**EPA Comment**

**G-11 Inclusion of omitted areas in mining transmissivity calculation**

*"In section TFIELD-9.1 paragraph 2 of Attachment TFIELD the CRA states: "The current version of the map differs from the one used for the CCA calculations in that several areas north of the LWB have been ruled out as potential mining areas in the updated version due to recent oil and gas drilling in those areas." EPA does not agree with this approach.*

*In the WIPP Compliance Application Guidance (CAG), we explained that, in implementing this requirement for mining, DOE should examine the "estimated lives of existing mines and plans for new mines in the vicinity of the WIPP" and should "use mine-able reserves in estimating mine lives and the extent of potential mining." (See CAG, p. 45) That is, we expected DOE to look broadly at the potential for existing resources to be developed, without substantial deference to whether the leases were currently viable for development. The methodology in the CRA for mining outside the controlled area is inconsistent with this approach. We do not find that the presence of oil or gas drilling is a sufficient basis for eliminating potash mining areas from consideration, especially in light of anecdotal evidence that mining does occur in proximity to such boreholes. DOE must account for the potash mining areas that have been omitted from the current modeling."*

**DOE Response:**

In response to comment G-11, we have redefined the mining areas to include all areas of mined and unmined potash resources, including where they fall within 1-mile-radius exclusion zones around oil and gas wells. This new delineation was used for what we designate as the CRA-revised analysis. Mining calculations done as part of the CRA did not include the 1-mile-radius exclusion zones as part of the potential mining areas and also did not include areas containing potash resources not currently leased. This analysis re-calculates the mining scenarios addressed in the CRA using new mining zone delineations that include the areas previously excluded. (Lowry 2003)

Two categories of mining-impacted transmissivity fields are modeled: one with mining outside the land withdrawal boundary (LWB) only and the other with regions both inside and outside the LWB mined (partial and full-mining scenarios, respectively). Flow modeling is performed starting with 100 stochastically calibrated T-fields from McKenna and Hart (2003). Each T-field is modified to reflect the effects of mining by multiplying the transmissivity value in cells that lie within designated mining zones by a random factor between 1 and 1000. A forward steady-state flow simulation is run for each new T-field under each mining scenario (full and partial) across three replicates of mining factors, resulting in 600 simulations (there are 100 calibrated T-fields from Task 1 of AP-100). Particle tracking is performed on the modified flow fields to determine the flow path and groundwater travel time from a point above the center of the WIPP disposal panels to the LWB. Cumulative probability distribution functions (CDFs) are produced for each mining scenario and compared to the undisturbed scenario generated from Task 4 of AP-088, as well as to the full- and partial-mining scenarios from the 1996 CCA and the 2004 CRA. The CDFs describe the probability of a conservative tracer reaching the LWB at a given time. In addition to comparing travel times, particle-tracking directions are also examined to determine the effect on the regional flow direction in the WIPP area due to mining. The flow fields

generated from the mining scenarios are then refined and passed to Task 6 of AP-100 that performs radionuclide transport modeling in the Culebra. (Lowry 2003)

For the full- and partial-mining scenarios, the median particle travel times of 75,774 and 129,202 years are 4.14 and 7.06 times longer than for the non-mining scenario (18,289 years). The increase in transmissivity due to mining increases the relative flow rate through the mining zones, with a corresponding decrease in flow through the non-mining zones. This decrease in flow through the non-mining zones produces longer travel times for the mining scenarios. Comparing the full-mining results of the CRA-revised analysis to the CCA and CRA calculations, the median CRA-revised travel times are approximately 2.53 and 1.14 times longer, respectively. For the partial-mining case, the median travel time is 9.33 times greater than the median for the CCA, and 2.67 times greater than for the CRA. This increase in the travel time over the CRA can be attributed to the higher percentage of area included in the mining zone.

For the CRA-revised analysis, a negative correlation was found between the travel times and the random mining factor (the higher the random mining factor, the longer the particle travel time). No such correlation was observed for the CRA analysis. This again is due to a higher percentage of mining zone area in the CRA-revised analysis as compared to the CRA. With a higher percentage of mining area, the random mining factor has a larger influence on the regional flow regime. As the mining factor is increased, the flow through the non-mining areas is decreased, producing longer travel times and the negative correlation. However, additional analysis shows that most of the travel time variability is due to differences in the base T-fields and not the random mining factor. Complete documentation of the CRA-revised analysis is given in Lowry (2004).

**References**

Lowry, T.S. 2004. Analysis Report for Inclusion of Omitted Areas in Mining Transmissivity Calculations in Response to EPA Comment G-11. ERMS# 538218. Carlsbad, NM: Sandia WIPP Records Center.

Lowry, T.S. 2003. Analysis Report, Task 5 of AP-088, Evaluation of Mining Scenarios. ERMS# 531138. Carlsbad, NM: Sandia WIPP Records Center.

McKenna, S.A., and D.B. Hart. 2003. Analysis Report, Task 4 of AP-088, Conditioning of Base T Fields to Transient Heads. ERMS# 531124. Carlsbad, NM: Sandia WIPP Records Center.

**EPA Comment**

**C-14-1 Figure 2-37 Revision**

*"Figure 2-37 does not include the data points from which the contours were drawn. Additionally, the figure does not indicate the monitoring cycle/time period represented by this surface, and related text does not indicate whether there are mappable fluctuations in the potentiometric surface based on the monitoring period. DOE must revise Figure 2-37 to include this information, and to address periodicity associated with water level fluctuations, if observed. If water level fluctuations were not observed, DOE should so state."*

**DOE Response**

Figure 2-37 should be replaced with the following three figures (Figures 2-37a, 2-37b, and 2-37c), and the following text should be inserted in Chapter 2 at the top of page 2-112.

