



**Department of Energy**

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**May 9, 1997**



Mr. Benito J. Garcia, Chief  
Hazardous and Radioactive Materials Bureau  
New Mexico Environment Department  
2044-A Galisteo Street  
Santa Fe, NM 87505

Reference: Response to NMED Letter of April 29, 1997: Modeling and Parameter Selection Information

Dear Mr. Garcia:

We are in receipt of your letter dated April 29, 1997, requesting additional information to facilitate preparation of the Draft Hazardous Waste Permit for the Waste Isolation Pilot Plant (WIPP). In your letter, you requested three categories of information: 1) responses to four specific comments; 2) specific documents listed in Attachment 1 of your letter; and 3) any other information deemed necessary for the administrative record prior to the issuance of the draft permit. We would like to provide a status on each of these categories.

We have attached detailed responses to your four specific comments. We are providing two copies to you and one copy to your technical contractor pursuant to direction from Mr. Steve Zappe. However, with regard to the documents listed, we have questions and/or concerns which we need to address with you and the NMED legal staff in detail. Therefore, we are requesting a meeting at the earliest opportunity to discuss and fully understand the Bureau's request. I understand my staff has been in contact with you regarding this meeting request.

The following requested documents have already been submitted to the NMED and should be in the administrative record:

- Appendix SEAL of the CCA was submitted to the NMED on October 1, 1996, per the commitment in the Permit Application as an update to Appendix I2
- Appendix MASS, Attachment 8-2 of the CCA is included in the Permit Application as a portion of Appendix D16

With regard to the last category of information requested, we are in the process of preparing page changes to the Permit Application reflecting information that supplements, modifies, or clarifies the text in the application.




In all cases, these revisions fall into those categories. Some are revisions driven by changes in laws, regulations, or DOE Orders that affect the WIPP facility. An example of this type of change are those necessitated by the Land Withdrawal Amendments Act of 1996 referred to in your letter. Others are changes identified during our assessment of facility readiness where statements in the Permit Application do not accurately represent the actual configuration of the facility or the actual operating plans. These changes will be provided as page changes indicated as Revision 6.3 and as WordPerfect 5.2 files. We estimate that the remaining portions of your request will be provided to you by Monday, May 19, 1997.

Mr. Craig Snider of the CAO staff has been directed to continue coordination with Mr. Steve Zappe or yourself in order to establish a time and location for a meeting to discuss these matters.

Should you need to discuss the information contained within this submittal, please contact Craig Snider at (505) 234-7452.

Sincerely,

  
George E. Dials  
Manager

Enclosure

cc w/enclosure:

C. Walker, A.T. Kearney  
C&C File

cc w/o enclosure:

M. McFadden, CAO  
C. Wayman, CAO  
J. Epstein, WID

## RESPONSES TO NMED INFORMATION REQUESTS DATED APRIL 29, 1997

### Information #1

#### Comment:

Clarify whether gas generation rate assumptions in Appendix E1, Table E1-1, assume the presence of MgO in the repository.

#### Response:

There are 7 parameters listed in Table E1-1 that are related to gas generation rates. Each is discussed below:

Inundated Corrosion Rate for Steel without CO<sub>2</sub> Present (m/s) : The inundated corrosion rate for steel without CO<sub>2</sub> present was used in the BRAGFLO model input. The inundated corrosion rate of  $7.94 \times 10^{-15}$  m/s (without CO<sub>2</sub>) is consistent with the assumption that significant quantities of MgO will remove CO<sub>2</sub> from the repository.

Inundated Corrosion Rate for Steel with CO<sub>2</sub> Present (m/s) : The inundated corrosion rate for steel with CO<sub>2</sub> present was not used in the BRAGFLO model input. As indicated in the discussion section of the parameter sheet in Appendix D16 (Sheet 34N.DOC), this rate was modified to account for the presence of MgO. The Discussion section of the parameter sheet states: "This rate will not be used due to the addition of backfill MgO which will remove practically all of the CO<sub>2</sub> in the repository."

Humid Corrosion Rate for Steel: This parameter is set to zero based on experimental data reported in the Wang and Brush memo in Appendices D11 and D16. This parameter was not modified to account for the presence of backfill.

