on calculations of risk due to exposure to VOCs. If $V_{exhaust}$ is lowered, the concentrations of VOCs in the entrained air increases, resulting

in greater receptor concentrations and increased risk levels. With the requirement to maintain a minimum $V_{exhaust}$ of 425,000 standard ft^3/min eliminated, all calculations previously provided by the Permittees are invalid.

The approach taken to calculate room-based limits and COCs was as follows:

1. First, I obtained a new value for the RfD for 1,1,1-trichloroethane, since discussions with WID indicated they had used 1,1,2-trichloroethane as a substitute after discovering EPA's Integrated Risk Information System (**IRIS**) didn't have any information. Barbara Toth of NMED called the National Center for Environmental Assessment (**NCEA**) to see if they could help. While NCEA did not have data on 1,1,1-trichloroethane's carcinogenicity, they provided an oral RfD = 2E-01 mg/kg-day, which I converted to a Reference Concentration (**RfC**) = 7E-01 for use in this and subsequent spreadsheets.
2. Next, I apportioned all carcinogenic risk evenly so the sum = 1E-05 for the surface worker case, and all non-carcinogenic risk summed to 1.
3. Back-calculated concentrations to yield the apportioned risk level for each VOC.
4. Compared resultant concentrations with the table on Page 10 for LEL and IDLH limits and ensured these limits were not exceeded. As a result, chlorobenzene and toluene maximum concentrations were set at the LEL. 1,2-dichloroethane and 1,1,1-trichloroethane maximum concentrations were set to not exceed the closed room IDLH limit.
5. The methylene chloride concentration was set below its LEL and IDLH limit because of notes I took during a conversation with WID several years ago in which they stated that, in order to avoid exceeding IDLH during a roof fall event, the maximum concentration was 100,000 ppmv. Although NMED's calculations indicated a higher concentration could be used, I retained the Permittees' proposed concentration.
6. Adjusting these concentrations established carcinogenic risks levels which were no longer evenly apportioned. I re-apportioned the risk levels for the remaining constituents (except for non-carcinogens, which didn't matter). Then I again back calculated concentrations as in step 3 above. These are the concentrations that appear in the revised Draft Permit.

Note that while the lower mine ventilation rate is used to determine exhaust shaft concentrations of VOCs, the ratio of the typical mine exhaust ventilation rate to the panel rate (425,000/130,000) is used to calculate COCs. Permit Attachment N, Section N-3e, provides the equation to normalize VOC concentrations measured during a sampling event to be comparable to samples collected under typical mine ventilation rate operating conditions.

res-fnl-6 - Exposure to Resident at WIPP LWA Boundary, VOCs Not Exceeding 1E-06 Additive Excess Risk for Cancer, 1.0 for HI. Note that I lowered the additive excess cancer risk in step 2 above for the resident scenario to 1E-06 consistent with footnote 2, otherwise the approach is identical to the surface worker scenario described above. If the concentrations imposed in the revised Draft Permit (from the sur-fnl-5 calculations) are used here instead of the concentrations on this spreadsheet (i.e., the imposed concentrations are used to determine risk to a resident rather than a surface worker), the

resultant additive excess cancer risk is approximately 1.6E-06. NMED believes this is still protective of a resident at the WIPP LWA Boundary.

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sur-doe - Exposure to Surface Worker within WIPP PPA, What DOE Asked For (Using Lower V exhaust). This spreadsheet uses the original maximum VOC concentrations proposed by the Permittees and calculates revised COCs and risk to surface workers using the lower mine ventilation rate of 260,000 standard ft^3/min.

This spreadsheet identifies the following problems with the VOC concentration limits proposed by the Permittees when modeled using the assumptions provided in the revised Draft Permit:

- Chlorobenzene, toluene, and 1,1,1-trichloroethane concentrations exceed LEL;
- 1,2-dichloroethane, 1,1,2,2-tetrachloroethane, toluene, and 1,1,1-trichloroethane concentrations exceed IDLH for closed room scenario; and
- Additive excess carcinogenic risk to a surface worker exceeds the acceptable excess cancer risk level of 1E-05 by 2.5 times.

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res-doe - Exposure to Resident at WIPP LWA Boundary, What DOE Asked For (Using Lower V exhaust). This spreadsheet uses the original maximum VOC concentrations proposed by the Permittees and calculates revised COCs and risk to residents using the lower mine ventilation rate of 260,000 standard ft^3/min.

This spreadsheet notes the same exceedances of the LEL and IDLH limits as for the surface worker scenario, and additionally identifies that additive excess carcinogenic risk to a resident at the WIPP LWA Boundary exceeds the acceptable excess cancer risk level of 1E-06 by nearly 4 times.

These last two spreadsheets demonstrate that NMED is justified in not using the Permittees' proposed concentrations under the conditions required by the revised Draft Permit.

Constituent	Lower Explosive Limit (LEL) by % Volume[1]	Equivalent LEL, ppmv	Closed Room Maximum VOC Not to Exceed IDLH, ppmv	Permittees's Requested Maximum VOC, ppmv	VOC Room-Based Limits in Draft Permit, ppmv
Carbon Tetrachloride	not combustible	--	13,427	7,510	11,475
Chlorobenzene	1.3%	13,000	67,138	17,660[3]	13,000
Chloroform	not combustible	--	33,570	6,325	9,030
1,1-Dichloroethylene	6.5%	65,000	--	28,750	5,050
1,2-Dichloroethane	6.2%	62,000	3,357	9,100[4]	3,350
Methylene Chloride	13.0%	130,000	154,417	100,000	100,000
1,1,2,2-Tetrachloroethane	not combustible	--	6,710	7,924[4]	2,720
Toluene	1.1%	11,000	33,570	41,135[3,4]	11,000
1,1,1-Trichloroethane	7.5%	75,000	47,000	100,000[3,4]	47,000

[1] Lower explosive limit (LEL) values from the 1998 NIOSH Pocket Guide
[2] IDLH limit values determined from spreadsheet developed by TechLaw, Inc.
[3] Permittees' requested maximum VOC exceeded LEL
[4] Permittees' requested maximum VOC exceeded IDLH limit

September 16, 1998 **Exposure to Resident at WIPP LWA Boundary, Average VOC Headspace Concentrations - DOE Calculations**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride	375.5	3.76E-04	1.21E-06	0.014	153.84	81000	425000	28.2	0.37	11571	0.5	165.8	2.2	178.8	4.35	130000	103.2	16.4	1.5E-05		8760	35	613200	1.20E-04	1111	32	3.789E-03	6.022E-07	2.8E-08	1.0E-06	0.133
Chlorobenzene	12.5	1.25E-05	1.16E-06	0.000	112.56	81000	425000	0.7	0.01	11571	0.5	5.3	0.1	5.7	0.10	130000	2.4	0.5		2.0E-02	8760	35	306600	1.20E-04	166667	1	8.887E-05	1.931E-08	4.4E-06	1.0E+00	20.000
Chloroform	25.3	2.53E-05	1.34E-06	0.001	119.39	81000	425000	1.6	0.02	11571	0.5	12.4	0.1	13.2	0.25	130000	5.9	1.2	2.3E-05		8760	35	613200	1.20E-04	725	2	2.172E-04	4.447E-08	2.5E-09	1.0E-06	0.087
1,1-Dichloroethylene	11.5	1.15E-05	1.40E-06	0.001	96.95	81000	425000	0.6	0.01	11571	0.5	5.9	0.1	6.3	0.10	130000	2.3	0.6	5.0E-05		8760	35	613200	1.20E-04	3333	1	8.340E-05	2.103E-08	2.1E-09	1.0E-05	0.400
1,2-Dichloroethane	9.1	9.10E-06	1.32E-06	0.000	98.97	81000	425000	0.5	0.01	11571	0.5	4.4	0.1	4.7	0.07	130000	1.7	0.4	2.6E-05		8760	35	613200	1.20E-04	641	1	6.388E-05	1.578E-08	8.3E-10	1.0E-06	0.077
Methylene Chloride	368.5	3.69E-04	1.47E-06	0.017	84.94	81000	425000	19	0.20	11571	0.5	197.7	2.1	210.5	2.83	130000	66.7	19.2	4.7E-07		8760	35	613200	1.20E-04	35461	20	2.448E-03	7.045E-07	5.8E-10	1.0E-06	4.255
1,1,2,2-Tetrachloroethane	9.4	9.40E-06	1.21E-06	0.000	167.86	81000	425000	0.8	0.01	11571	0.5	4.2	0.1	4.5	0.12	130000	2.8	0.4	5.8E-05		8760	35	613200	1.20E-04	2874	1	1.035E-04	1.507E-08	3.0E-09	1.0E-05	0.345
Toluene	19.4	1.94E-05	1.19E-06	0.001	92.13	81000	425000	0.9	0.01	11571	0.5	8.4	0.1	9.1	0.13	130000	3.1	0.8		4.0E-01	8760	35	306600	1.20E-04	3333333	1	1.155E-04	3.065E-08	2.9E-07	1.0E+00	400.000
1,1,1-Trichloroethane	317.1	3.17E-04	1.21E-06	0.012	133.42	81000	425000	21	0.27	11571	0.5	140.0	1.8	151.0	3.19	130000	75.6	13.9	1.6E-05		8760	35	613200	1.20E-04	10417	23	2.775E-03	5.085E-07	2.2E-08	1.0E-05	1.250

HS voc	Average headspace concentration for VOC, ppmv - Table D9-1
MF voc	Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc	VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc	Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW	Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel	Drums per panel
V exhaust	Mine ventilation exhaust rate, cubic ft/min
SOPE	Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE	Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room	(Drums/panel) / 7
GR	Effective gas generation rate
AORE voc	Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc	Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc	Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc	Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel	Mine ventilation panel rate, cubic ft/min
COC ug/m3	Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv	Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF	Unit risk factor for VOC, m3/ug - Table D9-3
RfC	Reference concentration, mg/m3 - Table D9-4
EF	Exposure frequency, hours/year
ED	Exposure duration, years (35 years)
AT	Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF	Air dispersion factor, unitless - Table D9-2
ECS max	Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act	Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ no ventilation barriers (Equation D9-9, modified)
Rcon ug/m3	Receptor concentration (SOPE+9*SCPE)*ADF, ug/m3 - full repository assumption (Equation D9-9 multiplied by ADF)
Rcon ppmv	Receptor concentration expressed in parts/million volume
Risk recept	Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept	Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL	Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