"Potentiometric surface maps of the freshwater head in the Culebra in December 1998 and December 2002 are shown in Figures 2-37a and 2-37b, respectively. The maps are generally similar and indicate no changes in flow directions across the WIPP site over that period. Figure 2-37c shows the changes in heads at the wells monitored in both December 1998 and December 2002. Freshwater heads in most wells increased by 2-4 ft from 1998 to 2002. The largest rise was 4.84 ft at DOE-1. Only one well, AEC-7, showed a drop over this period (-0.85 ft) larger than potential measurement error."

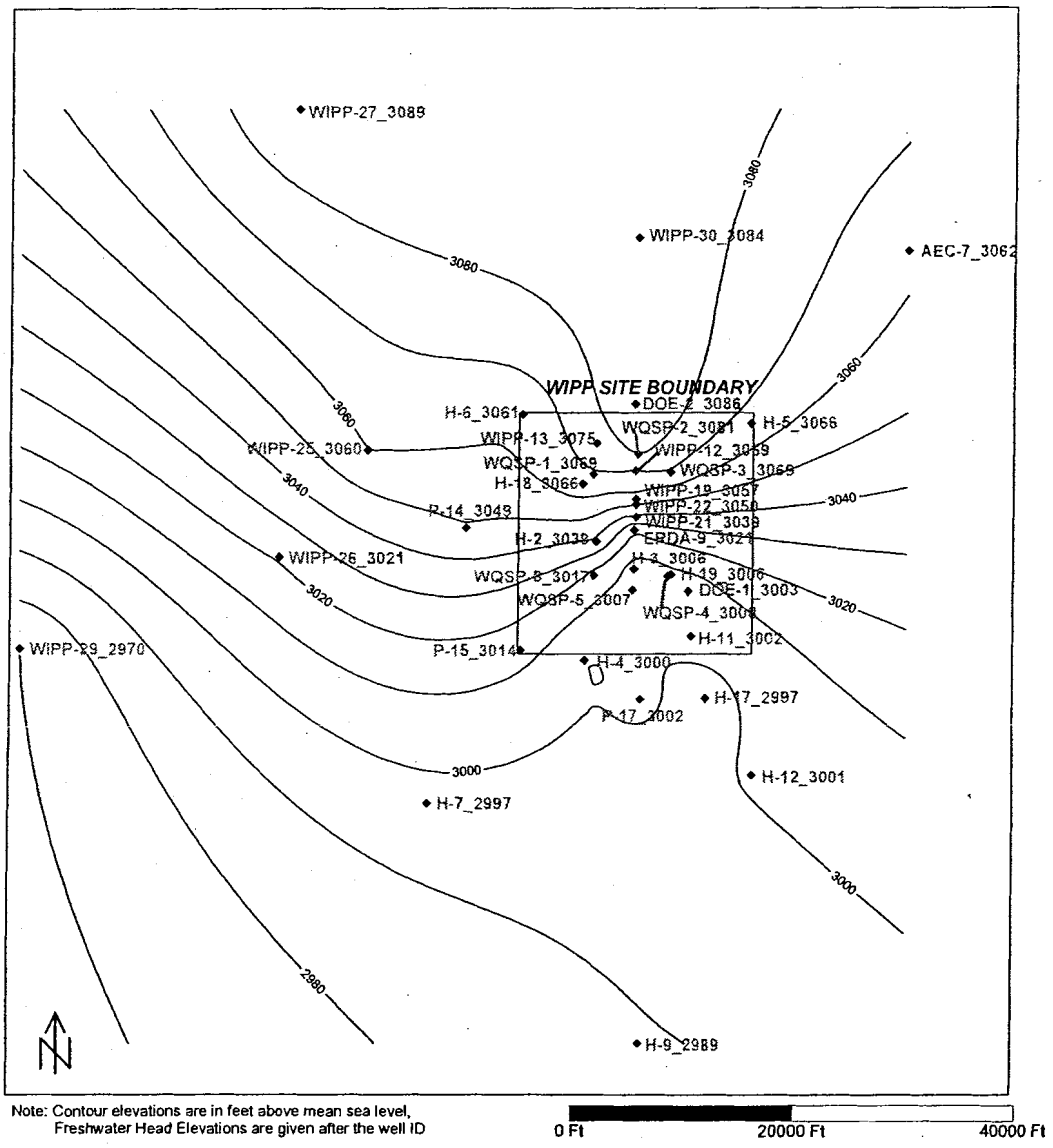


**Figure 2-37a.** Potentiometric Surface, Expressed as Equivalent Freshwater Head, of the Culebra in December 1998.

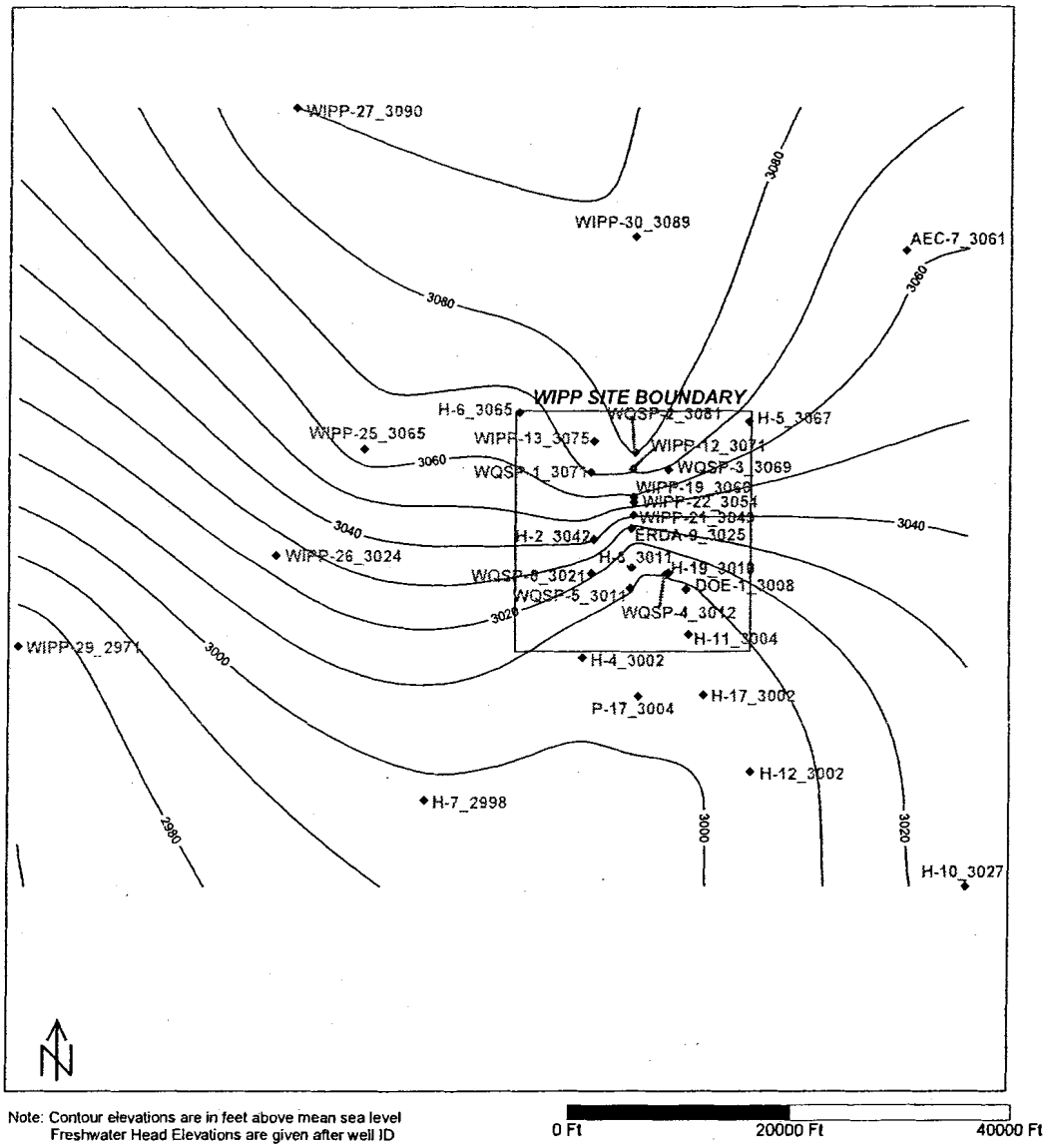


**Figure 2-37b.** Potentiometric Surface, Expressed as Equivalent Freshwater Head, of the Culebra in December 2002.

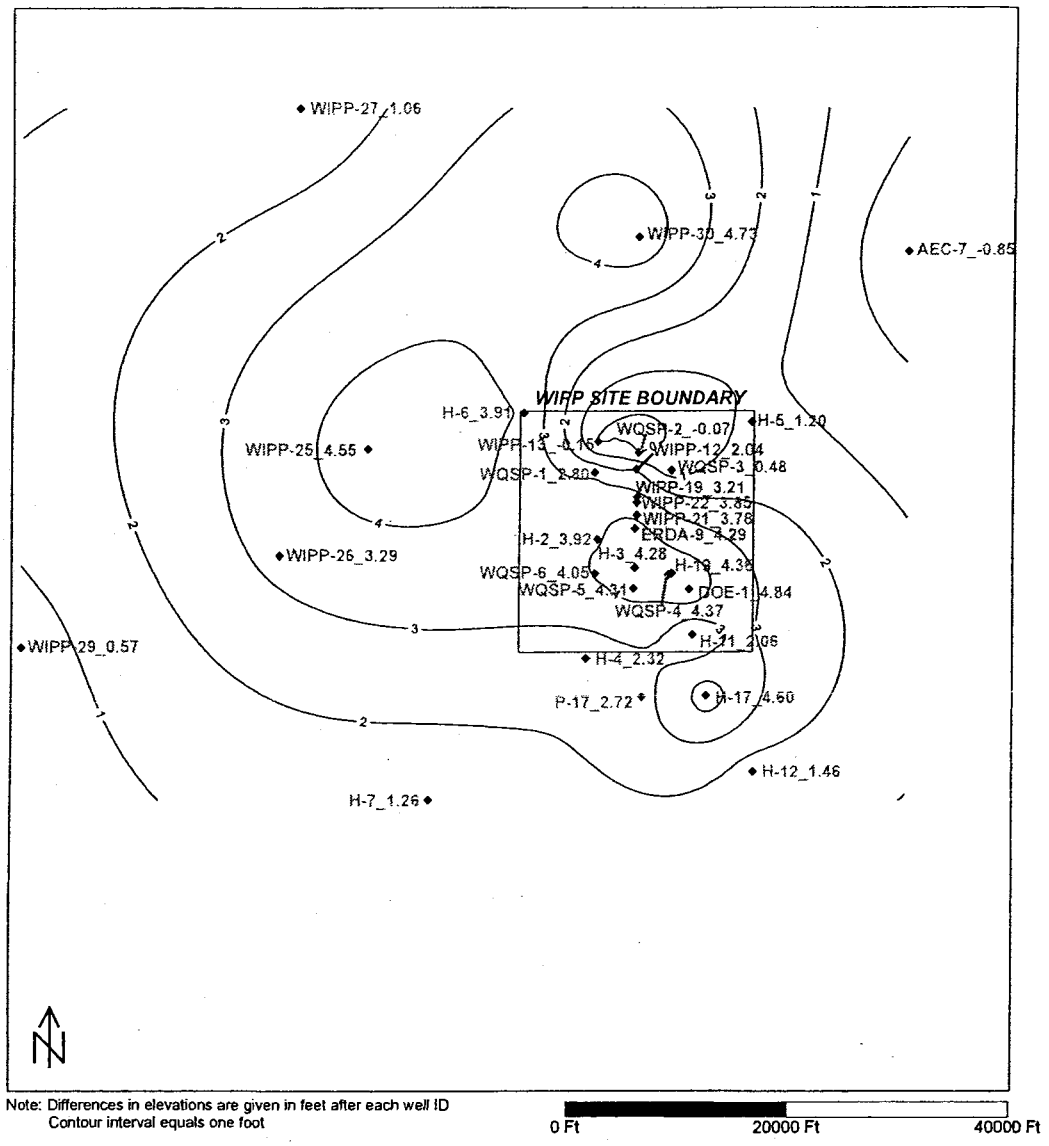


**Figure 2-37c.** Changes in Freshwater Heads in the Culebra Between December 1998 and December 2002.

**EPA Comment**

**C-23-11 95 percent confidence interval**

*On page 6-188, Figure 6-38 the CRA provides a graphic that indicates the 95 percent confidence interval about the mean. For completeness, please provide the actual interval values for the regulatory probabilities of 0.1 and 0.001 for the CRA and the PAVT.*

**DOE Response**

*Rationale for the revision*

This revision of the results reflects the changes introduced by correcting an error in the CCDFGF code and three errors in the inputs to PRECCDFGF. First, there was an omission in the code for CCDFGF Version 5.00 of a correction of spallings releases for the volume fraction of contact handled waste in the repository. Second, an error in the input control files for SUMMARIZE used for the CRA incorrectly listed the variable representing spallings area where the variable representing spallings