Gas Generation Rate for Microbial Degradation Under Humid Conditions (mol/kg \* s): According to the Wang and Brush memo in Appendices D11 and D16, microbial degradation generates CO<sub>2</sub>. According to the discussion in Appendix D22, Section 3.1, there does not appear to be a relationship between the pH (as buffered by the backfill) and the rate of CO<sub>2</sub> generation. Therefore, this parameter is independent of the presence of backfill in the repository.

Gas Generation Rate for Microbial Degradation Under Inundated Conditions (mol/kg \* s): According to the Wang and Brush memo in Appendices D11 and D16, microbial degradation generates CO<sub>2</sub>. According to the discussion in Appendix D22, Section 3.1, there does not appear to be a relationship between the pH (as buffered by the backfill) and the rate of CO<sub>2</sub> generation. Therefore, this parameter is independent of the presence of backfill in the repository.

Factor  $\beta$  for Microbial Reaction Rates (unitless): This factor is related to the average stoichiometric factor “y” for microbial reaction by the following equation:

$$y = y_{\min} + B (y_{\max} - y_{\min})$$

Stoichiometric factor “y” is defined to account for the expected proportions of gas generation products that will be generated:



while Factor  $\beta$  is used to account for the consumption of microbially-generated gas through reactions with steel and steel corrosion products. Factor  $\beta$  is unaffected by any assumption involving the use of MgO. However, the stoichiometric factor “y” is modified to include the effect of no CO<sub>2</sub> production resulting from MgO being added to the WIPP repository.

Anoxic Corrosion Stoichiometric Factor X (unitless): Constant set to eliminate the formation of magnetite as a reaction product from steel corrosion. Experimental evidence discussed by Wang and Brush (Appendices D11 and D16, p. 9) justify this value. Based on expected repository temperature and oxygen conditions, this value is unaffected by MgO because MgO will not affect the oxygen content of the repository or the temperature.

## Information #2

### Comment:

Provide references to specific experimental data that support the assumption of assigning a value of 1.0 to the Anoxic Corrosion Stoichiometric Factor, as indicated [in] Appendix E1, Table E1-1.

### Response:

Wang and Brush in Appendices D11 and D16 cite experimental observations from the test program as the basis for the assumption that the Anoxic Corrosion Stoichiometric Factor should be set to 1. Data which support this can be found in SAND92-7347 by Telander and Westerman (Hydrogen Generation by Metal Corrosion in Simulated Waste Isolation Pilot Plant Environments: Progress Report for the Period November 1989 through December 1992). (See also SAND96-2538.) On page ES-2 of SAND92-7347, in summarizing the results, the authors state: “In low-carbon steel corrosion studies, the molar equivalency between Fe reacted and H<sub>2</sub> formed was satisfactory in both the ...” This conclusion is the basis for Wang’s and Brush’s statement that H<sub>2</sub> was not observed in excess of the Fe reacted, thereby arguing against a value for “x” in Equation 11 (on page 6 of Wang and Brush) other than 1.

### Information #3

#### Comment:

DOE/WID asserts in Appendix E1, page E1-1, lines 28 - 30, that they are “. . . seeking to demonstrate, to a reasonable degree of certainty, that there will be no migration of hazardous waste or hazardous constituents via groundwater for as long as the waste remains hazardous.” In Appendix E1, Tables E1-3 and E1-4, Note “a” indicates that median values for Salado formation halite and anhydrite parameters were used in modeling calculations, based upon the data and parameter distributions contained in Appendix D16, Section D16-6. However, 20 NMAC 4.1, Section V, §264.90(b) (4) states that, “In order to provide an adequate margin of safety in the prediction of potential migration of liquid, the owner or operator must base any predictions made under this paragraph on assumptions that maximize the rate of liquid migration.” It is not clear how the use of median values maximize the rate of liquid migration, and it appears that worst-case assumptions have not been modeled in a single realization. Section 8.1.1 of the CCA identifies Salado anhydrite interbeds as a potential pathway to the facility boundary, and demonstrates that nine out of 300 realizations indicate releases are possible. Justify how the use of median values maximize the rate of liquid migration in modeling calculations. Alternately, submit modeling results based on worst-case assumptions that maximize the rate of liquid migration.