Σ Carconogenic Risk	6.0E-08
Σ Non-Carcinogenic Risk	4.7E-06

September 16, 1998 **Exposure to Antelope Ridge Rancher within WIPP LWA Boundary, Average VOC Headspace Concentrations - DOE Calculations**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride	375.5	3.76E-04	1.21E-06	0.014	153.84	81000	425000	28.2	0.37	11571	0.5	165.8	2.2	178.8	4.35	130000	103.2	16.4	1.5E-05		2080	35	613200	6.70E-05	8381	32	2.116E-03	3.362E-07	3.8E-09	1.0E-06	0.562
Chlorobenzene	12.5	1.25E-05	1.16E-06	0.000	112.56	81000	425000	0.7	0.01	11571	0.5	5.3	0.1	5.7	0.10	130000	2.4	0.5		2.0E-02	2080	35	306600	6.70E-05	1257176	1	4.962E-05	1.078E-08	5.9E-07	1.0E+00	84.231
Chloroform	25.3	2.53E-05	1.34E-06	0.001	119.39	81000	425000	1.6	0.02	11571	0.5	12.4	0.1	13.2	0.25	130000	5.9	1.2	2.3E-05		2080	35	613200	6.70E-05	5466	2	1.212E-04	2.483E-08	3.3E-10	1.0E-06	0.366
1,1-Dichloroethylene	11.5	1.15E-05	1.40E-06	0.001	96.95	81000	425000	0.6	0.01	11571	0.5	5.9	0.1	6.3	0.10	130000	2.3	0.6	5.0E-05		2080	35	613200	6.70E-05	25144	1	4.657E-05	1.174E-08	2.8E-10	1.0E-05	1.685
1,2-Dichloroethane	9.1	9.10E-06	1.32E-06	0.000	98.97	81000	425000	0.5	0.01	11571	0.5	4.4	0.1	4.7	0.07	130000	1.7	0.4	2.6E-05		2080	35	613200	6.70E-05	4835	1	3.566E-05	8.811E-09	1.1E-10	1.0E-06	0.324
Methylene Chloride	368.5	3.69E-04	1.47E-06	0.017	84.94	81000	425000	19	0.20	11571	0.5	197.7	2.1	210.5	2.83	130000	66.7	19.2	4.7E-07		2080	35	613200	6.70E-05	267484	20	1.367E-03	3.934E-07	7.6E-11	1.0E-06	17.921
1,1,2,2-Tetrachloroethane	9.4	9.40E-06	1.21E-06	0.000	167.86	81000	425000	0.8	0.01	11571	0.5	4.2	0.1	4.5	0.12	130000	2.8	0.4	5.8E-05		2080	35	613200	6.70E-05	21675	1	5.778E-05	8.417E-09	4.0E-10	1.0E-05	1.452
Toluene	19.4	1.94E-05	1.19E-06	0.001	92.13	81000	425000	0.9	0.01	11571	0.5	8.4	0.1	9.1	0.13	130000	3.1	0.8		4.0E-01	2080	35	306600	6.70E-05	2.5E+07	1	6.449E-05	1.711E-08	3.8E-08	1.0E+00	1684.615
1,1,1-Trichloroethane	317.1	3.17E-04	1.21E-06	0.012	133.42	81000	425000	21	0.27	11571	0.5	140.0	1.8	151.0	3.19	130000	75.6	13.9	1.6E-05		2080	35	613200	6.70E-05	78573	23	1.549E-03	2.839E-07	2.9E-09	1.0E-05	5.264

HS voc	Average headspace concentration for VOC, ppmv - Table D9-1
MF voc	Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc	VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc	Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW	Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel	Drums per panel
V exhaust	Mine ventilation exhaust rate, cubic ft/min
SOPE	Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE	Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room	(Drums/panel) / 7
GR	Effective gas generation rate
AORE voc	Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc	Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc	Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc	Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel	Mine ventilation panel rate, cubic ft/min
COC ug/m3	Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv	Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF	Unit risk factor for VOC, m3/ug - Table D9-3
RfC	Reference concentration, mg/m3 - Table D9-4
EF	Exposure frequency, hours/year
ED	Exposure duration, years (35 years)
AT	Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF	Air dispersion factor, unitless - Table D9-2
ECS max	Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act	Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ no ventilation barriers (Equation D9-9, modified)
Rcon ug/m3	Receptor concentration (SOPE+9*SCPE)*ADF, ug/m3 - full repository assumption (Equation D9-9 multiplied by ADF)
Rcon ppmv	Receptor concentration expressed in parts/million volume
Risk recept	Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept	Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL	Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

Σ Carconogenic Risk	7.9E-09
Σ Non-Carcinogenic Risk	6.3E-07

September 16, 1998 **Exposure to Livingstone Ridge Rancher within WIPP LWA Boundary, Average VOC Headspace Concentrations - DOE Calculations**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride	375.5	3.76E-04	1.21E-06	0.014	153.84	81000	425000	28.2	0.37	11571	0.5	165.8	2.2	178.8	4.35	130000	103.2	16.4	1.5E-05		2080	35	613200	9.80E-05	5730	32	3.094E-03	4.918E-07	5.5E-09	1.0E-06	0.562
Chlorobenzene	12.5	1.25E-05	1.16E-06	0.000	112.56	81000	425000	0.7	0.01	11571	0.5	5.3	0.1	5.7	0.10	130000	2.4	0.5		2.0E-02	2080	35	306600	9.80E-05	859498	1	7.258E-05	1.577E-08	8.6E-07	1.0E+00	84.231
Chloroform	25.3	2.53E-05	1.34E-06	0.001	119.39	81000	425000	1.6	0.02	11571	0.5	12.4	0.1	13.2	0.25	130000	5.9	1.2	2.3E-05		2080	35	613200	9.80E-05	3737	2	1.773E-04	3.632E-08	4.8E-10	1.0E-06	0.366
1,1-Dichloroethylene	11.5	1.15E-05	1.40E-06	0.001	96.95	81000	425000	0.6	0.01	11571	0.5	5.9	0.1	6.3	0.10	130000	2.3	0.6	5.0E-05		2080	35	613200	9.80E-05	17190	1	6.811E-05	1.718E-08	4.0E-10	1.0E-05	1.685
1,2-Dichloroethane	9.1	9.10E-06	1.32E-06	0.000	98.97	81000	425000	0.5	0.01	11571	0.5	4.4	0.1	4.7	0.07	130000	1.7	0.4	2.6E-05		2080	35	613200	9.80E-05	3306	1	5.217E-05	1.289E-08	1.6E-10	1.0E-06	0.324
Methylene Chloride	368.5	3.69E-04	1.47E-06	0.017	84.94	81000	425000	19	0.20	11571	0.5	197.7	2.1	210.5	2.83	130000	66.7	19.2	4.7E-07		2080	35	613200	9.80E-05	182872	20	1.999E-03	5.754E-07	1.1E-10	1.0E-06	17.921
1,1,2,2-Tetrachloroethane	9.4	9.40E-06	1.21E-06	0.000	167.86	81000	425000	0.8	0.01	11571	0.5	4.2	0.1	4.5	0.12	130000	2.8	0.4	5.8E-05		2080	35	613200	9.80E-05	14819	1	8.452E-05	1.231E-08	5.8E-10	1.0E-05	1.452
Toluene	19.4	1.94E-05	1.19E-06	0.001	92.13	81000	425000	0.9	0.01	11571	0.5	8.4	0.1	9.1	0.13	130000	3.1	0.8		4.0E-01	2080	35	306600	9.80E-05	1.7E+07	1	9.432E-05	2.503E-08	5.6E-08	1.0E+00	1684.615
1,1,1-Trichloroethane	317.1	3.17E-04	1.21E-06	0.012	133.42	81000	425000	21	0.27	11571	0.5	140.0	1.8	151.0	3.19	130000	75.6	13.9	1.6E-05		2080	35	613200	9.80E-05	53719	23	2.266E-03	4.153E-07	4.3E-09	1.0E-05	5.264

HS voc	Average headspace concentration for VOC, ppmv - Table D9-1
MF voc	Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc	VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc	Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW	Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel	Drums per panel
V exhaust	Mine ventilation exhaust rate, cubic ft/min
SOPE	Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE	Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room	(Drums/panel) / 7
GR	Effective gas generation rate
AORE voc	Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc	Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc	Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc	Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel	Mine ventilation panel rate, cubic ft/min
COC ug/m3	Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv	Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF	Unit risk factor for VOC, m3/ug - Table D9-3
RfC	Reference concentration, mg/m3 - Table D9-4
EF	Exposure frequency, hours/year
ED	Exposure duration, years (35 years)
AT	Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF	Air dispersion factor, unitless - Table D9-2
ECS max	Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act	Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ no ventilation barriers (Equation D9-9, modified)
Rcon ug/m3	Receptor concentration (SOPE+9*SCPE)*ADF, ug/m3 - full repository assumption (Equation D9-9 multiplied by ADF)
Rcon ppmv	Receptor concentration expressed in parts/million volume
Risk recept	Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept	Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL	Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