volume was required. The two errors were somewhat compensatory in that the first caused the spallings releases to be overstated by a factor of about 2.6 while the second caused the spallings releases to be understated by a factor of about 4. The net change in spallings releases is an increase by a factor of 1.544. These errors had a small impact on total releases at probabilities greater than about 0.01, and a larger impact on total releases at the lower probabilities. Preliminary analyses show that the corrected total releases remain well within the regulatory limits. These problems are documented in Kirchner and Vugrin (2004).

The third error was that the incorrect LHS transfer files were used as input to PRECCDFGF for replicates 2 and 3. This error only affected calculations for replicates 2 and 3. The only sampled parameter that CCDFGF uses directly is GLOBAL:PBRINE, the probability that a drilling intrusion into excavated area encounters a pressurized brine pocket. The impact of using the same values of GLOBAL:PBRINE for all three replicates was minimal. The variance on the estimated means was increased slightly because additional variation was expressed. This impact was extremely small and only noticeable at small probabilities where only a small number of vectors contribute to the releases. (Vugrin and Kirchner, 2004) (Vugrin 2004c)

Finally, an error in the input control files to SUMMARIZE resulted in reading the $^{234}U$ colloid mobilization fraction as representing $^{230}Th$ and vice versa. For the CRA and AMW PAs, colloidal mobilization fractions affect only releases from the Culebra. Typically, Culebra releases have only a very small colloid content. In addition, the releases from the Culebra are generally several orders of magnitude smaller than cuttings, spallings, and DBR releases. The impact of this error on total releases was extremely small, and all releases remained within EPA limits. This error had no significant impact on the conclusions of the CRA. (Vugrin and Kirchner, 2004) (Vugrin 2004c)