#### Response:

While it is true the standards of 20 NMAC 4.1 Subpart V §264.90(b)(4) state that a demonstration of no-migration requires assumptions that tend to maximize the rate of flow, this does not necessarily require the use of worst-case values for permeability or any other hydrologic parameter. This is particularly true for the case at the WIPP, where flow during the post-closure period depends entirely on the pressure created in the disposal room and the quantity of brine that flows into the room. Discussion of this follows.

A range of permeabilities for the anhydrite marker beds was determined in the WIPP facility using standard in situ testing techniques as described in Appendix D16 (Parameter sheet k\_ANH 2:38 PM3/11/96). In all cases, the permeability was below  $10^{-17}$  m<sup>2</sup>. Rocks with this permeability are classified by nearly all authors of groundwater flow texts as “impervious.” Therefore, it is not reasonable to consider the marker beds as aquifers or water bearing zones in the context of the groundwater protection regulations in RCRA. Instead, the marker beds become significant only if they can become conduits through which contamination can reach potable waters in aquifers or water bearing zones. Because they have the highest permeabilities of all the members of the Salado in the vicinity of the repository, they become the most likely pathways for migration under certain conditions. In order for liquids to flow through these beds, one must either model over extremely long time frames (for example 10,000 years as opposed to the 30 year post-closure period), or increase the driving forces (pressure) to high levels. In the case of the nine CCA simulations referred to in the comment, both high pressures and long time frames (as well

as high radionuclide solubilities) are necessary for contaminants to migrate to the boundary. In these simulations, while all had permeabilities greater than the mean, only one was actually near the high end of the permeability range. In all cases, however, the gas pressures were high, including, in some instances, enough gas to locally fracture the anhydrites.

The statements in Appendix E1, Page E1-33 beginning at line 28, indicate that conservative assumptions were used to purposely maximize the potential for gas generation in the simulation. This was to assure that the potential for flow in the marker beds was maximized as required by 20 NMAC 4.1 Subpart V §264.90(b)(4). These assumptions, as discussed in Appendix E1, include:

- The entire inventory of ferrous metal, cellulose, plastics, and rubber are available to generate gas.
- No credit taken for the 50 percent probability that biodegradation might not occur as discussed in the Wang and Brush memo in Appendices D11 and D16.
- Anoxic conditions exist from the outset even though oxic conditions and the associated lower gas generation rates are likely to exist until the shafts are sealed.
- No credit taken for de-watering of the disturbed rock zone (DRZ) during operation of the facility even though this is observed to occur throughout operations.
- The repository is assumed to be filled and sealed instantaneously so that gas pressurization begins during the period in the model when brine flow into the disposal room is greatest. In reality, much of this gas will leak into the ventilation system prior to sealing the shafts as indicated by the discussion of the panel closure design in Chapter I.
- The DRZ permeability remains high throughout the simulation even though it is subject to the compaction forces generated by salt creep. This assures a conduit to drain brine from other portions of the Salado into the disposal rooms.

An additional conservatism not pointed out in the text is the effect of dip. The waste region is modeled as being down dip from the rest of the repository. This tends to maximize the brine saturation in the waste over that in the rest of the repository.

The net effect of these conservative assumptions is to assure that there is plenty of brine for gas generation to proceed at maximum rates during the initial years following sealing the repository. The observation that repository saturation in Figure E1-16 continues to increase

for the first 50 years after closure indicates that brine is flowing into the repository faster than it can be consumed by gas generating processes. This means that gas generation processes are proceeding at the highest rates possible, thereby maximizing the potential for groundwater movement into and through the marker beds.

In summary, modeling the permeability of the marker beds affects the inflow of brine and consequent gas generation in the repository, and causes the increase in pressure in the repository and subsequent flow outward. The median values used for the marker bed permeability, when combined with other conservative assumptions in the analysis such as the permeability of the DRZ, tends to maximize the rate of flow outward.

#### **Information #4**

##### **Comment:**

Appendix E1, Figure E1-12, and text on page E1-33, lines 35-43, shows that average pressure in the waste disposal region increases with time. Comparison of the threshold values for each shaft seal component with the anticipated gas generation values indicates that approximately 50 years after shaft seal emplacement, the repository pressure will exceed the threshold pressure for seal components. Provide additional information that discusses the effects of pressure build-up in the subsurface relative to the individual and cumulative effect of shaft seals, and how this might influence contaminant migration.

##### **Response:**

According to Davies (1991) there are three physical characteristics of a rock or seal material that control the flow of gas through the rock or seal pores. These characteristics are pore fluid pressure, threshold pressure, and gas permeability. The difference between fluid pressures in the pores of the waste rooms, the seal materials, and the host rocks are the primary drivers for the movement of gas and brine between the three components of the disposal system.

The pore pressure in the repository is initially assumed to be one atmosphere (0.101 MPa). The pressure in the rock ranges from lithostatic in the far field (14.8 MPa) to near atmospheric in the near field where the disturbed rock zone is well developed and depressurization of the rock has occurred. Seal materials are assumed to have an initial pore pressure of atmospheric; however, the creep closure process causes this pressure to increase rapidly, depending on assumptions about initial density and the extent of the shaft DRZ development.

The threshold pressure is defined by Davies (1991) as the pressure required to overcome capillary resistance and drive gas into the brine-filled pores of a rock. A rock that is fully saturated with brine is impervious to gas penetration until the gas pressure is high enough to overcome the capillary pressures. At that time a network of interconnected gas-filled pores is established. The sum of the existing pore pressure in the rock and the threshold pressure is the pressure that must be exceeded before gas can flow through a rock.

The final property is the intrinsic permeability. This parameter has been measured for the in situ materials and is estimated for the disposal room as creep closure occurs and for seal materials, based on known properties and on the effects of creep closure on salt consolidation. These properties are discussed in the Waste Isolation Pilot Plant Shaft Sealing System Compliance Submittal Design Report (SAND96-1326), which was provided to the NMED on October 1, 1996.

Davies has developed an empirical relationship between threshold pressure and permeability which demonstrates that higher permeabilities exhibit lower threshold pressures. The coefficients for this relationship are provided in Appendix D16 as parameters "PCT\_A" and "PCT\_EXP".

The comparison of the pressures generated in the repository to the threshold pressures in Table E1-6 is merely an indication of whether or not sufficient pressure exists for a gas phase to exist in the porosity of the seal material and not an indication of whether or not the seal integrity is jeopardized. This latter determination must consider a number of other factors, including the pore pressure and the change in permeability that occurs with time in those seal elements that are affected by creep closure, brine saturation, and gas saturation (like the salt column).

Chapter 8 of the final shaft seal design report discusses the migration of brine and as out of the repository through or around the shaft seals. The discussion references Appendices A, C and D of the same report for more detailed information regarding the integrity of the seals. The analysis used two repository pressures for evaluation, 7MPa and 14 MPa. Both are conservative relative to the pressures expected during the first 100 years of the post-closure period (4.9 MPa) as shown in Figure E1-16 and Table E1-2. The results are discussed in Appendix C, §C5.3. Under the most conservative assumptions used in the modeling, the most gas that invades the seals is 600 m<sup>3</sup>. This fills the pore space of the shaft seal to an elevation of the middle concrete component (750 feet above the repository floor).

#### **REFERENCES:**

Davies, Peter B., "Evaluation for the Role of Threshold Pressure in controlling Flow of Waste-Generated Gas into Bedded Salt at the Waste Isolation Pilot Plant", SAND90-3246, Sandia National Laboratories, Albuquerque, NM, June 1991.

Sandia, 1996, "Waste Isolation Pilot Plant Shaft Sealing System Compliance Submittal Design Report", SAND96-1326, Sandia National Laboratories, Albuquerque, NM, August 1996. (Copies of this report were provided to the NMED on October 1, 1996.)

Telander, M. R., and R. E. Westerman, 1993, "Hydrogen Generation by Metal Corrosion in Simulated Waste Isolation Pilot Plant Environments: Progress Report for the Period November 1989 through December 1992", SAND92-7347, Sandia National Laboratories, Albuquerque, NM, July 1993.



Telander, M. R., and R. E. Westerman, 1993, "Hydrogen Generation by Metal Corrosion in Simulated Waste Isolation Pilot Plant", SAND96-2538, Sandia National Laboratories, Albuquerque, NM, March 1997.

Wang, Y., and Larry Brush, 1996, Memo to Martin S. Tierney on Estimates of Gas-Generation Parameters for the Long-Term WIPP Performance Assessment, Sandia National Laboratories, Albuquerque, NM, January 26, 1996.