Σ Carconogenic Risk	1.2E-08
Σ Non-Carcinogenic Risk	9.2E-07

September 16, 1998 **Exposure to Resident at WIPP LWA Boundary, Maximum VOC Headspace Concentrations - DOE Calculations**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride	7510	7.51E-03	1.21E-06	0.287	153.84	81000	425000	564.9	7.40	11571	0.5	3316.0	43.5	3576.7	87.04	130000	2065	328	1.5E-05		8760	35	613200	1.20E-04	1111	631	7.578E-02	1.204E-05	5.7E-07	1.0E-06	0.133
Chlorobenzene	17660	1.77E-02	1.16E-06	0.646	112.56	81000	425000	931.7	12.74	11571	0.5	7475.5	102.2	8088.6	144.02	130000	3421	743		2.0E-02	8760	35	306600	1.20E-04	166667	1046	1.256E-01	2.727E-05	6.3E-03	1.0E+00	20.000
Chloroform	6325	6.33E-03	1.34E-06	0.267	119.39	81000	425000	408.9	4.84	11571	0.5	3092.9	36.6	3312.4	62.56	130000	1479	303	2.3E-05		8760	35	613200	1.20E-04	725	452	5.429E-02	1.112E-05	6.2E-07	1.0E-06	0.087
1,1-Dichloroethylene	28750	2.88E-02	1.40E-06	1.269	96.95	81000	425000	1576.8	17.86	11571	0.5	14687.9	166.3	15685.9	240.56	130000	5680	1433	5.0E-05		8760	35	613200	1.20E-04	3333	1738	2.085E-01	5.258E-05	5.2E-06	1.0E-05	0.400
1,2-Dichloroethane	9100	9.10E-03	1.32E-06	0.379	98.97	81000	425000	480.4	5.77	11571	0.5	4383.4	52.7	4699.3	73.57	130000	1740	430	2.6E-05		8760	35	613200	1.20E-04	641	532	6.388E-02	1.578E-05	8.3E-07	1.0E-06	0.077
Methylene Chloride	100000	1.00E-01	1.47E-06	4.636	84.94	81000	425000	5045	54.42	11571	0.5	53642.7	578.6	57114.2	767.41	130000	18096	5209	4.7E-07		8760	35	613200	1.20E-04	35461	5535	6.642E-01	1.912E-04	1.6E-07	1.0E-06	4.255
1,1,2,2-Tetrachloroethane	7924	7.92E-03	1.21E-06	0.302	167.86	81000	425000	650.3	8.52	11571	0.5	3498.8	45.8	3773.9	100.21	130000	2377	346	5.8E-05		8760	35	613200	1.20E-04	2874	727	8.724E-02	1.271E-05	2.5E-06	1.0E-05	0.345
Toluene	41135	4.11E-02	1.19E-06	1.544	92.13	81000	425000	1822.3	24.28	11571	0.5	17862.9	238.0	19290.9	281.14	130000	6672	1771		4.0E-01	8760	35	306600	1.20E-04	3333333	2041	2.449E-01	6.499E-05	6.1E-04	1.0E+00	400.000
1,1,1-Trichloroethane	100000	1.00E-01	1.21E-06	3.816	133.42	81000	425000	6523	85.48	11571	0.5	44154.9	578.6	47626.3	1005.17	130000	23841	4369	1.6E-05		8760	35	613200	1.20E-04	10417	7293	8.751E-01	1.604E-04	7.0E-06	1.0E-05	1.250

HS voc	Maximum headspace concentration for VOC, ppmv - Table D-9
MF voc	Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc	VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc	Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW	Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel	Drums per panel
V exhaust	Mine ventilation exhaust rate, cubic ft/min
SOPE	Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE	Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room	(Drums/panel) / 7
GR	Effective gas generation rate
AORE voc	Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc	Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc	Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc	Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel	Mine ventilation panel rate, cubic ft/min
COC ug/m3	Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv	Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF	Unit risk factor for VOC, m3/ug - Table D9-3
RfC	Reference concentration, mg/m3 - Table D9-4
EF	Exposure frequency, hours/year
ED	Exposure duration, years (35 years)
AT	Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF	Air dispersion factor, unitless - Table D9-2
ECS max	Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act	Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ no ventilation barriers (Equation D9-9, modified)
Rcon ug/m3	Receptor concentration (SOPE+9*SCPE)*ADF, ug/m3 - full repository assumption (Equation D9-9 multiplied by ADF)
Rcon ppmv	Receptor concentration expressed in parts/million volume
Risk recept	Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept	Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL	Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

Σ Carconogenic Risk	1.7E-05
Σ Non-Carcinogenic Risk	6.9E-03

† Problems with DOE's requested maximum concentrations:
Chlorobenzene, Toluene, and 1,1,1-Trichloroethane concentrations exceed Lower Explosive Limit (LEL)
Additive carcinogenic risk to resident exceeded by 17 times acceptable risk level of 10-6

September 16, 1998 **Exposure to Surface Worker within WIPP PPA, Maximum VOC Headspace Concentrations - DOE Calculations**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride	7510	7.51E-03	1.21E-06	0.287	153.84	81000	425000	564.9	7.40	11571	0.5	3316.0	43.5	3576.7	87.04	130000	502	80	1.5E-05		1920	10	613200	1.23E-02	173	154	1.89	3.004E-04	8.9E-07	1.0E-06	2.129
Chlorobenzene	17660	1.77E-02	1.16E-06	0.646	112.56	81000	425000	931.7	12.74	11571	0.5	7475.5	102.2	8088.6	144.02	130000	846	184		2.0E-02	1920	10	87600	1.23E-02	7419	259	3.18	6.910E-04	3.5E-02	1.0E+00	91.250
Chloroform	6325	6.33E-03	1.34E-06	0.267	119.39	81000	425000	408.9	4.84	11571	0.5	3092.9	36.6	3312.4	62.56	130000	347	71	2.3E-05		1920	10	613200	1.23E-02	113	106	1.31	2.673E-04	9.4E-07	1.0E-06	1.389
1,1-Dichloroethylene	28750	2.88E-02	1.40E-06	1.269	96.95	81000	425000	1576.8	17.86	11571	0.5	14687.9	166.3	15685.9	240.56	130000	1312	331	5.0E-05		1920	10	613200	1.23E-02	519	401	4.94	1.245E-03	7.7E-06	1.0E-05	6.388
1,2-Dichloroethane	9100	9.10E-03	1.32E-06	0.379	98.97	81000	425000	480.4	5.77	11571	0.5	4383.4	52.7	4699.3	73.57	130000	410	101	2.6E-05		1920	10	613200	1.23E-02	100	125	1.54	3.813E-04	1.3E-06	1.0E-06	1.228
Methylene Chloride	100000	1.00E-01	1.47E-06	4.636	84.94	81000	425000	5045	54.42	11571	0.5	53642.7	578.6	57114.2	767.41	130000	4110	1183	4.7E-07		1920	10	613200	1.23E-02	5525	1257	15.46	4.451E-03	2.3E-07	1.0E-06	67.952
1,1,2,2-Tetrachloroethane	7924	7.92E-03	1.21E-06	0.302	167.86	81000	425000	650.3	8.52	11571	0.5	3498.8	45.8	3773.9	100.21	130000	578	84	5.8E-05		1920	10	613200	1.23E-02	448	177	2.18	3.169E-04	4.0E-06	1.0E-05	5.506
Toluene	41135	4.11E-02	1.19E-06	1.544	92.13	81000	425000	1822.3	24.28	11571	0.5	17862.9	238.0	19290.9	281.14	130000	1633	434		4.0E-01	1920	10	87600	1.23E-02	148374	500	6.15	1.631E-03	3.4E-03	1.0E+00	1825.000
1,1,1-Trichloroethane	100000	1.00E-01	1.21E-06	3.816	133.42	81000	425000	6523	85.48	11571	0.5	44154.9	578.6	47626.3	1005.17	130000	5801	1063	1.6E-05		1920	10	613200	1.23E-02	1623	1774	21.83	4.000E-03	1.1E-05	1.0E-05	19.961

HS voc	Maximum headspace concentration for VOC, ppmv - Table D-9 †
MF voc	Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc	VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc	Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW	Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel	Drums per panel
V exhaust	Mine ventilation exhaust rate, cubic ft/min
SOPE	Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE	Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room	(Drums/panel) / 7
GR	Effective gas generation rate
AORE voc	Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc	Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc	Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc	Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel	Mine ventilation panel rate, cubic ft/min
COC ug/m3	Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv	Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF	Unit risk factor for VOC, m3/ug - Table D9-3
RfC	Reference concentration, mg/m3 - Table D9-4
EF	Exposure frequency, hours/year
ED	Exposure duration, years (10 years)
AT	Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF	Air dispersion factor, unitless - Table D9-2
ECS max	Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act	Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ug/m3	Receptor concentration (SXPE+9*SCPE)*ADF, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ppmv	Receptor concentration expressed in parts/million volume
Risk recept	Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept	Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL	Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

Σ Carconogenic Risk	2.6E-05
Σ Non-Carcinogenic Risk	3.8E-02

† Problems with DOE's requested maximum concentrations:
Chlorobenzene, Toluene, and 1,1,1-Trichloroethane concentrations exceed Lower Explosive Limit (LEL)
1,2-Dichloroethane and 1,1,1-Trichloroethane each exceed their respective acceptable risk levels
Additive carcinogenic risk to surface worker exceeded by 2.5 times acceptable risk level of 10-5

September 16, 1998 **DOE COC Calculation, Based Upon Exposure to Surface Worker within WIPP PPA, Maximum VOC Headspace Concentrations**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride	7510	7.51E-03	1.21E-06	0.287	153.84	81000	425000	564.9	7.40	11571	0.5	3316.0	43.5	3576.7	87.04	130000	566	90	1.5E-05		1920	10	613200	1.23E-02	173	154	1.89	3.004E-04	8.9E-07	1.0E-06	2.129
Chlorobenzene	17660	1.77E-02	1.16E-06	0.646	112.56	81000	425000	931.7	12.74	11571	0.5	7475.5	102.2	8088.6	144.02	130000	24253	5268		2.0E-02	1920	10	87600	1.23E-02	7419	259	3.18	6.910E-04	3.5E-02	1.0E+00	91.250
Chloroform	6325	6.33E-03	1.34E-06	0.267	119.39	81000	425000	408.9	4.84	11571	0.5	3092.9	36.6	3312.4	62.56	130000	369	76	2.3E-05		1920	10	613200	1.23E-02	113	106	1.31	2.673E-04	9.4E-07	1.0E-06	1.389
1,1-Dichloroethylene	28750	2.88E-02	1.40E-06	1.269	96.95	81000	425000	1576.8	17.86	11571	0.5	14687.9	166.3	15685.9	240.56	130000	1698	428	5.0E-05		1920	10	613200	1.23E-02	519	401	4.94	1.245E-03	7.7E-06	1.0E-05	6.388
1,2-Dichloroethane	9100	9.10E-03	1.32E-06	0.379	98.97	81000	425000	480.4	5.77	11571	0.5	4383.4	52.7	4699.3	73.57	130000	326	81	2.6E-05		1920	10	613200	1.23E-02	100	125	1.54	3.813E-04	1.3E-06	1.0E-06	1.228
Methylene Chloride	100000	1.00E-01	1.47E-06	4.636	84.94	81000	425000	5045	54.42	11571	0.5	53642.7	578.6	57114.2	767.41	130000	18061	5199	4.7E-07		1920	10	613200	1.23E-02	5525	1257	15.46	4.451E-03	2.3E-07	1.0E-06	67.952
1,1,2,2-Tetrachloroethane	7924	7.92E-03	1.21E-06	0.302	167.86	81000	425000	650.3	8.52	11571	0.5	3498.8	45.8	3773.9	100.21	130000	1464	213	5.8E-05		1920	10	613200	1.23E-02	448	177	2.18	3.169E-04	4.0E-06	1.0E-05	5.506
Toluene	41135	4.11E-02	1.19E-06	1.544	92.13	81000	425000	1822.3	24.28	11571	0.5	17862.9	238.0	19290.9	281.14	130000	485069	128738		4.0E-01	1920	10	87600	1.23E-02	148374	500	6.15	1.631E-03	3.4E-03	1.0E+00	1825.000
1,1,1-Trichloroethane	100000	1.00E-01	1.21E-06	3.816	133.42	81000	425000	6523	85.48	11571	0.5	44154.9	578.6	47626.3	1005.17	130000	5305	972	1.6E-05		1920	10	613200	1.23E-02	1623	1774	21.83	4.000E-03	1.1E-05	1.0E-05	19.961