The errors described above have all been corrected and the impacts assessed and documented.

*Results*

- Table 1 from Vugrin (2004a) compares 95% upper and lower confidence limits (CL) for total releases at probabilities of 0.1 and 0.001 for the CRA PA and CCA PAVT, is

repeated below. Vugrin (2004b) documents the run control that created the files for this analysis.

**Table 1. Upper and Lower 95% Confidence Limits at Probabilities of 0.1 and 0.001 For Mean CRA PA and CCA PAVT Total Releases, All Replicates Pooled**

| Probability | Analysis | Lower 95% CL | Upper 95% CL |
|---|---|---|---|
| 0.1 | CRA PA | 0.0807 | 0.1104 |
| | CCA PAVT | 0.1231 | 0.1373 |
| 0.001 | CRA PA | 0.2778 | 0.5518 |
| | CCA PAVT | 0.2809 | 0.4357 |

**References**

Kirchner, T. B. and E. D. Vugrin. 2004. "Errors Affecting Spallings Releases." Memorandum to David Kessel. November 10, 2004. Sandia National Laboratories. Carlsbad, NM. ERMS# 537852.

Vugrin, E. D. 2004a. "Comparison of total releases mean upper and lower 95% confidence limits, for the CRA PA and the CCA PAVT, at probabilities of 0.1 and 0.001 in response to C-23-11, Revision 2." Memorandum to David Kessel dated December 3, 2004. Sandia National Laboratories. Carlsbad, NM. ERMS # 537991.

Vugrin, E. D. 2004b. "Run Control for Correction of Releases for the CRA." Memorandum to David Kessel. December 3, 2004. Sandia National Laboratories. Carlsbad, NM. ERMS# 537987.

Vugrin, E. D. and T. Kirchner. 2004. "Incorrect LHS and SUMMARIZE Input Files for PRECCDFGF." Memorandum to David Kessel. December 1, 2004. Sandia National Laboratories. Carlsbad, NM. ERMS# 537965.

Vugrin, E. D. 2004c. "Corrected CRA Figures." Memorandum to David Kessel, December 14, 2004. Sandia National Laboratories. Carlsbad, NM. ERMS# 538260.