HS voc	Maximum headspace concentration for VOC, ppmv - Table D-9 †
MF voc	Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc	VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc	Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW	Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel	Drums per panel
V exhaust	Mine ventilation exhaust rate, cubic ft/min
SOPE	Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE	Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room	(Drums/panel) / 7
GR	Effective gas generation rate
AORE voc	Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc	Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc	Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc	Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel	Mine ventilation panel rate, cubic ft/min
COC ug/m3	Concentration of concern, ug/m3 - panel exhaust concentration of VOC ([HBL/ADF] multiplied by ratio of air volumes) †
COC ppbv	Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF	Unit risk factor for VOC, m3/ug - Table D9-3
RfC	Reference concentration, mg/m3 - Table D9-4
EF	Exposure frequency, hours/year
ED	Exposure duration, years (10 years)
AT	Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF	Air dispersion factor, unitless - Table D9-2
ECS max	Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act	Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ug/m3	Receptor concentration (SXPE+9*SCPE)*ADF, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ppmv	Receptor concentration expressed in parts/million volume
Risk recept	Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept	Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL	Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

Σ Carconogenic Risk	2.6E-05
Σ Non-Carcinogenic Risk	3.8E-02

† Problems with DOE's calculations for Concentration of Concern:

Chlorobenzene, Toluene, and 1,1,1-Trichloroethane concentrations all exceed Lower Explosive Limit (LEL)

Chlorobenzene and Toluene incorrectly assumed an Averaging Time (**AT**) of 70 years instead of 10 years in determining non-carcinogenic Health Based Limit (**HBL**)

COC (and HBL) calculations for 1,1,1-Trichloroethane apparently used non-carcinogenic Reference Dose for 1,1,2-TCA **as well as** wrong AT

Open Room Scenario with Room Vent Rate @ 35,000 ft3/min using DOE Maximum VOC Concentrations

		Carbon tetrachloride	Chlorobenzene	Chloroform	1,1-Dichloro-ethylene	1,2-Dichloro-ethane	Methylene chloride (dichloro-methane)	1,1,2,2-Tetrachloro-ethane	Toluene	1,1,1-Trichloro-ethane
Volume of clean air in the room headspace (RHV) (ft^3)	14850									
Number of drums breached	21									
Volume of contaminated air released from the containers (CAC) (ft3) = (number of drums) * 5.2 ft^3/drum	109.2									
Headspace Table C-5 Limit VOC concentration (ppmv)		7510	17660	6325	28750	9100	100000	7924	41135	100000
Concentration of contaminant in the room air (CCR1)	**In DOE Tables**	**27.51**		**23.17**	**105.3**	**33.34**	**366.3**			
= (VOC concentration - Table C-5) * (CAC/(RHV + CAC)) = ppmv		55	129	46	210	66	730	58	300	730
Duration of worker exposure (DWE) (min) = (RHV + CAC)/35,000 ft3/min	0.427405714									
8-Hour time weighted average (TWA1) (ppm) = (CCR1 * DWE * hr/60 min)/8 hr		0.05	0.11	0.04	0.19	0.06	0.65	0.05	0.27	0.65
Exposure Limit (ppm)										
NIOSH STEL		2	NL	2	20	2	NL	NL	150	450
ACGIH TWA		5	10	10	5	10	10	1	50	350
NIOSH IDLH		200	1000	500	ND	50	2300	100	500	700

Closed Room Scenario with Room Vent Rate @ 35,000 ft3/min using DOE Maximum VOC Concentrations		Carbon tetrachloride	Chlorobenzene	Chloroform	1,1-Dichloro-ethylene	1,2-Dichloro-ethane	Methylene chloride (dichloro-methane)	1,1,2,2-Tetrachloro-ethane	Toluene	1,1,1-Trichloro-ethane
Volume of clean air in the room headspace (RHV) (ft^3)	14850									
Table C-5 VOC Concentration limit (CCR1) (ppmv)		7510	17660	6325	28750	9100	100000	7924	41135	100000
Duration of worker exposure (DWE) (min) = (f * RHV)/35,000 ft3/min	0.021214286									
8-Hour time weighted average (TWA) (ppm) = (CCR1 * DWE * hr/60 min)/8 hr		0.33	0.78	0.28	1.27	0.40	4.42	0.35	1.82	4.42
Maximum 1-minute concentration (MAXC) (ppm)	**In DOE Tables**	156		131	597	189	2080			
= CCR1* f * RHV/(35,000 ft^3 + (f * RHV)		156	367	131	597	189	2077	165	855	2077
Exposure Limit (ppm)										
NIOSH STEL		2	NL	2	20	2	NL	NL	150	450
ACGIH TWA		5	10	10	5	10	10	1	50	350
NIOSH IDLH		200	1000	500	ND	50	2300	100	500	700

Closed Room Scenario with Room Vent Rate @ 35,000 ft3/min, Maximum VOC Concentrations Not To Exceed IDLH Limit

		Carbon tetrachloride	Chlorobenzene	Chloroform	1,1-Dichloro-ethylene	1,2-Dichloro-ethane	Methylene chloride (dichloro-methane)	1,1,2,2-Tetrachloro-ethane	Toluene	1,1,1-Trichloro-ethane
Volume of clean air in the room headspace (RHV) (ft^3)	14850									
Back-calculated maximum VOC not to exceed IDLH limit (CCR1) (ppmv)		9625	48150	24070	28750	2400	110700	4800	24050	33700
Duration of worker exposure (DWE) (min) = (f * RHV)/35,000 ft3/min	0.021214286									
8-Hour time weighted average (TWA) (ppm) = (CCR1 * DWE * hr/60 min)/8 hr		0.4	2.1	1.1	1.3	0.1	4.9	0.2	1.1	1.5
Maximum 1-minute concentration (MAXC) (ppm) = CCR1* f * RHV/(35,000 ft^3 + (f * RHV))		200	1000	500	597	50	2300	100	500	700
Exposure Limit (ppm)										
NIOSH STEL		2	NL	2	20	2	NL	NL	150	450
ACGIH TWA		5	10	10	5	10	10	1	50	350
NIOSH IDLH		200	1000	500	ND	50	2300	100	500	700

October 1, 1998 **Exposure to Surface Worker within WIPP PPA, VOCs Not Exceeding 1E-5 Additive Excess Risk for Cancer, 1.0 for HI**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride†	9625	9.63E-03	1.21E-06	0.367	153.84	81000	260000	1183.4	15.5	11571	0.5	4249.9	55.7	4584.0	182.35	130000	1052	167	1.5E-05		1920	10	613200	1.23E-02	322	322	3.96	6.29E-04	1.9E-06	1.9E-06	3.96
Chlorobenzene†	13000	1.30E-02	1.16E-06	0.476	112.56	81000	260000	1121.1	15.3	11571	0.5	5502.9	75.2	5954.2	173.30	130000	1017	221		2.0E-02	1920	10	87600	1.23E-02	7419	311	3.83	8.31E-04	4.2E-02	3.3E-01	30.41
Chloroform	9930	9.93E-03	1.34E-06	0.420	119.39	81000	260000	1049.3	12.4	11571	0.5	4855.7	57.5	5200.4	160.54	130000	890	182	2.3E-05		1920	10	613200	1.23E-02	272	272	3.35	6.86E-04	2.4E-06	2.4E-06	3.35
1,1-Dichloroethylene	5490	5.49E-03	1.40E-06	0.242	96.95	81000	260000	492.2	5.6	11571	0.5	2804.7	31.8	2995.3	75.09	130000	409	103	5.0E-05		1920	10	613200	1.23E-02	125	125	1.54	3.89E-04	2.4E-06	2.4E-06	1.54
1,2-Dichloroethane†	2400	2.40E-03	1.32E-06	0.100	98.97	81000	260000	207.1	2.5	11571	0.5	1156.1	13.9	1239.4	31.72	130000	177	44	2.6E-05		1920	10	613200	1.23E-02	54	54	0.67	1.64E-04	5.4E-07	5.4E-07	0.67
Methylene Chloride†	100000	1.00E-01	1.47E-06	4.636	84.94	81000	260000	8247	89.0	11571	0.5	53642.7	578.6	57114.2	1254.41	130000	6718	1934	4.7E-07		1920	10	613200	1.23E-02	2055	2055	25.28	7.28E-03	3.7E-07	3.7E-07	25.28
1,1,2,2-Tetrachloroethane	2960	2.96E-03	1.21E-06	0.113	167.86	81000	260000	397.1	5.2	11571	0.5	1307.0	17.1	1409.7	61.19	130000	353	51	5.8E-05		1920	10	613200	1.23E-02	108	108	1.33	1.94E-04	2.4E-06	2.4E-06	1.33
Toluene†	11000	1.10E-02	1.19E-06	0.413	92.13	81000	260000	796.6	10.6	11571	0.5	4776.8	63.6	5158.6	122.89	130000	714	189		4.0E-01	1920	10	87600	1.23E-02	148374	218	2.69	7.13E-04	1.5E-03	3.3E-01	608.27
1,1,1-Trichloroethane†	33700	3.37E-02	1.21E-06	1.286	133.42	81000	260000	3593.5	47.1	11571	0.5	14880.2	195.0	16050.1	553.71	130000	3196	586		7.0E-01	1920	10	87600	1.23E-02	259654	977	12.02	2.20E-03	3.8E-03	3.3E-01	1064.48

Σ Carconogenic Risk	1.0E-05	1.0E-05		
Σ Non-Carcinogenic Risk	4.7E-02	1.0E+00		

HS voc — Maximum headspace concentration for VOC, ppmv †
MF voc — Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc — VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc — Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW — Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel — Drums per panel
V exhaust — Mine ventilation exhaust rate, cubic ft/min (minimum flow rate for COC calculations)
SOPE — Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE — Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room — (Drums/panel) / 7
GR — Effective gas generation rate
AORE voc — Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc — Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc — Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc — Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel — Mine ventilation panel rate, cubic ft/min
COC ug/m3 — Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv — Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF — Unit risk factor for VOC, m3/ug - Table D9-3
RfC — Reference concentration, mg/m3 - Table D9-4 (except 1,1,1-TCA, revised as non-carcinogen per NCEA)
EF — Exposure frequency, hours/year
ED — Exposure duration, years (10 years)
AT — Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF — Air dispersion factor, unitless - Table D9-2
ECS max — Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act — Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ug/m3 — Receptor concentration (SXPE+9*SCPE)*ADF, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ppmv — Receptor concentration expressed in parts/million volume
Risk recept — Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept — Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL — Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

† Limits adjusted below evenly apportioned risk as follows:
Chlorobenzene and Toluene maximum concentrations set at Lower Explosive Limit (LEL)
Carbon Tetrachloride, 1,2-Dichloroethane, Methylene Chloride, and 1,1,1-Trichloroethane maximum concentrations based on roof fall scenario, to avoid exceeding IDLH

October 1, 1998 **Exposure to Resident at WIPP LWA Boundary, VOCs Not Exceeding 1E-6 Additive Excess Risk for Cancer, 1.0 for HI**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride	7125	7.13E-03	1.21E-06	0.272	153.84	81000	260000	876.0	11.5	11571	0.5	3146.0	41.2	3393.4	134.99	130000	779	124	1.5E-05		8760	35	613200	1.20E-04	238	238	0.029	4.54E-06	2.1E-07	2.1E-07	0.029
Chlorobenzene†	13000	1.30E-02	1.16E-06	0.476	112.56	81000	260000	1121.1	15.3	11571	0.5	5502.9	75.2	5954.2	173.30	130000	1017	221		2.0E-02	8760	35	306600	1.20E-04	166667	311	0.037	8.11E-06	1.9E-03	3.3E-01	6.666
Chloroform	5665	5.67E-03	1.34E-06	0.239	119.39	81000	260000	598.6	7.1	11571	0.5	2770.1	32.8	2966.8	91.59	130000	508	104	2.3E-05		8760	35	613200	1.20E-04	155	155	0.019	3.82E-06	2.1E-07	2.1E-07	0.019
1,1-Dichloroethylene	3135	3.14E-03	1.40E-06	0.138	96.95	81000	260000	281.1	3.2	11571	0.5	1601.6	18.1	1710.4	42.88	130000	234	59	5.0E-05		8760	35	613200	1.20E-04	71	72	0.009	2.16E-06	2.1E-07	2.1E-07	0.009
1,2-Dichloroethane†	2400	2.40E-03	1.32E-06	0.100	98.97	81000	260000	207.1	2.5	11571	0.5	1156.1	13.9	1239.4	31.72	130000	177	44	2.6E-05		8760	35	613200	1.20E-04	54	54	0.006	1.60E-06	8.4E-08	8.4E-08	0.006
Methylene Chloride†	100000	1.00E-01	1.47E-06	4.636	84.94	81000	260000	8247	89.0	11571	0.5	53642.7	578.6	57114.2	1254.41	130000	6718	1934	4.7E-07		8760	35	613200	1.20E-04	2055	2055	0.247	7.10E-05	5.8E-08	5.8E-08	0.247
1,1,2,2-Tetrachloroethane	1690	1.69E-03	1.21E-06	0.064	167.86	81000	260000	226.7	3.0	11571	0.5	746.2	9.8	804.9	34.94	130000	202	29	5.8E-05		8760	35	613200	1.20E-04	62	62	0.007	1.08E-06	2.1E-07	2.1E-07	0.007
Toluene†	11000	1.10E-02	1.19E-06	0.413	92.13	81000	260000	796.6	10.6	11571	0.5	4776.8	63.6	5158.6	122.89	130000	714	189		4.0E-01	8760	35	306600	1.20E-04	3333333	218	0.026	6.96E-06	6.6E-05	3.3E-01	133.320
1,1,1-Trichloroethane†	33700	3.37E-02	1.21E-06	1.286	133.42	81000	260000	3593	47.1	11571	0.5	14880.2	195.0	16050.1	553.71	130000	3196	586		7.0E-01	8760	35	306600	1.20E-04	5833333	977	0.117	2.15E-05	1.7E-04	3.3E-01	233.310

HS voc	Maximum headspace concentration for VOC, ppmv †
MF voc	Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc	VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc	Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW	Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel	Drums per panel
V exhaust	Mine ventilation exhaust rate, cubic ft/min (minimum flow rate for COC calculations)
SOPE	Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE	Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room	(Drums/panel) / 7
GR	Effective gas generation rate
AORE voc	Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc	Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc	Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc	Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel	Mine ventilation panel rate, cubic ft/min
COC ug/m3	Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv	Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF	Unit risk factor for VOC, m3/ug - Table D9-3
RfC	Reference concentration, mg/m3 - Table D9-4 (except 1,1,1-TCA, revised as non-carcinogen per NCEA)
EF	Exposure frequency, hours/year
ED	Exposure duration, years (10 years)
AT	Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF	Air dispersion factor, unitless - Table D9-2
ECS max	Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act	Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ug/m3	Receptor concentration (SXPE+9*SCPE)*ADF, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ppmv	Receptor concentration expressed in parts/million volume
Risk recept	Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept	Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL	Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

Σ Carconogenic Risk	1.0E-06	1.0E-06
Σ Non-Carcinogenic Risk	2.1E-03	1.0E+00

† Limits adjusted below evenly apportioned risk as follows:
Chlorobenzene and Toluene maximum concentrations set at Lower Explosive Limit (LEL)
1,2-Dichloroethane, Methylene Chloride, and 1,1,1-Trichloroethane maximum concentrations based on roof fall scenario, to avoid exceeding IDLH

September 16, 1998 **Exposure to Surface Worker within WIPP PPA, What DOE Asked For (Using Lower V exhaust)**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride	7510	7.51E-03	1.21E-06	0.287	153.84	81000	260000	923.4	12.1	11571	0.5	3316.0	43.5	3576.7	142.28	130000	821	131	1.5E-05		1920	10	613200	1.23E-02	333	251	3.09	4.91E-04	1.5E-06	1.9E-06	4.10
Chlorobenzene	17660	1.77E-02	1.16E-06	0.646	112.56	81000	260000	1523.0	20.8	11571	0.5	7475.5	102.2	8088.6	235.42	130000	1382	300		2.0E-02	1920	10	87600	1.23E-02	7419	423	5.20	1.13E-03	5.7E-02	3.3E-01	30.41
Chloroform	6325	6.33E-03	1.34E-06	0.267	119.39	81000	260000	668.4	7.9	11571	0.5	3092.9	36.6	3312.4	102.26	130000	567	116	2.3E-05		1920	10	613200	1.23E-02	217	173	2.13	4.37E-04	1.5E-06	1.9E-06	2.67
1,1-Dichloroethylene	28750	2.88E-02	1.40E-06	1.269	96.95	81000	260000	2577.4	29.2	11571	0.5	14687.9	166.3	15685.9	393.23	130000	2144	541	5.0E-05		1920	10	613200	1.23E-02	100	656	8.07	2.03E-03	1.3E-05	1.9E-06	1.23
1,2-Dichloroethane	9100	9.10E-03	1.32E-06	0.379	98.97	81000	260000	785.2	9.4	11571	0.5	4383.4	52.7	4699.3	120.26	130000	671	166	2.6E-05		1920	10	613200	1.23E-02	192	205	2.52	6.23E-04	2.1E-06	1.9E-06	2.37
Methylene Chloride	100000	1.00E-01	1.47E-06	4.636	84.94	81000	260000	8247	89.0	11571	0.5	53642.7	578.6	57114.2	1254.41	130000	6718	1934	4.7E-07		1920	10	613200	1.23E-02	2055	2055	25.28	7.28E-03	3.7E-07	3.7E-07	25.28
1,1,2,2-Tetrachloroethane	7924	7.92E-03	1.21E-06	0.302	167.86	81000	260000	1063.0	13.9	11571	0.5	3498.8	45.8	3773.9	163.80	130000	945	138	5.8E-05		1920	10	613200	1.23E-02	86	289	3.56	5.18E-04	6.5E-06	1.9E-06	1.06
Toluene	41135	4.11E-02	1.19E-06	1.544	92.13	81000	260000	2978.8	39.7	11571	0.5	17862.9	238.0	19290.9	459.56	130000	2670	709		4.0E-01	1920	10	87600	1.23E-02	148374	817	10.05	2.67E-03	5.5E-03	3.3E-01	608.27
1,1,1-Trichloroethane	100000	1.00E-01	1.21E-06	3.816	133.42	81000	260000	10663	139.7	11571	0.5	44154.9	578.6	47626.3	1643.06	130000	9483	1738		7.0E-01	1920	10	87600	1.23E-02	259654	2901	35.68	6.54E-03	1.1E-02	3.3E-01	1064.48