**EPA Comment**

**C-23-15: Organic Ligand Sensitivity**

*DOE states that no upper or lower limit need be established for the quantities of organic ligands in the repository because organic ligand concentrations in the solubility calculations had an insignificant impact on actinide solubility. However, review of SOTERM-5.0 does not indicate that a sensitivity analysis was conducted to establish that no upper limit on organic ligands is required. Because new thermodynamic data are available for organic ligands at high ionic strength, the CCA analysis of the potential effects of organic ligands carried out using low-ionic-strength data may no longer be valid.*

*The concentrations of actinides calculated for the CCA and CRA are compared in Table 6-13.*

*Comparison of the concentrations in the two sets of calculations indicates that there are significant differences in some of the calculated solubilities for the +III and +V actinides. Based on information in Appendix SOTERM, the principal difference in the solubility calculations appears to be the inclusion of the effects of organic ligands.*

*DOE must provide an assessment of the sensitivity of calculated actinide solubilities to organic ligand inventories in the waste.*

**DOE Response**

***Introduction***

The DOE used the code Fracture-Matrix Transport (FMT) to quantify the sensitivities of the solubilities of +III, +IV, and +V actinides (An(III), An(IV), and An(V)) to the concentrations of organic ligands in WIPP brines. The DOE found that organic ligands at the concentrations used for the CRA-2004 PA, and at these concentrations plus those produced by microbial activity had a modest effect on An(III) solubilities, essentially no effect on An(IV) solubilities, and a significant effect on An(V) solubilities. However, the overall effects of these organics at these concentrations on the long-term performance of the repository were negligible. (Brush and Xiong, 2004)

The DOE found that multiplying the concentrations of organic ligands that included microbially produced acetate and lactate by 10 had a greater effect on An(III), An(IV), and An(V) solubilities than addition of these microbial metabolites to the concentrations used for the CRA-2004 PA. (Brush and Xiong, 2004)

**Response**

This response summarizes the results of a detailed DOE analysis of the sensitivities of An(III), An(IV), and An(V) solubilities to the concentrations of organic ligands in WIPP brines. Because the DOE has not developed a model for U(VI) in brines, it estimated the effects of organic ligands on the solubility of the +VI oxidation state. (Brush and Xiong 2004) (Wall and Wall 2004)

The DOE used 12 new and 4 previous calculations with the speciation and solubility code FMT to quantify the sensitivities of An(III), An(IV), and An(V) solubilities to the concentrations of organic ligands in representative brines from the Salado and Castile formations (Brush and Xiong, 2004). The DOE demonstrated that acetate, citrate, EDTA, and oxalate at

the concentrations used in the FMT calculations for CRA-2004 PA: (1) increased An(III) solubilities by factors of 1.35 to 1.95 times their solubilities in the absence of organic ligands; (2) had essentially no effect of An(IV) solubilities; and (3) increased An(V) solubilities by factors of 4.23 to 19.9. The conclusion that these organic ligands at these concentrations had a modest effect on An(III) solubilities is important because the +III oxidation state is the most important actinide oxidation state expected in the WIPP from the standpoint of the long-term performance of the disposal system. However, this increase in An(III) solubilities will not affect disposal-system performance significantly because direct brine releases (DBR) are a small part of the total releases from the repository. The DOE's conclusion that organic ligands at these concentrations had no effect on An(IV) solubilities is significant because the +IV oxidation state is the second-most important oxidation state expected in the WIPP. The significant effect of organic ligands on An(V) solubilities had essentially no impact on the long-term performance of the repository because: (1) Np is the only actinide expected to speciate in the +V oxidation state (see above), (2) the probability that Np will speciate as Np(V) is 0.5, and (3) from the standpoint of its potential effects on long-term performance, Np is much less important than Pu, Am, U, or Th. Therefore, based on the effects of acetate, citrate, EDTA, and oxalate at the concentrations used for the CRA-2004 PA on An(III), An(IV), and An(V) solubilities, the DOE maintains that the overall effects of organics on the long-term performance of the repository were negligible. (Brush and Xiong, 2004) (Vugrin, 2004)

Addition of microbially produced acetate and lactate by the DOE had no effect on An(III) solubilities, essentially no effect on An(IV) solubilities, and a slight effect on An(V) solubilities. Therefore, the effects of addition of microbially produced acetate and lactate on long-term repository performance would also be negligible (Brush and Xiong, 2004).

Finally, the DOE found that multiplying the concentrations of organic ligands that included microbially produced acetate and lactate by 10 had a greater effect on An(III), An(IV), and An(V) solubilities than addition of these microbial metabolites to the concentrations used for the CRA-2004 PA. Multiplying these concentrations by 10 increased An(III) solubilities by factors of 2.93 to 5.42; the resulting An(III) solubilities exceeded those predicted in the absence of organic ligands by 3.96 to 10.6. Multiplying the concentrations of organic ligands that included microbially produced acetate and lactate by 10 had essentially no effect on An(IV) solubilities in two cases, and slightly greater effects - albeit in opposite directions - in the other two cases. Multiplication by 10 increased An(V) solubilities by factors of 5.59 to 7.47; the resulting An(V) solubilities exceeded those predicted without organic ligands by factors of 30.5 to 111. Nevertheless, these An(V) solubilities would still have no significant impact on long-term performance for the reasons discussed above. (Brush and Xiong, 2004)

**References**

Brush, L.H., and Y. Xiong, 2004. "Sensitivities of the Solubilities of +III, +IV, and +V Actinides to the Concentrations of Organic Ligands in WIPP Brines, Rev. 0." Analysis report, December 15, 2004. Carlsbad, NM: Sandia National Laboratories. ERMS 538203.

Vugrin, E. 2004. "Routine Calculation of CRA Mean Total Releases and Mean DBR Releases at Probabilities of 0.1 and 0.001." Memorandum to L.H. Brush, December 14, 2004. Carlsbad, NM: Sandia National Laboratories. ERMS 538179.

Wall, N.A. and D.E. Wall. 2004. "Discussion on the Influence of Organic Ligands on the Solubility of U(VI)." Memorandum to Records, November 30, 2004. Carlsbad, NM: Sandia National Laboratories. ERMS 537938.

**EPA Comment**

**C-23-16 Actinide Solubility Uncertainty**

*DOE used the differences between modeled and measured actinide solubilities to estimate the uncertainties associated with actinide solubilities for the PA. Based on the figure presented in the CRA (Figure SOTERM-1), it appears DOE used the solubilities calculated for the CCA rather than for the CRA. However, DOE indicates that solubilities calculated for the CRA were different than the CCA (Table SOTERM-2).*

*DOE must re-evaluate the uncertainties associated with actinide solubilities using solubilities calculated for the CRA, and use this information in the CRA PA.*

**DOE Response**

***Introduction***

The DOE did indeed use the actinide solubilities calculated for the CCA to estimate uncertainties associated with solubilities for the CRA-2004 PA. Therefore, the DOE carried out an uncertainty analysis of solubility predictions for the +III, +IV, and +V actinides (An(III), An(IV), and An(V)) after the CRA-2004 was submitted. The results of this analysis are: (1) the An(III) thermodynamic speciation and solubility model implemented in the speciation and solubility code Fracture-Matrix Transport (FMT) overpredicted measured An(III) solubilities slightly, (2) the An(IV) model in FMT underpredicted measured An(IV) solubilities, (3) the An(V) model in FMT overpredicted the measured An(V) solubilities slightly, and (4) overall, the combined results of the An(III), An(IV), and An(V) models in FMT underpredicted the solubilities measured for these three oxidation states. (Xiong et al., 2004)

***Response***

This response summarizes the results of a detailed DOE uncertainty analysis of the FMT predictions of An(III), An(IV), and An(V) solubilities used for the CRA-2004-PA (Xiong et al., 2004). The DOE carried out an uncertainty analysis of the FMT predictions of An(III), An(IV, and An(V) solubilites used for the Compliance Certification Application (CCA) PA. Since that time, both the FMT speciation and solubility code and the FMT thermodynamic database have been updated. This is the first uncertainty analysis of FMT predictions of actinide solubilities since that carried out by the DOE for the CCA. (Xiong et al., 2004) (Bynum, 1996a; 1996b; 1996c)

The DOE analysis for the CRA compared both previous (pre-CCA) measurements of actinide solubilities - including data used by the DOE for the CCA - and new (post-CCA) measurements of actinide solubilities, and predictions made with the latest (post-CCA) version of FMT and the current FMT thermodynamic database. This analysis included 243 comparisons for An(III), 159 comparisons for An(IV), and 136 comparisons for An(V), or a total of 538 comparisons for all three oxidation states. This analysis provided individual probability distributions for An(III), An(IV), and An(V), and combined results for all three oxidation states. (Bynum, 1996a; 1996b; 1996c) (Xiong et al., 2004)

This analysis included the first comparisons for An(IV), because the DOE did not include any comparisons for this oxidation state at the time of the CCA. The DOE analysis for the CRA did not include any comparisons with organic ligands because none of the experiments that produced the measured solubilities used in this analysis included any organic ligands. This analysis did not include any An(VI) comparisons, because the DOE has not developed a thermodynamic speciation and solubility model for this oxidation state. (Estimates were used for the CCA PA, the 1997 PAVT, and the CRA-2004 PA). (Bynum, 1996a; 1996b; 1996c) (Xiong et al., 2004)

The results of this analysis are: (1) the An(III) thermodynamic speciation and solubility model implemented in the speciation and solubility code FMT overpredicted the measured An(III) solubilities slightly, (2) the An(IV) model in FMT underpredicted the measured An(IV) solubilities, (3) the An(V) model in FMT overpredicted the measured An(V) solubilities slightly, and (4) overall, the combined results of the An(III), An(IV), and An(V) models in FMT underpredicted the solubilities measured for these three oxidation states.

**References**

Bynum, R.V. 1996a. "Estimation of Uncertainty for Predicted Actinide Uncertainties." Analysis plan, AP-024, Rev. 0, May 22, 2004. Albuquerque, NM: Sandia National Laboratories. ERMS 410354.

Bynum, R.V. 1996b. "Update of Uncertainty Range and Distribution for Actinide Solubilities to Be Used in CCA NUTS Calculation." Memorandum to M.S. Tierney and C.T. Stockman, May 22, 1996. Albuquerque, NM: Sandia National Laboratories. ERMS 238268.

Bynum, R.V. 1996c. "Analysis to Estimate the Uncertainty for Predicted Actinide Solubilities." Analysis report, Rev. 0, September 6, 1996. Albuquerque, NM: Sandia National Laboratories. ERMS 241374.

Xiong, Y.-L., E.J. Nowak, and L.H. Brush. 2004. "Updated Uncertainty Analysis of Actinide Uncertainties for the Response to EPA Comment C-23-16." Analysis report, December 17, 2004. Carlsbad, NM: Sandia National Laboratories. ERMS 538219.

**EPA Comment**

**C-23-18 Sensitivity to top ten releases**

*The results of a stepwise regression analysis of mean total normalized releases are presented in Section PA-9.6, Table PA-31 for the four most important parameters. Sensitivity analysis results for incremental releases are also presented by release pathway for the parameters identified as most important. This information is found in Sections PA-8.4.3 and PA-8.4.4 for releases through the Culebra, in Section PA-8.5.1 for cuttings and cavings, in Section PA-8.5.2 for spallings, and in Section PA-8.5.3 for direct brine releases. At most, the sensitivity results are limited to about 5 parameters and comparative, quantitative results are not always shown. DOE needs to identify the importance of the top ten sampled parameters relative to final releases, similar to the table with the top four parameters, and for releases from each release pathway*

**DOE Response**

*Rationale for the revision*

This revision of the results reflects the changes introduced by correcting an error in the CCDFGF code and three errors in the inputs to PRECCDFGF. First, there was an omission in the code for CCDFGF Version 5.00 of a correction of spallings releases for the volume fraction of contact handled waste in the repository. Second, an error in the input control files for SUMMARIZE used for the CRA incorrectly listed the variable representing spallings area where the variable representing spallings volume was required. The two errors were somewhat compensatory in that the first caused the spallings releases to be overstated by a factor of about 2.6 while the second caused the spallings releases to be understated by a factor of about 4. The net change in spallings releases is an increase by a factor of 1.544. These errors had a small impact on total releases at probabilities greater than about 0.01, and a larger impact on total releases at the lower probabilities. Preliminary analyses show that the corrected total releases remain well within the regulatory limits. These problems are documented in Kirchner and Vugrin (2004) and the impact documented in Kirchner (2004).

The third error was that the incorrect LHS transfer files were used as input to PRECCDFGF for replicates 2 and 3.. This error only affected calculations for replicates 2 and 3. The only sampled parameter that CCDFGF uses directly is GLOBAL:PBRINE, the probability that a drilling intrusion into excavated area encounters a pressurized brine pocket. The impact of using the same values of GLOBAL:PBRINE for all three replicates was minimal. The variance on the estimated means was increased slightly because additional variation was expressed. This impact was extremely small and only noticeable at small probabilities where only a small number of vectors contribute to the releases. (Vugrin and Kirchner, 2004) (Vugrin 2004)

Finally, an error in the input control files to SUMMARIZE resulted in reading the $^{234}U$ colloid mobilization fraction as representing $^{230}Th$ and vice versa. For the CRA and AMW PAs, colloidal mobilization fractions affect only releases from the Culebra. Typically, Culebra releases have only a very small colloid content. In addition, the releases from the Culebra are generally several orders of magnitude smaller than cuttings, spallings, and DBR releases. The impact of this error on total releases was extremely small, and all releases remained within EPA

limits (Vugrin 2004). This error had no significant impact on the conclusions of the CRA. (Vugrin and Kirchner, 2004)

The errors described above have all been corrected and the impacts assessed and documented.

*Amended results*

The results herein document the sensitivities of the various releases to the input parameters subsequent to correcting the errors and running PRECCDFGF and CCDFGF. The only variables affected by this correction are the total releases, Culebra releases and spallings releases.

The code STEPWISE version 2.21 was used to determine the relative importance of sampled parameters in the CRA. STEPWISE receives sampled input parameter values and the corresponding calculated mean release data. STEPWISE relates the sampled input parameter values to the calculated release data by performing a multiple regression analysis using either the original data or ranked data. The advantage of using ranked data is that ranking tends to linearize non-linear but monotonic response curves, thus better matching the assumptions of the linear regression model. The results of this ranked regression analysis are presented in Tables 1-5. The sensitivity analysis is described in detail in Kirchner (2004).

Most of the regression models produced by STEPWISE do not include ten variables, even after ranking the data. This simply indicates that the uncertainties in many of the parameters have statistically insignificant effects on the output variable. Statistical insignificance can arise because the output variable has a low functional response to the input variable, because the magnitude of uncertainty in the input variable is small relative to the other inputs, or from a combination of both conditions. This is not to say that these non-significant variables have no influence on the releases. Their exclusion from the tables reflects the inability of this statistical technique to rank their importance with an acceptable degree of confidence. For example, if the response of the output variable to an input variable was non-monotonic then the regression analysis might fail to properly identify that variable's importance. This possibility is remote for total releases and cuttings and cavings releases because the $R^2$ value indicates that nearly all the variability in the output variables has been accounted for by the listed input variables.

Tables 1-5 show the parameters that appeared in the STEPWISE regression. Table 1 shows the parameters for mean Total Release. Table 1 should replace Table PA-31 in Appendix PA of the CRA (DOE 2004). Table PA-31 was not updated in the CRA (DOE 2004). Tables 1-5 are explained in and come directly from Kirchner (2004).

**Table 1 Stepwise Ranked Regression Analysis-For Mean Total Releases**

| | Expected Normalized Release | | |
|---|---|---|---|
| Step[a] | Variable[b] | SRRC[c] | $R^{2d}$ |
| 1 | WTAUFAIL | -0.95137 | 0.91345 |
| 2 | WMICDFLG | 0.11538 | 0.92727 |
| 3 | DOMEGA | 0.10735 | 0.93639 |
| 4 | SPALLVOL | 0.08003 | 0.94139 |
| 5 | BPINTPRS | 0.06271 | 0.94475 |
| 6 | PLGPRM | 0.05841 | 0.94802 |
| 7 | SHLPRM3 | -0.04728 | 0.95022 |

a Steps in stepwise regression analysis

b Variables listed in order of selection in regression analysis

c Standardized Rank Regression Coefficient in final regression model

d Cumulative $R^2$ value with entry of each variable into regression model

**Table 2 Stepwise Ranked Regression Analysis -For Mean Cuttings and Cavings Releases**

| | Expected Normalized Release | | |
|---|---|---|---|
| Step[a] | Variable[b] | SRRC[c] | $R^{2d}$ |
| 1 | WTAUFAIL | -0.98460 | 0.97783 |
| 2 | DOMEGA | 0.11275 | 0.99035 |
| 3 | BPINTPRS | 0.02284 | 0.99086 |
| 4 | ANHBCEXP | 0.02018 | 0.99130 |
| 5 | CTRANSFM | -0.01973 | 0.99166 |
| 6 | WASTWICK | -0.01872 | 0.99200 |

a Steps in stepwise regression analysis

b Variables listed in order of selection in regression analysis

c Standardized Rank Regression Coefficient in final regression model

d Cumulative $R^2$ value with entry of each variable into regression model

**Table 3 Stepwise Ranked Regression Analysis -For Mean Direct Brine Releases**

| | Expected Normalized Release | | |
|---|---|---|---|
| Step[a] | Variable[b] | SRRC[c] | $R^{2d}$ |
| 1 | WMICDFLG | -0.46784 | 0.15776 |
| 2 | BPINTPRS | 0.48223 | 0.34337 |
| 3 | PBRINE | 0.36000 | 0.47058 |
| 4 | WSOLAM3C | 0.29070 | 0.51608 |
| 5 | WRBRNSAT | -0.15397 | 0.55481 |
| 6 | CONGSSAT | -0.22426 | 0.57556 |
| 7 | REPIPERM | -0.21496 | 0.60771 |
| 8 | WGRCOR | -0.16265 | 0.63011 |
| 9 | TENSLSTR | -0.14810 | 0.64990 |

a Steps in stepwise regression analysis

b Variables listed in order of selection in regression analysis

c Standardized Rank Regression Coefficient in final regression model

d Cumulative $R^2$ value with entry of each variable into regression model

**Table 4 Stepwise Regression Analysis -For Mean Culebra Releases**

| | Expected Normalized Release | | |
|---|---|---|---|
| Step[a] | Variable[b] | SRRC[c] | $R^{2d}$ |
| 1 | BHPERM | 0.31578 | 0.10521 |
| 2 | CMKDPU | 0.24096 | 0.14942 |
| 3 | WSOLU4S | 0.19943 | 0.18822 |
| 4 | CFRACPOR | -0.18933 | 0.22229 |
| 5 | CONBRSAT | -0.18257 | 0.25531 |

a Steps in stepwise regression analysis

b Variables listed in order of selection in regression analysis

c Standardized Rank Regression Coefficient in final regression model

d Cumulative $R^2$ value with entry of each variable into regression model

**Table 5 Stepwise Ranked Regression Analysis -For Mean Spallings Releases**

| | Expected Normalized Release | | |
|---|---|---|---|
| Step[a] | Variable[b] | SRRC[c] | $R^{2d}$ |
| 1 | WMICDFLG | 0.63522 | 0.37104 |
| 2 | SPALLVOL | 0.35434 | 0.49801 |
| 3 | ANHBCVGP | -0.19019 | 0.53781 |
| 4 | REPIPERM | 0.16671 | 0.57065 |
| 5 | WRBRNSAT | 0.13350 | 0.59318 |
| 6 | WSOLPU3C | -0.14104 | 0.61377 |
| 7 | SHLPRM2 | 0.13278 | 0.63023 |
| 8 | HALPOR | 0.13018 | 0.64674 |

[a] Steps in stepwise regression analysis

[b] Variables listed in order of selection in regression analysis

[c] Standardized Rank Regression Coefficient in final regression model

[d] Cumulative $R^2$ value with entry of each variable into regression model

## References

Kirchner, T. 2004. "Stepwise regression analysis of the final release for each release mechanism, in response to C-23-18, Revision 2." Memorandum to David Kessel dated December 6, 2004. Sandia National Laboratories. Carlsbad, NM. ERMS #537992

Kirchner, T. and E. Vugrin. 2004. Errors affecting spallings releases, Rev. 0. Sandia National Laboratories, Carlsbad, NM. ERMS #537852.

U.S. Department of Energy (DOE). 2004. Title 40 CFR Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant. DOE/WIPP 2004-3231. U.S. Department of Energy Waste Isolation Pilot Plant, Carlsbad Field Office, Carlsbad, NM.

U.S. Environmental Protection Agency (EPA). "EPA's Completeness Comments, 3rd Set." Letter from Elizabeth Cotsworth to Dr. R. Paul Detwiler. September 2, 2004. C-23-18, Tracking 09/02/04Q. ERMS # 536771.

Vugrin, E. and T. Kirchner. 2004. Incorrect LHS and SUMMARIZE Input Files for PRECCDFGF. Memo to Dave Kessel dated December 3, 2004. Sandia National Laboratories, Carlsbad, NM. ERMS #537965.

**EPA Comment**

**C-23-19 Identification and justification for changes to all parameters**

*"Comparison of CRA Attachment PAR with the CCA indicates that the number of sampled parameters has increased from 57 to 64. The DOE identifies these in CRA Appendix PA, Section 5.0 and provides a discussion and references to documentation justifying the changes in the sampled parameters for the CRA in the Parameter Sheets in CRA Appendix PA, Attachment PAR. However, the data sheets provided in CRA Appendix PA, Attachment PAR only address sampled parameters that are still being used; they do not address parameters that were removed (see Table PA-18 in CRA Appendix PA). DOE should provide a brief discussion justifying the removal of those parameters identified in Table PA-18 as being removed from the database), including citation of appropriate reference documentation.*

*In addition, changes to the parameters not selected for sampling are not identified in Appendix PA Attachment PAR and no discussion is provided for changes from the CCA to the unsampled parameters in CRA Attachment PA.*

*DOE must identify and provide a brief discussion justifying changes for ALL (sampled and constant) parameters changed since the CCA and used in the CRA, including citation of appropriate reference documentation (not just the sampled parameters). This discussion is to include parameters whose values were changed/over-ridden from the values in the PA parameter database (PAPDB) for use in the CRA, and any parameters used in the CRA that are not in the PAPDB."*

**DOE Response**

Sandia National Laboratories (SNL) has prepared the enclosed report that summarizes changes that have occurred since the CCA/PAVT for parameters used in WIPP PA calculations. (Kanney 2004)

**References**

Kanney, J. F. 2004. Summary of Parameter Changes for the 2004 Compliance Recertification Application Assessment Calculations. Analysis Report ERMS 538214, Sandia National Laboratories, Carlsbad, NM.