Σ Carconogenic Risk	2.5E-05	1.0E-05	
Σ Non-Carcinogenic Risk	7.4E-02	1.0E+00	

HS voc — Maximum headspace concentration for VOC, ppmv - Table D-9 †
MF voc — Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc — VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc — Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW — Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel — Drums per panel
V exhaust — Mine ventilation exhaust rate, cubic ft/min (minimum flow rate for COC calculations)
SOPE — Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE — Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room — (Drums/panel) / 7
GR — Effective gas generation rate
AORE voc — Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc — Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc — Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc — Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel — Mine ventilation panel rate, cubic ft/min
COC ug/m3 — Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv — Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF — Unit risk factor for VOC, m3/ug - Table D9-3
RfC — Reference concentration, mg/m3 - Table D9-4 (except 1,1,1-TCA, revised as non-carcinogen per NCEA)
EF — Exposure frequency, hours/year
ED — Exposure duration, years (10 years)
AT — Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF — Air dispersion factor, unitless - Table D9-2
ECS max — Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act — Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ug/m3 — Receptor concentration (SXPE+9*SCPE)*ADF, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ppmv — Receptor concentration expressed in parts/million volume
Risk recept — Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept — Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL — Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

† Problems with DOE's requested maximum concentrations:
Chlorobenzene, Toluene, and 1,1,1-Trichloroethane concentrations exceed Lower Explosive Limit (LEL)
1,2-Dichloroethane, 1,1,2,2-Tetrachloroethane, Toluene, and 1,1,1-Trichloroethane concentrations exceed IDLH for closed room scenario
Additive excess carcinogenic risk to surface worker exceeded by 2.5 times acceptable risk level of 1E-05

September 16, 1998 **Exposure to Resident at WIPP LWA Boundary, What DOE Asked For (Using Lower V exhaust)**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride	7510	7.51E-03	1.21E-06	0.287	153.84	81000	260000	923.4	12.1	11571	0.5	3316.0	43.5	3576.7	142.28	130000	821	131	1.5E-05		8760	35	613200	1.20E-04	209	251	0.030	4.79E-06	2.3E-07	1.9E-07	0.025
Chlorobenzene	17660	1.77E-02	1.16E-06	0.646	112.56	81000	260000	1523.0	20.8	11571	0.5	7475.5	102.2	8088.6	235.42	130000	1382	300		2.0E-02	8760	35	306600	1.20E-04	166667	423	0.051	1.10E-05	2.5E-03	3.3E-01	6.666
Chloroform	6325	6.33E-03	1.34E-06	0.267	119.39	81000	260000	668.4	7.9	11571	0.5	3092.9	36.6	3312.4	102.26	130000	567	116	2.3E-05		8760	35	613200	1.20E-04	137	173	0.021	4.26E-06	2.4E-07	1.9E-07	0.016
1,1-Dichloroethylene	28750	2.88E-02	1.40E-06	1.269	96.95	81000	260000	2577.4	29.2	11571	0.5	14687.9	166.3	15685.9	393.23	130000	2144	541	5.0E-05		8760	35	613200	1.20E-04	63	656	0.079	1.99E-05	2.0E-06	1.9E-07	0.008
1,2-Dichloroethane	9100	9.10E-03	1.32E-06	0.379	98.97	81000	260000	785.2	9.4	11571	0.5	4383.4	52.7	4699.3	120.26	130000	671	166	2.6E-05		8760	35	613200	1.20E-04	121	205	0.025	6.08E-06	3.2E-07	1.9E-07	0.014
Methylene Chloride	100000	1.00E-01	1.47E-06	4.636	84.94	81000	260000	8247	89.0	11571	0.5	53642.7	578.6	57114.2	1254.41	130000	6718	1934	4.7E-07		8760	35	613200	1.20E-04	2055	2055	0.247	7.10E-05	5.8E-08	5.8E-08	0.247
1,1,2,2-Tetrachloroethane	7924	7.92E-03	1.21E-06	0.302	167.86	81000	260000	1063.0	13.9	11571	0.5	3498.8	45.8	3773.9	163.80	130000	945	138	5.8E-05		8760	35	613200	1.20E-04	54	289	0.035	5.05E-06	1.0E-06	1.9E-07	0.006
Toluene	41135	4.11E-02	1.19E-06	1.544	92.13	81000	260000	2978.8	39.7	11571	0.5	17862.9	238.0	19290.9	459.56	130000	2670	709		4.0E-01	8760	35	306600	1.20E-04	3333333	817	0.098	2.60E-05	2.5E-04	3.3E-01	133.320
1,1,1-Trichloroethane	100000	1.00E-01	1.21E-06	3.816	133.42	81000	260000	10663	139.7	11571	0.5	44154.9	578.6	47626.3	1643.06	130000	9483	1738		7.0E-01	8760	35	306600	1.20E-04	5833333	2901	0.348	6.38E-05	5.0E-04	3.3E-01	233.310

Σ Carconogenic Risk	3.8E-06	1.0E-06	
Σ Non-Carcinogenic Risk	3.3E-03	1.0E+00	

HS voc — Maximum headspace concentration for VOC, ppmv - Table D-9 †
MF voc — Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc — VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc — Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW — Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel — Drums per panel
V exhaust — Mine ventilation exhaust rate, cubic ft/min (minimum flow rate for COC calculations)
SOPE — Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE — Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room — (Drums/panel) / 7
GR — Effective gas generation rate
AORE voc — Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc — Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc — Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc — Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel — Mine ventilation panel rate, cubic ft/min
COC ug/m3 — Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv — Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF — Unit risk factor for VOC, m3/ug - Table D9-3
RfC — Reference concentration, mg/m3 - Table D9-4 (except 1,1,1-TCA, revised as non-carcinogen per NCEA)
EF — Exposure frequency, hours/year
ED — Exposure duration, years (10 years)
AT — Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF — Air dispersion factor, unitless - Table D9-2
ECS max — Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act — Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ug/m3 — Receptor concentration (SXPE+9*SCPE)*ADF, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ppmv — Receptor concentration expressed in parts/million volume
Risk recept — Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept — Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL — Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

† Problems with DOE's requested maximum concentrations:
Chlorobenzene, Toluene, and 1,1,1-Trichloroethane concentrations exceed Lower Explosive Limit (LEL)
1,2-Dichloroethane, 1,1,2,2-Tetrachloroethane, Toluene, and 1,1,1-Trichloroethane concentrations exceed IDLH for closed room scenario
Additive excess carcinogenic risk to resident at WIPP LWA Boundary exceeded by nearly 4 times acceptable risk level of 1E-06

December 22, 1998 **Exposure to Surface Worker within WIPP PPA, DOE Proposal in Comments Submitted on Revised Draft Permit**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride	11475	1.15E-02	1.21E-06	0.438	153.84	81000	260000	1410.9	18.5	11571	0.5	5066.8	66.4	5465.1	217.40	130000	1255	199	1.5E-05		1920	10	613200	1.23E-02	384	384	4.72	7.50E-04	2.2E-06	2.2E-06	4.72
Chlorobenzene†	13000	1.30E-02	1.16E-06	0.476	112.56	81000	260000	1121.1	15.3	11571	0.5	5502.9	75.2	5954.2	173.30	130000	1017	221		2.0E-02	1920	10	87600	1.23E-02	7419	311	3.83	8.31E-04	4.2E-02	3.3E-01	30.41
Chloroform	9130	9.13E-03	1.34E-06	0.386	119.39	81000	260000	964.8	11.4	11571	0.5	4464.5	52.8	4781.4	147.61	130000	818	168	2.3E-05		1920	10	613200	1.23E-02	250	250	3.08	6.31E-04	2.2E-06	2.2E-06	3.08
1,1-Dichloroethylene	28750	2.88E-02	1.40E-06	1.269	96.95	81000	260000	2577.4	29.2	11571	0.5	14687.9	166.3	15685.9	393.23	130000	2144	541	5.0E-05		1920	10	613200	1.23E-02	115	656	8.07	2.03E-03	1.3E-05	2.2E-06	1.42
1,2-Dichloroethane†	9100	9.10E-03	1.32E-06	0.379	98.97	81000	260000	785.2	9.4	11571	0.5	4383.4	52.7	4699.3	120.26	130000	671	166	2.6E-05		1920	10	613200	1.23E-02	76	205	2.52	6.23E-04	2.1E-06	7.6E-07	0.93
Methylene Chloride†	100000	1.00E-01	1.47E-06	4.636	84.94	81000	260000	8247	89.0	11571	0.5	53642.7	578.6	57114.2	1254.41	130000	6718	1934	4.7E-07		1920	10	613200	1.23E-02	2055	2055	25.28	7.28E-03	3.7E-07	3.7E-07	25.28
1,1,2,2-Tetrachloroethane	7924	7.92E-03	1.21E-06	0.302	167.86	81000	260000	1063.0	13.9	11571	0.5	3498.8	45.8	3773.9	163.80	130000	945	138	5.8E-05		1920	10	613200	1.23E-02	99	289	3.56	5.18E-04	6.5E-06	2.2E-06	1.22
Toluene†	11000	1.10E-02	1.19E-06	0.413	92.13	81000	260000	796.6	10.6	11571	0.5	4776.8	63.6	5158.6	122.89	130000	714	189		4.0E-01	1920	10	87600	1.23E-02	148374	218	2.69	7.13E-04	1.5E-03	3.3E-01	608.27
1,1,1-Trichloroethane†	47000	4.70E-02	1.21E-06	1.793	133.42	81000	260000	5011.6	65.7	11571	0.5	20752.8	271.9	22384.4	772.24	130000	4457	817		7.0E-01	1920	10	87600	1.23E-02	259654	1363	16.77	3.07E-03	5.3E-03	3.3E-01	1064.48

Σ Carconogenic Risk	2.6E-05	1.0E-05	
Σ Non-Carcinogenic Risk	4.9E-02	1.0E+00	

HS voc — Maximum headspace concentration for VOC, ppmv †
MF voc — Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc — VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc — Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW — Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel — Drums per panel
V exhaust — Mine ventilation exhaust rate, cubic ft/min (minimum flow rate for COC calculations)
SOPE — Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE — Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room — (Drums/panel) / 7
GR — Effective gas generation rate
AORE voc — Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc — Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc — Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc — Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel — Mine ventilation panel rate, cubic ft/min
COC ug/m3 — Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv — Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF — Unit risk factor for VOC, m3/ug - Table D9-3
RfC — Reference concentration, mg/m3 - Table D9-4 (except 1,1,1-TCA, revised as non-carcinogen per NCEA)
EF — Exposure frequency, hours/year
ED — Exposure duration, years (10 years)
AT — Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF — Air dispersion factor, unitless - Table D9-2
ECS max — Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act — Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ug/m3 — Receptor concentration (SXPE+9*SCPE)*ADF, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ppmv — Receptor concentration expressed in parts/million volume
Risk recept — Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept — Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL — Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

† Limits adjusted below evenly apportioned risk as follows:
Chlorobenzene and Toluene maximum concentrations set at Lower Explosive Limit (LEL)
1,2-Dichloroethane, Methylene Chloride, and 1,1,1-Trichloroethane maximum concentrations based on roof fall scenario, to avoid exceeding IDLH

Closed Room Scenario with Room Vent Rate @ 35,000 ft3/min using DOE Proposal in Comments Submitted on Revised Draft Permit

		Carbon tetrachloride	Chlorobenzene	Chloroform	1,1-Dichloro-ethylene	1,2-Dichloro-ethane	Methylene chloride (dichloro-methane)	1,1,2,2-Tetrachloro-ethane	Toluene	1,1,1-Trichloro-ethane
Volume of clean air in the room headspace (RHV) (ft^3)	14850									
Table C-5 VOC Concentration limit (CCR1) (ppmv)		11475	13000	9130	28750	9100	100000	7924	11000	47000
Duration of worker exposure (DWE) (min) = (f * RHV)/35,000 ft3/min	0.021214286									
8-Hour time weighted average (TWA) (ppm) = (CCR1 * DWE * hr/60 min)/8 hr		0.51	0.57	0.40	1.27	0.40	4.42	0.35	0.49	2.08
Maximum 1-minute concentration (MAXC) (ppm)	**In DOE Tables**	156		131	597	189	2080			
= CCR1* f * RHV/(35,000 ft^3 + (f * RHV))		238	270	190	597	189	2077	165	229	976
Exposure Limit (ppm)										
NIOSH STEL		2	NL	2	20	2	NL	NL	150	450
ACGIH TWA		5	10	10	5	10	10	1	50	350
NIOSH IDLH		200	1000	500	ND	50	2300	100	500	700

February 23, 2000 **Exposure to Surface Worker within WIPP PPA, Using VOC Emission Rates Proposed by DOE**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride†	9625	9.63E-03	1.66E-06	0.504	153.84	81000	260000	1623.9	15.5	11571	0.5	5832.0	55.7	6166.1	245.28	130000	1258	200	1.5E-05		1920	10	613200	1.23E-02	322	385	4.73	7.52E-04	2.2E-06	1.9E-06	3.96
Chlorobenzene†	13000	1.30E-02	1.89E-06	0.774	112.56	81000	260000	1824.7	15.3	11571	0.5	8956.3	75.2	9407.6	273.81	130000	1346	292		2.0E-02	1920	10	87600	1.23E-02	7419	412	5.06	1.10E-03	5.5E-02	3.3E-01	30.41
Chloroform	9930	9.93E-03	1.37E-06	0.428	119.39	81000	260000	1070.2	12.4	11571	0.5	4952.6	57.5	5297.3	163.53	130000	900	184	2.3E-05		1920	10	613200	1.23E-02	272	275	3.39	6.93E-04	2.4E-06	2.4E-06	3.35
1,1-Dichloroethylene	5490	5.49E-03	2.22E-06	0.384	96.95	81000	260000	779.7	5.6	11571	0.5	4443.4	31.8	4634.0	116.17	130000	544	137	5.0E-05		1920	10	613200	1.23E-02	125	166	2.05	5.16E-04	3.2E-06	2.4E-06	1.54
1,2-Dichloroethane†	2400	2.40E-03	2.23E-06	0.169	98.97	81000	260000	349.9	2.5	11571	0.5	1953.0	13.9	2036.3	52.11	130000	244	60	2.6E-05		1920	10	613200	1.23E-02	54	74	0.92	2.26E-04	7.5E-07	5.4E-07	0.67
Methylene Chloride†	100000	1.00E-01	2.40E-06	7.560	84.94	81000	260000	13449	89.0	11571	0.5	87480.0	578.6	90951.4	1997.59	130000	9148	2633	4.7E-07		1920	10	613200	1.23E-02	2055	2798	34.42	9.91E-03	5.1E-07	3.7E-07	25.28
1,1,2,2-Tetrachloroethane	2960	2.96E-03	1.91E-06	0.178	167.86	81000	260000	627.1	5.2	11571	0.5	2063.8	17.1	2166.6	94.04	130000	461	67	5.8E-05		1920	10	613200	1.23E-02	108	141	1.73	2.52E-04	3.1E-06	2.4E-06	1.33
Toluene†	11000	1.10E-02	1.95E-06	0.677	92.13	81000	260000	1306.4	10.6	11571	0.5	7833.9	63.6	8215.7	195.72	130000	952	253		4.0E-01	1920	10	87600	1.23E-02	148374	291	3.58	9.51E-04	2.0E-03	3.3E-01	608.27
1,1,1-Trichloroethane†	33700	3.37E-02	1.99E-06	2.120	133.42	81000	260000	5924.2	47.1	11571	0.5	24531.4	195.0	25701.3	886.67	130000	4284	788		7.0E-01	1920	10	87600	1.23E-02	259654	1310	16.12	2.95E-03	5.0E-03	3.3E-01	1064.48

Σ Carcinogenic Risk	1.2E-05	1.0E-05		
Σ Non-Carcinogenic Risk	6.3E-02	1.0E+00		

HS voc — Maximum headspace concentration for VOC, ppmv †
MF voc — Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc — VOC diffusion characteristic, mole/s/mole fraction/drum - (back calculated from ADE voc)
ADE voc — Average drum VOC emission rate, mole/drum/year - DOE 1/25/00 proposal, Table 3, "Bounding VOC Drum Emission Rates"
MW — Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel — Drums per panel
V exhaust — Mine ventilation exhaust rate, cubic ft/min (minimum flow rate for COC calculations)
SOPE — Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE — Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room — (Drums/panel) / 7
GR — Effective gas generation rate
AORE voc — Average yearly open room VOC emission rate, mole/room/year (Equation D9-13) [Agrees with DOE 1/25/00 proposal, Table 3, "Bounding VOC Room Emission Rates"]
ACRE voc — Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc — Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc — Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel — Mine ventilation panel rate, cubic ft/min
COC ug/m3 — Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv — Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF — Unit risk factor for VOC, m3/ug - Table D9-3
RfC — Reference concentration, mg/m3 - Table D9-4 (except 1,1,1-TCA, revised as non-carcinogen per NCEA)
EF — Exposure frequency, hours/year
ED — Exposure duration, years (10 years)
AT — Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF — Air dispersion factor, unitless - Table D9-2
ECS max — Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act — Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ug/m3 — Receptor concentration (SXPE+9*SCPE)*ADF, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ppmv — Receptor concentration expressed in parts/million volume
Risk recept — Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept — Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL — Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

† Limits adjusted below evenly apportioned risk as follows:
Chlorobenzene and Toluene maximum concentrations set at Lower Explosive Limit (LEL)
Carbon Tetrachloride, 1,2-Dichloroethane, Methylene Chloride, and 1,1,1-Trichloroethane maximum concentrations based on roof fall scenario, to avoid exceeding IDLH

April 12, 2010

Constituent	HS voc	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL	IRIS Carcinogen
Carbon Tetrachloride	95545	1660.32	6.0E-06		1920	10	613200	1.23E-02	3198	3195	39.30	6.25E-03	7.384E-06	7.4E-06	39.34	B2
Chlorobenzene†	12970	220.49		5.0E-02	1920	10	87600	1.23E-02	18547	310	3.82	8.30E-04	1.674E-02	2.5E-01	57.03	D
Chloroform	4925	90.41	2.3E-05		1920	10	613200	1.23E-02	134	135	1.66	3.40E-04	1.196E-06	1.2E-06	1.65	B2
1,1-Dichloroethylene	5490	103.27		2.0E-01	1920	10	613200	1.23E-02	519309	125	1.54	3.89E-04	2.412E-04	2.5E-01	1596.88	C
1,2-Dichloroethane	2475	45.06	2.6E-05		1920	10	613200	1.23E-02	56	56	0.69	1.70E-04	5.587E-07	5.6E-07	0.69	B2
Methylene Chloride	53780	1040.02	4.7E-07		1920	10	613200	1.23E-02	1105	1105	13.59	3.91E-03	2.000E-07	2.0E-07	13.59	B2
1,1,2,2-Tetrachloroethane	805	13.99	5.8E-05		1920	10	613200	1.23E-02	0	29	0.36	5.26E-05	6.562E-07	6.6E-07	0.36	C
Toluene†	11000	189.49		5.0E+00	1920	10	87600	1.23E-02	1854675	218	2.69	7.13E-04	1.178E-04	2.5E-01	5703.13	Inadequate
1,1,1-Trichloroethane†	33700	585.62		5.0E+00	1920	10	87600	1.23E-02	1854675	977	12.02	2.20E-03	5.270E-04	2.5E-01	5703.13	Inadequate

Σ Carconogenic Risk	9.995E-06	9.995E-06		
Σ Non-Carcinogenic Risk	1.8E-02	1.0E+00		

HS voc	Maximum headspace concentration for VOC, ppmv †
MF voc	Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc	VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc	Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW	Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel	Drums per panel
V exhaust	Mine ventilation exhaust rate, cubic ft/min (minimum flow rate for COC calculations)
SOPE	Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE	Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room	(Drums/panel) / 7
GR	Effective gas generation rate
AORE voc	Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc	Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc	Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc	Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel	Mine ventilation panel rate, cubic ft/min
COC ug/m3	Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv	Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF	Unit risk factor for VOC, m3/ug - Table D9-3
RfC	Reference concentration, mg/m3 - Table D9-4 (except 1,1,1-TCA, revised as non-carcinogen per NCEA)
EF	Exposure frequency, hours/year
ED	Exposure duration, years (10 years)
AT	Averaging time, hours (70 years)
ADF	Air dispersion factor, unitless - Table D9-2
ECS max	Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act	Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ug/m3	Receptor concentration (SXPE+9*SCPE)*ADF, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ppmv	Receptor concentration expressed in parts/million volume
Risk recept	Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept	Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL	Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

† Limits adjusted below evenly apportioned risk as follows:

Chlorobenzene and Toluene maximum concentrations set at Lower Explosive Limit (LEL)

1,1,1-Trichloroethane maximum concentration based on roof fall scenario, to avoid exceeding IDLH

All carcinogenic VOCs reapportioned to reflect actual distributions in disposal inventory

March 25, 2010 **Exposure to Surface Worker within WIPP PPA, Original Proportions of VOCs, Reflect 4/12/2010 Temporary Authorization Request**

Constituent	HS voc	MF voc	D voc	ADE voc	MW	Drums/panel	V exhaust	SOPE	SCPE	Drums/room	GR	AORE voc	ACRE voc	AOPE voc	SXPE voc	V panel	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride†	36250	3.63E-02	1.21E-06	1.38	153.84	81000	260000	4457	58.4	11571	0.5	16006	209.7	17265	686.77	130000	3964	630	6.0E-06		1920	10	613200	1.23E-02	805	1212	14.91	2.37E-03	2.8E-06	1.9E-06	9.90
Chlorobenzene†	159514	1.60E-01	1.16E-06	5.84	112.56	81000	260000	13757	188.0	11571	0.5	67523	922.9	73060	2126.43	130000	12484	2712		2.0E-02	1920	10	87600	1.23E-02	7419	3819	46.97	1.02E-02	5.1E-01	3.3E-01	30.41
Chloroform	2669	2.67E-03	1.34E-06	0.11	119.39	81000	260000	282	3.3	11571	0.5	1305	15.4	1398	43.15	130000	239	49	2.3E-05		1920	10	613200	1.23E-02	272	73	0.90	1.84E-04	6.5E-07	2.4E-06	3.35
1,1-Dichloroethylene	1213	1.21E-03	1.40E-06	0.05	96.95	81000	260000	109	1.2	11571	0.5	620	7.0	662	16.59	130000	90	23	0.0E+00	0.0E+00	1920	10	613200	1.23E-02	0	28	0.34	8.59E-05	0.0E+00	2.4E-06	0.00
1,2-Dichloroethane†	960	9.60E-04	1.32E-06	0.04	98.97	81000	260000	83	1.0	11571	0.5	462	5.6	496	12.69	130000	71	17	2.6E-05		1920	10	613200	1.23E-02	54	22	0.27	6.58E-05	2.2E-07	5.4E-07	0.67
Methylene Chloride†	38872	3.89E-02	1.47E-06	1.80	84.94	81000	260000	3206	34.6	11571	0.5	20852	224.9	22201	487.61	130000	2611	752	4.7E-07		1920	10	613200	1.23E-02	2055	799	9.83	2.83E-03	1.4E-07	3.7E-07	25.28
1,1,2,2-Tetrachloroethane	992	9.92E-04	1.21E-06	0.04	167.86	81000	260000	133	1.7	11571	0.5	438	5.7	472	20.50	130000	118	17	5.8E-05		1920	10	613200	1.23E-02	108	36	0.45	6.48E-05	8.1E-07	2.4E-06	1.33
Toluene†	247566	2.48E-01	1.19E-06	9.29	92.13	81000	260000	17927	238.9	11571	0.5	107506	1432.3	116100	2765.78	130000	16070	4265		4.0E-01	1920	10	87600	1.23E-02	148374	4915	60.46	1.60E-02	3.3E-02	3.3E-01	608.27
1,1,1-Trichloroethane†	4046563	4.05E+00	1.21E-06	154.41	133.42	81000	260000	431488	5653.9	11571	0.5	1786756	23412.3	1927229	66487.38	130000	383717	70318		7.0E-01	1920	10	87600	1.23E-02	259654	117372	1443.68	2.65E-01	4.5E-01	3.3E-01	1064.48

Σ Carconogenic Risk	4.6E-06	1.0E-05	2.17
Σ Non-Carcinogenic Risk	1.0E+00	1.0E+00	1.00

HS voc — Maximum headspace concentration for VOC, ppmv †
MF voc — Mole fraction of the VOC, mole/mole (Equation D9-6)
D voc — VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-1
ADE voc — Average drum VOC emission rate, mole/drum/year (Equation D9-5)
MW — Molecular weight of the VOC, g/mole - Table D9-1
Drums/panel — Drums per panel
V exhaust — Mine ventilation exhaust rate, cubic ft/min (minimum flow rate for COC calculations)
SOPE — Exhaust shaft concentration of VOC from single full open panel (no barriers), ug/m3 (Equation D9-4, modified)
SCPE — Exhaust shaft concentration of VOC from single full closed panel, ug/m3 (Equation D9-1)
Drums/room — (Drums/panel) / 7
GR — Effective gas generation rate
AORE voc — Average yearly open room VOC emission rate, mole/room/year (Equation D9-13)
ACRE voc — Average yearly closed room VOC emission rate, mole/room/year (Equation D9-14)
AOPE voc — Average yearly open panel VOC emission rate, mole/panel/year (Equation D9-12) - 1 open, 6 closed rooms
SXPE voc — Exhaust shaft concentration of VOC from single open panel with room barriers, ug/m3 (Equation 5-24, NMVP)
V panel — Mine ventilation panel rate, cubic ft/min
COC ug/m3 — Concentration of concern, ug/m3 - panel exhaust concentration of VOC (ECS act multiplied by ratio of air volumes[=425/130])
COC ppbv — Concentration of concern, ppbv - panel exhaust concentration of VOC in ppbv
URF — Unit risk factor for VOC, m3/ug - Table D9-3
RfC — Reference concentration, mg/m3 - Table D9-4 (except 1,1,1-TCA, revised as non-carcinogen per NCEA)
EF — Exposure frequency, hours/year
ED — Exposure duration, years (10 years)
AT — Averaging time, hours (70 years) Note: for non-carcinogenic risk, AT is the exposure duration in hours
ADF — Air dispersion factor, unitless - Table D9-2
ECS max — Maximum exhaust shaft concentration for VOC limited by acceptable risk, ug/m3 (Equation D9-15)
ECS act — Actual exhaust shaft concentration for VOC, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ug/m3 — Receptor concentration (SXPE+9*SCPE)*ADF, ug/m3 - full repository assumption w/ventilation barriers (Equation D9-9, modified)
Rcon ppmv — Receptor concentration expressed in parts/million volume
Risk recept — Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-23)
Risk accept — Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-4
HBL — Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVP)

† Limits adjusted below evenly apportioned risk as follows:
Chlorobenzene and Toluene maximum concentrations set at Lower Explosive Limit (LEL)
Carbon Tetrachloride, 1,2-Dichloroethane, Methylene Chloride, and 1,1,1-Trichloroethane maximum concentrations based on roof fall scenario, to avoid exceeding IDLH

July 2, 2010

Constituent	HS voc	COC ug/m3	COC ppbv	URF	RfC	EF	ED	AT	ADF	ECS max	ESC act	Rcon ug/m3	Rcon ppmv	Risk recept	Risk accept	HBL
Carbon Tetrachloride†	23735	2595	412.5	6.0E-06		1920	10	613200	1.23E-02	1844	794	9.76	1.55E-03	1.8E-06	4.3E-06	22.68
Chlorobenzene†	13000	1017	221		2.0E-02	1920	10	87600	1.23E-02	7419	311	3.83	8.31E-04	4.2E-02	2.5E-01	22.81
Chloroform	9930	890	182	2.3E-05		1920	10	613200	1.23E-02	272	272	3.35	6.86E-04	2.4E-06	2.4E-06	3.35
1,1-Dichloroethylene	5490	409	103		2.0E-01	1920	10	613200	1.23E-02	519309	125	1.54	3.89E-04	2.4E-04	2.5E-01	1596.88
1,2-Dichloroethane†	2400	177	44	2.6E-05		1920	10	613200	1.23E-02	54	54	0.67	1.64E-04	5.4E-07	5.4E-07	0.67
Methylene Chloride†	100000	6718	1934	4.7E-07		1920	10	613200	1.23E-02	2055	2055	25.28	7.28E-03	3.7E-07	3.7E-07	25.28
1,1,2,2-Tetrachloroethane	2960	353	51	5.8E-05		1920	10	613200	1.23E-02	108	108	1.33	1.94E-04	2.4E-06	2.4E-06	1.33
Toluene†	11000	714	189		4.0E-01	1920	10	87600	1.23E-02	148374	218	2.69	7.13E-04	1.5E-03	2.5E-01	456.25
1,1,1-Trichloroethane†	33700	3196	586		7.0E-01	1920	10	87600	1.23E-02	259654	977	12.02	2.20E-03	3.8E-03	2.5E-01	798.44

HS voc	Maximum headspace concentration for VOC, ppmv †
MF voc	Mole fraction of the VOC, mole/mole (Equation D9-6
D voc	VOC diffusion characteristic, mole/s/mole fraction/drum - Table D9-:
ADE voc	Average drum VOC emission rate, mole/drum/year (Equation D9-5
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Drums/room	(Drums/panel) / 7
GR	Effective gas generation rate
AORE voc	Average yearly open room VOC emission rate, mole/room/year (Equation D9-1:
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V panel	Mine ventilation panel rate, cubic ft/mir
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Risk recept	Receptor risk level (carcinogenic - Equation D9-15) or hazard quotient (noncarcinogenic - Equation D9-2
Risk accept	Acceptable risk level or hazard quotient, unitless - Table D9-3, D9-
HBL	Health-Based Levels, ug/m3 - (Equations 5-1(carcinogenic) & 5-9 (non-carcinogenic), NMVF

Σ Carconogenic Risk	7.6E-06	1.0E-05	
Σ Non-Carcinogenic Risk	4.7E-02	1.0E+00	

† Limits adjusted below evenly apportioned risk as follows:

Chlorobenzene and Toluene maximum concentrations set at Lower Explosive Limit (LEI

1,2-Dichloroethane, Methylene Chloride, and 1,1,1-Trichloroethane maximum concentrations based on roof fall scenario, to avoid exceeding ID

Carbon Tetrachloride risk revised to reflect EPA reduction of inhalation unit risk by a factor of 2.5 on March 31, 20: