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Parameter Summary Report for the CRA-2009

(Formerly: CRA Appendix PA – Attachment PAR)

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ACRONYMS AND ABBREVIATIONS

AIS	Air Intake Shaft
CCA	Compliance Certification Application
CCDF	Complementary cumulative distribution function
CDF	Cumulative distribution function
CH	Contact-handled
DOE	Department of Energy
DRZ	Disturbed rock zone
EPA	Environmental Protection Agency
ERMS	Electronic Records Management System
GTFM	Graph Theoretic Field Model
LANL	Los Alamos National Laboratory
LHS	Latin hypercube sample
MB	Marker bed
MU	Map unit
NP	Nuclear Waste Management Program Procedure
PA	Performance Assessment
PAVT	Performance Assessment Verification Test
PABC	CRA-2004 Performance Assessment Baseline Calculation
PDF	Probability distribution function
QA	Quality Assurance
QAP	Quality Assurance Procedure
RH	Remote-handled
SMC	Salado Mass Concrete
SNL	Sandia National Laboratories
SSSPT	Small Scale Seal Performance Tests
TRU	Transuranic
WES	Waterways Experiment Station
WIPP	Waste Isolation Pilot Plant

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1.0 INTRODUCTION

This document contains information on the parameters used by performance assessment (PA) codes. This work is covered under the Analysis Plan for the Performance Assessment for the 2009 Compliance Recertification Application, AP-137 (Clayton, 2007). Documentation, in the form of parameter sheets, is provided for the 56 parameters (the 75 listed parameters include 19 "place-holder" parameters as described in Section 5 of this document) sampled by the Latin hypercube sampling (LHS) code during the PA (see also Appendix PA, Section PA-6.1 for discussion on probabilistic analyses and on LHS). In addition, this document includes a listing of the sampled values for LHS sampled parameters (see Table 4), modified and added parameters between the CRA-2004 and the CRA-2009 (see Table 5 and Table 6), the fixed-value parameters used in the PA codes (see Table 13 through Table 47) and the parameters relating to the TRU waste inventory (see Table 48 and Table 49).

Although the parameter development terminology used in this attachment is not the same as in Appendix PAR of the Compliance Certification Application (CCA), it is equivalent. Differences in terminology include; Nuclear Waste Management Program Procedure (NP) 9-2 rather than Quality Assurance Procedure (QAP) 9-2, Parameter Data Entry Forms rather than Form 464s, material:property for identification rather than ID numbers (no longer used for referencing parameters), slightly different definitions for mean, median, and mode, and justification documents rather than parameter record package.

For additional information regarding all parameters, readers are referred to the parameter supporting information packages, which are contained in the Sandia National Laboratories (SNL) Waste Isolation Pilot Plant (WIPP) Records Center located at the SNL office in Carlsbad, New Mexico.

The parameters sampled by LHS are listed in Table 1. The table identifies the parameter number (the number represents the sample order), the Material Name, the Property Name, the code that utilizes the parameter and the corresponding parameter number from the CRA-2004 (when applicable). Parameter sampling order has changed to adopt a more logical means of grouping the parameters with their codes for the CRA-2009.

Table 1. Index of LHS Sampled Parameters for the CRA-2009

CRA-2009				CRA-2004
Parameter #	Material Name	Property Name	Code	Parameter #
Parameter 1	GLOBAL	PBRINE	CCDFGF	60
Parameter 2	REFCON	LHSBLANK	N/A	N/A
Parameter 3	REFCON	LHSBLANK	N/A	N/A
Parameter 4	BOREHOLE	DOMEGA	CUTTINGS_S	61
Parameter 5	BOREHOLE	TAUFAIL	CUTTINGS_S	58
Parameter 6	REFCON	LHSBLANK	N/A	N/A

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Table 1. Index of LHS Sampled Parameters for the CRA-2009 (continued)

CRA-2009				CRA-2004
Parameter #	Material Name	Property Name	Code	Parameter #
Parameter 7	REFCON	LHSBLANK	N/A	N/A
Parameter 8	SPALLMOD	REPIPERM	DRSPALL	*
Parameter 9	SPALLMOD	TENSLSTR	DRSPALL	*
Parameter 10	SPALLMOD	PARTDIAM	DRSPALL	*
Parameter 11	SPALLMOD	REPIPOR	DRSPALL	*
Parameter 12	REFCON	LHSBLANK	N/A	N/A
Parameter 13	REFCON	LHSBLANK	N/A	N/A
Parameter 14	REFCON	LHSBLANK	N/A	N/A
Parameter 15	SOLMOD3	SOLVAR	PANEL	N/A
Parameter 16	SOLMOD4	SOLVAR	PANEL	N/A
Parameter 17	PHUMOX3	PHUMCIM	PANEL	44
Parameter 18	GLOBAL	OXSTAT	PANEL / SECOTP2D	45
Parameter 19	REFCON	LHSBLANK	N/A	N/A
Parameter 20	REFCON	LHSBLANK	N/A	N/A
Parameter 21	REFCON	LHSBLANK	N/A	N/A
Parameter 22	REFCON	LHSBLANK	N/A	N/A
Parameter 23	CULEBRA	MINP_FAC	SECOTP2D	46
Parameter 24	GLOBAL	TRANSIDX	SECOTP2D	47
Parameter 25	GLOBAL	CLIMTIDX	SECOTP2D	48
Parameter 26	CULEBRA	HMBLKLT	SECOTP2D	49
Parameter 27	CULEBRA	APOROS	SECOTP2D	50
Parameter 28	CULEBRA	DPOROS	SECOTP2D	51
Parameter 29	U+6	MKD_U	SECOTP2D	52
Parameter 30	U+4	MKD_U	SECOTP2D	53
Parameter 31	PU+3	MKD_PU	SECOTP2D	54
Parameter 32	PU+4	MKD_PU	SECOTP2D	55
Parameter 33	TH+4	MKD_TH	SECOTP2D	56
Parameter 34	AM+3	MKD_AM	SECOTP2D	57
Parameter 35	REFCON	LHSBLANK	N/A	N/A
Parameter 36	REFCON	LHSBLANK	N/A	N/A
Parameter 37	REFCON	LHSBLANK	N/A	N/A
Parameter 38	REFCON	LHSBLANK	N/A	N/A
Parameter 39	STEEL	CORRMCO2	BRAGFLO	1
Parameter 40	WAS_AREA	PROBDEG	BRAGFLO / PANEL	2
Parameter 41	WAS_AREA	GRATMICI	BRAGFLO	3
Parameter 42	WAS_AREA	GRATMICH	BRAGFLO	4
Parameter 43	CELLULS	FBETA	BRAGFLO	5

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Table 1. Index of LHS Sampled Parameters for the CRA-2009 (continued)

CRA-2009				CRA-2004
Parameter #	Material Name	Property Name	Code	Parameter #
Parameter 44	WAS_AREA	SAT_RGAS	BRAGFLO	6
Parameter 45	WAS_AREA	SAT_RBRN	BRAGFLO	7
Parameter 46	WAS_AREA	SAT_WICK	BRAGFLO	8
Parameter 47	DRZ_PCS	PRMX_LOG	BRAGFLO	9
Parameter 48	CONC_PCS	PRMX_LOG	BRAGFLO	10
Parameter 49	CONC_PCS	SAT_RGAS	BRAGFLO	14
Parameter 50	CONC_PCS	SAT_RBRN	BRAGFLO	15
Parameter 51	CONC_PCS	PORE_DIS	BRAGFLO	16
Parameter 52	S_HALITE	POROSITY	BRAGFLO	17
Parameter 53	S_HALITE	PRMX_LOG	BRAGFLO	18
Parameter 54	S_HALITE	COMP_RCK	BRAGFLO	19
Parameter 55	S_MB139	PRMX_LOG	BRAGFLO	20
Parameter 56	S_MB139	RELP_MOD	BRAGFLO	22
Parameter 57	S_MB139	SAT_RBRN	BRAGFLO	23
Parameter 58	S_MB139	PORE_DIS	BRAGFLO	25
Parameter 59	S_HALITE	PRESSURE	BRAGFLO	26
Parameter 60	CASTILER	PRESSURE	BRAGFLO	27
Parameter 61	CASTILER	PRMX_LOG	BRAGFLO	28
Parameter 62	CASTILER	COMP_RCK	BRAGFLO	29
Parameter 63	BH_SAND	PRMX_LOG	BRAGFLO	30
Parameter 64	DRZ_1	PRMX_LOG	BRAGFLO	31
Parameter 65	CONC_PLG	PRMX_LOG	BRAGFLO	32
Parameter 66	SHFTU	SAT_RBRN	BRAGFLO	62
Parameter 67	SHFTU	SAT_RGAS	BRAGFLO	63
Parameter 68	SHFTU	PRMX_LOG	BRAGFLO	64
Parameter 69	SHFTL_T1	PRMX_LOG	BRAGFLO	65
Parameter 70	SHFTL_T2	PRMX_LOG	BRAGFLO	66
Parameter 71	WAS_AREA	BIOGENFC	BRAGFLO	N/A
Parameter 72	REFCON	LHSBLANK	N/A	N/A
Parameter 73	REFCON	LHSBLANK	N/A	N/A
Parameter 74	REFCON	LHSBLANK	N/A	N/A
Parameter 75	REFCON	LHSBLANK	N/A	N/A

* These DRSPALL parameters were sampled in a separate LHS run during the CRA-2004 and do not have a corresponding parameter number.

Some parameters sampled by LHS during the CRA-2004 were not utilized during the CRA-2009. Two parameters previously sampled for BRAGFLO were changed to a constants (S_MB139:COMP_RCK and S_MB139:SAT_RGAS), therefore making them unnecessary to sample. One parameter (SPALLMOD:RNDSPALL), designed to map BRAGFLO vectors to DRSPALL vectors, was never added to the parameter database and therefore removed. The

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remaining removed parameters, previously sampled for PANEL, were replaced in the CRA-2009 by the parameters SOLMOD3: SOLVAR and SOLMOD4: SOLVAR. Table 2 identifies those sampled parameters that were removed, or not sampled for the CRA-2009, the parameter number listed is the parameter number identified in the CRA-2004.

Table 2. Sampled Parameters Removed Since the CRA-2004

CRA-2004 Parameter #	Material Name	Property Name	Code
11	SOLU4	SOLCIM	PANEL
12	SOLTH4	SOLCIM	PANEL
21	S_MB139	COMP_RCK	BRAGFLO*
24	S_MB139	SAT_RGAS	BRAGFLO*
34	SOLAM3	SOLSIM	PANEL
35	SOLAM3	SOLCIM	PANEL
36	SOLPU3	SOLSIM	PANEL
37	SOLPU3	SOLCIM	PANEL
38	SOLPU4	SOLSIM	PANEL
39	SOLPU4	SOLCIM	PANEL
40	SOLU4	SOLSIM	PANEL
41	SOLU6	SOLSIM	PANEL
42	SOLU6	SOLCIM	PANEL
43	SOLTH4	SOLSIM	PANEL
75	SPALLMOD	RNDSPALL	DRSPALL

* Parameters not sampled, but still used in the CRA-2009

The inclusion of new parameters sampled by LHS was needed for the CRA-2009. A parameter placeholder was developed and added for clarity. Replacement parameters for PANEL solution modeling were added to replace those removed. Lastly, a parameter for microbial gas generation rates was added. Sampled parameters added since the CRA-2004 are listed in Table 3.

Table 3. Sampled Parameters Added Since the CRA-2004

CRA-2009 Parameter #	Material Name	Property Name	Code
Various	REFCON	LHSBLANK	Placeholder
15	SOLMOD3	SOLVAR	PANEL
16	SOLMOD4	SOLVAR	PANEL
71	WAS_AREA	BIOGENFC	BRAGFLO

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2.0 PARAMETER DEVELOPMENT PROCESS

The development of parameter values is controlled by the application of Nuclear Waste Management Program Procedure Parameters (NP 9-2). The process includes documentation of parameter development by those responsible for completion of a particular experimental investigation, development of a system design, or by staff involved in the PA modeling process. All of the references pertaining to parameter selection are contained within the three levels of parameter and data documentation: (1) Parameter Data Entry Form NP-9-2-1, (2) Analysis records packages, and (3) supporting data records packages.

The Parameter Data Entry Form is the highest-level record documenting parameter development that includes application of statistics and interpretations. The Parameter Data Entry Forms include a justification section, which is a pointer to supporting information including, where applicable, the Analysis plan and source document. All values provided in this attachment were derived from the WIPP PA parameter database. The numbers from the WIPP PA parameter database may differ slightly from those contained in the Parameter Data Entry Forms because of rounding.

The parameter supporting information package includes references to related information, such as Analysis Plans, SAND reports, analysis report, justifications, test plans, and related Electronic Records Management System (ERMS) file codes, and, where applicable, a summary on the experimental data collection (that is, method used, assumptions made in testing, and interpretation). The parameter supporting information packages point to the data records packages contain information such as the raw data, analysis, and data interpretation.

Each Parameter Data Entry Form and parameter supporting information package are assigned unique ERMS numbers. Copies of the Parameter Data Entry Forms and parameter supporting information packages are maintained in the SNL WIPP Records Center.

3.0 PARAMETER DISTRIBUTIONS

Probability distributions are used to characterize the uncertainty concerning the value of a parameter. Numbers that characterize a particular distribution include the range, the mean, median, and mode (only for triangular distributions).

- ***Range***. The range of a distribution can be denoted by (a,b), a pair of numbers in which a and b are minimum and maximum values of the parameter, respectively.
- ***Mean***. The expectation of a random variable: i.e., the sum (or integral) of the product of the variable and the probability distribution function (PDF) over the range of the variable. There is a distinction between the sample mean and the true mean of a distribution: The mean, μ, of a distribution is one measure of the central tendency of a distribution, analogous to the arithmetic average of a series of numbers. The sample mean, $\overline{X}$, is the arithmetic average of value in an empirical data set.
- ***Median.*** The value of a random variable at which its cumulative distribution function (CDF) takes the value 0.5; i.e., the 50^{th} percentile point.

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- ***Mode.*** The value of a random variable at which its probability distribution function (PDF) takes its maximum value. The mode of a set of data is the value in the set that occurs most often.

Distributions used to characterize uncertainty in parameters of the PA include: uniform, log uniform, cumulative, log cumulative, triangular, delta, normal, log normal and Student's-t. Constant is not a distribution type; however the databse accepts constant as an identifier.

3.1 Uniform Distribution

A uniform distribution is described by the following equations.

Density Function: $$f(x) = \frac{1}{B - A} \qquad A \le x \le B \qquad (1)$$

Distribution Function: $$F(x) = \frac{x - A}{B - A} \qquad A \le x \le B \qquad (2)$$

Expected Value $$E(X) = \frac{A + B}{2} \qquad (3)$$

Variance: $$V(X) = \frac{(B - A)^2}{12} \qquad (4)$$

Median: $$X_{0.5} = \text{Expected Value (Mean)} \qquad (5)$$

Use of the uniform distribution is appropriate when all that is known about a parameter is its range (*a*,*b*); the uniform distribution is the Maximum Entropy distribution under these circumstances (Tierney, 1990).

3.2 Log Uniform Distribution

If X has a log uniform distribution on the interval from A to B where $B > A > 0$, then $Y = \log_{10} X$ has a uniform distribution from $\log_{10} A$ to $\log_{10} B$ (Iman and Shortencarier 1984).

Density Function: $$f(x) = \frac{1}{x}(\ln B - \ln A) \qquad A < x < B \qquad (6)$$

Distribution Function: $$F(x) = \frac{\ln x - \ln A}{\ln B - \ln A} \qquad A < x < B \qquad (7)$$

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Expected Value: $$E(X)=\frac{B-A}{\ln B-\ln A} \qquad (8)$$

Variance: $$V(X)=(B-A)\left[\frac{(\ln B-\ln A)(B+A)-2(B-A)}{2(\ln B-\ln A)^2}\right] \qquad (9)$$

Median: $$X_{0.5}=\sqrt{AB} \qquad (10)$$

Use of the log uniform distribution is appropriate when all that is known about a parameter is its range (A,B) and $B/A > 100$; that is, the range (A,B) spans more than two orders of magnitude.

3.3 Cumulative Distribution

A cumulative distribution (also called a constructed distribution) is described by a set of N ordered pairs:

$$(x_1,0),(x_2,P_2),(x_3,P_3),\ldots,(x_N,1)\{i.e., P_1=0 \text{ and } P_N=1 \text{ always}\} \qquad (11)$$

where $x_1 < x_2 < x_3 < \ldots < x_N$ and $0 < P_2 < P_3 < \ldots < P_{N-1} < 1$

Because of the nature of the data, the PDF for this distribution takes the form:

$$P(\xi)=\begin{cases} 0 & \xi < x1 \\ \dfrac{P_n-P_{n-1}}{x_n-x_{n-1}}; & x_{n-1}\le\xi\le x_n,\ n=2,3,\ldots,N \\ 0 & \xi\ge x_N \end{cases} \qquad (12)$$

and so the CDF takes the form:

$$P_r[X\le\xi]\approx\Pi(\xi)=\begin{cases} 0 & \xi<x_1 \\ P_{n-1}+\dfrac{(P_n-P_{n-1})(\xi-x_{n-1})}{(x_n-x_{n-1})}; & x_{n-1}\le\xi\le x_x \\ & n=2,3,\ldots,N \\ 1 & \xi>x_N \end{cases} \qquad (13)$$

Expected Value: $$E(X)=\sum_{n=2}^{N}(P_n-P_{n-1})\frac{(x_n+x_{n-1})}{2} \qquad (14)$$

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Variance: $$V(X)=\sum_{n=2}^{N}(P_n-P_{n-1})\frac{\left(x_n^2+x_n\,x_{n-1}+x_{n-1}^2\right)}{3}-\{E(X)\}\qquad(15)$$

Median: $$x_{0.50}=x_{m-1}+(x_m-x_{m-1})\frac{(0.50-P_{m-1})}{(P_m-P_{m-1})}\text{ where }P_{m-1}\leq 0.50<P_m\qquad(16)$$

The cumulative distribution takes its name from the fact that it closely resembles the empirical CDF obtained by plotting the empirical percentiles of the data set $(x_1,x_2,x_3, ..., x_N)$ (Blom 1989, p. 216). The cumulative distribution used here is the result of plotting the subjectively determined percentile points (x_1,P_1), (x_2,P_2), (x_3,P_3) ... , that arise in a formal elicitation of expert opinion concerning the form of the distribution of the parameter in question. A simple form of the cumulative distribution is used when the range (a,c) of the parameter is known and the analyst believes that his or her best estimate value, b, is also the median (or 50th percentile) of the unknown distribution. In this case, the subjectively determined percentile points take the form: $(a,0.0)$, $(b,0.5)$, $(c,1.0)$ (Tierney 1990).

The cumulative distribution is the Maximum Entropy distribution associated with a set of percentile points (x_1,P_1), (x_2,P_2), ..., (x_N, P_N), no matter how that set of percentile points is obtained (that is, independent of whether the points are empirically or subjectively derived) (Tierney 1990).

3.4 Log Cumulative Distribution

In this case, the independent variable is Y, where $Y = \ln X$. As with the cumulative distribution, this distribution is described by a set of N ordered pairs:

$$(y_1,0),(y_2,P_2),(y_3,P_3),\ldots,(y_N,1)\{i.e., P_1=0\text{ and }P_N=1\text{ always}\}\qquad(17)$$

where $y_1 < y_2 < y_3 < \ldots < y_N$ and $0 < P_2 < P_3 < \ldots < P_{N-1} < 1$

Because of the nature of the data, the PDF for this distribution takes the form:

$$P(\xi)=\begin{cases}0 & \xi<x_1\\ \dfrac{P_n-P_{n-1}}{\ln x_n-\ln x_{n-1}}\dfrac{1}{\xi}; & x_{n-1}\leq\xi\leq x_n,\ n=2,3,\ldots,N\\ 0 & \xi\geq x_N\end{cases}\qquad(18)$$

and so the CDF takes the form:

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$$P_r\, X \le \xi = \begin{cases} 0 & \xi < x_1 \\ P_{n-1} + \dfrac{(P_n - P_{n-1})(\ln \xi - \ln x_{n-1})}{(\ln x_n - \ln x_{n-1})}; & \dfrac{x_{n-1} \le \xi \le x_x}{n = 2, 3, \ldots, N} \\ 1 & \xi > x_N \end{cases} \tag{19}$$

Expected Value: $$E(X) = \sum_{n=2}^{N} (P_n - P_{nl}) \frac{(x_n - x_{n-1})}{\ln x_n - \ln x_{n-1}} \tag{20}$$

Variance: $$V(X) = \sum_{n=2}^{N} \frac{1}{2}(P_n - P_{n-1}) \frac{(x_n^2 - x_{n-1}^2)}{\ln x_n - \ln x_{n-1}} - \{E(X)\}^2 \tag{21}$$

Median: $$X_{0.5} = 10^{\left\{x_{m-1} + (x_m - x_{m-1}) \frac{(0.50 - P_{m-1})}{P_m - P_{m-1}}\right\}}; \; P_{m-1} \le 0.50 \le P_m. \tag{22}$$

3.5 Triangular Distribution

The triangular distribution is defined on the range (*a*,*c*) and has mode *b*. The mode can equal either of the two boundary values, which may simplify the computations above (Iman and Shortencarier 1984).

Density Function: $$f(x) = \begin{cases} \dfrac{2(x-a)}{(c-a)(b-a)} & \alpha \le x < b \\ \dfrac{2(c-x)}{(c-a)(c-b)} & b \le x \le c \end{cases} \tag{23}$$

Distribution Function: $$F(x) = \begin{cases} \dfrac{(x-a)^2}{(c-a)(b-a)} & \alpha \le x < b \\ \dfrac{(b-a)}{(c-a)} - \dfrac{(x+b-2c)(x-b)}{(c-a)(c-b)} & b \le x \le c \end{cases} \tag{24}$$

Expected Value: $$E(X) = \frac{a+b+c}{3} \tag{25}$$

Variance: $$V(X) = \frac{a(a-b) + b(b-c) + c(c-a)}{18} \tag{26}$$

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Median:

$$X_{0.5} = \begin{cases} a + \sqrt{\dfrac{(c-a)(b-a)}{2}} & b \le \dfrac{a+c}{2} \\ c - \sqrt{\dfrac{(c-b)(c-a)}{2}} & b > \dfrac{a+c}{2} \end{cases} ; \tag{27}$$

Use of the triangular distribution is appropriate when the range, (a,c), of the parameter is known and the analyst believes that his or her best estimate value, b, is also the mode (or most probable value) of the unknown distribution.

3.6 Delta Distribution

The delta distribution is used to assign probabilities to the elements of some set of objects. For example, if the set consists of four alternative mathematical models of some phenomena and each model is labeled with one of the integers {1, 2, 3, 4}, in other words, $\{M_1, M_2, M_3, M_4\}$, then we might assign the vector of probabilities $\{p_1, p_2, p_3, p_4\}$, where each p_i is a number between 0 and 1 and

$$p_1 + p_2 + p_3 + p_4 = 1. \tag{28}$$

The CDF associated with this delta distribution can be symbolically expressed by

$$F(x) = \sum_{n=1}^{4} p_n u(x-n). \tag{29}$$

The function $u()$ is an indexing function that returns 0 if $(x-n)$ is negative. The graph of this CDF can be visualized as an ascending staircase starting at zero level for x less than one, and having steps of height p_n at the points $x = 1, 2, 3, 4$.

The notion of mean value and variance still apply to a delta distribution, but the meanings of these quantities may require careful interpretation. If the M_n represents four different functions (say, discharge as a function of pressure), then it makes sense to talk about mean and variance functions. For the example of the four alternative mathematical models, the mean mathematical model is the linear combination

$$\overline{M} = \sum_{n=1}^{4} p_n M_n \tag{30}$$

and the variance of the models is similarly defined:

$$\Sigma^2 = \sum_{n=1}^{4} p_n \left(\overline{M} - M_n\right)^2 \tag{31}$$

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3.7 Normal Distribution

A normal distribution is described by the following equations.

Density function: $$f(x)=\frac{1}{\sigma\sqrt{2\pi}}\exp\left\{\frac{-(x-\mu)^2}{2\sigma^2}\right\};-\infty<x<\infty \quad (32)$$

Distribution function: $$F(x)=\int_{-\infty}^{x} f(t)\,dt\ ;-\infty<x<\infty \quad (33)$$

Expected Value: $$E(X)=\mu \quad (34)$$

Variance: $$V(X)=\sigma^2. \quad (35)$$

Median: $$X_{0.5}=\mu \quad (36)$$

Mu and sigma (μ and σ) are the mean and standard deviation of the distribution and as parameters of the distribution.

The WIPP PA Program employs a truncated normal distribution where data are concentrated within an interval (lowrange, hirange) (Iman and Shortencarier 1984). The parameters of the truncated distribution can be expressed as follows:

$$E(X)=\mu=\frac{(\text{lowrange}+\text{hirange})}{2} \quad V(X)=\sigma^2=\left(\frac{\text{hirange}-\text{lowrange}}{6.18}\right)^2 \quad (37)$$

where, lowrange = 0.01 quantile, hirange = 0.99 quantile.

Use of the normal distribution is appropriate when it is known that the parameter is the sum of independent, identically-distributed random variables (this is seldom the case in practice) and there are a sufficient number of measurements of the parameter ($N > 10$) to make accurate, unbiased estimates of the mean (μ) and variance (σ^2) (Sandia WIPP Project 1992; Tierney 1990).

3.8 Log Normal Distribution

If X ~ normal distribution with mean, μ, and variance, σ^2, and $Y = e^X$, the Y has a lognormal distribution.

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Density function: $$f\left(y\right)=\frac{1}{y\sigma\sqrt{2\pi}}\exp\left\{\frac{-\left(\ln y-\mu\right)^2}{2\sigma^2}\right\}\ ;y>0 \qquad (38)$$

Distribution function: $$F\left(y\right)=\int_0^y f\left(t\right)dt\quad ;y>0 \qquad (39)$$

Expected Value: $$E\left(Y\right)=\exp\left(\mu+\frac{\sigma^2}{2}\right) \qquad (40)$$

Variance: $$V\left(Y\right)=\exp\left(2\mu+\sigma^2\right)\left[\exp\left(\sigma^2\right)\ -1\right] \qquad (41)$$

Median: $$X_{0.5}=e^{\mu} \qquad (42)$$

As with the normal distribution, the lognormal distribution requires lowrange and hirange values. These values are in logarithmic form and are utilized in a normal distribution to determine a mean (μ) and a variance (σ^2), which in turn are used to identify the expected value and variance for the lognormal distribution (Iman and Shortencarier 1984).

3.9 Student's-t Distribution

A Student's-t distribution is a distribution for the unknown mean value of a parameter. Its use is appropriate when one has measured values of the parameter available (in contrast to values obtained subjectively through elicitation of professional opinion). If N denotes the number of measurements available, and X_1, X_2, X_3, ... , X_N denote the values of the measurements, then the expected value of the Student's-t distribution is the sample mean and the standard deviation is the standard error divided by $\sqrt{N}$; the median value is equal to the mean value.

The Student's-t distribution applies when there are few measurements, say $3<N<10$. The t-distribution converges to the normal distribution as N becomes large, i.e. $N>20$. The WIPP PA Program employs a truncated Sudent's-t distribution where data are concentrated within an interval (low range, high range) similar to the implementation of the normal distribution as discussed in Section 3.7.

3.10 Constants

Parameters may also be assigned a constant value in the PA parameter database.

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4.0 PARAMETER CORRELATION

Parameter correlations only affects sampled parameters described in the attached parameter sheets. Two types of parameter correlations are used. They are defined as explicit parameter correlation and induced parameter correlation. This section addresses the following criteria concerning parameter correlations, as specified in 40 CFR § 194.23(c)(6):

> (c) Documentation of all models and computer codes included, as part of any compliance application performance assessment calculation shall be provided. Such documentation shall include, but shall not be limited to:
>
> > (6) An explanation of the manner in which models and computer codes incorporate the effects of parameter correlation.

Explicit parameter correlations are introduced or prohibited in LHS by the restricted pairing technique of Iman and Conover (1982). Two parameter correlations are specified in this PA through this technique. These correlations are all related to rock compressibility and permeability. In the Salado Formation impure halite material region in BRAGFLO, rock compressibility (S_Halite:COMP_RCK) and intrinsic permeability (S_Halite:PRMX_LOG) are inverse correlated with a correlation coefficient of -0.99. In the Castile brine reservoir material region in BRAGFLO, rock compressibility (Castiler:COMP_RCK) and intrinsic permeability (Castiler:PRMX_LOG) are inverse correlated with a correlation coefficient of -0.75. Explicit parameter correlation is not used to correlate other sampled parameters.

Rock compressibilities and intrinsic permeabilities are correlated to be most consistent with interpretations of the hydraulic tests that have been performed in these units. In hydraulic testing, hydraulic diffusivity (the ratio of permeability to compressibility) is determined more precisely than either permeability or compressibility alone. Introducing the correlation of the permeability and compressibility parameters in PA better represents the knowledge of the formation gained from hydraulic testing than specifying no correlation whatsoever.

An induced correlation in PA is created when a parameter sampled in LHS (the underlying variable) is used to define the values of other parameters (defined variables). This is a prevalent method of correlation in this PA. For example, uncertainty in dissolved actinide oxidation states is represented in LHS by sampling the OXSTAT parameter (Global:OXSTAT). The results of this sampling are used in part to determine actinide solubilities (NUTS and PANEL), colloidal actinide concentrations (NUTS and PANEL), and K_D values (SECOTP2D) used for a particular vector. Selected examples of other induced parameter correlations include:

- the underlying variable x-direction permeability and the defined variables y- and z-direction permeabilities in many materials (BRAGFLO),
- the underlying variable x-direction permeability and defined variable threshold pressure in many materials (BRAGFLO),
- the underlying variable Lower Salado Clay permeability and the defined variable permeabilities of other clay members of the shaft seal system (BRAGFLO), and

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- the underlying variable residual gas saturation (or other two-phase flow parameters) in many materials and the defined variable residual gas saturation (or other two-phase flow parameters) in other materials (BRAGFLO).
- the underlying variable americium properties and the defined variable curium properties (NUTS, PANEL, and SECOTP2D).

Where relevant, parameter sheets in this attachment contain information related to parameter correlation.

No correlations were used in this PA for certain parameters used to describe transport in the Culebra for which the possibility of correlation might be suspected. The treatment in PA is most consistent with available information, because, as discussed in CCA Appendix MASS (Attachments MASS 15-10 and 15-6, 14), correlation of well-to-well transmissivity versus well-to-well advective porosity and matrix block length is not evident in existing data, nor is the correlation between advective porosity and matrix block length.

Sampled values for LHS sampled parameters are listed in Table 4. The table identifies the Parameter number (sample order), the Material Name, Material description, Property name, Property description, Distribution type, Units of measure, Mean value, Median value, Low value, High value and Standard Deviation.

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Table 4. Parameters Sampled in LHS Code (and parameters to which sampled values were applied)

Parameter #	Material	Material Description	Property	Property Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation
1	GLOBAL	Information that applies globally	PBRINE	Prob. that Drilling Intrusion In Excavated Area Encounters Pressurized Brine	Uniform	NONE	3.05E-01	3.05E-01	1.00E-02	6.00E-01	1.70E-01
2	*REFCON*	*Reference Constant*	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
3	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
4	BOREHOLE	Borehole and Fill	DOMEGA	Drill string angular velocity (0)	Cumulative	radian/s	8.63E+00	7.80E+00	4.20E+00	2.30E+01	3.16E+00
5	BOREHOLE	Borehole and Fill	TAUFAIL	Effective shear strength for erosion (rfail)	Log uniform	Pa	1.05E+01	1.96E+00	5.00E-02	7.70E+01	1.71E+01
6	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
7	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
8	SPALLMOD	Material developed for DRSPALL	REPIPERM	Waste permeability to gas local to intrusion borehole	Log Uniform	m^2	5.16E-13	2.4E-13	2.4E -14	2.4E -12	6.0E-13
9	SPALLMOD	Material developed for DRSPALL	TENSLSTR	Tensile strength of waste	Uniform	Pa	1.45E+05	1.45E+05	1.20E +5	1.70E +5	1.44E+04
10	SPALLMOD	Material developed for DRSPALL	PARTDIAM	Particle diameter of diaggregated waste	Log Uniform	m	2.15E-02	1.0E-02	1.00E -3	1.00E -1	2.5E-02
11	SPALLMOD	Material developed for DRSPALL	REPIPOR	Waste porosity at time of drilling intrusion	Uniform	NONE	5.05E-01	5.05E-01	3.5E-01	6.6E-01	8.95E-02
12	REFCON	Blank placeholder parameter for LHS	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01

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Table 4. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

Parameter #	Material	Material Description	Property	Property Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation
13	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
14	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
15	SOLMOD3	Oxidation state III model	SOLVAR	Solubility multiplier	Cumulative	NONE	3.4877E-02	-3.0682E-02	-3.0E+00	2.85E+00	9.002E-01
16	SOLMOD4	Oxidation state IV model	SOLVAR	Solubility multiplier	Cumulative	NONE	1.08333E-01	7.5E-02	-1.8E+00	2.4E+00	8.37116E-01
17	PHUMOX3	Proportionality Constant, +3 State, Humic Colloids	PHUMCIM	Proportionality Const., Humic Colloids, Castile Brine, MgO controls pH	Cumulative	NONE	1.10E+00	1.37E+00	6.50E-02	1.60E+00	4.69E-01
18	GLOBAL	Information that applies globally	OXSTAT	Index for the Oxidation State	Uniform	NONE	5.00E-01	5.00E-01	0.00E+00	1.00E+00	2.89E-01
19	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
20	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
21	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
22	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
23	CULEBRA	Culebra member of the Rustler formation	MINP_FAC	Mining Transmissivity Multiplier	Uniform	NONE	5.01E+02	5.01E+02	1.00E+00	1.00E+03	2.88E+02
24	GLOBAL	Information that applies globally	TRANSIDX	Index for selecting realizations of the Transmissivity Field	Uniform	NONE	5.00E-01	5.00E-01	0.00E+00	1.00E+00	2.89E-01
25	GLOBAL	Information that applies globally	CLIMTIDX	Climate Index	Cumulative	NONE	1.31E+00	1.17E+00	1.00E+00	2.25E+00	3.48E-01
26	CULEBRA	Culebra member of the Rustler formation	HMBLKLT	Culebra Half Matrix-Block Length	Uniform	m	2.75E-01	2.75E-01	5.00E-02	5.00E-01	1.30E-01
27	CULEBRA	Culebra member of the Rustler formation	APOROS	Culebra Advective Porosity	Log uniform	NONE	2.10E-03	1.00E-03	1.00E-04	1.00E-02	2.50E-03

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Table 4. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

Parameter #	Material	Material Description	Property	Property Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation
28	CULEBRA	Culebra member of the Rustler formation	DPOROS	Diffusive Porosity for Culebra Dolomite	Cumulative	NONE	1.60E-01	1.60E-01	1.00E-01	2.50E-01	3.50E-02
29	U+6	Uranium VI	MKD_U	Matrix Partition Coefficient for Uranium	Log uniform	m^3/kg	3.10E-03	7.70E-04	3.00E-05	2.00E-02	4.60E-03
30	U+4	Uranium IV	MKD_U	Matrix Partition Coefficient for Uranium	Log uniform	m^3/kg	3.50E+00	2.60E+00	7.00E-01	1.00E+01	2.50E+00
31	PU+3	Plutonium III	MKD_PU	Matrix Partition Coefficient for Plutonium	Log uniform	m^3/kg	1.30E-01	9.00E-02	2.00E-02	4.00E-01	1.00E-01
32	PU+4	Plutonium IV	MKD_PU	Matrix Partition Coefficient for Plutonium	Log uniform	m^3/kg	3.50E+00	2.60E+00	7.00E-01	1.00E+01	2.50E+00
33	TH+4	Thorium IV	MKD_TH	Matrix Partition Coefficient for Thorium	Log uniform	m^3/kg	3.50E+00	2.60E+00	7.00E-01	1.00E+01	2.50E+00
34	Am+3	Americium III	MKD_AM	Matrix partition coefficient for americium	Log uniform	m^3/kg	1.3E-01	9.0E-02	2.0E-02	4.0E-01	1.0E-01
35	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
36	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
37	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
38	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
39	STEEL	Generic steel in waste	CORRMCO2	Inundated corrosion rate for steel without CO2 present	Uniform	m/s	1.59E-14	1.59E-14	0.00E+00	3.17E-14	9.15E-15
40	WAS_AREA	Waste emplacement area and waste	PROBDEG	Probability of plastics and rubber biodegradation in event of microbial gas generation	Delta	NONE	1.25E+00	1.25E+00	1.00E+00	2.00E+00	0.00E+00

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Table 4. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

Parameter #	Material	Material Description	Property	Property Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation
41	WAS_AREA	Waste emplacement area and waste	GRATMICI	Inundated biodegradation rate for cellulose	Uniform	moles/(kg*s)	2.94E-10	2.94E-10	3.08E-11	5.57E-10	1.52E-10
42	WAS_AREA	Waste emplacement area and waste	GRATMICH	Humid biodegredation rate for cellulose	Uniform	moles/(kg*s)	5.14E-10	5.14E-10	0.00E+00	1.03E-09	2.97E-10
43	CELLULS	Cellulose	FBETA	Factor beta for microbial reaction rates	Uniform	NONE	5.00E-01	5.00E-01	0.00E+00	1.00E+00	2.89E-01
44	WAS_AREA	Waste emplacement area and waste	SAT_RGAS	Residual Gas Saturation	Uniform	NONE	7.50E-02	7.50E-02	0.00E+00	1.50E-01	4.33E-02
(44)	DRZ_PCS	DRZ directly above concrete portion of panel closure	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.0E+00	0.0E+00	0.00E+00	0.0E+00	0.0E+00
(44)	REPOSIT	Repository regions outside of panel region	SAT_RGAS	Residual Gas Saturation	Uniform	NONE	7.50E-02	7.50E-02	0.00E+00	1.50E-01	4.33E-02
45	WAS_AREA	Waste emplacement area and waste	SAT_RBRN	Residual Brine Saturation	Uniform	NONE	2.76E-01	2.76E-01	0.00E+00	5.52E-01	1.59E-01

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Table 4. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

Parameter #	Material	Material Description	Property	Property Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation
(45)	DRZ_PCS	DRZ directly above concrete portion of panel closure	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.0E+00	0.0E+00	0.00E+00	0.0E+00	0.0E+00
(45)	REPOSIT	Repository regions outside of panel region	SAT_RBRN	Residual Brine Saturation	Uniform	NONE	2.76E-01	2.76E-01	0.00E+00	5.52E-01	1.59E-01
46	WAS_AREA	Waste emplacement area and waste	SAT_WICK	Index for computing wicking	Uniform	NONE	5.00E-01	5.00E-01	0.00E+00	1.00E+00	2.89E-01
47	DRZ_PCS	DRZ directly above concrete portion of panel closure	PRMX_LOG	Log of intrinsic permeability, X-direction	Triangular	log(m^2)	-1.88E+01	-1.87E+01	-2.07E+01	-1.70E+01	7.55E-01
(47)	DRZ_PCS	DRZ directly above concrete portion of panel closure	PRMY_LOG	Log of intrinsic permeability, Y-direction	Triangular	log(m^2)	-1.88E+01	-1.87E+01	-2.07E+01	-1.70E+01	7.55E-01
(47)	DRZ_PCS	DRZ directly above concrete portion of panel closure	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Triangular	log(m^2)	-1.88E+01	-1.87E+01	-2.07E+01	-1.70E+01	7.55E-01
48	CONC_PCS	Concrete portion of PCS	PRMX_LOG	Log of intrinsic permeability, X-direction	Triangular	log(m^2)	-1.88E+01	-1.87E+01	-2.07E+01	-1.70E+01	7.55E-01
(48)	CONC_PCS	Concrete portion of PCS	PRMY_LOG	Log of intrinsic permeability, Y-direction	Triangular	log(m^2)	-1.88E+01	-1.87E+01	-2.07E+01	-1.70E+01	7.55E-01
(48)	CONC_PCS	Concrete portion of PCS	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Triangular	log(m^2)	-1.88E+01	-1.87E+01	-2.07E+01	-1.70E+01	7.55E-01
49	CONC_PCS	Concrete portion of PCS	SAT_RGAS	Residual Gas Saturation	Uniform	NONE	2.00E-01	2.00E-01	0.00E+00	4.00E-01	1.16E-01
50	CONC_PCS	Concrete portion of PCS	SAT_RBRN	Residual Brine Saturation	Cumulative	NONE	2.50E-01	2.00E-01	0.00E+00	6.00E-01	1.76E-01
51	CONC_PCS	Concrete portion of PCS	PORE_DIS	Brooks-Corey pore distribution parameter	Cumulative	NONE	2.52E+00	9.40E-01	1.10E-01	8.10E+00	2.48E+00

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Table 4. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

Parameter #	Material	Material Description	Property	Property Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation
52	S_HALITE	Salado halite, intact	POROSITY	Effective porosity	Cumulative	NONE	1.82E-02	1.00E-02	1.00E-03	5.19E-02	1.54E-02
53	S_HALITE	Salado halite, intact	PRMX_LOG	Log of intrinsic permeability, X-direction	Uniform	log(m^2)	-2.25E+01	-2.25E+01	-2.40E+01	-2.10E+01	8.66E-01
(53)	S_HALITE	Salado halite, intact	PRMY_LOG	Log of intrinsic permeability, Y-direction	Uniform	log(m^2)	-2.25E+01	-2.25E+01	-2.40E+01	-2.10E+01	8.66E-01
(53)	S_HALITE	Salado halite, intact	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Uniform	log(m^2)	-2.25E+01	-2.25E+01	-2.40E+01	-2.10E+01	8.66E-01
54	S_HALITE	Salado halite, intact	COMP_RCK	Bulk Compressibility	Uniform	Pa^{-1}	9.75E-11	9.75E-11	2.94E-12	1.92E-10	5.46E-11
55	S_MB139	Salado marker bed 139, intact and fractured	PRMX_LOG	Log of intrinsic permeability, X-direction	Student	log(m^2)	-1.89E+01	-1.89E+01	-2.10E+01	-1.71E+01	1.20E+00
(55)	S_MB139	Salado marker bed 139, intact and fractured	PRMY_LOG	Log of intrinsic permeability, Y-direction	Student	log(m^2)	-1.89E+01	-1.89E+01	-2.10E+01	-1.71E+01	1.20E+00
(55)	S_MB139	Salado marker bed 139, intact and fractured	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Student	log(m^2)	-1.89E+01	-1.89E+01	-2.10E+01	-1.71E+01	1.20E+01
56	S_MB139	Salado marker bed 139, intact and fractured	RELP_MOD	Model number, relative permeability model	Delta	NONE	4.00E+00	4.00E+00	1.00E+00	4.00E+00	0.00E+00
57	S_MB139	Salado marker bed 139, intact and fractured	SAT_RBRN	Residual Brine Saturation	Student	NONE	8.36E-02	8.36E-02	7.78E-03	1.74E-01	5.01E-02
58	S_MB139	Salado marker bed 139, intact and fractured	PORE_DIS	Brooks-Corey pore distribution parameter	Student	NONE	6.44E-01	6.44E-01	4.91E-01	8.42E-01	1.09E-01
59	S_HALITE	Salado halite, intact	PRESSURE	Brine far-field pore pressure	Uniform	Pa	1.25E+07	1.25E+07	1.10E+07	1.39E+07	8.23E+05
60	CASTILER	Castile Brine Reservoir	PRESSURE	Brine far-field pore pressure	Triangular	Pa	1.36E+07	1.27E+07	1.11E+07	1.70E+07	1.25E+06
61	CASTILER	Castile Brine Reservoir	PRMX_LOG	Log of intrinsic permeability, X-direction	Triangular	log(m^2)	-1.21E+01	-1.18E+01	-1.47E+01	-9.80E+00	1.01E+00

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Table 4. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

Parameter #	Material	Material Description	Property	Property Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation
(61)	CASTILER	Castile Brine Reservoir	PRMY_LOG	Log of intrinsic permeability, Y-direction	Triangular	log(m^2)	-1.21E+01	-1.18E+01	-1.47E+01	-9.80E+00	1.01E+00
(61)	CASTILER	Castile Brine Reservoir	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Triangular	log(m^2)	-1.21E+01	-1.18E+01	-1.47E+01	-9.80E+00	1.01E+00
62	CASTILER	Castile Brine Reservoir	COMP_RCK	Bulk Compressibility	Triangular	Pa^{-1}	5.30E-11	4.00E-11	2.00E-11	1.00E-10	1.70E-11
63	BH_SAND	Borehole filled with silty sand	PRMX_LOG	Log of intrinsic permeability, X-direction	Uniform	log(m^2)	-1.37E+01	-1.37E+01	-1.63E+01	-1.10E+01	1.53E+00
(63)	BH_SAND	Borehole filled with silty sand	PRMY_LOG	Log of intrinsic permeability, Y-direction	Uniform	log(m^2)	-1.37E+01	-1.37E+01	-1.63E+01	-1.10E+01	1.53E+00
(63)	BH_SAND	Borehole filled with silty sand	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Uniform	log(m^2)	-1.37E+01	-1.37E+01	-1.63E+01	-1.10E+01	1.53E+00
64	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	PRMX_LOG	Log of intrinsic permeability, X-direction	Uniform	log(m^2)	-1.60E+01	-1.60E+01	-1.94E+01	-1.25E+01	2.00E+00
(64)	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	Uniform	log(m^2)	-1.60E+01	-1.60E+01	-1.94E+01	-1.25E+01	2.00E+00
(64)	DRZ_2	Disturbed rock zone; time period 0 to 10,000 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Uniform	log(m^2)	-1.60E+01	-1.60E+01	-1.94E+01	-1.25E+01	2.00E+00
65	CONC_PLG	Concrete Plug, surface and Rustler	PRMX_LOG	Log of intrinsic permeability, X-direction	Uniform	log(m^2)	-1.80E+01	-1.80E+01	-1.90E+01	-1.70E+01	5.80E-01
(65)	CONC_PLG	Concrete Plug, surface and Rustler	PRMY_LOG	Log of intrinsic permeability, Y-direction	Uniform	log(m^2)	-1.80E+01	-1.80E+01	-1.90E+01	-1.70E+01	5.80E-01
(65)	CONC_PLG	Concrete Plug, surface and Rustler	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Uniform	log(m^2)	-1.80E+01	-1.80E+01	-1.90E+01	-1.70E+01	5.80E-01
66	SHFTU	Upper portion of simplified shaft	SAT_RBRN	Residual Brine Saturation	Cumulative	NONE	2.50E-01	2.00E-01	0.00E+00	6.00E-01	1.76E-01
(66)	CONC_MON	Concrete Monolith	SAT_RBRN	Residual Brine Saturation	Cumulative	NONE	2.50E-01	2.00E-01	0.00E+00	6.00E-01	1.76E-01

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Table 4. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

Parameter #	Material	Material Description	Property	Property Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation
67	SHFTU	Upper portion of simplified shaft	SAT_RGAS	Residual Gas Saturation	Uniform	NONE	2.00E-01	2.00E-01	0.00E+00	4.00E-01	1.16E-01
(67)	CONC_MON	Concrete Monolith	SAT_RGAS	Residual Gas Saturation	Uniform	NONE	2.00E-01	2.00E-01	0.00E+00	4.00E-01	1.16E-01
68	SHFTU	Upper portion of simplified shaft	PRMX_LOG	Log of intrinsic permeability, X-direction	Cumulative	log(m^2)	-1.82E+01	-1.83E+01	-2.05E+01	-1.65E+01	7.94E-01
69	SHFTL_T1	Lower portion of simplified shaft from 0 - 200 years	PRMX_LOG	Log of intrinsic permeability, X-direction	Cumulative	log(m^2)	-1.80E+01	-1.82E+01	-2.00E+01	-1.65E+01	5.97E-01
70	SHFTL_T2	Lower portion of simplified shaft from 200 - 10,000 years	PRMX_LOG	Log of intrinsic permeability, X-direction	Cumulative	log(m^2)	-1.98E+01	-2.01E+01	-2.25E+01	-1.80E+01	9.37E-01
71	WAS_AREA	Waste emplacement area and waste	BIOGENFC	Probability of attaining sampled microbial-gas-generation rartes	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.88675E-01
72	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
73	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
74	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01
75	REFCON	Reference Constant	LHSBLANK	Blank placeholder for the LHS Code	Uniform	NONE	5.0E-01	5.0E-01	0.0E+00	1.0E+01	2.858E-01

[1]For parameters with a triangular distribution, the value provided for the median is actually the mode

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5.0 KEY TO PARAMETER SHEETS

The parameter sheets included in this attachment contain a variety of information, some of which is extracted from the WIPP PA parameter database. Parameters are listed in the order in which they are retrieved from the WIPP PA parameter database. Nineteen of the parameters retrieved from the database are dummy parameters (or "place holders") and are not actually utilized by the code. Those parameters are identified as REFCON: LHSBLANK (see description of Parameter 2 in Section 8) and therefore have little information in the associated parameter sheet.

Information presented in the parameter sheets is grouped into boxes labeled as follows:

5.1 Parameter(s)

The name of the parameter and the disposal system feature with which it is associated.

5.2 Parameter Description

The Parameter Description box defines the parameter and, where appropriate, explains the role of the parameter in the modeling.

5.3 Material and Property Name(s)

This box provides a link to the PA parameter database. The parameter label listed first is taken from the PA model parameter database and identifies the type of material in the disposal system being modeled (for example, S_MB139 means Salado MB139). The second label describes the PA model parameter name for the property of the material physical or operational meaning for the parameter (for example, SAT_RBRN means residual brine saturation).

5.4 Computational Code(s)

A list of the current computational models used by the PA Department that use this parameter.

5.5 Parameter Statistics

This box identifies the minimum and maximum for uniform distributions, the mode, minimum and maximum for Triangular distributions, the probability and the value associated with that probability for cumulative and delta distributions, and the measured values for the student's-t distribution. All values provided in this attachment were derived from the WIPP PA parameter database. These numbers may differ slightly from those contained in the Parameter Data Entry Forms because of rounding.

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5.6 Units

The physical units of the parameters (usually expressed in metric units).

5.7 Distribution Type

This box identifies the type of parameter distribution (see Section 3.0).

5.8 Data

The basis for the parameter values or parameter distribution is provided in this section. All values provided in this attachment were derived from the WIPP PA parameter database. These numbers may differ slightly from those contained in the Parameter Data Entry Forms because of rounding. The parameters are derived from the following kinds of data and information:

- Site-specific or waste-specific experimental data. These data includes information obtained from in situ experiments and research conducted at off-site laboratories (for example, permeability data, microbial gas generation). This category also includes simulated waste experiments and may indicate correlations made with other material regions based on professional judgment.
- Waste-specific observational data. This category includes data obtained through observation or empirical analysis, such as semi-quantitative and qualitative visual characterization or acceptable knowledge of transuranic (TRU) waste (for example, waste components).
- Professional judgment. This category of information may involve the use of experimental or observational data from other non-WIPP contexts; interpreting information obtained from the general literature; or may be based on general engineering knowledge (see below).
- General Literature Data. This category of information includes that obtained from reports, journal articles, or handbooks relevant to systems or processes being modeled in the PA. It is often employed in conjunction with professional judgment.
- General Engineering Knowledge. This category of information identifies parameter values obtained from knowledge of standard engineering principles.

Readers are referred to justification documents and associated data packages maintained in the SNL WIPP Records Center for additional information.

5.9 Discussion

This box identifies the source(s) of parameter value(s) and the rationale for the parameter distribution and may clarify use of a particular parameter. Other relevant background information is also included in this section, where clarification is appropriate.

5.10 References

This box contains the references pertaining to parameter selection. The references are contained within the three levels of parameter and data documentation: (1) Parameter Data Entry Form,

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and, (2) parameter supporting information packages. Selected references cited in the parameter supporting information packages are included in the parameter sheets to establish data quality.

6.0 PARAMETER ADDITIONS AND MODIFICATIONS TO CRA-2009

A number of parameters were updated or added since the CRA-2004. Section 6.1 describes the parameter modifications occurring between the CRA-2004 and the CRA-2004 Performance Assessment Baseline Calculation (PABC). Section 6.2 describes the parameter modifications occurring between the CRA-2004 PABC and the CRA-2009.

6.1 Changes to Parameters Between the CRA-2004 and the CRA-2004 PABC

Parameters updated or added for the CRA-2004 PABC are listed in Table 5, further details of these parameters can be found in the Compliance Recertification Application Performance Assessment Baseline Calculation (Leigh et. al., 2004).
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Table 5. Parameter Changes for the CRA-2004 PABC.

Description	Name	Modification
WIPP-Scale Initial Radionuclide Inventory In Curies	INVCHD and INVRHD for the following materials: AM 241; AM 243; CF 252; CM 243; CM 244; CM 245; CM248; CS 137; NP 237; PA 231; PB 210; PM 147; PU 238; PU 239; PU 240; PU 241; PU 242; PU 244; RA 226; RA 228; SR 90; TH 229; TH 230; TH 232; U 233; U 234; U 235; U 236; U 238	Parameter Changed
WIPP-Scale Initial Radionuclide Inventory In Curies	INVCHD and INVRHD for the following materials: AM241L, TH230L, PU238L, U234L, PU239L	Parameter Changed
Waste Unit Factor	WUF for the material: BOREHOLE	Parameter Changed
WIPP-Scale Masses of nitrate and sulfate	QINIT for the following materials: NITRATE and SULFATE	Parameter Changed
Residual saturation and rock compressibility for MB 138, MB 139 and Anhydrite A & B	COMP_RCK and SAT_RGAS for the following materials: S_MB139, S_MB138, and S_ANH_AB	Parameter Changed
Waste Material Parameters	DCELLCHW, DCELLRHW, DIRONCHW ,DIRONRHW, DIRNCCHW ,DIRNCRHW, DPLASCHW, DPLASRHW, DPLSCCHW, DPLSCRHW, DRUBBCHW, DRUBBRHW for the following material: WAS_AREA	Parameter Changed

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Table 5 Parameter Changes for the CRA-2004 PABC (Continued)

Description	Name	Modification
Inundated Rate Of Cellulose Biodegradation In The Waste Area	GRATMICI for the following materials: WAS_AREA	Parameter Changed
Humid Rate Of Cellulose Biodegradation In The Waste Area	GRATMICH for the following materials: WAS_AREA	Parameter Changed
Actinide Solubilities in Castile and Salado Brines	SOLCOH and SOLSOH for the following properties: SOLMOD3, SOLMOD4, SOLMOD5 and SOLMOD6.	Parameter Changed
Probability of microbial degradation In The Waste Area	PROBDEG for the following materials: WAS_AREA	Parameter Changed
Probability of attaining sampled microbial gas sampled microbial gas generation rate	BIOGENFC for the following materials: WAS_AREA	Parameter Added
Shear rate and flow rate for the drilling fluid for the Cuttings model.	DRILLMUD for the following properties: MUDFLWRT and SHEARRT	Parameter Added
Actinide solubility variability	SOLVAR for the following materials: SOLMOD4 and SOLMOD3	Parameter Added

6.2 Changes to Parameters Between the CRA-2004 PABC and the CRA-2009

Some parameters were modified or added since the CRA-2004 PABC as well. Those parameters are listed in Table 6. The table identifies the Material Name, Property Name, the Code that utilizes the parameter, the distribution type and the type of modification to the parameter (changed or added). Details and justification of parameter changes are documented the individual parameter's data entry form and supporting justification document(s).

Table 6. Parameters Changed or Added for the CRA-2009

Material Name	Property Name	Code	Distribution	Modification
REFCON	MW_FEOH2	BRAGFLO	Constant	Parameter Added
REFCON	MW_FES	BRAGFLO	Constant	Parameter Added
REFCON	MW_MGCO3	BRAGFLO	Constant	Parameter Added

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Table 6. Parameters Changed or Added for the CRA-2009 (Continued)

Material Name	Property Name	Code	Distribution	Modification
REFCON	MW_MGO	BRAGFLO	Constant	Parameter Added
REFCON	MW_MGOH2	BRAGFLO	Constant	Parameter Added
REFCON	STCO_11	BRAGFLO	Constant	Parameter Added
REFCON	STCO_12	BRAGFLO	Constant	Parameter Added
REFCON	STCO_13	BRAGFLO	Constant	Parameter Added
REFCON	STCO_14	BRAGFLO	Constant	Parameter Added
REFCON	STCO_15	BRAGFLO	Constant	Parameter Added
REFCON	STCO_16	BRAGFLO	Constant	Parameter Added
REFCON	STCO_17	BRAGFLO	Constant	Parameter Added
REFCON	STCO_18	BRAGFLO	Constant	Parameter Added
REFCON	STCO_19	BRAGFLO	Constant	Parameter Added
REFCON	STCO_21	BRAGFLO	Constant	Parameter Added
REFCON	STCO_22	BRAGFLO	Constant	Parameter Added
REFCON	STCO_23	BRAGFLO	Constant	Parameter Added
REFCON	STCO_24	BRAGFLO	Constant	Parameter Added
REFCON	STCO_25	BRAGFLO	Constant	Parameter Added
REFCON	STCO_26	BRAGFLO	Constant	Parameter Added
REFCON	STCO_27	BRAGFLO	Constant	Parameter Added
REFCON	STCO_28	BRAGFLO	Constant	Parameter Added
REFCON	STCO_29	BRAGFLO	Constant	Parameter Added
REFCON	STCO_31	BRAGFLO	Constant	Parameter Added
REFCON	STCO_32	BRAGFLO	Constant	Parameter Added
REFCON	STCO_33	BRAGFLO	Constant	Parameter Added
REFCON	STCO_34	BRAGFLO	Constant	Parameter Added
REFCON	STCO_35	BRAGFLO	Constant	Parameter Added
REFCON	STCO_36	BRAGFLO	Constant	Parameter Added
REFCON	STCO_37	BRAGFLO	Constant	Parameter Added
REFCON	STCO_38	BRAGFLO	Constant	Parameter Added
REFCON	STCO_39	BRAGFLO	Constant	Parameter Added
REFCON	STCO_41	BRAGFLO	Constant	Parameter Added
REFCON	STCO_42	BRAGFLO	Constant	Parameter Added
REFCON	STCO_43	BRAGFLO	Constant	Parameter Added
REFCON	STCO_44	BRAGFLO	Constant	Parameter Added
REFCON	STCO_45	BRAGFLO	Constant	Parameter Added
REFCON	STCO_46	BRAGFLO	Constant	Parameter Added

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Table 6. Parameters Changed or Added for the CRA-2009 (Continued)

Material Name	Property Name	Code	Distribution	Modification
REFCON	STCO_47	BRAGFLO	Constant	Parameter Added
REFCON	STCO_48	BRAGFLO	Constant	Parameter Added
REFCON	STCO_49	BRAGFLO	Constant	Parameter Added
REFCON	STCO_51	BRAGFLO	Constant	Parameter Added
REFCON	STCO_52	BRAGFLO	Constant	Parameter Added
REFCON	STCO_53	BRAGFLO	Constant	Parameter Added
REFCON	STCO_54	BRAGFLO	Constant	Parameter Added
REFCON	STCO_55	BRAGFLO	Constant	Parameter Added
REFCON	STCO_56	BRAGFLO	Constant	Parameter Added
REFCON	STCO_57	BRAGFLO	Constant	Parameter Added
REFCON	STCO_58	BRAGFLO	Constant	Parameter Added
REFCON	STCO_59	BRAGFLO	Constant	Parameter Added
REFCON	STCO_61	BRAGFLO	Constant	Parameter Added
REFCON	STCO_62	BRAGFLO	Constant	Parameter Added
REFCON	STCO_63	BRAGFLO	Constant	Parameter Added
REFCON	STCO_64	BRAGFLO	Constant	Parameter Added
REFCON	STCO_65	BRAGFLO	Constant	Parameter Added
REFCON	STCO_66	BRAGFLO	Constant	Parameter Added
REFCON	STCO_67	BRAGFLO	Constant	Parameter Added
REFCON	STCO_68	BRAGFLO	Constant	Parameter Added
REFCON	STCO_69	BRAGFLO	Constant	Parameter Added
REFCON	STCO_71	BRAGFLO	Constant	Parameter Added
REFCON	STCO_72	BRAGFLO	Constant	Parameter Added
REFCON	STCO_73	BRAGFLO	Constant	Parameter Added
REFCON	STCO_74	BRAGFLO	Constant	Parameter Added
REFCON	STCO_75	BRAGFLO	Constant	Parameter Added
REFCON	STCO_76	BRAGFLO	Constant	Parameter Added
REFCON	STCO_77	BRAGFLO	Constant	Parameter Added
REFCON	STCO_78	BRAGFLO	Constant	Parameter Added
REFCON	STCO_79	BRAGFLO	Constant	Parameter Added
WAS_AREA	MGO_EF	BRAGFLO	Constant	Parameter Added
WAS_AREA	DCELCCHW	BRAGFLO	Constant	Parameter Added
WAS_AREA	DCELCRHW	BRAGFLO	Constant	Parameter Added
WAS_AREA	DCELECHW	BRAGFLO	Constant	Parameter Added
WAS_AREA	DCELERHW	BRAGFLO	Constant	Parameter Added
WAS_AREA	DPLSECHW	BRAGFLO	Constant	Parameter Added

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Table 6. Parameters Changed or Added for the CRA-2009 (Continued)

Material Name	Property Name	Code	Distribution	Modification
WAS_AREA	DPLSERHW	BRAGFLO	Constant	Parameter Added
WAS_AREA	DRUBCCHW	BRAGFLO	Constant	Parameter Added
WAS_AREA	DRUBCRHW	BRAGFLO	Constant	Parameter Added
WAS_AREA	DRUBECHW	BRAGFLO	Constant	Parameter Added
WAS_AREA	DRUBERHW	BRAGFLO	Constant	Parameter Added
DRZ_0	POROSITY	BRAGFLO	Cumulative	Parameter Changed
CAVITY_1	RELP_MOD	BRAGFLO	Constant	Parameter Changed
CAVITY_2	RELP_MOD	BRAGFLO	Constant	Parameter Changed
CAVITY_3	RELP_MOD	BRAGFLO	Constant	Parameter Changed
CAVITY_4	RELP_MOD	BRAGFLO	Constant	Parameter Changed
EXP_AREA	RELP_MOD	BRAGFLO	Constant	Parameter Changed
OPS_AREA	RELP_MOD	BRAGFLO	Constant	Parameter Changed
WAS_AREA	BRUCITEC	BRAGFLO	Constant	Parameter Added
WAS_AREA	BRUCITEH	BRAGFLO	Constant	Parameter Added
WAS_AREA	BRUCITES	BRAGFLO	Constant	Parameter Added
DRZ_PCS	POROSITY	BRAGFLO	Cumulative	Parameter Changed
REFCON	DN_CELL	BRAGFLO / DBR	Constant	Parameter Added
REFCON	DN_FE	BRAGFLO / DBR	Constant	Parameter Added
REFCON	DN_FEOH2	BRAGFLO / DBR	Constant	Parameter Added
REFCON	DN_FES	BRAGFLO / DBR	Constant	Parameter Added
REFCON	DN_MGCO3	BRAGFLO / DBR	Constant	Parameter Added
REFCON	DN_MGO	BRAGFLO / DBR	Constant	Parameter Added
REFCON	DN_MGOH2	BRAGFLO / DBR	Constant	Parameter Added
REFCON	DN_SALT	BRAGFLO / DBR	Constant	Parameter Added
DRZ_1	POROSITY	BRAGFLO / DBR	Cumulative	Parameter Changed
WAS_AREA	RELP_MOD	BRAGFLO / DBR	Constant	Parameter Changed
BLOWOUT	MAXFLOW	BRAGFLO / DBR	Constant	Parameter Changed
S_HALITE	POROSITY	BRAGFLO / DBR / PRELHS	Cumulative	Parameter Changed
BOREHOLE	TAUFAIL	CUTTINGS_S / PRELHS	Loguniform	Parameter Changed*
REFCON	FVW	PRECCDFGF	Constant	Parameter Changed
GLOBAL	LAMBDAD	PRECCDFGF	Constant	Parameter Changed
REPOSIT	RELP_MOD	BRAGFLO	Constant	Parameter Changed

* Parameter BOREHOLE:TAUFAIL was modified from the CRA-2004 PABC for AP-132 and then changed back to its original value for the CRA-2009.

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6.3 Constant Parameters

The following list identifies the tables (found later in this document) that give details regarding specific constant parameters and their contribution to calculations and analysis regarding various categories of the CRA-2009.

- Table 13. Borehole, Blowout and Drill Mud Parameters
- Table 14. Borehole (Concrete Plug) Parameters
- Table 15. Borehole (Open) Parameters
- Table 16. Borehole (Silty Sand) Parameters
- Table 17. Borehole (Creep) Parameters
- Table 18. DRSPALL Parameters
- Table 19. Shaft Material Parameters
- Table 20. Panel Closure Parameters
- Table 21. Santa Rosa Formation Parameters
- Table 22. Dewey Lake Formation
- Table 23. Forty-Niner Member of the Rustler Formation Parameters
- Table 24. Magenta Member of the Rustler Formation Parameters
- Table 25. Tamarisk Member of the Rustler Formation Parameters
- Table 26. Culebra Member of the Rustler Formation Parameters
- Table 27. Los Medanos (Unnamed Lower) Member of the Rustler Formation Parameters
- Table 28. Salado Formation – Intact Halite – Parameters
- Table 29. Salado Formation – Brine – Parameters
- Table 30. Salado Formation – Marker Bed 138 – Parameters
- Table 31. Salado Formation – Marker Bed 139 – Parameters
- Table 32. Salado Formation – Anhydrite a and b, Intact and Fractured – Parameters
- Table 33. Disturbed Rock Zone Parameters
- Table 34. Waste Area and Waste Material Parameters
- Table 35. Waste Chemistry Parameters
- Table 36. Radionuclide Parameters
- Table 37. Isotope Inventory
- Table 38. Waste Container Parameters
- Table 39. Stoichiometric Gas Generation Model Parameters
- Table 40. Predisposal Cavities (Waste Area) Parameters
- Table 41. Operations Region Parameters
- Table 42. Area Parameters
- Table 43. Castile Formation Parameters
- Table 44. Castile Brine Reservoir Parameters
- Table 45. Reference Constants
- Table 46. Global Parameters
- Table 47. Reference Thicknesses for Hydrostratigraphic Units in BRAGFLO

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7.0 EPAUNI INPUT DATA

The WIPP repository radionuclide inventory build-up and decay is determined by a computational method found in the code: EPAUNI Version 1.15A. Inventory data, provided by Los Alamos National Laboratory (LANL), is formatted for use by the code and input for use in the cuttings / cavings calculation. Inventory data is not maintained in the SNL parameter database. Table 48 and Table 49 represent input files used for the code EPAUNI Version 1.15A. Output data, radionuclide inventory data decayed to specified times after repository closure is then input to the code PRECCDFGF (for more information regarding EPAUNI output files, see Fox, 2005). Previous versions of this document included output data only.

The radionuclide inventory is input differently for Remote Handled (RH) and Contact Handled (CH) wastes in the EPAUNI code. Radionuclide data for CH waste streams are individually identified and build-up / decay calculations take place by waste stream. Radionuclide data for RH waste streams are totaled and calculations of build-up and decay are for the entire RH inventory. Table 48 contains radionuclide inventory data from the EPAUNI RH input file EPU_CRA1BC_RH.DAT found in the library LIBCRA1BC_EPU. Table 49 contains radionuclide inventory data from the EPAUNI CH input file EPU_CRA1BC_CH.DAT found in the library LIBCRA1BC_EPU. More information on the radionuclide inventory can be found in the radionuclide inventory (Crawford, 2005).

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8.0 PARAMETER SHEETS

Parameter 1: Probability of Hitting a Brine Reservoir

Parameter Description:

The parameter represents the probability of hitting a brine reservoir during a drilling intrusion.

Material and Property Name(s):
GLOBAL PBRINE

Computational Code: CCDFGF

minimum	maximum
0.01	0.60

Units: None

Distribution Type: Uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

In CCA Appendix PAR, geophysical methods, geological structure analysis, and geostatistical correlation were performed to determine the probability of intersection of a borehole with both the waste disposal region and a pressurized brine reservoir in the Castile formation. The DOE estimated that there is a 0.08 probability that any random borehole that penetrates waste at the WIPP also would penetrate an underlying brine reservoir (DOE 1996).

During preparation of the CCA, DOE reexamined their time-domain electromagnetic geophysical survey and found that between 10 and 55 percent of the waste panel area may be underlain by relatively conductive units, possibly due to one or more brine reservoirs (Alumbaugh 1996). The data did not support a means to distinguish boundaries between possible brine reservoirs and non-reservoir areas. As a consequence, DOE assumed that only one reservoir existed below the waste panels.

The DOE also mapped the geologic structure of selected units within the Castile and Salado Formations to examine the relationship between identified brine intercepts and evaporite deformation. Studies indicated that many of the observed brine encounters in the Delaware

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Basin were associated with structural deformation in the Castile Formation (e.g. ERDA-6). The mapping exercise reaffirmed DOE's belief that much of the Castile Formation underlying the WIPP site is generally not deformed (and therefore, the likelihood of a brine reservoir beneath the waste panels was expected to be low). However, DOE did not consider the results of this geologic structural analysis in quantifying the probability of a drilling intrusion intersecting a brine reservoir.

The DOE then conducted a geostatistical analysis to estimate the probability of drilling into a fractured reservoir in areas overlain by the waste disposal panels. The analysis was based on 354 drill holes and 27 brine reservoir intercepts within the vicinity of the WIPP. Geostatistical techniques were used to estimate the probabilities that a randomly placed drilling intrusion would encounter pressurized brine in the Castile Formation. The overall probability for the waste panel area was determined to be 0.08 (a probability of 0.08 that a drilling intrusion would intersect a waste panel and penetrate into a underlying, pressurized brine reservoir). This value was selected for the parameter PBRINE in the PA calculation.

The EPA reviewed the CCA and supporting documentation and concluded that the parameter PBRINE should be changed from a constant having a value of 0.08 to a uniform distribution represented by a range of 0.01 to 0.60 (median value of 0.305). The EPA believes that this range better reflects the uncertainty in the parameter and is a more appropriate representation of the concept of reasonable expectation than the fixed value of 0.08 used by DOE in the CCA (EPA 1998a).

In reaching its conclusion, EPA considered the possibility that the WIPP-12 brine reservoir may underlie the entire WIPP site and thus the probability of a drilling intrusion encountering the pressurized reservoir could approach certainty (100 percent). This would require the assumption that this reservoir is cylindrical in shape, which EPA considered unlikely because brine resides in vertical or subvertical fractures, and because of the nature of the results from the time domain electromagnetic soundings.

For these reasons, EPA agreed with DOE that there exists a significant uncertainty concerning the magnitude and extent of brine reservoirs beneath the waste panels, but questioned DOE's basis for the probability of encountering such a brine reservoir to be only eight percent, since other DOE-generated information indicated that this probability could be as high as 60 percent (EPA 1998a and 1998b).

EPA found that the most direct information on the presence of brine reservoirs was provided by the time domain electromagnetic information, which could be interpreted to indicate that brine reservoirs underlie as much as 55 percent of the repository. The EPA also found that these same data could be interpreted to mean that brine reservoirs may underlie as little as 10 percent of the repository.

Using the time domain electromagnetic information, EPA developed probability distributions for four cases involving either random or block models to correlate adjacent measurements and assumed either the base of the Castile Formation or the base of the Anhydrite III layer in the Castile Formation was the cutoff point above which brine reservoirs may exist (EPA 1998a

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and 1998b). EPA found that it made little difference whether the random model or block model was used to characterize correlation between the time domain electromagnetic measurements. However, the simulated probability distributions for encountering brine were highly sensitive to the geologic assumption of whether or not brine reservoirs exist below the bottom of the Anhydrite III layer. Using the base of the Castile Formation Anhydrite Layer III as the lowermost stratigraphic layer below which no brine reservoirs occur, the simulations showed that the area beneath the WIPP containing brine reservoirs varies from one to six percent. However, if the base of the Castile Formation is the lowermost stratigraphic layer below which no brine reservoirs occur, the area of the excavated repository underlain by reservoirs increases to about 35 to 58 percent.

For these reasons, EPA selected one percent as the lower limit and 60 percent as the upper limit for the fraction of the excavated area underlain by brine reservoirs. The upper limit was slightly larger than the largest estimated value for this parameter, but was less than 100 percent because it was unreasonable to assume that brine reservoirs must exist. The lower limit was equal to the smallest estimated value and was greater than zero because it was also unreasonable to assume with absolute certainty that a reservoir does not exist. A uniform distribution was mandated because the range of this parameter spans slightly more than an order of magnitude and the use of a uniform distribution conservatively biased the sampling toward the high end. The DOE has adopted the value for the probability of a drilling intrusion intersecting a brine reservoir in the Castile Formation beneath the WIPP (Hansen and Leigh 2003).

Parameter Data Entry Form ERMS: #248783

References:

Alumbaugh, D.L. 1996. "Re-analysis of the Time Domain Electromagnetic (TDEM) Data Collected at the WIPP Site." ERMS #245405. Sandia National Laboratories. Albuquerque, NM.

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office.

U.S. Environmental Protection Agency (EPA). 1998a. Technical Support Document for

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Section 194.23:Parameter Justification Report. Docket No. A-93-02, V-B-14. U.S. Environmental Protection Agency. Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1998b. Response to Comments, Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with 40 CFR 191 Disposal Regulations: Certification Decision. Docket No. A-93-02, V-C-1. U.S. Environmental Protection Agency. Washington D.C.

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Parameter 2: Blank Placeholder

Parameter Description:

This parameter is a blank placeholder for the LHS Code.

Material and Property Name(s):

REFCON LHSBLANK

Computational Code: LHS

minimum	maximum
0	1

Units: None

Distribution Type: Uniform

Data: Professional Judgment - General Engineering Knowledge

No experimental data are associated with the blank placeholder value. The parameter's distribution and related value mirror that of GLOBAL: TRANSIDX. It varies uniformly from 0 to 1.

Discussion:

To alleviate some ambiguity, a placeholder parameter, to be used with LHS, was needed. Previously, the parameter GLOBAL: TRANSIDX (a uniform distribution ranging from zero to one) was used when a placeholder was needed to operate LHS. However, as GLOBAL: TRANSIDX often is sampled on at the same time it also functions as a placeholder, it takes staff members an extra effort to determine which set of LHS output values is the one used and which other ones are for the placeholders.

For the sake of clarity, a true "blank," placeholder was created.

Parameter Data Entry Form ERMS: #527692

References:

Tisinger, Stephen 2003. "Creation of a Placeholder Parameter for LHS" Carlsbad, NM. Sandia National Laboratories. ERMS #525047

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Parameter 3: Blank Placeholder

Blank Placeholder – see description of Parameter 2

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Parameter 4: Drill String Angular Velocity

Parameter Description:

This parameter describes the drill string angular velocity. This value is required to calculate the fluid-generated shear stress.

Material and Property Name(s):

BOREHOLE DOMEGA

Computational Code: CUTTINGS_S

Value	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.8	20.9	23.0
Percentiles	0	0.15	0.65	0.80	0.90	0.95	0.97	0.98	0.99	1.0

Units: Radians/second

Distribution Type: Cumulative

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

The quantity of waste brought to the surface due to an inadvertent penetration of the repository by an exploratory drill bit depends upon three physical processes:

- Cuttings - waste contained in the cylindrical volume created by the cutting action of the drill bit passing through the waste.
- Cavings - waste that erodes from the borehole in response to movement of drilling fluid within the annulus between the drill collars and the borehole wall
- Spallings - waste forced into the drilling fluid due to pressurization of the repository by waste-generated gas. This requires a repository gas pressure that exceeds the hydrostatic pressure of the drilling mud.

The cavings component of direct surface release, after a waste disposal room is penetrated, consists of that quantity of waste material that is eroded from the borehole wall by the action of the flowing drilling fluid. The erosion process model describes the shearing action on the waste by the drilling fluid as it moves up the borehole annulus. The amount of material eroded from the borehole wall is dependent upon the magnitude of the fluid-generated shear

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stress acting on the wall and the effective shear resistance to erosion of the compacted, decomposed waste. The drill string angular velocity is required to calculate the fluid-generated shear stress.

For the CCA, the DOE had information about the rotational velocities used in current practice when drilling through salt. Using this information, the DOE derived a median value based on a constructed cumulative distribution of the known, applicable rotational velocities for drilling in salt. The derived median value was 7.8 radians/second. The CCA PA calculation assigned a constant value of 7.8 radians/second to the drill string angular velocity.

In its review, the EPA found that the data used to derive the median drill string angular velocity encompassed a rather large range of values, from 4.2 to 23 radians/second. Because of this large range, the EPA questioned whether the PA model showed sensitivity to variations in drill string angular velocity over this range. The EPA performed a sensitivity analysis over the range of drill string angular velocities and observed a 60 percent change in cavings releases. As a result, the EPA determined that a constant value for drill string angular velocity did not sufficiently reflect the uncertainty due to the wide range of possible values. The EPA also found that the potential impact on repository performance was sufficient to warrant use of a range of values and required the DOE to treat the drill string angular velocity as a sampled variable with a constructed cumulative distribution with a minimum of 4.2 radians/second, a maximum of 23 radians/second, and a median of 7.77 radians/second. The data were based on a study of current drilling practices in salt, documented in EPA (1998). DOE has adopted the distribution for the drill angular velocity (Hansen and Leigh 2003).

Parameter Data Entry Form ERMS: #231512

References:

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

EPA (U.S. Environmental Protection Agency). 1998. Technical Support Document for Section 194.23:Parameter Justification Report.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582

Information Only

Parameter 5: Effective Shear Resistance to Erosion

Parameter Description:

This parameter describes the intrusion borehole's effective shear strength for erosion.

Material and Property Name(s):

BOREHOLE TAUFAIL

Computational Code: CUTTINGS_S

minimum	maximum
0.05	77.0

Units: Pascals

Distribution Type: Log uniform

Data: Professional Judgment

WIPP specific experimental data were not available for the effective shear resistance to erosion of the waste. Therefore, at the recommendation of the EPA, an estimation technique based on particle size distributions was used. A discussion of this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

The waste shear resistance was estimated based on particle size distributions as determined by an expert elicitation panel. The estimate used the Shield's parameter, which relies on a measure of the central point of a population of particles of various sizes, to determine the critical shear stress for an erodible, cohesionless sediment bed (Simon and Senturk 1992). With this approach, the calculated critical shear stresses ranged from 0.64 Pa to 77 Pa. For conservatism, the low value for waste shear resistance from the CCA PA was retained for the low value in the PAVT while the high value from the Shield's parameter method was used for the high value in the PAVT. The decision to use 0.05 Pa for the low value was supported by information that indicated that very fine-grained materials are not cohesionless as assumed in the Shield's parameter calculation. The information also showed that a lower bound of the critical shear stress for fine-grained cohesive sediments is on the order of the 0.05 Pa. (Parthenaides and Paaswell 1970) The high end of the range was considered appropriate for cohesionless particles and was retained based on the expert elicitation results. A log uniform

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distribution for the waste shear resistance was selected for the PAVT to provide equal weighting over the three orders of magnitude in the range, 0.05 to 77 Pa.

Until additional experimental data becomes available, the range of values selected for the PAVT is certainly inclusive of any reasonable values for the shear strength of the waste. Therefore, DOE has adopted the PAVT values for the shear strength of the waste (Hansen and Leigh 2003). See also Clayton (2007).

Parameter Data Entry Form ERMS: #547524

References:

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Clayton, D. 2007. Analysis Plan for the Performance Assessment for the 2009 Compliance recertification Application, AP-137 Rev. 0. December 7, 2007. Sandia National Laboratories, Carlsbad, NM. ERMS # 547515.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582.

Partheniades, E. and Paaswell, R. 1970. Erodibility of Channels with Cohesive Boundary. March 01, 1970. Sandia National Laboratories, Carlsbad, NM. ERMS # 241125.

Simon, D.B. and Senturk, F. 1992. "Sediment Transport Technology Water and Sediment Dynamics." Water Resource Publication.

Information Only

Parameter 6: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 7: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 8: Range of Waste Permeability

Parameter Description:

This parameter defines a range of waste permeability for the DRSPALL model.

Material and Property Name(s):

SPALLMOD REPIPERM

Computational Code: DRSPALL

minimum	maximum
2.4×10^{-14}	2.4×10^{-12}

Units: m^2

Distribution Type: Log Uniform

Data: Analysis of Conceptual Model Peer Review

The waste permeability was previously treated in BRAGFLO as a constant assigned as the repository scale average. This was implemented in the WIPP PA database by specifying the logarithm of waste permeability (Lord, 2003). This supports the objectives outlined in AP-096, Analysis Plan for Completion of the Spallings Model for WIPP Recertification.

Discussion:

It was determined through analysis produced for the spallings conceptual model peer review (Lord and Rudeen, 2003) that spallings release volumes predicted by the spallings model are sufficiently sensitive to permeability to justify definition of a new local waste permeability for DRSPALL. It was shown in the reports (Lord and Rudeen, 2003), for example, that a critical permeability exists near $k = 2\text{x}10^{-13}$ m^2 above which spallings releases are possible, but below which they are extremely unlikely due to low gas velocity and no fluidization of failed solids. Given (a) the uncertainty in permeability of wastes local to intrusion boreholes subject to spallings, and (b) the proximity of the critical permeability found in the report (Lord and Rudeen, 2003) to the $k = 2.4\text{x}10^{-13}$ m^2 defined for BRAGFLO, it was deemed appropriate to vary the permeability in the spallings model to capture responses above and below this value.

Parameter Data Entry Form ERMS: #531931

Information Only

References:

Lord, D. L. 2003. Memo: Justification for waste permeability range used in DRSPALL. Carlsbad, NM. Sandia National Laboratories. ERMS #531473

Lord, D.L and Rudeen, D.K. 2003. Sensitivity Analysis Report – Parts I & II, DRSPALL version 1.00. Report for Conceptual Model Peer Review Panel Convening July 7 – 11, 2003. Carlsbad, NM: Sandia National Laboratories.

Information Only

Parameter 9: Tensile Strength of Waste

Parameter Description:

This parameter defines the tensile strength of waste for the DRSPALL model.

Material and Property Name(s):

SPALLMOD TENSLSTR

Computational Code: DRSPALL

minimum	maximum
1.2×10^5	1.7×10^5

Units: Pascals

Distribution Type: Uniform

Data: Laboratory Experimentation

Strength and mechanical properties were derived from laboratory experiments on surrogate materials during preparation of the CCA. The primary emphasis of the waste surrogate testing was devoted to quantifying tensile strength, although many other characteristics such as particle size, permeability, and heterogeneity will greatly influence potential spall release. (Hansen et. al., 2003)

Discussion:

Particular attention was given to determining tensile strength, because the initial work in the spallings model suggested that tensile strength was a parameter of parameter of paramount importance to performance assessment. Two techniques were used to investigate tensile strength for the surrogate waste samples: the Brazilian indirect method and hollow cylinders. These sample geometries were conducive to our specimen preparation apparatus. The Brazilian technique applies a compressive state to induce a tensile field, assuming an elastic solution. The indirect technique is probably satisfactory for partially dry (stiffer) surrogate waste; however, the saturated specimens were sufficiently ductile that tensile stress states predicted by elastic solutions might not be applicable. Therefore, an alternative test technique using hollow cylinders subjected to internal pressure was developed for most tensile strength values. The thick-walled cylinder tests were performed by pressurizing the cylinders over their internal surface without applying any external pressure or axial stress. With this configuration, the maximum tensile stress experienced by the specimen occurs at the surface of the inner wall and may be calculated. (Hansen et. al., 2003)

Information Only

Parameter Data Entry Form ERMS: #532364

References:
Hansen et al. 2003. "Parameter Justification Report for DRSPALL" Carlsbad, NM. Sandia National Laboratories. ERMS #531057

Information Only

Parameter 10: Waste Particle Diameter

Parameter Description:

This parameter defines the particle diameter of waste for the DRSPALL model.

Material and Property Name(s):

SPALLMOD PARTDIAM

Computational Code: DRSPALL

minimum	maximum
1 x 10^{-3}	1 x 10^{-1}

Units: meters

Distribution Type: Log Uniform

Data: Laboratory Experimentation

Strength and mechanical properties were derived from laboratory experiments on surrogate materials during preparation of the CCA. The primary emphasis of the waste surrogate testing was devoted to quantifying tensile strength, although many other characteristics such as particle size, permeability, and heterogeneity will greatly influence potential spall release. (Hansen et. al., 2003)

Discussion:

Based on the expert elicitation result, Wang (1997) estimated the particle size distribution for degraded wastes. To be physically meaningful, Wang first converted a particle number-based distribution, specified by the expert panel, into a volume fraction-based distribution, because the waste volume is an important parameter in spalling and caving releases. Wang then quantified the effects of dissolution and cementation processes on waste particle size distributions. Waste particles can be reduced in size by various dissolution processes, such as that concomitant with steel corrosion and organic material biodegradation. However, the calculations show that these dissolution processes will not produce any significant volume fraction of fine particles in the repository. As a matter of fact, dissolution tends even to eliminate small particles present in the initial wastes. Cementation was identified be the expert panel as an important process leading to the aggregation of waste particles in the repository. Based on the panel's assumption that the particle size would approach room size (i.e. cemented mass) as the cement volume approaches about 40% of the available pore space, Wang demonstrated that cementation induced by either MgO hydration or steel corrosion,

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could effectively aggregate waste particles to a room size

To calculate the lower limit of particle size distribution, Wang invoked a bounding case, in which fine particles precipitated during steel corrosion and MgO hydration were assumed to remain un-cemented with a diameter of 2 μm and no particle aggregation is assumed for partially-reacted and non-reactive waste components. The calculation shows that, even in this bounding case, particles smaller than 120 μm account for only 16% of total volume and 30% degradation of either steel or MgO will produce enough cements to raise the smallest particle size from 2 μm to > 120 μm. Therefore, in actual worst cases, particles smaller than 120 μm will account for less than 10% of total volume.\

Wang further argued that, the appropriate particle size range must be estimated based on mean particle size, for the following reasons:

- A small fraction of fine particles can be present in the initial waste. However, there is no conceivable mechanism by which the fine particles will be segregated from coarse particles in space on a multiple-drum scale.
- The fine particles produced by MgO hydration and steel corrosion can be present only when MgO and steel are partially reacted, and thus those particles will be always mixed with remaining MgO and steel particles.
- Therefore, the fine particles not only account for a small fraction of total solid volume but will also remain mixed with large particles. From a mechanistic point of view, small particles cannot be eroded unless large particles become mobile.

There are various ways to define mean particle sizes. The most commonly used definitions are arithmetic mean, the geometric mean, and the median. Wang calculated all three mean values for the lower bounding case. It was found that all three means were larger than 1 mm. Since cementation can effectively aggregate waste particles to a room size, and also because particles larger than the drill bit diameter cannot be released through a borehole, 0.1 m is recommended as the upper limit of mean particle size for the spalling and caving models. Therefore, Wang established the range of mean particle size to be 1mm to 10 cm.

Parameter Data Entry Form ERMS: #531932

References:

Hansen et al. 2003. "Parameter Justification Report for DRSPALL" Carlsbad, NM. Sandia National Laboratories. ERMS #531057

Wang, Yifeng. 1997. Estimate WIPP waste particle sizes based on expert elicitation results: Revision 1. Memorandum to Margaret S.Y. Chu and Mel G. Marietta, August 5, 1997. WPO# 46936. Albuquerque, NM: Sandia National Laboratories.

Information Only

Parameter 11: Waste Porosity

Parameter Description:

This parameter defines the porosity of waste for the DRSPALL model

Material and Property Name(s):

SPALLMOD REPIPOR

Computational Code: DRSPALL

minimum	maximum
0.35	0.66

Units: None

Distribution Type: Uniform

Data: Laboratory Experimentation

Strength and mechanical properties were derived from laboratory experiments on surrogate materials during preparation of the CCA. The primary emphasis of the waste surrogate testing was devoted to quantifying tensile strength, although many other characteristics such as particle size, permeability, and heterogeneity will greatly influence potential spall release.

Discussion:

This section documents the range of values selected for the waste intrinsic porosity, defined as the void volume divided by the current bulk volume, in the DRSPALL model. Porosity enters into DRSPALL in both the porous flow equations that govern compressible gas flow in the repository, as well as in the Ergun equation for fluidized bed transport of disaggregated waste material. While repository pressure and waste porosity for specific intrusions in the WIPP can potentially come directly from BRAGFLO output during compliance calculations, it is necessary to define a distribution of possible input values in order to execute a sensitivity study. Moreover, if the ultimate implementation of DRSPALL takes the form of a spallings response surface, this range must be defined in the event that it takes a primary role as an independent variable in the response function. (Hansen et. al., 2003)

Parameter Data Entry Form ERMS: #533669

Information Only

References:

Hansen et al. 2003. "Parameter Justification Report for DRSPALL." Carlsbad, NM. Sandia National Laboratories. ERMS #531057

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Parameter 12: Blank Placeholder

Blank Placeholder – see description of Parameter 2

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Parameter 13: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 14: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 15: An(III) Actinide Solubility

Parameter Description:

This parameter defines the actinide solubilities (oxidation state An(III)) in brines.

Material and Property Name(s):

SOLMOD3 SOLVAR

Computational Code: PANEL

Probability	0.00E+00	0.00E+00	4.12E-03	4.12E-03	4.12E-03	4.12E-03	4.12E-03
Value	-3.15E+00	-3.00E+00	-2.85E+00	-2.70E+00	-2.55E+00	-2.40E+00	-2.25E+00
Probability	4.12E-03	4.12E-03	8.23E-03	2.47E-02	2.88E-02	5.35E-02	8.64E-02
Value	-2.10E+00	-1.95E+00	-1.80E+00	-1.65E+00	-1.50E+00	-1.35E+00	-1.20E+00
Probability	1.19E-01	1.40E-01	1.85E-01	2.35E-01	2.67E-01	3.46E-01	4.28E-01
Value	-1.05E+00	-9.00E-01	-7.50E-01	-6.00E-01	-4.50E-01	-3.00E-01	-1.50E-01
Probability	5.19E-01	5.84E-01	6.50E-01	7.28E-01	7.53E-01	7.94E-01	8.27E-01
Value	0.00E+00	1.50E-01	3.00E-01	4.50E-01	6.00E-01	7.50E-01	9.00E-01
Probability	8.56E-01	8.85E-01	9.26E-01	9.51E-01	9.59E-01	9.63E-01	9.79E-01
Value	1.05E+00	1.20E+00	1.35E+00	1.50E+00	1.65E+00	1.80E+00	1.95E+00
Probability	9.79E-01	9.84E-01	9.88E-01	9.96E-01	9.96E-01	1.00E+00	1.00E+00
Value	2.10E+00	2.25E+00	2.40E+00	2.55E+00	2.70E+00	2.85E+00	3.00E+00
Probability	1.00E+00						
Value	3.15E+00						

Units: None

Distribution Type: Cumulative

Data: Data Analysis

Comparisons were made between measured solubilites from each study in the analysis and FMT predictions from the actinide oxidation state (An(III), An(IV), or An(V)) and the conditions used in that study. The results were then combined for each oxidation state. Finally, the results for each oxidation state were combined to produce an overall comparison for all three oxidation states. (Xiong et. al. 2005)

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Discussion:

This actinide-solubility uncertainty analysis is Rev 1 of the first uncertainty analysis carried out to compare measured solubilities and predictions made with FMT (Xiong et al, 2004) since that of Bynum (1996a, 1996b, 1996c).

Rev. 1 of this analysis used both previous (pre-CCA) measurements of actinide solubilities – including values used by Bynum (1996a, 1996b, 1996c) in the analysis for the CCA PA – and new (post-CCA) measurements of actinide solubilities, and predictions made with the last (post-CCA) version of FMT (Babb and Novak, 1997 and addenda; Wang, 1998) and the most recent FMT thermodynamic database (Xiong, 2005). This analysis included 243 An(III) comparisons, 45 An(IV) comparisons, and 136 An(V) comparisons, for a total of 424 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.

This analysis included the first comparison for An(iv), but did not include any comparisons with organic ligands or any An(VI) comparisons.

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

Parameter Data Entry Form ERMS: #539652

References:

Babb, S.C. and C.F. Novak. 1997 and addenda. "User's Manual for FMT Version 2.3: A Computer Code Employing the Pitzer Activity Coefficient Formalism for Calculating Thermodynamic Equilibrium in Geochemical Systems to High Electrolyte Concentrations." Albuquerque, NM: Sandia National Laboratories. ERMS 243037.

Bynum, R.V. 1996a. "Estimation of Uncertanty 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.

Information Only

ERMS 241374.

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

Xiong Y. 2005. "Release of FMT_050405.CHEMDAT." E-mail to J.F. Kanney and J.J. Long, April 5, 2005. Carlsbad, NM: Sandia National Laboratories. ERMS 539304.

Xiong Y., Nowak E. J., and Brush L. H.. 2005. "Updated Uncertainty Analysis of Actinide Solubilities For the Response to EPA Comment C-23-16, Rev. 1" Carlsbad, NM. Sandia National Laboratories. ERMS #539595.

Information Only

Parameter 16: An(IV) Actinide Solubility

Parameter Description:

This parameter defines the actinide solubilities (oxidation state An(IV)) in brines.

Material and Property Name(s):

SOLMOD4 SOLVAR

Computational Code: PANEL

Probability	0.00E+00	0.00E+00	0.00E+00	2.22E-02	2.22E-02	2.22E-02	2.22E-02	2.22E-02
Value	-2.10E+00	-1.95E+00	-1.80E+00	-1.65E+00	-1.50E+00	-1.35E+00	-1.20E+00	-1.05E+00
Probability	4.44E-02	8.89E-02	2.00E-0	4.00E-01	4.22E-01	4.22E-01	4.89E-01	5.11E-01
Value	-9.00E-01	-7.50E-01	-6.00E-0	-4.50E-01	-3.00E-01	-1.50E-01	0.00E+00	1.50E-01
Probability	6.22E-01	6.67E-01	6.89E-0	7.78E-01	8.67E-01	9.11E-01	9.11E-01	9.11E-01
Value	3.00E-01	4.50E-01	6.00E-0	7.50E-01	9.00E-01	1.05E+00	1.20E+00	1.35E+00
Probability	9.33E-01	9.33E-01	9.56E-0	9.56E-01	9.78E-01	9.78E-01	1.00E+00	1.00E+00
Value	1.50E+00	1.65E+00	1.80E+0	1.95E+00	2.10E+00	2.25E+00	2.40E+00	2.55E+00
Probability	1.00E+00							
Value	2.70E+00							

Units: None

Distribution Type: Cumulative

Data: Data Analysis

Comparisons were made between measured solubilites from each study in the analysis and FMT predictions fro the actinide oxidation state (An(III), An(IV), or An(V)) and the conditions used in that study. The results were then combined for each oxidation state. Finally, the results for each oxidation state were combined to produce an overall comparison for all three oxidation states. (Xiong et. al. 2005)

Discussion:

This actinide-solubility uncertainty analysis is Rev 1 of the first uncertainty analysis carried out to compare measured solubilities and predictions made with FMT (Xiong et al, 2004) since that of Bynum (1996a, 1996b, 1996c).

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Rev. 1 of this analysis used both previous (pre-CCA) measurements of actinide solubilities – including values used by Bynum (1996a, 1996b, 1996c) in the analysis for the CCA PA – and new (post-CCA) measurements of actinide solubilities, and predictions made with the last (post-CCA) version of FMT (Babb and Novak, 1997 and addenda; Wang, 1998) and the most recent FMT thermodynamic database (Xiong, 2005). This analysis included 243 An(III) comparisons, 45 An(IV) comparisons, and 136 An(V) comparisons, for a total of 424 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.

This analysis included the first comparison for An(iv), but did not include any comparisons with organic ligands or any An(VI) comparisons.

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

Parameter Data Entry Form ERMS: #539652

References:

Babb, S.C. and C.F. Novak. 1997 and addenda. "User's Manual for FMT Version 2.3: A Computer Code Employing the Pitzer Activity Coefficient Formalism for Calculating Thermodynamic Equilibrium in Geochemical Systems to High Electrolyte Concentrations." Albuquerque, NM: Sandia National Laboratories. ERMS 243037.

Bynum, R.V. 1996a. "Estimation of Uncertanty 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.

Wang, Y. 1998. "WIPP PA Validation Document for FMT (Version 2.4), Document Version 2.4." Carlsbad, NM: Sandia National Laboratories. ERMS 251587.

Xiong Y., Nowak E. J., and Brush L. H.. 2004. "Updated Uncertainty Analysis of Actinide Solubilities for the Response to EPA Comment C-23-16." Analysis Report, December 17,

Information Only

2004. Carlsbad, NM: Sandia National Laboratories. ERMS 538219.

Xiong Y. 2005. "Release of FMT_050405.CHEMDAT." E-mail to J.F. Kanney and J.J. Long, April 5, 2005. Carlsbad, NM: Sandia National Laboratories. ERMS 539304.

Xiong Y., Nowak E. J., and Brush L. H.. 2005. "Updated Uncertainty Analysis of Actinide Solubilities For the Response to EPA Comment C-23-16, Rev. 1" Carlsbad, NM. Sandia National Laboratories. ERMS #539595.

Information Only

Parameter 17: Humic Proportionality Constant

Parameter Description:

The humic proportionality constant is used to calculate concentrations of actinides associated with mobile humic substances for actinide elements with oxidation state of +III, in the Castile brine.

Material and Property Name(s):

PHUMOX3 PHUMCIM

Computational Code(s): PANEL

Value	0.07	1.37	1.60
Percentiles	0	0.50	1.0

Units: None

Distribution Type: Cumulative

Data: Site-Specific Experimental Data

Experiments were conducted at Florida State University (Greg R. Choppin) and at SNL (Hans W. Papenguth and co-workers). These results, combined with WIPP-specific data on calcium and magnesium concentrations, formed the basis for this parameter distribution. The parameter records package associated with this parameter is located at: Mobile Colloidal Actinide Source Term 3, Humic Substances (Papenguth, 1996).

Discussion:

Humic substances encompass a broad variety of high-molecular-weight organic compounds that can mobilize actinides. To determine the concentration of actinides associated with humic substances, four pieces of information are required: (1) the concentration of reactive humic substance in the aqueous phase (that is, humic solubility); (2) the binding capacity of the humic substance; (3) actinide uptake (that is, actinide complexation constants); and (4) concentration of actinide ions in the aqueous phase (that is, actinide solubility). Quantification of actinide solubilities is described in Novak and Moore (1996). Collection of the other data, interpretation of that information, and development of parameter values for PA calculations is described in detail in Papenguth and Moore (1996). The humic proportionality constant is a combination of information from (1) and (3) above. This constant is multiplied by (4), the actinide concentration, to obtain the concentrations of actinides mobilized on humic colloids.

Further information on this parameter is found in Appendix SOTERM.

Information Only

Parameter Data Entry Form ERMS: #237683

References:

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. ERMS #236207.

Papenguth, Hans W. 1996. Memo to Christine T. Stockman. RE: Colloidal Actinide Source Term Parameters, Revision 2, April 22, 1996. ERMS #237522.

Papenguth, Hans W., and Moore, R.C. 1996. Mobile - Colloidal- Actinide Source Term, 3. Humic Substances, Sandia National Laboratories (ERMS #235855 Attachment A).

Information Only

Parameter 18: Oxidation State Distribution Parameter

Parameter Description:
This parameter determines whether the repository environment is more reducing or less reducing for a particular realization.

Material and Property Name(s):
GLOBAL OXSTAT

Computational Code(s): PANEL / SECOTP2D

minimum	maximum
0	1.0

Units: None

Distribution Type: Uniform

Data: Site-Specific Experimental Data and Literature Research
Experimental results from Los Alamos National Laboratory, Pacific Northwest National Laboratory, and Argonne National Laboratories-East were used, as well as data from an extensive literature search. The parameter records package associated with this parameter is located at: Oxidation State Distribution (Novak and Moore, 1996; Stockman, 1996).

Discussion:
The oxidation state distribution parameter is used to designate which oxidation states dominate the solubility. Actinides addressed are thorium, uranium, neptunium, plutonium, americium, and curium. Analysis of literature data demonstrated that certain actinides (that is, americium, thorium, curium) will exist only in one oxidation state given the expected WIPP repository conditions. Therefore, this distribution is not used with the PA for these actinides. Experimental evidence indicated that two oxidation states were possible for plutonium, uranium, and neptunium under the expected WIPP repository conditions. For these actinides, it is assumed that their solubilities and k_ds will be dominated by only one oxidation state, but it is uncertain which of two possible states will dominate. Therefore, in half of the realizations employing this parameter (if >0.5), the higher oxidation state solubilities and k_ds will be used, and in the other half of the realizations (if <0.5), the lower oxidation state solubilities and k_ds will be used (Weiner et al. 1996). Further information on this parameter is found in Appendix SOTERM.

Parameter Data Entry Form ERMS: #237663

Information Only

References:

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. ERMS #236207.

Stockman, Christine. 1996. Memo to Martin Tierney. RE: Implementation of Chemistry Parameters in PA. April 16, 1996. ERMS #237536.

Weiner, Ruth F., Hobart, D.E., Tait, C.D., and Clark, D.L. 1996. Analysis of Actinide Oxidation States in the WIPP. Contained in package ERMS #235194.

Information Only

Parameter 19: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 20: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 21: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 22: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 23: Mining Transmissivity Multiplier

Parameter Description:

This parameter is a multiplier, which applies to the transmissivity in areas of the Culebra, which are located above areas of present and future potash mining.

Material and Property Name(s):

CULEBRA MINP_FAC

Computational Code: SECOTP2D

minimum	maximum
1.0	1000.0

Units: None

Distribution Type: Uniform

Data: Regulatory Basis

Data for the Mining Transmissivity Multiplier comes directly from the Preamble published in 40 CFR Part 194 (61 FR 5229). Based on its review of the literature, the EPA determined that mining can increase the conductivity of overlying formations by a factor of much as 1,000. Since the EPA does not specify a distribution for the multiplier, the DOE has assigned it a uniform distribution from 1 to 1,000 with a median value of 500.5. A discussion of the data associated with this parameter may be found in the following parameter records package: Mining Transmissivity Multiplier (Wallace, 1996).

Discussion:

EPA's 40 CFR Part 194 requires that the DOE evaluate the consequences of mining in the McNutt on the performance of the WIPP (Larson 1996). The impacts of mining are taken into account by using a multiplier, which varies from 1 to 1,000 with a uniform distribution. The multiplier applies only to the transmissivity in the Culebra and it applies to areas that qualify under a range of criteria, including both mined areas and areas to be mined (Howard 1996).

In the PA, two cases are considered: (1) the partial mining case which includes all mining outside of the controlled area and (2) the full mining case which includes mining outside and inside of the controlled area. Everywhere that the Culebra is underlain by economical quantities of potash (see Section 2.3.1.1), the transmissivity is multiplied by the multiplier. The multiplier is applied uniformly over the entire mined area for a particular Tfield; however, the value of the multiplier changes for different Tfields. The partial mining case applies to all transmissivity vectors in the PA analysis. Starting from that initial condition, the full mining

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case has a 1 in 100 probability of occurring in any century over the 10,000 year regulatory time frame (for any given Tfield).

Parameter Data Entry Form ERMS: #237666

References:

Howard, B. A. 1996. Memo from B. A. Howard to Mel Marietta, April 3, 1996, RE: Future Mining Events in the Performance Assessment. Attachment: Extent of Mining Position Paper, Revision 1. ERMS #238571.

Larson, Kurt. 1996. Memo to Mike Wallace, "Mining Transmissivity Multiplier—Area to be mined." April 25, 1996. ERMS #237455.

Wallace, M. 1996. Memo to M. Tierney, "Distribution for Non-Salado Parameter for SECOFL2D: Mining Transmissivity Multiplier," April 18, 1996. ERMS #239355.

Information Only

Parameter 24: Culebra Transmissivity Field Index

Parameter Description:

This parameter is intended to incorporate uncertainty in the transmissivity field within the Culebra Dolomite Member of the Rustler Formation.

Material and Property Name(s):

GLOBAL TRANSIDX

Computational Code(s): SECOTP2D

minimum	maximum
0.0	1.0

Units: None

Distribution Type: Uniform

Data: Professional Judgment - General Engineering Knowledge

No experimental data are associated with the transmissivity field index. The parameter is an index for selecting 1 of 100 transmissivity fields produced by PEST and MODFLOW. It varies uniformly from 0 to 1.

Discussion:

Using an approach known as conditioning, or making realizations of random fields coherent with measured information such as hydraulic head values, 100 equally likely Culebra transmissivity fields were generated (employing PEST and MODFLOW). After incorporating changes requested by EPA to account for future potash mining. Each realization was then converted to a flow field, using MODFLOW, assuming uniform Culebra thickness of 8 m and 16 percent effective porosity. TRANSDIX was used to sample on the interval (0,1). The result was mapped onto the integers 1-100 (the number of transmissivity fields) and the resulting integer was used to select a transmissivity field (Ruskauff 1996; Sandia WIPP Project 1992).

Parameter Data Entry Form ERMS: #233055

References:

Ruskauff, Greg. 1996. Memorandum to Martin Tierney, Re: Culebra Transmissivity Field Index, March 13, 1996. ERMS #235193

Sandia WIPP Project. 1992. Preliminary Performance Assessment for the Waste Isolation

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Pilot Plant, December 1992, Vol.3: Model Parameters. SAND92-0700/3. Albuquerque, NM: Sandia National Laboratories. ERMS #223529.

Information Only

Parameter 25: Climate Index

Parameter Description:

A change in climate over the next 10,000 years could alter flow rates in the Culebra, thereby impacting radionuclide transport. The Climate Index is a multiplication factor to enhance the magnitude of flow in each realization of the Culebra flow field caused by changes in future climate.

Material and Property Name(s):

GLOBAL CLIMTIDX

Computational Code(s): SECOTP2D

Value	1	1.25	1.50	2.25
Percentiles	0	0.75	0.75	1

Units: None

Distribution Type: Cumulative

Data: General Literature and Professional Judgment

The parameter distribution was obtained by first surveying the available literature to obtain information that can be used to infer the annual precipitation rate since the end of the Pleistocene and for the next 10,000 years. Next, numerical simulations were performed to see how various assumed rates and temporal patterns of recharge would impact groundwater flow velocities in the Culebra within the WIPP site. The parameter records package associated with this parameter is located at: Climate Index (SNL, 1999).

Discussion:

The following main assumptions were used in the numerical simulations:

1. the groundwater basin conceptual model is applicable,
2. the lateral boundaries are flow divides (that is, no-flow boundaries) during the period simulated,
3. flow in the unsaturated zone can be neglected, and
4. the flow system was equilibrated to a recharge rate sufficient to maintain the water table near the land surface at the start of the simulations.

As described in the Climate Index Record Package (Corbet and Swift 1996), a step recharge function, which represents a radical disruption of the climate pattern of the Holocene, is unlikely and is assigned a 0.25 probability of occurrence and the Holocene recharge pattern is

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assigned a 0.75 probability of occurrence.

First, simulations were performed using a step recharge function for the pattern of future recharge. The results specify a uniform distribution between 1.5 and 2.25.

Next, six transient simulations using the Holocene pattern of future recharge were performed. The results specify a uniform distribution between 1.0 and 1.25.

Parameter Data Entry Form ERMS: #233031

References:

Corbet, T. and Swift, P. 1996. Memo to M. Tierney. Re: Distribution for Non-Salado Parameter for SECOFL2D: Climate Index, April 12, 1996. ERMS #237465.

SNL 1999. Climate Index, Non Salado, Climate Index Package. 6/15/1999. ERMS #236425.

Information Only

Parameter 26: Culebra Half Matrix Block Length

Parameter Description:

This parameter is used to describe the half matrix block length (defined as one-half the thickness of a matrix slab between two parallel plates of fractures) for the Culebra dolomite. It is one of the parameters required in the SECOTP2D code for the double-porosity conceptualization of the Culebra (see also Appendix PA, Section PA-4.9).

Material and Property Name(s):

CULEBRA HMBLKLT

Computational Code(s): SECOTP2D

minimum	maximum
0.05	0.5

Units: Meters

Distribution Type: Uniform

Data: Professional Judgment - General Engineering Knowledge

The half matrix block length distribution is derived from numerical simulations of tracer test data. The data associated with this parameter are located in the following parameter records packages: Culebra Half Matrix Block Length (Culebra Transport Parameter) (SNL 1996a). Supporting data records packages for this parameter include: Tracer Test Interpretations, Simulations for Determination of Adective Porosity and Half Matrix Block Length parameters for CCA Calculations (Altman, 1996); Tracer Test Sample Analyses, H-19 Tracer Tests Conducted June 1995 through July 1995 (SNL 1996b); Tracer Test Sample Analyses, H-19 Tracer Tests Conducted December 1995 through April 1996 (SNL 1996c); and Tracer Test Sample Analyses, H-11 Tracer Tests Conducted February 1996 through March 1996 (Chocas, 1996).

Discussion:

The half matrix block length is defined as one-half the thickness of a matrix slab between two parallel plates of fractures. Diffusive processes at the WIPP will cause some fraction of actinides, which are released from the repository, to diffuse from the advective porosity into the diffusive porosity (or matrix), thereby delaying and attenuating discharges at the site boundary. The larger the half matrix block length (smaller surface area for diffusion), the larger the release because there will be less diffusion and in turn less access to surface area for sorption (Meigs and McCord 1996; see CCA Appendix MASS).

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The distribution of values for the half matrix block length is uniform, with values ranging from 0.05 to 0.5 m (that is, full matrix block length values from 0.1 to 1.0 m). This distribution is based on numerical simulations of tracer test data from the H-3, H-11, and H-19 hydropads (Meigs and McCord 1996). Multiwell convergent flow tracer tests have been performed previously at H-3 and H-11 (Stensrud et al. 1989; Hydro Geo Chem, Inc. 1985). Additional tracer tests have been performed at H-11 and at H-19 (Beauheim et al. 1995). The 1995-96 tests at H-11 and H-19 consisted of single-well injection-withdrawal tests and multiwell convergent flow tests.

The matrix block length and the advective porosity are essentially fitting parameters inferred from comparing the results of numerical simulations of the tracer tests to the field data. Numerical simulations were performed with double-porosity models with both homogeneous and heterogeneous hydraulic conductivity fields. For the homogeneous approach, the field data was analyzed using the SWIFT-II transport code, and for the heterogeneous approach, the field data was analyzed using the THEMM code. Both modeling approaches yielded consistent results for each well-to-well path with regard to matrix block length (Meigs and McCord 1996).

Parameter Data Entry Form ERMS: #238356

References:

Altman, S. J. 1996. Tracer Test Interpretations, Simulations for Determination of Advective Porosity and Half Matrix Block Length Parameters for CCA Calculations. ERMS 237450. Sandia National Laboratories. Albuquerque, NM

Beauheim, R. L., Meigs, L.C., Saulnier, G.J., and Stensrud, W.A. 1995. Culebra Transport Program Test Plan: Tracer Testing of the Culebra Dolomite Member of the Rustler Formation at the H-19 and H-11 Hydropads on the WIPP Site. ERMS #230156.

Chocas, C. S. 1996. Tracer Test Sample Analyses H-11 Tracer Tests Conducted February1996 through March 1996 [including University of Nevada Las Vegas (UNLV) Contract AJ-8745]. ERMS 237467. Sandia National Laboratories. Albuquerque, NM.

Hydro Geo Chem, Inc. 1985. WIPP Hydrology Program Waste Isolation Pilot Plant, SENM Hydrologic Data Report #1. SAND85-7206. Albuquerque, NM: Sandia National Laboratories. ERMS #228430.

Meigs, Lucy, and McCord, Jim. 1996. Memo to file. RE: Physical Transport in the Culebra Dolomite, July 11, 1996. ERMS #239167.

SNL 1996a. Culebra Half Matrix Block Length. ERMS 237225. Sandia National Laboratories. Albuquerque, NM.

SNL 1996b. Tracer Test Sample Analyses H-19 Tracer Tests Conducted June 1995 through July 1995. ERMS 237468. Sandia National Laboratories. Albuquerque, NM

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SNL 1996c. Tracer Test Sample Analyses, H-19 Tracer Tests Conducted December 1995 through April 1996 [including University of Nevada Las Vegas (UNLV) Contract AJ-8745]". ERMS 237452. Sandia National Laboratories. Albuquerque, NM

Stensrud, W.A., Bame, M.A., Lantz, K.D., Palmer, J.B., and Saulnier, G.J., Jr. 1989. WIPP Hydrology Program Waste Isolation Pilot Plant Southeastern New Mexico Hydrologic Data Report #8. SAND89-7056. Albuquerque, NM: Sandia National Laboratories. ERMS #228582.

Information Only

Parameter 27: Culebra Advective Porosity

Parameter Description:

This parameter is used to describe the advective porosity (typically referred to as the fracture porosity) for the Culebra dolomite. It is one of the parameters required in the SECOTP2D code for the double-porosity conceptualization of the Culebra.

Material and Property Name(s):

CULEBRA APOROS

Computational Code(s): SECOTP2D

minimum	maximum
1.0×10^{-4}	0.01

Units: None

Distribution Type: Log uniform

Data: Professional Judgment - General Engineering Knowledge

This porosity distribution is derived from numerical simulations of tracer test data. The data associated with this parameter are located in the following parameter records packages: Culebra Advective Porosity (Culebra Transport parameter) (SNL 1996a). Supporting data records packages for this parameter include: Tracer Test Interpretations, Simulations for Determination of Adective Porosity and Half Matrix Block Length parameters for CCA Calculations (Altman, 1996); Tracer Test Sample Analyses, H-19 Tracer Tests Conducted December 1995 through April 1996 (SNL 1996b); and Tracer Test Sample Analyses, H-11 Tracer Tests Conducted February 1996 through March 1996 (Chocas, 1996).

Discussion:

The Culebra is a fractured dolomite with nonuniform properties and multiple scales of porosity, including fractures ranging from microscale to large, vuggy zones, inter-particle and inter-crystalline porosity. When the permeability contrast is significant between different scales of connected porosity, the total porosity of the system can be modeled by dividing it into the advective porosity (for example, fractures, and to some extent vugs connected by fractures, and interparticle porosity) and the diffusive (or matrix) porosity. The advective porosity refers to porosity through which most of the flow occurs (for example, fractures), while the diffusive porosity includes features such as intercrystalline porosity, and to some extent microfractures, vugs, and interparticle porosity, accessible to solutes only through diffusion. The advective porosity used for the PA simulations has been determined from

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evaluation of tracer test data (Meigs and McCord 1996). The diffusive porosity has been determined from laboratory measurements of core plugs, which do not contain large fractures (Meigs and McCord 1996).

The distribution for the advective porosity is based on numerical simulations of tracer test data from the H-3, H-11, and H-19 hydropads (Meigs and McCord 1996). Multiwell convergent flow tests have been performed previously at H-3 and H-11 (Stensrud et al. 1989; Hydro Geo Chem, Inc. 1985). Additional tracer tests have been performed at H-11 and at H-19 (Beauheim et al. 1995). The recent tests at H-11 and H-19 consisted of single-well injection-withdrawal tests and multiwell convergent flow tests.

The advective porosity and the matrix block length are essentially fitting parameters inferred from comparing the results of numerical simulations of the tracer tests to the field data. Numerical simulations were performed with double-porosity models with both homogeneous and heterogeneous hydraulic conductivity fields. For the homogeneous approach, the field data was analyzed using the SWIFT-II transport code, and for the heterogeneous approach, the field data was analyzed using the THEMM code. Both modeling approaches yielded consistent results for each well-to-well path with regard to advective porosity (Meigs and McCord 1996).

Parameter Data Entry Form ERMS: #238358

References:

Altman, S. J. 1996. Tracer Test Interpretations, Simulations for Determination of Advective Porosity and Half Matrix Block Length Parameters for CCA Calculations. ERMS 237450. Sandia National Laboratories. Albuquerque, NM

Beauheim, R. L., Meigs, L.C., Saulnier, G.J., and Stensrud, W.A. 1995. Culebra Transport Program Test Plan: Tracer Testing of the Culebra Dolomite Member of the Rustler Formation at the H-19 and H-11 Hydropads on the WIPP Site. ERMS #230156.

Chocas, C. S. 1996. Tracer Test Sample Analyses H-11 Tracer Tests Conducted February1996 through March 1996 [including University of Nevada Las Vegas (UNLV) Contract AJ-8745]. ERMS 237467. Sandia National Laboratories. Albuquerque, NM.

Hydro Geo Chem, Inc. 1985. WIPP Hydrology Program Waste Isolation Pilot Plant, SENM Hydrologic Data Report #1. SAND85-7206. Albuquerque, NM: Sandia National Laboratories. ERMS #228430.

Meigs, Lucy, and McCord, Jim. 1996. Memo to file. RE: Physical Transport in the Culebra Dolomite, July 11, 1996. ERMS #239167.

SNL 1996a. Culebra Advective Porosity. ERMS 237227. Sandia National Laboratories. Albuquerque, NM.

Information Only

SNL 1996b. Tracer Test Sample Analyses, H-19 Tracer Tests Conducted December 1995 through April 1996 [including University of Nevada Las Vegas (UNLV) Contract AJ-8745]". ERMS 237452. Sandia National Laboratories. Albuquerque, NM

Stensrud, W.A., Bame, M.A., Lantz, K.D., Palmer, J.B., and Saulnier, G.J., Jr. 1989. WIPP Hydrology Program Waste Isolation Pilot Plant Southeastern New Mexico Hydrologic Data Report #8. SAND89-7056. Albuquerque, NM: Sandia National Laboratories. ERMS #28582.

Information Only

Parameter 28: Culebra Diffusive Porosity

Parameter Description:

This parameter is used to describe the diffusive porosity (typically referred to as the matrix porosity) for the Culebra dolomite. It is one of the parameters required in the SECOTP2D code for the double-porosity conceptualization of the Culebra (see also Section PA-4.9).

Material and Property Name(s):

CULEBRA DPOROS

Computational Code(s): SECOTP2D

Value	0.10	0.11	0.12	0.16	0.18	0.19	0.25
Percentiles	0	0.10	0.25	0.50	0.75	0.90	1

Units: None

Distribution Type: Cumulative

Data: Site-Specific Experimental Data and Professional Judgment - General Engineering Knowledge

This porosity distribution is derived from laboratory measurements. The data associated with this parameter are located in the following parameter records packages: Culebra Diffusive Porosity (Culebra Transport Parameter) (SNL 1996a). Supporting data records packages for this parameter includes: Non-Salado Core Analyses Performed by Terra Tek (AA-2896) (SNL 1996b).

Discussion:

The Culebra is a fractured dolomite with nonuniform properties and multiple scales of porosity, including fractures ranging from microscale to large, vuggy zones and inter-particle and inter-crystalline porosity. When the permeability contrast is significant between different scales of connected porosity, the total porosity of the system can be modeled by dividing it into the advective (for example, fractures and, to some extent, vugs connected by fractures, and interparticle porosity) porosity and the diffusive (or matrix) porosity. The advective porosity refers to porosity through which most of the flow occurs, while the diffusive porosity includes features such as intercrystalline porosity and, to some extent, microfractures, vugs, and interparticle porosity accessible to solutes only through diffusion. The advective porosity to be used for the PA simulations has been determined from evaluation of tracer test data. The diffusive porosity has been determined from laboratory measurement of core plugs, which do not contain large fractures (Meigs and McCord 1996).

This diffusive porosity distribution is derived from laboratory measurements. Boyle's Law

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helium porosity measurements have been made from 103 Culebra core plugs from 17 locations as reported in Kelley and Saulnier (1990) as well as additional porosity measurements completed by Terra Tek (SNL 1996b). The methodology used for porosity measurements are described in Kelley and Saulnier (1990). To account for areal averaging, individual porosity measurements from a borehole and/or hydropad were averaged to yield a borehole/hydropad average porosity. The averaged values were used to construct the distribution (Meigs and McCord 1996).

Parameter Data Entry Form ERMS: #238357

References:

Kelley, V. A., and Saulnier, G. 1990. Core Analyses for Selected Samples from the Culebra Dolomite at the Waste Isolation Pilot Plant Site. SAND90-7011. Albuquerque, NM: Sandia National Laboratories. ERMS #228629.

Meigs, Lucy, and McCord, Jim. 1996. Memo to file. RE: Physical Transport in the Culebra Dolomite, July 11, 1996. ERMS #239167.

SNL 1996a. Culebra Diffusive Porosity. ERMS 237228. Sandia National Laboratories. Albuquerque, NM

SNL 1996b. Non-Salado Core Analyses Performed by Terra Tek (AA-2896). ERMS 238234. Sandia National Laboratories. Albuquerque, NM

Information Only

Parameter 29: Matrix Distribution Coefficient for U(VI)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for uranium in the +VI oxidation state. K_d is the equilibrium ratio of the mass of U adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Property Name(s):

U+6 MKD_U

Computational Code(s): SECOTP2D

minimum	maximum
3×10^{-5}	0.02

Units: Cubic meters/kilogram

Distribution Type: Log uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

In CCA Appendix PAR , Brush (1996) described the laboratory sorption studies used to determine matrix K_ds for dissolved uranium. The experimental data did not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believed that this was a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for uranium in the Culebra was set to zero, which was also conservative (DOE 1996). The laboratory sorption studies supporting the CCA values are summarized below.

I. Triay at LANL studied the sorption of Th(IV), U(VI), Np(V), Pu(V), and Am(III) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of K_ds versus the final dissolved radionuclide concentration. The samples, which Triay used, contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's K_ds are conservative (Brush 1996).

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P.V. Brady at SNL studied the sorption of Nd(III) (a nonradioactive analog of Pu(III) and Am(III)), Th(IV), U(VI), Np(V), Pu(V), and Am(III) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock and Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D.A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP air intake shaft (AIS). This study did not yield K_ds directly. Instead, Lucero calculated retardation factors (Rs) and K_ds. For U(VI) and Np(V), which were eluted from the cores, Lucero was able to calculate discrete K_ds. For Th(IV), Pu(V), and Am(III), which were not eluted during the experiments, Lucero was only able to calculate minimum values of K_ds.

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties as to the extent to which deep (Castile and Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

Subsequent to the CCA PA calculations, two errors were found in the procedures used to calculate the matrix K_ds. First, a brine density of 1.00 g/ml was used rather than the measured brine density. Second, incorrect values for the mass of dolomite were incorporated (Brush and Storz 1996). The erroneous use of these values led to incorrectly calculated distribution coefficients. However, the influence of the changes in these values on the distribution coefficients was believed to be insignificant (Brush and Storz 1996). Brush and Storz (1996) provided the corrected values of these K_ds.

For some isotopes, Brush and Storz (1996) calculated K_ds for both deep (Castile or Salado) and Culebra brines. To remain conservative and consistent with the CCA, the range of K_d values for the brine that has the smaller mean value were used.

In 1997, the EPA's review of experimental K_d data indicated that K_d values appeared to be logarithmically distributed. In addition, since the actinide K_ds ranged over more than an order of magnitude, the EPA felt that a log uniform distribution was more appropriate (EPA 1998) than the uniform distribution specified by Brush and Storz (1996). The DOE has adopted the revised values and distribution for the K_ds (Hansen and Leigh 2003).

Parameter Data Entry Form ERMS: #522016

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. ERMS #238801.

Information Only

Brush, L.H. and Storz, L. 1996. Memo to M. S. Tierney, RE: Revised Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA calculations to Support the WIPP CCA, July 24, 1996. ERMS #241561.

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582.

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office.

U.S. Environmental Protection Agency (EPA). 1998. Technical Support Document for Section 194.23:Parameter Justification Report. Docket No. A-93-02, V-B-14. U.S. Environmental Protection Agency. Washington, D.C.

Information Only

Parameter 30: Matrix Distribution Coefficient for U(IV)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for uranium in the +IV oxidation state. K_d is the equilibrium ratio of the mass of uranium adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Property Name(s):

U+4 MKD_U

Computational Code(s): SECOTP2D

minimum	maximum
0.70	10.0

Units: Cubic meters/kilogram

Distribution Type: Log uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

In CCA Appendix PAR , Brush (1996) described the laboratory sorption studies used to determine matrix K_ds for dissolved uranium. The experimental data did not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believed that this was a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for uranium in the Culebra was set to zero, which was also conservative (DOE 1996). The laboratory sorption studies are summarized below.

I. Triay at LANL studied the sorption of Th(IV), U(VI), Np(V), Pu(V), and Am(III) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of K_ds versus the final dissolved radionuclide concentration. The samples, which Triay used, contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's K_ds are conservative (Brush 1996).

Information Only

P.V. Brady at SNL studied the sorption of Nd(III) (a nonradioactive analog of Pu(III) and Am(III)), Th(IV), U(VI), Np(V), Pu(V), and Am(III) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock and Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D.A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP AIS. This study did not yield K_ds directly. Instead, Lucero calculated retardation factors (Rs) and K_ds. For U(VI) and Np(V), which were eluted from the cores, Lucero was able to calculate discrete K_ds. For Th(IV), Pu(V), and Am(III), which were not eluted during the experiments, Lucero was only able to calculate minimum values of K_ds.

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties as to the extent to which deep (Castile and Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

Subsequent to the CCA PA calculations, two errors were found in the procedures used to calculate the matrix K_ds. First, a brine density of 1.00 g/ml was used rather than the measured brine density. Second, incorrect values for the mass of dolomite were incorporated (Brush and Storz 1996). The erroneous use of these values led to incorrectly calculated distribution coefficients. However, the influence of the changes in these values on the distribution coefficients was believed to be insignificant (Brush and Storz 1996). Brush and Storz (1996) provided the corrected values of these K_ds.

For some isotopes, Brush and Storz (1996) calculated K_ds for both deep (Castile or Salado) and Culebra brines. To remain conservative and consistent with the CCA, the range of K_d values for the brine that has the smaller mean value were used.

In 1997, the EPA's review of experimental K_d data indicated that K_d values appeared to be logarithmically distributed. In addition, since the actinide K_ds ranged over more than an order of magnitude, the EPA felt that a log uniform distribution was more appropriate (EPA 1998) than the uniform distribution specified by Brush and Storz (1996). The DOE has adopted the revised values and distribution for the K_ds (Hansen and Leigh 2003).

Parameter Data Entry Form ERMS: #522016

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. ERMS #238801.

Information Only

Brush, L.H. and Storz, L. 1996. Memo to M. S. Tierney, RE: Revised Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA calculations to Support the WIPP CCA, July 24, 1996. ERMS #241561.

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office.

U.S. Environmental Protection Agency (EPA). 1998. Technical Support Document for Section 194.23:Parameter Justification Report. Docket No. A-93-02, V-B-14. U.S. Environmental Protection Agency. Washington, D.C.

Information Only

Parameter 31: Matrix Distribution Coefficient for Pu(III)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for plutonium in the +III oxidation state. K_d is the equilibrium ratio of the mass of plutonium adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Property Name(s):

PU+3 MKD_PU

Computational Code(s): SECOTP2D

minimum	maximum
0.02	0.40

Units: Cubic meters/kilogram

Distribution Type: Log uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

In CCA Appendix PAR , Brush (1996) described the laboratory sorption studies used to determine matrix K_ds for dissolved plutonium. The experimental data did not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believed that this was a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for plutonium in the Culebra was set to zero, which was also conservative. (DOE 1996) The laboratory sorption studies are summarized below.

I. Triay at LANL studied the sorption of Th(IV), U(VI), Np(V), Pu(V), and Am(III) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of Kds versus the final dissolved radionuclide concentration. The samples, which Triay used, contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's Kds are conservative (Brush 1996).

P.V. Brady at SNL studied the sorption of Nd(III) (a nonradioactive analog of Pu(III) and

Information Only

Am(III)), Th(IV), U(VI), Np(V), Pu(V), and Am(III) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock and Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D.A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP AIS. This study did not yield K_ds directly. Instead, Lucero calculated retardation factors (Rs) and K_ds. For U(VI) and Np(V), which were eluted from the cores, Lucero was able to calculate discrete K_ds. For Th(IV), Pu(V), and Am(III), which were not eluted during the experiments, Lucero was only able to calculate minimum values of K_ds.

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties as to the extent to which deep (Castile and Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

Subsequent to the CCA PA calculations, two errors were found in the procedures used to calculate the matrix K_ds. First, a brine density of 1.00 g/ml was used rather than the measured brine density. Second, incorrect values for the mass of dolomite were incorporated (Brush and Storz 1996). The erroneous use of these values led to incorrectly calculated distribution coefficients. However, the influence of the changes in these values on the distribution coefficients was believed to be insignificant (Brush and Storz 1996). Brush and Storz (1996) provided the corrected values of these K_ds.

For some isotopes, Brush and Storz (1996) calculated K_ds for both deep (Castile or Salado) and Culebra brines. To remain conservative and consistent with the CCA, the range of K_d values for the brine that has the smaller mean value were used.

In 1997, the EPA's review of experimental K_d data indicated that K_d values appeared to be logarithmically distributed. In addition, since the actinide K_ds ranged over more than an order of magnitude, the EPA felt that a log uniform distribution was more appropriate (EPA 1998) than the uniform distribution specified by Brush and Storz (1996). The DOE has adopted the revised values and distribution for the K_ds (Hansen and Leigh 2003)

Parameter Data Entry Form ERMS: #527707

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. ERMS #238801.

Information Only

Brush, L.H. and Storz, L. 1996. Memo to M. S. Tierney, RE: Revised Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA calculations to Support the WIPP CCA, July 24, 1996. ERMS #241561.

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582.

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office.

U.S. Environmental Protection Agency (EPA). 1998. Technical Support Document for Section 194.23:Parameter Justification Report. Docket No. A-93-02, V-B-14. U.S. Environmental Protection Agency. Washington, D.C.

Information Only

Parameter 32: Matrix Distribution Coefficient for Pu(IV)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for plutonium in the +IV oxidation state. K_d is the equilibrium ratio of the mass of plutonium adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Property Name(s):

PU+4 MKD_PU

Computational Code(s): SECOTP2D

minimum	maximum
0.70	10.0

Units: Cubic meters/kilogram

Distribution Type: Log uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

In CCA Appendix PAR , Brush (1996) described the laboratory sorption studies used to determine matrix K_ds for dissolved plutonium. The experimental data did not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believed that this was a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for plutonium in the Culebra was set to zero, which was also conservative (DOE 1996). The laboratory sorption studies are summarized below.

I. Triay at LANL studied the sorption of Th(IV), U(VI), Np(V), Pu(V), and Am(III) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of K_ds versus the final dissolved radionuclide concentration. The samples, which Triay used, contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's K_ds are conservative (Brush 1996).

Information Only

P. V. Brady at SNL studied the sorption of Nd(III) (a nonradioactive analog of Pu(III) and Am(III)), Th(IV), U(VI), Np(V), Pu(V), and Am(III) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock and Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D.A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP AIS. This study did not yield K_ds directly. Instead, Lucero calculated retardation factors (Rs) and K_ds. For U(VI) and Np(V), which were eluted from the cores, Lucero was able to calculate discrete K_ds. For Th(IV), Pu(V), and Am(III), which were not eluted during the experiments, Lucero was only able to calculate minimum values of K_ds.

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties as to the extent to which deep (Castile and Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

Subsequent to the CCA PA calculations, two errors were found in the procedures used to calculate the matrix K_ds. First, a brine density of 1.00 g/ml was used rather than the measured brine density. Second, incorrect values for the mass of dolomite were incorporated (Brush and Storz 1996). The erroneous use of these values led to incorrectly calculated distribution coefficients. However, the influence of the changes in these values on the distribution coefficients was believed to be insignificant (Brush and Storz 1996). Brush and Storz (1996) provided the corrected values of these K_ds.

For some isotopes, Brush and Storz (1996) calculated K_ds for both deep (Castile or Salado) and Culebra brines. To remain conservative and consistent with the CCA, the range of K_d values for the brine that has the smaller mean value were used.

In 1997, the EPA's review of experimental K_d data indicated that K_d values appeared to be logarithmically distributed. In addition, since the actinide K_ds ranged over more than an order of magnitude, the EPA felt that a log uniform distribution was more appropriate (EPA 1998) than the uniform distribution specified by Brush and Storz (1996). DOE has adopted the revised values and distribution for the K_ds (Hansen and Leigh 2003).

Parameter Data Entry Form ERMS: #522016

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. ERMS #238801.

Information Only

Brush, L.H. and Storz, L. 1996. Memo to M. S. Tierney, RE: Revised Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA calculations to Support the WIPP CCA, July 24, 1996. ERMS #241561.

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office.

U.S. Environmental Protection Agency (EPA). 1998. Technical Support Document for Section 194.23: Parameter Justification Report. Docket No. A-93-02, V-B-14. U.S. Environmental Protection Agency. Washington, D.C.

Information Only

Parameter 33: Matrix Distribution Coefficient for Th(IV)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for thorium in the +IV oxidation state. K_d is the equilibrium ratio of the mass of thorium adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Property Name(s):

TH+4 MKD_TH

Computational Code(s): SECOTP2D

minimum	maximum
0.70	10.0

Units: Cubic meters/kilogram

Distribution Type: Log uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

In CCA Appendix PAR , Brush (1996) described the laboratory sorption studies used to determine matrix K_ds for dissolved thorium. The experimental data do not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believed that this was a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for thorium in the Culebra was set to zero, which was also conservative (DOE 1996). The laboratory sorption studies are summarized below.

I. Triay at LANL studied the sorption of Th(IV), U(VI), Np(V), Pu(V), and Am(III) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of K_ds versus the final dissolved radionuclide concentration. The samples, which Triay used, contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's K_ds are conservative (Brush 1996).

Information Only

P.V. Brady at SNL studied the sorption of Nd(III) (a nonradioactive analog of Pu(III) and Am(III)), Th(IV), U(VI), Np(V), Pu(V), and Am(III) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock and Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D.A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP AIS. This study did not yield K_ds directly. Instead, Lucero calculated retardation factors (Rs) and K_ds. For U(VI) and Np(V), which were eluted from the cores, Lucero was able to calculate discrete K_ds. For Th(IV), Pu(V), and Am(III), which were not eluted during the experiments, Lucero was only able to calculate minimum values of K_ds.

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties as to the extent to which deep (Castile and Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

Subsequent to the CCA PA calculations, two errors were found in the procedures used to calculate the matrix K_ds. First, a brine density of 1.00 g/ml was used rather than the measured brine density, and, second, incorrect values for the mass of dolomite were incorporated (Brush and Storz 1996). The erroneous use of these values led to incorrectly calculated distribution coefficients. However, the influence of the changes in these values on the distribution coefficients was believed to be insignificant (Brush and Storz 1996). Brush and Storz (1996) provided the corrected values of these K_ds.

For some isotopes, Brush and Storz (1996) calculated K_ds for both deep (Castile or Salado) and Culebra brines. To remain conservative and consistent with the CCA, the range of K_d values for the brine that has the smaller mean value were used.

In 1997 the EPA's review of experimental K_d data indicated that K_d values appeared to be logarithmically distributed. In addition, since the actinide K_ds ranged over more than an order of magnitude, the EPA felt that a log uniform distribution was more appropriate (EPA, 1998) than the uniform distribution specified by Brush and Storz (1996). The DOE has adopted the revised values and distribution for the K_ds (Hansen and Leigh 2003).

Parameter Data Entry Form ERMS: #522016

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. ERMS #238801.

Information Only

Brush, L.H. and Storz, L. 1996. Memo to M. S. Tierney, RE: Revised Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA calculations to Support the WIPP CCA, July 24, 1996. ERMS #241561.

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582.

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office.

U.S. Environmental Protection Agency (EPA). 1998. Technical Support Document for Section 194.23:Parameter Justification Report. Docket No. A-93-02, V-B-14. U.S. Environmental Protection Agency. Washington, D.C.

Information Only

Parameter 34: Matrix Distribution Coefficient for Am(III)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for americium in the +III oxidation state. K_d is the equilibrium ratio of the mass of americium adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Property Name(s):

AM+3 MKD_AM

Computational Code(s): SECOTP2D

minimum	maximum
0.02	0.40

Units: Cubic meters/kilogram

Distribution Type: Log uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

In CCA Appendix PAR , Brush (1996) described the laboratory sorption studies used to determine matrix K_ds for dissolved americium. The experimental data did not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believed that this was a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for americium in the Culebra was set to zero, which was also conservative (DOE 1996). The laboratory sorption studies are summarized below.

I. Triay at LANL studied the sorption of Th(IV), U(VI), Np(V), Pu(V), and Am(III) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of K_ds versus the final dissolved radionuclide concentration. The samples, which Triay used, contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's K_ds are conservative (Brush 1996).

Information Only

P.V. Brady at SNL studied the sorption of Nd(III) (a nonradioactive analog of Pu(III) and Am(III)), Th(IV), U(VI), Np(V), Pu(V), and Am(III) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock and Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D.A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP AIS. This study did not yield K_ds directly. Instead, Lucero calculated retardation factors (Rs) and K_ds. For U(VI) and Np(V), which were eluted from the cores, Lucero was able to calculate discrete K_ds. For Th(IV), Pu(V), and Am(III), which were not eluted during the experiments, Lucero was only able to calculate minimum values of K_ds.

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties as to the extent to which deep (Castile and Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

Subsequent to the CCA PA calculations, two errors were found in the procedures used to calculate the matrix K_ds. First, a brine density of 1.00 g/ml was used rather than the measured brine density, and, second, incorrect values for the mass of dolomite were incorporated (Brush and Storz 1996). The erroneous use of these values led to incorrectly calculated distribution coefficients. However, the influence of the changes in these values on the distribution coefficients was believed to be insignificant (Brush and Storz 1996). Brush and Storz (1996) provided the corrected values of these K_ds.

For some isotopes, Brush and Storz (1996) calculated K_ds for both deep (Castile or Salado) and Culebra brines. To remain conservative and consistent with the CCA, the range of K_d values for the brine that has the smaller mean value were used.

In 1997, the EPA's review of experimental K_d data indicated that K_d values appeared to be logarithmically distributed. In addition, since the actinide K_ds ranged over more than an order of magnitude, the EPA felt that a log uniform distribution was more appropriate (EPA 1998) than the uniform distribution specified by Brush and Storz (1996). The DOE has adopted the revised values and distribution for the K_ds (Hansen and Leigh 2003).

Parameter Data Entry Form ERMS: #527706

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. ERMS #238801.

Information Only

Brush, L.H. and Storz, L. 1996. Memo to M. S. Tierney, RE: Revised Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA calculations to Support the WIPP CCA, July 24, 1996. ERMS #241561.

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office.

U.S. Environmental Protection Agency (EPA). 1998. Technical Support Document for Section 194.23:Parameter Justification Report. Docket No. A-93-02, V-B-14. U.S. Environmental Protection Agency. Washington, D.C.

Information Only

Parameter 35: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 36: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 37: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 38: Blank Placeholder

Blank Placeholder – see description of Parameter 2

Information Only

Parameter 39: Steel Corrosion

Parameter Description:

This parameter is used to describe the rate of anoxic steel corrosion under brine-inundated conditions and with no CO_2 present (Appendix PA, Section PA-4.2)..

Material and Property Name(s):

STEEL CORRMCO2

Computational Code: BRAGFLO

minimum	maximum
0	3.17×10^{-14}

Units: m/s

Distribution Type: Uniform

Data: Site- Specific Experimental Data

A discussion of the data associated with this parameter for the initial application may be found in Appendix PAR (DOE 1996). Justification for the change of this parameter for CRA may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the PA Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

Based on experimental results (Telander and Westerman 1993; 1997), steel is expected to corrode in the repository via the following reaction (Wang and Brush, 1996a, 1996b):

$$Fe^0 + 2H_2O \rightarrow Fe(OH)_2 + H_2$$

The rate of this reaction under a brine-inundated condition (no CO_2 present at all) is estimated to be 0 - 0.5 μm/year (0 - 1.59×10^{-14} m/s). This steel corrosion rate was estimated by DOE based on long-term anoxic steel corrosion experiments. Because of its uncertainty, this parameter was treated as a sampled variable in the CCA with a uniform distribution ranging from 0.0 to 1.59×10^{-14} m/s (see CCA Appendix PAR).

Subsequent to the CCA, the EPA questioned both the upper and lower bounds on DOE's assigned range of values for CORRMCO2. After evaluating the values DOE assigned to the steel corrosion rate, the EPA carefully examined experimental results. In all cases, except for

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the case of high pressure, the EPA, like the DOE, concluded that the steel corrosion rate used in the CCA was appropriate.

However, the EPA questioned the upper bound for the steel corrosion rate in the case of high pressures in the repository. Some experiments of six months duration conducted on steel immersed in brine under a hydrogen atmosphere indicated that the steel corrosion rate first decreased at pressures from 2 to 70 atm and then increased at pressures from 70 to 127 atm (Telander and Westerman 1993). Because the repository may approach or exceed lithostatic pressure and because of the increase in the experimental corrosion rates at higher pressures, the EPA requested that DOE double the upper bound of the inundated corrosion rate to 3.17×10^{-14} m/s (EPA 1998). DOE has adopted this revised range for the rate of anoxic steel corrosion (Hansen and Leigh 2003).

Parameter Data Entry Form ERMS: #522016

References:

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS 528582

Telander M. R. and Westerman, R.E. 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.

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

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office. Vols 1-XXI.

U.S. Environmental Protection Agency (EPA). 1998. Technical Support Document for Section 194.23:Parameter Justification Report. Docket No. A-93-02, V-B-14. U.S. Environmental Protection Agency. Washington, D.C. ERMS 525158.

Wang Y., and Brush L. H. 1996a. "Estimates Of Gas-Generation Parameters For The Long-Term WIPP PA" Memorandum to M. Tierney, 1/26/1996.. Sandia National Labs.

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Albuquerque, NM. ERMS 231943

Wang Y., and Brush L. H. 1996b. "Modify The Stoichiometric Factor Y In The BRAGFLO To Include The Effect Of MgO Added To WIPP Repository As A Backfill". Memorandum to M. Tierney, 2/23/1996. Sandia National Labs. Albuquerque, NM. ERMS 232286.

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Parameter 40: Probability of Microbial Degradation of Plastics and Rubbers in the Waste in the Event of Significant Microbial Gas Generation

Parameter Description:

This parameter is used to index alternative models of microbial degradation of plastics and rubbers in the waste in the repository in the event of significant microbial gas generation. It is a sampled parameter for the waste emplacement area and the waste, and the values are then applied to the repository regions outside of the panel region.

Material and Property Name(s):

WAS_AREA PROBDEG

Computational Code: BRAGFLO / PANEL

Value	1.0	2.0
Percentiles	.75	.25

Units: None

Distribution Type: Delta

Data: General Engineering Knowledge - Professional Judgment

A discussion of the data associated with this parameter may be found in (Tierney, 1996) and the following parameter records package: Estimates of Gas Generation Parameters Required for BRAGFLO.

Discussion:

Cellulosics, plastics, and rubbers have been identified as the major organic materials to be emplaced in the WIPP repository (Appendix TRU WASTE) and could be degraded by microbes in 10,000 years. The occurrence of significant microbial gas generation in the repository will depend on: (1) whether microbes capable of consuming the emplaced organic materials will be present and active; (2) whether sufficient electron acceptors will be present and available; and (3) whether enough nutrients will be present and available. Considering uncertainties in evaluation of these factors and also in order to bracket all possible effects of gas generation on the WIPP PA, a probability of 50 percent is assigned to the occurrence of significant microbial gas generation (Wang and Brush 1996).

There are two factors that may potentially increase the biodegradability of these materials: long time scale and cometabolism. Over a time scale of 10,000 years, plastics and rubbers may change their chemical properties and therefore their biodegradability.

Cometabolism means that microbes degrade an organic compound, but do not use it or its

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constituent elements as a source of energy; these are derived from other substrates (Alexander 1994). In the WIPP repository, plastics and rubbers, which are resistant to biodegradation, may still be cometabolized with cellulosics and other more biodegradable organic compounds. Because of these uncertainties, a probability of 50 percent is assigned to the biodegradation of plastics and rubbers in the event of significant microbial gas generation (Wang and Brush 1996).

In March, 2005 the EPA dictated to DOE that the probability of microbial degredation and gas generation must be changed from 0.5 to 1 (Cotsworth, 2005). EPA's position is that given new science on extremophiles, they believe that there is always some possibility of microbial activity. For the 2004 CRA PABC, DOE agreed to implement EPA's position and thus the parameter PROBDEG was changed. In response to EPA, DOE argued that the probability of cellulosics decomposing should be increased but not the probability of all CPR degrading. This assertion comes from experiements performed at Brookhaven National Laboratory in which cellulosics and plastics & rubber were inoculated with microbes and allowed to biodegrade for 10 years (Francis et al., 1997). In these experiements, celluosics yielded significant microbial gas generation, but plastics and rubbers did not. EPA accepted this assertion which leads to the following values and probabilities for WAS_AREA:PROBDEG

PROBDEG=0	no microbial degredation	(P = 0)
PROBDEG=1	microbial degredation of cellulose only	(P = 0.75)
PROBDEG=2	microbial degredation of all CPR material	(P = 0.25)

This was implemented in the WIPP parameter database by changing the range of values assigned to PROBDEG from 0,1,2 to 1 or 2, and assigning the probabilities to each value as given above. (Nemer, 2005)

Parameter Data Entry Form ERMS: #234881

References:

Alexander, M. 1994. Biodegradation and Bioremediation. Academic Press, N.Y.
DOE/CAO. 1996. Transuranic Waste Baseline Inventory Report (Rev. 2). DOE/CAO-95-1121.

Tierney, M. 1996. Memorandum to File, Re: Reasons for choice of the PROBDEG parameter (id nos. 2824 and 2823) on February 22, 1996, March 29, 1996 (contained in ERMS 234881).

Wang, Y., and Brush, L. 1996. Memorandum to Martin Tierney, Re: Estimates of Gas-Generation Parameters for the Long-Term WIPP Performance Assessment, January 26, 1996. ERMS 231943.

Cotsworth, E. 2005. EPA letter on conducting the performance assessment baseline change (PABC) verification test. U.S. EPA, Office of Radiation and Indoor Air, Washington, D.C. ERMS # 538858.

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Francis, A.J., J. B. Gillow and M. R. Giles 1997. Microbial Gas Generation Under Expected Waste Isolation Pilot Plant repository Conditions. Sandia National Laboratories, Albuquerque, NM. SAND96-2582. ERMS# 244883.

Nemer, M. 2005. Memo to David Kessel Re: Updated Value of WAS_AREA PROBDEG. April 20, 2005. Sandia National Laboratories, Carlsbad, NM. ERMS # 539441

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Parameter 41: Biodegradation Rate of Cellulosics Under Brine-Inundated Conditions

Parameter Description:

This parameter is used to describe the rate of cellulosics biodegradation under anaerobic, brine-inundated conditions (see Appendix PA, Section PA-4.2). It is a sampled parameter for the waste emplacement area and the waste, and the values are then applied to the repository regions outside of the panel region.

Material and Property Name(s):
WAS_AREA GRATMICI

Computational Code: BRAGFLO

minimum	maximum
3.08269×10^{-11}	5.56921×10^{-10}

Units: Moles/(kilograms*second)

Distribution Type: Uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the parameter records package: Estimates of Gas Generation Required for BRAGFLO (ERMS #230819).

Discussion:

Microbial gas-generation rates used in the CCA, the 1997 PAVT, and the 2004 CRA PA were based on three years of BNL experimental data. The first task of this analyis was to analyze the full 10 years of experimental data to develop updated distributions of the microbial gas-generation rates.

The microbial gas-generation rate parameters used by BRAGFLO are WAS_AREA:GRATMICI and WAS_AREA:GRATMICH. The parameter GRATMICI is the rate of microbial gas generation from consumption of CPR materials in a brine-inundated environment, and GRATMICH is the humid gas-generation rate. The microbial inoculum was prepared from a mixture of WIPP-relevant samples in accordance with procedures described by Francis et al. (1997). Conversion of the rates from experimental conditions to WIPP conditions is described in Nemer et al. (2005).

The maximum rate is estimated using the data obtained from both NO_3 - and nutrients-amended experiments, whereas the minimum rate is derived using the data obtained from the inoculated-only experiments without any nutrient and NO_3 amendment. The rates were calculated from the initial linear part of the experimental curve of CO_2 vs. time by assuming that cellulosics biodegradations in those experiments were nitrate- or nutrient-limited (Wang

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and Brush 1996).

Parameter Data Entry Form ERMS: #513367

References:

Wang, Y. and Brush, L. 1996. Memorandum to Martin Tierney, Re: Estimates of Gas-Generation Parameters for the Long-Term WIPP Performance Assessment, January 26, 1996. ERMS 231943.

Francis, A.J., J. B. Gillow and M. R. Giles 1997. Microbial Gas Generation Under Expected Waste Isolation Pilot Plant repository Conditions. Sandia National Laboratories, Albuquerque, NM. SAND96-2582. ERMS# 244883.

Nemer, M. et. al. 2005. Analysis Report for BRAGFLO Preliminary Modeling Results With New Gas Generation Rates Based Upon Recent Experimental Results. April 20, 2005. Sandia National Laboratories, Carlsbad, NM. ERMS # 539437.

Information Only

Parameter 42: Biodegradation Rate of Cellulosics Under Humid Conditions

Parameter Description:

This parameter is used to describe the rate of cellulosics biodegradation under anaerobic, humid conditions (see Appendix PA, Section PA-4.2). It is a sampled parameter for the waste emplacement area and the waste, and the values are then applied to the repository regions outside of the panel region.

Material and Property Name(s):

WAS_AREA GRATMICH

Computational Code: BRAGFLO

minimum	maximum
0.0	1.02717×10^{-9}

Units: Moles/(kilograms*second)

Distribution Type: Uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the parameter records package: Estimates of Gas Generation Required for BRAGFLO (Wang and Brush, 2002).

Discussion:

Microbial gas-generation rates used in the CCA, the 1997 PAVT, and the 2004 CRA PA were based on three years of BNL experimental data. The first task of this analyis was to analyze the full 10 years of experimental data to develop updated distributions of the microbial gas-generation rates.

The microbial gas-generation rate parameters used by BRAGFLO are WAS_AREA:GRATMICI and WAS_AREA:GRATMICH. The parameter GRATMICI is the rate of microbial gas generation from consumption of CPR materials in a brine-inundated environment, and GRATMICH is the humid gas-generation rate. The microbial inoculum was prepared from a mixture of WIPP-relevant samples in accordance with procedures described by Francis et al. (1997). Conversion of the rates from experimental conditions to WIPP conditions is described in Nemer et al. (2005).

The maximum rate was estimated from cellulosics biodegradation experiments under anaerobic, humid conditions. The minimum rate is set to zero, corresponding to the cases where microbes become inactive because of water or nutrient stresses (Wang and Brush 1996).

Parameter Data Entry Form ERMS: #539566

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References:

Wang, Y. and Brush, L. 1996. Memorandum to Martin Tierney, Re: Estimates of Gas-Generation Parameters for the Long-Term WIPP Performance Assessment, January 26, 1996. ERMS 231943.

Wang, Y. and L. Brush 2002. Gas Generation Parameters Required for BRAGFLO. ERMS 230819. Sandia National Laboratory. Albuquerque, NM.

Francis, A.J., J. B. Gillow and M. R. Giles 1997. Microbial Gas Generation Under Expected Waste Isolation Pilot Plant repository Conditions. Sandia National Laboratories, Albuquerque, NM. SAND96-2582. ERMS# 244883.

Nemer, M. et. al. 2005. Analysis Report for BRAGFLO Preliminary Modeling Results With New Gas Generation Rates Based Upon Recent Experimental Results. April 20, 2005. Sandia National Laboratories, Carlsbad, NM. ERMS # 539437.

Information Only

Parameter 43: Factor β for Microbial Reaction Rates

Parameter Description:

Factor β is an index that characterizes the stoichiometry used to calculate the microbially generated gas, accounting for interaction with gases reacting with steel and steel corrosion products (see Appendix PA, Section PA-4.2).

Material and Property Name(s):

CELLULS FBETA

Computational Code: BRAGFLO

minimum	maximum
0.0	1.0

Units: None

Distribution Type: Uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the parameter records package: Estimates of Gas Generation Required for BRAGFLO (Wang and Brush, 2002).

Discussion:

Microbially generated gases CO_2 and H_2S may react with steel and steel corrosion products. Factor β characterizes the extent of CO_2 and H_2S consumption by those reactions: see Equation (18) in Wang and Brush 1996.

Parameter Data Entry Form ERMS: #231826

References:

Wang, Y. and Brush, L. 1996. Memorandum to Martin Tierney, Re: Estimates of Gas-Generation Parameters for the Long-Term WIPP Performance Assessment, January 26, 1996. ERMS #231943.

Wang, Y. and L. Brush 2002. Gas Generation Parameters Required for BRAGFLO. ERMS 230819. Sandia National Laboratory. Albuquerque, NM.

Information Only

Parameter 44: Residual Gas Saturation – Repository

Parameter Description:

The residual (critical) gas saturation (S_{gr}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves. S_{gr} corresponds to the degree of waste-generated gas saturation necessary to create an incipient interconnected pathway in porous material, a condition required for porous rock to be permeable to gas. Below values of the S_{gr}, gas is immobile. It is a sampled parameter for the waste emplacement area and the waste. The values are then applied to the repository regions outside of the panel region.

Material and Property Name(s):

WAS_AREA SAT_RGAS

Computational Code: BRAGFLO

minimum	maximum
0	0.15

Units: None

Distribution Type: Uniform

Data: General Literature and Professional Judgment

The parameter values are based on a November 15, 1995 Solutions Engineering letter report to D.M. Stoelzel of Sandia National Laboratories entitled "Critical (residual) Gas Saturation Recommendations for WIPP."

Discussion:

Under conditions of chemical and biochemical gas generation and repository closure, gas saturation may increase to a level where the pore network in repository material regions becomes connected and gas permeability begins to increase. The lowest gas saturation at which continuous gas flow will occur is the residual (critical) gas saturation (S_{gr}). In a review of studies involving S_{gr}, Solutions Engineering (1996) reports values ranging from 0 to 27 percent. The assigned range for S_{gr} between 0 to 15 percent is consistent with recommendations in the Solutions Engineering report.

Parameter Data Entry Form ERMS: #234905

References:

Solutions Engineering. 1996. "Critical Gas Saturation Recommendations for WIPP." Letter Report to D.M. Stoelzel, Sandia National Laboratories, November 15, 1995, Albuquerque, New Mexico. ERMS # 238769.

Information Only

Parameter 45: Residual Brine Saturation – Waste Area

Parameter Description:

The residual brine saturation (S_{br}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves. Referred to also as S_{wr} (wetting phase) or S_{lr} (liquid phase), residual brine saturation is the point reached under high gas saturation conditions when brine is no longer continuous throughout the pore network and relative brine permeability becomes zero. Below the value of the S_{br}, brine is immobile. It is a sampled parameter for the waste emplacement area and the waste, and the values are then applied to the repository regions outside of the panel region.

Material and Property Name(s):

WAS_AREA SAT_RBRN

Computational Code: BRAGFLO

minimum	maximum
0	0.552

Units: None

Distribution Type: Uniform

Data: General Literature and Professional Judgment

Two-phase flow parameters have not been measured for materials representing a collapsed empty, back-filled, or waste-filled room. Therefore, the parameter values are based on literature values for unconsolidated materials. (Vaughn 1996)

Discussion:

Brooks and Corey evaluated their two-phase characteristic equations against capillary pressure and relative permeability data obtained in laboratory experiments (Brooks and Corey 1964). (Mualem 1976) proposed a modified procedure to that of Brooks and Corey for determining the wetting phase (S_{wr}) permeability curve by adding the constraint that the extrapolated curve should pass through the highest capillary pressure data point. Although their wetting phase relative permeability predictions are similar to each other and to the data, the Mualem procedure, in some cases, results in S_{wr} values less than those predicted by the Brooks and Corey model. Consequently, Table 7 lists the (Mualem 1976) residual wetting phase saturations to ensure that the potential for brine mobility is not underestimated. As indicated in Table 7, single-phase liquid permeabilities of the Brooks and Corey materials are of the same order of magnitude as those assigned to waste disposal regions (10^{-13} m^2).

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Table 7. Brooks and Corey (1964) Materials Parameters - Unconsolidated Media[a]

Material	Permeability (m^2)[b]	Porosity	S_{wr}[c]
Volcanic Sand	1.1×10^{-11}	0.365	0.137
Fine Sand	2.85×10^{-12}	0.360	0.140
Glass Beads	1.05×10^{-11}	0.383	0.0783
Fragmented Mixture	1.50×10^{-11}	0.441	0.275
Fragmented Fox Hill Sandstone	1.61×10^{-11}	0.503	0.318
Touchet Silt Loam	5.00×10^{-13}	0.469	0.277
Poudre River Sand	2.26×10^{-11}	0.364	0.0824
Amarillo Silty Clay Loam	2.34×10^{-12}	0.455	0.242
Consolidated Berea Sandstone	4.81×10^{-13}	0.206	0.243
Consolidated Hygiene Sandstone	1.78×10^{-13}	0.250	0.560

a - Consolidated materials are identified in the material column
b - Single-phase liquid permeability
c - Mualem S_{wr} corrected for comparison to Brooks and Corey (1964)
S_{wr} - Wetting phase residual saturation

Parameter Data Entry Form ERMS: #234902

References:

Brooks, R.H., and Corey, A.T. 1964. Hydraulic Properties of Porous Media. Hydrology Paper No. 3. Fort Collins, CO: Colorado State University. NWM Library.

Mualem, Y. 1976. A New Model for Predicting the Hydraulic Conductivity of Unsaturated Porous Media. Water Resources Research. Vol. 12, no. 3, 513-522.

Vaughn, Palmer. 1996. Memo to Martin Tierney. RE: WAS_AREA and REPOSIT/SAT_RBRN Distribution, February 13, 1996. ERMS 234902.

Information Only

Parameter 46: Wicking Saturation – Waste Area

Parameter Description:

The wicking saturation in the waste is used in the gas generation model (see Appendix PA, Section PA-4.2). It is a sampled parameter for the waste emplacement area and the waste, and the values are then applied to the repository regions outside of the panel region.

Material and Property Name(s):

WAS_AREA SAT_WICK

Computational Code: BRAGFLO

minimum	maximum
0.0	1.0

Units: None

Distribution Type: Uniform

Data: Professional Judgment

The wicking parameter value varies from 0 (0 percent saturation) to 1.0 (100 percent saturation) and the parameter is assumed to be uniformly distributed. (Tierney and Vaughn 1996)

Discussion:

Wicking is the ability of a material to carry a fluid by capillary action above the level it would normally seek in response to gravity. The use of a two-phase Darcy flow model in BRAGFLO includes possible effects of capillary action, but uncertainty remains about the extent to which the assumed homogeneous properties of the waste adequately characterize wicking. Because estimated rates of gas generation are higher for waste that is in direct contact with brine, brine saturation in the repository is adjusted in BRAGFLO to account for the possibility of wicking in the waste. The adjustment is done as follows:

$$S_{b,eff} = S_b + S_w,$$

and

$$S_{b,eff} \leq 1.0,$$

where S_b is the brine saturation in the waste calculated by BRAGFLO, S_w is the wicking saturation that describes the additional amount of brine that may be present and in contact with the waste because of wicking, and $S_{b,eff}$ is the effective brine saturation used to determine the gas generation rates used in the analysis.

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Parameter Data Entry Form ERMS: #234908

References:

Tierney, M. and Vaughn, P. 1996. Memo: "Designation of 'Legacy Parameters' and 'Placeholders' in the WIPP Parameter Database." June 17, 1996. Sandia National Laboratories. WIPP Records Center, Carlsbad, NM. ERMS #238568.

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Parameter 47: Log of Intrinsic Permeability – DRZ directly above the concrete portion of the panel closure

Parameter Description:

This parameter describes the permeability of cells immediately above the concrete part of the panel closures in the upper DRZ (see CCA Appendix PA, Figure 4.2.1). It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions. The permeability of these cells will be sampled to reflect the range expected for healed DRZ. This will capture the effect of rigid panel closures that include excavation of the DRZ immediately surrounding the concrete monolith that is emplaced quickly to prevent the further local development of DRZ, and healing of the DRZ due to compressive stresses imposed by creep closure around the rigid structure. In this way the panel closures are modeled as effective seals, including healing effects, in accordance with their design.

Material and Property Name(s):

DRZ_PCS PRMX_LOG
DRZ_PCS PRMY_LOG
DRZ_PCS PRMZ_LOG

Computational Code: BRAGFLO

mode	minimum	maximum
-18.75	-20.70	-17.0

Units: Log(meters squared)

Distribution Type: Triangular

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records packages: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001) and Analysis Reports for AP-094 (Stein, 2003).

Discussion:

Option D panel closures are designed to remove the DRZ above and below the panel entry drifts. Loose salt in the roof would also be taken down just prior to construction of the concrete monolith. The remaining salt surrounding the panel closure concrete would be subjected to compressive stresses, which would tighten any disturbed zones. Owing to the rounded configuration of Option D, the compressive stress state creates a situation very favorable for concrete: high compressive stresses and low stress differences. In turn, the compressive stresses developed within the salt will quickly heal any damage caused by construction excavation, thereby effectively eliminating the DRZ along the length of the panel

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closure. The volume of salt immediately above and below the rigid concrete monolith will likely approach the intrinsic permeability of Salado salt.

Undisturbed Salado salt is essentially impermeable. A low-end permeability would be immeasurably low (10^{-23} m^2, for example). The salt above and below the rigid monolith would assume relatively impermeable conditions. Permeability values employed are the same range as described for the concrete (2×10^{-21} to 10^{-17} m^2) (Stein 2002). The reason this range was selected rather than using the range approved for use with the intact halite is twofold. First, because the healed DRZ zone is relatively thin (9.06-m-thick in the model) small-scale heterogeneities including thin clay seams introduce uncertainties to how well this DRZ will impede flow. Second, the Panel Closure System will perform as a composite system that includes the healed DRZ, the concrete monolith, and the surrounding marker beds. In this system any flow will be focused through the highest permeability component of the system. In order that the PA calculations represent the uncertainties of exactly where any flow will occur during the regulatory period, we set the permeability range of the healed DRZ equal to the concrete so that there will be an equal probability of potential flow in either material. The permeability distributions can be implemented in PA by fitting a triangular distribution to the log of the permeability values described for concrete.

Parameter Data Entry Form ERMS: #520524

References:

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Stein, J. 2002. Analysis Plan for Calculations of Salado Flow: Technical Baseline Migration (TBM), AP-086, February 13, 2002, ERMS #520612.

Stein, J. S. 2003. Analysis Reports for AP-094. ERMS 525186. Sandia National Laboratories. Carlsbad, NM.

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Parameter 48: Log of Intrinsic Permeability– Concrete portion of PCS

Parameter Description:

Log of the vertical and horizontal intrinsic permeability for the concrete portion of the Option D panel closure (see CCA Appendix PA, Figure 4.2.1). It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Property Name(s):

CONC_PCS PRMX_LOG
CONC_PCS PRMY_LOG
CONC_PCS PRMZ_LOG

Computational Code: BRAGFLO

mode	minimum	maximum
-18.75	-20.70	-17.0

Units: Log (meters squared)

Distribution Type: Triangular

Data: Site- Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records packages: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001) and Analysis Reports for AP-094 (Stein, 2003).

Discussion:

The distribution of permeability values for the concrete portion of the Option D panel closure is the same as were used for the concrete portion of the shaft seal in the original CCA (DOE 1996) shaft seal model (Stein 2002). The following justification is provided for permeability values used for the shaft seal concrete (see material CONC_T1, Appendix PAR in DOE 1996) As reported by Repository Isolation Systems Department (1996), traditional freshwater concrete has been widely used for hydraulic applications such as water storage tanks, water and sewer systems, and massive dams because it has exceptionally low permeability (less than 10^{-20} m^2 upon hydration). Salado Mass Concrete (SMC) is a specially-designed, salt-saturated concrete mix (Wakeley et al. 1994; Wakeley et al. 1995).

Pfeifle, et al. (1996) performed two permeability tests on concrete specimens prepared from cores recovered from the WIPP SSSPT field experiments and one test on an SMC specimen prepared from a sample batched by the Waterways Experiment Station (WES). The specimens were tested as received with no attempts made to dry the specimens or to determine their moisture contents. Each test was performed using nitrogen gas as the permeant, flowmeters to measure gas flow, and fluid pressure gradients of 0.3, 0.6, or 0.75 megapascals.

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Attempts were made to apply Klinkenberg corrections to measured values of permeability, but the range in pressure gradients used in the testing was not large enough to establish any particular trend when the permeability data were plotted as a function of reciprocal mean fluid pressure.A total of 18 permeability measurements were made on the three specimens. Measured permeabilities of the specimens were all very low with a range from 2.1×10^{-21} m^2 to 7.51×10^{-21} m^2 with an average of 4.71×10^{-21} m^2. Knowles and Howard (1996) presented results of field permeability tests performed in the WIPP SSSPT boreholes during 1985-1987 and 1993-1995. Although individual seal system component material permeabilities for concrete, DRZ salt, and salt were not determined, overall seal system permeabilities were determined and ranged from 1.0×10^{-20} m^2 to 1.0×10^{-17} m^2 and from 1.0×10^{-23} m^2 to 1.0×10^{-19} m^2 for the 1985–1987 tests and the 1993-1995 tests, respectively. These ranges encompass the laboratory values measured by Pfeifle, et al. (1996).

The data described above were derived from gas permeability measurements in which no Klinkenberg corrections were applied to the measured values. The Klinkenberg corrections were expected to be small because of the low mean pressure gradients used in the tests.

The interface between the Salado salt and the SMC components may provide a flow path around the SMC components. This flow path is possible if a small aperture develops as the concrete is curing or if the interface degrades because of corrosive brines. If such a flow path occurs, the effective permeability of the SMC will increase. Because of this uncertainty, the upper bound permeability was assigned to a value of -17, which corresponds to a permeability of 1.0×10^{-17} m^2. This value was selected after an effective permeability calculation was performed. In this calculation, the interface zone was assumed to have a permeability of 1.0×10^{-14} m^2 and concrete permeabilities were varied from 1.0×10^{-23} to 1.0×10^{-19} m^2. Assuming the interface zone had a thickness of 0.001 times the shaft radius or smaller, the effective permeability of the concrete was about 1.0×10^{-17} m^2 regardless of the value selected for the permeability of the SMC seal.

Parameter Data Entry Form ERMS: #520524

References:

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Knowles, M.K. and Howard, C.L. 1996. "Field and Laboratory Testing of Seal Materials Proposed for the Waste Isolation Pilot Plant," Proceedings of the Waste Management 1996 Symposium. Tucson, AZ, February 25-29, 1996. SAND95-2082C. Albuquerque, NM: Sandia National Laboratories. ERMS #230945.

Pfeifle, T.W., Hansen, F.D., and Knowles, M.K. 1996. "Salt-Saturated Concrete Strength and Permeability," Proceedings of the ASCE Fourth Materials Engineering Conference, Washington, DC, November 1996 (accepted for publication).

Repository Isolation Systems Department. 1996. Waste Isolation Pilot Plant Shaft Sealing

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System Compliance Submittal Design Report. SAND96-1326. Sandia National Laboratories. Albuquerque, NM. August 1996.

Stein, J. 2002. Analysis Plan for Calculations of Salado Flow: Technical Baseline Migration (TBM), AP-086, February 13, 2002, ERMS #520612.

Stein, J. S. 2003. Analysis Reports for AP-094. ERMS 525186. Sandia National Laboratories. Carlsbad, NM.

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office. Vols 1-XXI.

Wakeley, L.D., Poole, T.S. and Burkes, J.P. 1994. Durability of Concrete Materials in High-Magnesium Brine. SAND93-7073. Albuquerque, NM: Sandia National Laboratories. WPO 10674.

Wakeley, L.D., Harrington, P.T., and Hansen, F.D. 1995. Variability in Properties of Salado Mass Concrete. SAND94-1495. Albuquerque, NM: Sandia National Laboratories. WPO 22744.

Information Only

Parameter 49: Residual Gas Saturation – Concrete Portion of PCS

Parameter Description:

The residual (critical) gas saturation (S_{gr}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves (see CCA Appendix PA, Figure 4.2.1). S_{gr} corresponds to the degree of waste-generated gas saturation necessary to create an incipient interconnected pathway in porous material, a condition required for porous rock to be permeable to gas.

Material and Property Name(s):

CONC_PCS SAT_RGAS

Computational Code: BRAGFLO

minimum	maximum
0	0.40

Units: None

Distribution Type: Uniform

Data: General Literature Data

A discussion of the data associated with this parameter may be found in the following parameter records packages: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001) and Analysis Reports for AP-094 (Stein, 2003).

Discussion:

This distribution is the same as were used in the original CCA shaft seal model. The initial gas saturation in the simplified shaft is a volume-weighted average of the initial gas saturations in the original shaft's subcomponents (James and Stein 2002; 2003). The following justification is provided for gas saturation values used for the CCA shaft seal subcomponents (see material SALT_T1, in Appendix PAR) DOE (1996).

A literature search was conducted to obtain residual saturation values for consolidated geologic materials, concrete, and asphalt in support of the CCA.

A single value of 0.18 was found for normal concrete (Mayer et al. 1992). Based on this value, a distribution was assumed for the seal components. The recommended value was 0.2, and the recommended range was 0.0 to 0.4 with a uniform distribution for all shaft seal materials.

Parameter Data Entry Form ERMS: #520524

Information Only

References:

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

James, S.J., and Stein, J. 2002. Analysis Plan for the Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment. AP-094. Carlsbad, NM: Sandia National Laboratories. ERMS #524958.

James, S.J., Stein, J. 2003. Analysis Report for: Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment, Rev. 1. January 23, 2003. Carlsbad, NM: Sandia National Laboratories. ERMS #525203.

Mayer, G., Jacobs, F., and Wittmann, F.H. 1992. "Experimental Determination and Numerical Simulation of the Permeability of Cementitious Materials," Nuclear Engineering and Design. Vol. 138, no. 2, 171-177.

Stein, J. S. 2003. Analysis Reports for AP-094. ERMS 525186. Sandia National Laboratories. Carlsbad, NM.

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office.

Information Only

Parameter 50: Residual Brine Saturation – Concrete Portion of PCS

Parameter Description:

The residual brine saturation (S_{br}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves (see CCA Appendix PA, Figure 4.2.1). Referred to also as S_{wr} (wetting phase) or S_{lr} (liquid phase), residual brine saturation is the point reached under high gas saturation conditions when brine is no longer continuous throughout the pore network and relative brine permeability becomes zero.

Material and Property Name(s):
CONC_PCS SAT_RBRN

Computational Code: BRAGFLO

Value	0.0	0.20	0.60
Percentiles	0	0.50	1

Units: None

Distribution Type: Cumulative

Data: General Literature Data

A discussion of the data associated with this parameter may be found in the following parameter records packages: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001) and Analysis Reports for AP-094 (Stein, 2003).

Discussion:

This distribution is the same as were used for the original 1996 CCA shaft seal model. Recall that the initial brine saturation in the simplified shaft is a volume-weighted average of the initial brine saturations in the original shaft's subcomponents (James and Stein 2002, 2003). The following justification is provided for the residual brine saturation used for the CCA shaft components (see Material SALT_T1, CCA Appendix PAR in DOE [1996]).

A literature search was conducted to obtain residual liquid saturation values for consolidated geologic materials, concrete, and asphalt in support of the CCA. Residual liquid saturations for geologic materials were found in four references (Brooks and Corey 1964; Lappala et al. 1987; Parker et al. 1987; and Rawls et al. 1982). Brooks and Corey (1964) determined residual saturations for five unconsolidated samples based on measured values of liquid saturation as a function of capillary pressure. Lappala et al. (1987) determined residual moisture content for 11 soils by obtaining best fits to measured moisture content versus pressure head data using three models. The residual moisture contents determined for each soil using the three models were averaged and divided by the reported porosity to obtain a residual liquid saturation for each soil. Parker et al. (1987) fit their saturation-pressure

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relationship to observed data to obtain residual saturations for a sandy and clayey porous media. Residual water contents reported by Rawls et al. (1982) for 11 soil texture classes were divided by the reported porosity to obtain residual saturations.
Mayer et al. (1992) reported a residual liquid saturation for normal concrete of 0.30. Data regarding residual liquid saturations in asphalt materials were not found in the literature. The literature values of residual liquid saturation for geologic materials and concrete fall within the range of 0.0 to 0.6 with all but two values falling within the range of 0.0 to 0.4. It was recommended that a value of 0.2 be used for the residual liquid saturation of all seal components.

Parameter Data Entry Form ERMS: #520524

References:

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Brooks, R.H., and Corey, A.T. 1964. Hydraulic Properties of Porous Media. Hydrology Paper No. 3. Fort Collins, CO: Colorado State University.

Lappala, E.G., Healy, R.W., and Weeks, E.P. 1987. Documentation of Computer Program VS2D to Solve the Equations of Fluid Flow in Variably Saturated Porous Media. Water-Resources Investigations Report 83-4099. Denver, CO: U.S. Geological Survey. Tech Library books collection: PC173.4.P67L31987.

James, S.J., and Stein, J. 2002. Analysis Plan for the Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment. AP-094. Carlsbad, NM: Sandia National Laboratories. ERMS #524958.

James, S.J., Stein, J. 2003. Analysis Report for: Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment, Rev. 1. January 23, 2003. Carlsbad, NM: Sandia National Laboratories. ERMS #525203.

Mayer, G., Jacobs, F., and Wittmann, F.H. 1992. "Experimental Determination and Numerical Simulation of the Permeability of Cementitious Materials," Nuclear Engineering and Design. Vol. 138, no. 2, 171-177.

Parker, J.C., Lenhard, R.J., and Kuppusamy, T. 1987. "A Parametric Model for Constitutive Properties Governing Multiphase Flow in Porous Media," Water Resources Research. Vol. 23, no. 4, 618-624.

Rawls, W.J., Brakensiek, D.L., and Saxton, K.E. 1982. "Estimation of Soil Water Properties," Transactions of the ASAE. St. Joseph, MI: American Society of Agricultural Engineers. 1316-1328.

Stein, J. S. 2003. Analysis Reports for AP-094. ERMS 525186. Sandia National Laboratories. Carlsbad, NM.

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U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office. Vols 1-XXI.

Information Only

Parameter 51: Pore Distribution Parameter in the Concrete portion of PCS

Parameter Description:

The Brooks-Corey pore size distribution parameter (□) is used to calculate capillary pressure and relative permeabilities for gas and brine flow in the two-phase flow model (see CCA Appendix PA, Figure 4.2.1). It is a sampled parameter.

Material and Property Name(s):

CONC_PCS PORE_DIS

Computational Code: BRAGFLO

Value	0.11	0.94	8.1
Percentiles	0	0.50	1

Units: None

Distribution Type: Cumulative

Data: General Literature Data

A discussion of the data associated with this parameter may be found in the following parameter records packages: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001) and Analysis Reports for AP-094 (Stein, 2003).See also CCA (DOE 1996)

Discussion:

This distribution of pore size values for the concrete portion of the Option D panel closure is the same as were used for the concrete portion of the shaft seal in the original 1996 CCA shaft seal model. (James and Stein, 2002) The following justification is provided for pore size distribution values used for the shaft seal (see material SALT_T1, CCA Appendix PAR)

A literature search was conducted to find pore distribution (that is, lambda) values for geologic materials and concrete. For geologic materials, 81 lambda values were found in 5 references (Brooks and Corey 1964; Mualem 1976; Rawls et al. 1982; Haverkamp and Parlange 1986; and Lappala et al. 1987). In addition, 38 lambda values were calculated from values of the van Genuchten parameter n found in 6 references (van Genuchten 1980; van Genuchten and Nielsen 1985; Hopmans and Overmars 1986; Parker et al. 1987; Stephens et al. 1988; and Wösten and van Genuchten 1988).

The total number of lambda values found in the literature or calculated from n values found in the literature was 119. In a few cases, different literature sources reported different values of lambda and/or n for the same materials. For this situation, the different lambda values were arithmetically averaged to obtain a single value for the material. This procedure yielded

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lambda values for a total of 85 different geologic materials.

The lambda values range from 0.11 to 11.67 and have a median of 0.94. Based on the shape of the histogram and CDF, it appears that the lambda values are log normally distributed. The Lilliefors test for normality (Iman and Conover 1983) was applied to the data to verify that the logarithm of the lambda values can be described by a normal distribution. The mean of the log lambda values was found to be -0.064 with a standard deviation of 1.08. The Lilliefors bounds represent the region within which 95 percent of normally distributed values will fall. For concrete, a literature search yielded only one reference (Mayer et al. 1992). This reference indicates that the Corey (1954) relationships are appropriate for describing the two-phase characteristic curves for the normal concretes they tested. For asphalt materials, data regarding lambda values were not found in the literature.

Both a lognormal and cumulative distribution for this parameter was recommended for the seal components constructed from granular earth materials (that is, earthen fill, compacted clay, and reconsolidated crushed salt). A cumulative distribution is appropriate when the range (a, c) of the parameter is known and the best estimate value, b, is the median. The value recommended was 0.94, which is the median of the literature values for geologic materials. The recommended range for the distribution was 0.11 to 8.1. Consequently, a cumulative distribution is assigned. In the absence of literature data, the same lambda distribution type, value, and range were also recommended for the concrete and asphalt seal components.

Parameter Data Entry Form ERMS: #520524

References:

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Brooks, R.H., and Corey, A.T. 1964. Hydraulic Properties of Porous Media. Hydrology Paper No. 3. Fort Collins, CO: Colorado State University.

Corey, A.T. 1954. "The Interrelation Between Gas and Oil Relative Permeabilities," Producer's Monthly. Vol. XIX, no. 1, 38-41.

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office. Vols 1-XXI.

Haverkamp, R., and Parlange, J.Y. 1986. "Predicting the Water-Retention Curve From Particle-Size Distribution: 1. Sandy Soils Without Organic Matter," Soil Science. Vol. 142, no. 6, 325-339.

Hopmans, J.W., and Overmars, B. 1986. "Presentation and Application of an Analytical Model to Describe Soil Hydraulic Properties," Journal of Hydrology. Vol. 87, no. 1-2. 135-143.

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Iman, R.L., and Conover, W.J. 1983. Modern Business Statistics. New York, NY: John Wiley & Sons, Inc.

Lappala, E.G., Healy, R.W., and Weeks, E.P. 1987. Documentation of Computer Program VS2D to Solve the Equations of Fluid Flow in Variably Saturated Porous Media. Water-Resources Investigations Report 83-4099. Denver, CO: U.S. Geological Survey.

Mayer, G., Jacobs, F., and Wittmann, F.H. 1992. "Experimental Determination and Numerical Simulation of the Permeability of Cementitious Materials," Nuclear Engineering and Design. Vol. 138, no. 2, 171-177.

Mualem, Y. 1976. "A New Model for Predicting the Hydraulic Conductivity of Unsaturated Porous Media," Water Resources Research. Vol.12, no. 3, 513-522.

Parker, J.C., Lenhard, R.J., and Kuppusamy, T. 1987. "A Parametric Model for Constitutive Properties Governing Multiphase Flow in Porous Media," Water Resources Research. Vol. 23, no. 4, 618-624.

Rawls, W.J., Brakensiek, D.L., and Saxton, K.E. 1982. "Estimation of Soil Water Properties," Transactions of the ASAE. St. Joseph, MI: American Society of Agricultural Engineers. 1316-1328.

James, S.J., and Stein, J. 2002. Analysis Plan for the Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment. AP-094. Carlsbad, NM: Sandia National Laboratories. ERMS #524958.

Stein, J. S. 2003. Analysis Reports for AP-094. ERMS 525186. Sandia National Laboratories. Carlsbad, NM.

Stephens, D.B., Unruh, M., Havlena, J., Knowlton, R.G., Jr., Mattson, E., and Cox, W. 1988. "Vadose Zone Characterization of Low-Permeability Sediments Using Field Permeameters," Ground Water Monitoring Review. Vol. 8, no. 2, 59-66.

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office. Vols 1-XXI.

van Genuchten, M. Th. 1980. "A Closed-form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils," Soil Science Society of America Journal. Vol. 44, no. 5, 892-898.

van Genuchten, M. Th., and Nielsen, D.R. 1985. "On Describing and Predicting the Hydraulic Properties of Unsaturated Soils," Annales Geophysicae. Vol. 3, no. 5, 615-628.

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Wösten, J.H.M., and van Genuchten, M. Th. 1988. "Using Texture and Other Soil Properties to Predict the Unsaturated Soil Hydraulic Functions," Soil Science Society of America Journal. Vol. 52, no. 6, 1762-1770.

Information Only

Parameter 52: Effective Porosity – Halite

Parameter Description:

The effective porosity of Salado Formation halite and polyhalite refers to the ratio of the interconnected pore volume to the bulk volume.

Material and Property Name(s):

S_HALITE POROSITY

Computational Code: BRAGFLO

Value	1.0×10^{-3}	0.01	0.0519
Percentiles	0	0.50	1

Units: None

Distribution Type: Cumulative

Data: Site-Specific Experimental Data

The effective porosity distribution of Salado halite is supported by three separate porosity calculations: (1) Skokan et al. (1989; p. 15) determined from electromagnetic and DC resistivity experiments, (2) drying experiments described in Powers et al. (1978; p. 7-30), and (3) drying experiments reported in Deal et al. (1993). The parameter records package associated with this parameter is: Halite Porosity (SNL 1996).

Discussion:

The high value (0.03) for the range of porosity is suggested in Skokan et al. (1989; p.6,13), based on the low end (10 ohm) of the DC resistivity measurements registered in the underground repository. The low value (0.001) is suggested in Powers et al. (1978) based on drying experiments. The median value of 0.01 is suggested in Skokan et al. (1989; p.15). Deal et al. (1993) found an average value of 0.016 for total porosity from a different series of drying experiments. The high value is a weight fraction. Converting this value to a volume fraction gives 0.0519. See Ismail (2007) for more discussion.

Parameter Data Entry Form ERMS: #545804

References:

Deal, D.E., Abitz, R.J., Myers, J., Martin, M.L., Millgan, D.J., Sobocinski, R.W., Lipponer, P.P.J., and Belski, D.S. 1993. Brine Sampling and Evaluation Program, 1991 Report. DOE-WIPP-93-026. Carlsbad, NM: Westinghouse Electric Corporation, Waste Isolation Division.

Information Only

Powers, D.W., Lambert, S.J., Shaffer, S.E., Hill, L.R., and Weart, W.D., eds. 1978. Geological Characterization Report, Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico. SAND78-1596. Albuquerque, NM: Sandia National Laboratories. Vols. 1-2. V. 1 - ERMS #205448; V.2 - ERMS #226829 – #226830, original photos - ERMS #226859.

Ismail, A. 2007. Revised Porsosity Estimates for the DRZ. April 10, 2007. Sandia National Laboratories, Carlsbad, NM. ERMS # 545755

Skokan, C.K., Pfeifer, M.C., Keller, G.V., and Andersen, H.T. 1989. Studies of Electrical and Electromagnetic Methods for Characterizing Salt Properties at the WIPP Site, New Mexico. SAND87-7174. Albuquerque, NM: Sandia National Laboratories. ERMS #224033.

SNL 1996. Halite Porosity. ERMS 230601. Sandia National Laboratories. Albuquerque, NM.

Information Only

Parameter 53: Log of Intrinsic Permeability – Halite

Parameter Description:

The Salado Formation halite is assigned an intrinsic permeability intended to reflect the stratigraphic variability of Salado halite and far-field hydraulic conditions (see CCA Appendix PA, Figure 4.2.1). It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Property Name(s):
S_HALITE PRMX_LOG
S_HALITE PRMY_LOG
S_HALITE PRMZ_LOG

Computational Code: BRAGFLO

minimum	maximum
-24.0	-21.0

Units: Log (m^2)

Distribution Type: Uniform

Data: Site-Specific Experimental Data

The reported permeability range of undisturbed impure halite is based on four selected in situ hydraulic tests: three flow tests believed representative of far-field permeability and one flow test that measured permeability in a zone which included a range of halite lithologies. Computer-derived permeabilities based upon brine inflow data from Room Q fall within the range derived from flow tests. The reader is referred to the relevant parameter record package for more detail: Halite Permeability (SNL (1996a) Salado Halite Permeability from Room Q Analysis (SNL 1996b). See also Davies and Beauheim (1996).

Discussion:

Impure halite denotes a broad range of lithologic types ranging from pure halite to lithologies with various degrees of impurities, including polyhalite, argillaceous and anhydrite halite. Far-field tests of the pure halite exist; however, far-field hydraulic tests data do not exist for relatively impure halites, which tend to show higher permeabilities in the near-field. Thus a range of permeability is specified, bounded by rounded low and high permeability values determined from the testing program.

Three hydraulic tests believed representative of far-field pure halite permeability were conducted in the present location of Room Q in map units with relatively low impurities: a halite with less than 0.5 percent impurity, a halite containing approximately one percent impurity and a halite and polyhalite zone with a one to two percent impurity (Jensen et. al.

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1993). These tests are believed to represent the lower end of the permeability range for Salado halite (see Table 8). These units were tested before the large-scale brine inflow excavation was mined and at stratigraphic intervals located over 20 m (66 ft) from the excavation.

Although probably located within the influence of the DRZ, one flow test (C2H01-BGZ) was performed within map units 0-4. This permeability value in conjunction with Room Q model analysis determination of far-field permeability are used to bound the maximum permeability of Salado halite containing relatively high impurities.

A summary of selected interpretative results of these four flow and pressure tests is compiled in the attached table. A schematic representation of Salado map units near the disposal area horizon, adapted from Deal et. al. (1989), is attached for information purposes (see Figure -1).

Parameter Data Entry Form ERMS: #234397

References:

Davies, Peter and Rick Beauheim. 1996. Memo to Martin Tierney. RE: Changes to the parameter records package and form #464 for far-field permeability of Salado halites (id#s: 547, 548, and 549; idmtrl: S_HALITE; idpram: PRMX_LOG, PRMY_LOG, and PRMZ_LOG, respectively). March 7, 1996. ERMS #236772.

Deal, D.E., Abitz, R.J., Belski, D.S., and Case, J.B. 1989. Brine Sampling and Evaluation Program, 1988 Report. DOE-WIPP-89-015. Carlsbad, NM: Westinghouse Electric Corporation.

Jensen, A.L., Howard, C.L., Jones, R.L., and Peterson, T.P. 1993. Room Q Data Report: Test Borehole Data from April 1989 through November 1991. SAND92-1172. Albuquerque, NM: Sandia National Laboratories. ERMS #223548.

SNL 1996a. Halite Permeability, Salado Package 7 (X, Y, Z). ERMS 231218. Sandia National Laboratories. Albuquerque, NM

SNL 1996b. Salado Halite Permeability from Room Q Analysis, Salado Package 7. ERMS 230721. Sandia National Laboratories. Albuquerque, NM.

Table 8. Summary of Permeability Test-Interpretations Results from In Situ Permeability Tests Representing Undisturbed Impure Halite

Test Interval (meters from excavation)	Hole	Map unit(s)	Analysis Method	Permeability k (m^2)
20.13-21.03	QPPO5	MU 6	GTFM6.0	1.12×10^{-24}
23.35-24.20	QPP12	H3	GTFM6.0	2.69×10^{-22}
20.19-21.09	QPP15	MU O - MU PH-4	GTFM6.0	5.5×10^{-24}
4.50-5.58	C2H01-BGZ	MU O - MU 4	GTFM6.0	1.38×10^{-21}

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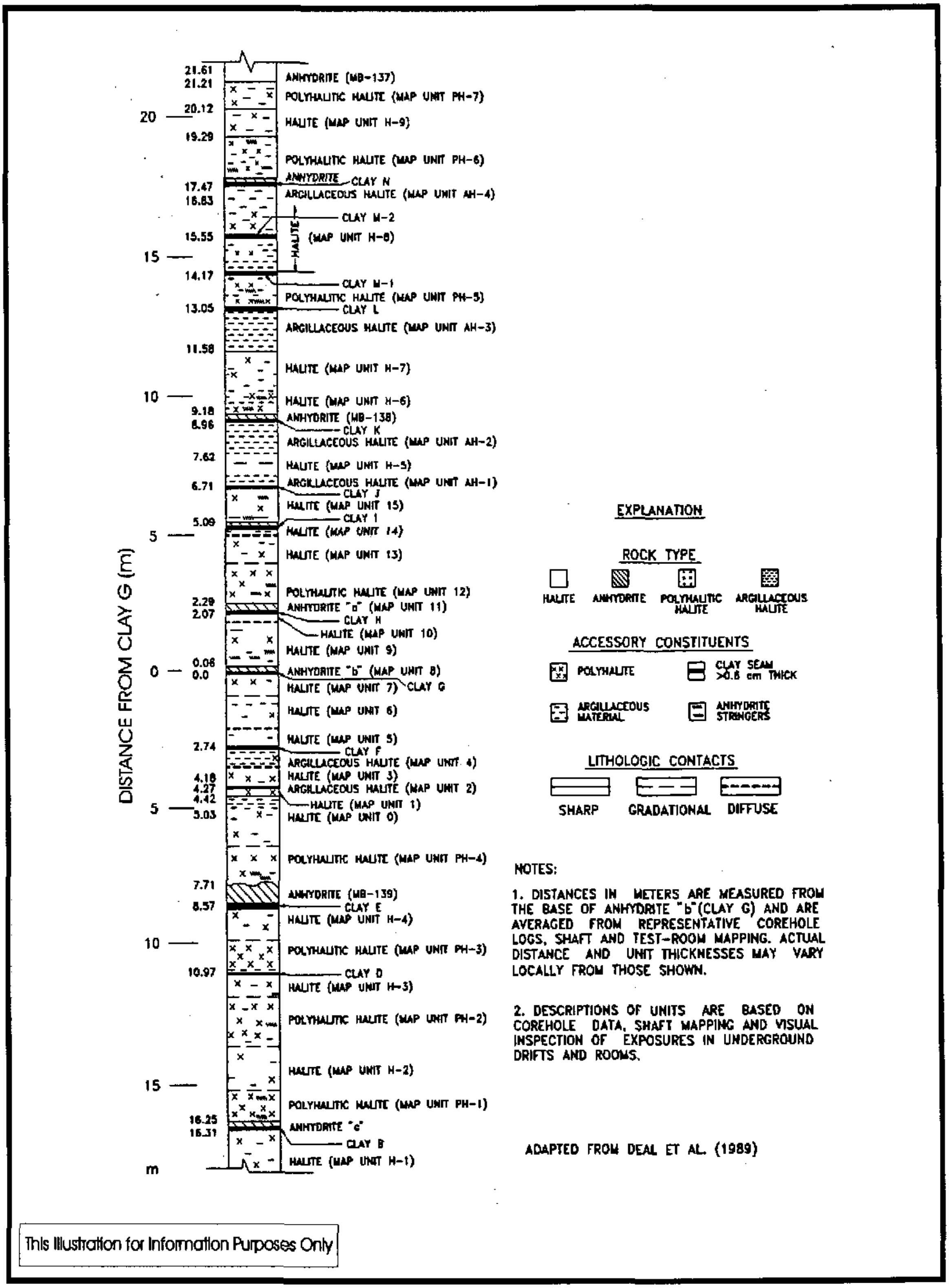

NMVP-6342-164-0

Figure -1. Salado Map Units Near the Disposal Area Horizon

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Parameter 54: Rock Compressibility – Halite

Parameter Description:

The rock (or bulk) compressibility of the Salado Formation halite is used to calculate the pore compressibility that is used in BRAGFLO. Pore compressibility is used to predict the effect of material compressibility on porosity and mass storage in the equation of state for flow through porous media as follows:

$$\phi = \phi_0 \exp(c_p(p - p_o))$$

where,

ϕ	=	porosity of solid matrix (cubic meters/cubic meters)
ϕ_0	=	porosity at reference pressure p_o
c_p	=	pore compressibility (pascals^{-1})
p	=	pore pressure (pascals)
p_o	=	reference pore pressure (pascals)

The rock compressibility is divided by effective porosity to calculate pore compressibility.

Material and Property Name(s):

S_HALITE COMP_RCK

Computational Code: BRAGFLO

minimum	maximum
2.94×10^{-12}	1.92×10^{-10}

Units: Pascals^{-1}

Distribution Type: Uniform

Data: Site-Specific Experimental Data

The parameter distribution for halite rock compressibility is based upon data from two hydraulic tests in Room Q: QPP05 and QPP15. Another data point calculated from sensitivity studies using brine inflow data from Room Q is within the range driven from the hydraulic tests. Parameter records packages associated with this parameter are: Halite Rock Compressibility (SNL, 1996a) and Salado Halite Rock Compressibility from Room Q ANALYSIS (SNL 1996b).

The two in-situ hydraulic tests were conducted in the location of Room Q before the large-scale brine inflow excavation was mined (see Table 9). Test intervals were located over 20 m (65 ft) from the excavation. Map units (MU) represented included MU 6 (halite) and MU 0 (halite)/MU PH-4 (polyhalite) within a radius of about 1 m (3.3 ft) of each borehole. Raw data

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included pressure, fluid volume, temperature, axial test-tool movement, and radial borehole closure.

Interpretation of all flow tests in the WIPP facility is based on the assumption that Darcy flow and borehole closure are the only forms of pressure/flow transmission during hydraulic tests. References related to data collection and interpretation are listed in the references section. See also Martell, M (1996) and Terney, M (1996).

Parameter Data Entry Form ERMS: #234210

References:

Martell, M. 1996. Memo: M. Martell to file, 3/25/96, Support Documentation (Salado, Non-Salado, and Shaft Seals) to Request the Need or Intended Use of a WIPP Parameter. Sandia National Laboratories. Carlsbad, NM. ERMS 235597

Tierney, M. 1996. Memo: M. Tierney to Distribution, 3/21/96, Distributions. Sandia National Laboratories. Carlsbad, NM. ERMS 235268

SNL 1996a. Halite Rock Compressibility. Salado, Halite Rock Compressibility Package. Sandia National Laboratories. 2/15/1996. ERMS 231220

SNL 1996b. Halite Rock Compressibility from Room Q Analysis. Salado, Halite Rock Compressibility from Room Q Analysis Package. Sandia National Laboratories. 1/31/1996. ERMS 230598

Table 9. Summary of Rock Compressibility Test-Interpretations Results from In Situ Permeability Tests for Undisturbed Halite and Polyhalite Map Units

Test Interval (meters from excavation)	Hole	Zone	Map Unit(s)	Analysis Method	Rock Compressibility C_r (1/pascal)	Formation Pore Pressure (megapascal)[1]
20.13-21.03 down	QPPO5 *Room Q*	undisturbed	MU 6	GTFM6.0	2.94×10^{-12}	13.89
20.19-21.09 down	QPP15 Room Q	undisturbed	MU 0 MU PH-4	GTFM6.0	1.92×10^{-10}	11.04

[1] Mean
Note: See Record Parameter Package for additional detail.

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Parameter 55: Log of Intrinsic Permeability - Marker Bed 139

Parameter Description:

This parameter represents the intrinsic permeabilities for MB139.

Material and Property Name(s):

S_MB139 PRMX_LOG
S_MB139 PRMY_LOG
S_MB139 PRMZ_LOG

Computational Code: BRAGFLO

Measured Values:	-21.0	-19.2	-19.1	-18.8	-18.1	-17.1

Units: Log (meters squared)

Distribution Type: Student's-t

Data: Site-Specific Experimental Data and Laboratory-Measured Data

The reported parameter range of undisturbed Salado anhydrite permeabilities is based upon selected data collected from the following in situ hydraulic tests and measurements conducted in the laboratory: (1) five hydraulic tests conducted in the underground experimental area; and (2) 31 Klinkenberg-corrected gas permeabilities measured in the laboratory on specimens collected from MB139 core samples. Summary data tables are attached for both in situ and laboratory tests (see Table 10 and Table 11). Parameter records packages associated with this parameter are Anhydrite Permeability (x,y,z) (SNL 1996a); Salado Anhydrite Permeability in the X-Direction (SNL 1996b); Salado Anhydrite Permeability in the Y-Direction (SNL 1996c); Salado Anhydrite Permeability in the Z-Direction (SNL 1996d).

Out of 15 borehole and field permeability tests conducted in MB140, MB139, MB138 and anhydrites a and b, 5 in situ hydraulic tests are considered representative of undisturbed anhydrite permeability. Located from about 10 to 24 m (33 to 79 ft) from the excavation, the test intervals for these five boreholes were outside of the DRZ. The radius of visibility ranged from 4 to 25 m (13 to 82 ft). The five successful tests are summarized as follows:

Borehole	Location	Map Unit	Testing Period
QPP03	Room Q	Anhydrite b	4/89 11/91
QPP13	Room Q	MB 139	4/89 11/91
C2H02	Room C2	MB 139	4/89 12/89
L4P51-C1	Room L4	MB 140	4/92 6/94
SCP01-A	Core Storage	MB 139	4/90 10/90

Klinkenberg-corrected gas permeability measured in the laboratory can be used as an

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equivalent measure of liquid permeability. Klinkenberg-corrected test specimen data exist from six whole cores taken from MB139 in the northern experimental area: E1X07, E1X08, E1X10, E1X11 (E140 Drift), P3X10, and P3X11 (Room L3).

For purposes of parameterization, in situ test data are treated differently than laboratory-derived data. Uncertainty exists in regards to the spatial representativeness of the core samples. In situ hydraulic tests are considered representative of expected permeability conditions on the scale of the grid system used in the BRAGFLO mesh. Consequently, for the parameter distribution above, laboratory data from the 6 megapascals net effective stress are averaged as one data point, whereas each of the five hydraulic tests is considered an individual data point. (Martell 2000)

Parameter Data Entry Form ERMS: #234865

References:

Martell, M. 2000. PAVT Changes Due to the New SQL Relational Data Model. Sandia National Laboratories. Carlsbad, NM. ERMS 514241.

SNL 1996a. Anyhydrite Permeability (X, Y, Z). ERMS 231217. Sandia National Laboratories. Albuquerque, NM

SNL 1996b. Anhydrite Permeability in the X-Direction, Salado Package 13. ERMS 230603. Sandia National Laboratories. Albuquerque, NM

SNL 1996c. Anhydrite Permeability in the Y-Direction, Salado Package 13. ERMS 230605. Sandia National Laboratories. Albuquerque, NM

SNL 1996d. Anhydrite Permeability in the Z-Direction, Salado Package 13. ERMS 230606. Sandia National Laboratories. Albuquerque, NM

Table 10. Summary of Test-Interpretations Results from In Situ Permeability Tests for Undisturbed Anhydrite Map Units

Test Interval (meters from excavation)	Hole	Zone	Map Unit	Analysis Method	Permeability k (m^2)	Formation Pore Pressure (megapascals)[1]
10.68-14.78 down	SCP01-A	undisturbed	MB139	GTFM6.0	1.4×10^{-19}	12.27
9.47-10.86 down	C2H02	undisturbed	MB139	GTFM6.0	1.0×10^{-21}	11.11
20.50-21.40 up	QPPO3	undisturbed	anhydrite b	GTFM6.0	7.6×10^{-20}	12.9
20.62-21.52 down	QPP13	undisturbed	MB139	GTFM6.0	6.0×10^{-20}	12.43
17.44-22.20 down	L4P51-C1	undisturbed	MB140	GTFM6.0	8.7×10^{-18}	9.38

[1] Mean
Note: See Record Parameter Package for additional detail.

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Table 11. Summary of MB139 Permeability Laboratory Test Results

	Permeability (pressure values are net effective stress)					
	Gas (Klinkenberg Corrected)			Log of Permeability		
	3.4 megapascals (m^2)	6 megapascals (m^2)	10 megapascals (m^2)	2 megapascals (m^2)	6 megapascals (m^2)	10 megapascals (m^2)
Minimum	1.5E-19	5.9E-20	5.0E-20	-18.84	-19.23	-19.30
Maximum	8.3E-16	3.0E-16	1.5E-16	-15.08	-15.52	-15.82
Sum	9.0E-16	3.4E-16	1.8E-16	-552.29	-524.43	-402.17
Points	31	29	22	31	29	22
Mean	2.9E-17	1.2E-17	8.0E-18	-17.82	-18.08	-18.28
Median	1.3E-18	5.7E-19	3.1E-19	-17.89	-18.24	-18.51
Std Deviation	1.5E-16	5.6E-17	3.2E-17	0.67	0.69	0.83
Variance	2.2E-32	3.2E-33	1.1E-33	0.45	0.48	0.69

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Parameter 56: Relative Permeability – Marker Bed 139

Parameter Description:

The relative permeability model number parameter is the flag used to select two-phase flow model for use in BRAGFLO. It is a sampled parameter for MB139 (see CCA Appendix PA, Figure 4.2.1).

Material and Property Name(s):

S_MB139 RELP_MOD

Computational Code: BRAGFLO

Value	1.0	2.0	3.0	4.0
Percentiles	.50	0	0	.50

Units: None

Distribution Type: Delta

Data: Site-Specific Experimental Data

Site-specific experimental data was collected from whole core taken from six underground boreholes at the WIPP. The specimens first underwent permeability and porosity testing, then subsequent capillary pressure tests.

Discussion:

Test data from MB 139 was applied to MB 138 and Anhydrite Layers a and b. All other material regions use the second modified Brooks-Corey two-phase flow model.

Assumptions made during testing were:

1) Cores were 100 percent saturated at initiation of capillary pressure tests.
2) Use of a 140° contact angle was appropriate for correcting mercury-air data to brine-air repository conditions.
3) Although tests were conducted at ambient conditions (no stress), the data are adequate to describe two-phase conditions at stress.

The following parameter records package is associated with the tests: Anhydrite Two-Phase Parameters, Appendix E for SAND94-0472.

There are several two-phase relative permeability models described in Appendix BRAGFLO, including the van Genuchten-Parker and the second modified Brooks-Corey. Interpretation of

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the experimental test results showed that either the second modified Brooks-Corey or the van Genuchten-Parker two-phase flow models could be used to describe the data. (Howarth and Christian-Frear, 1996)

Parameter Data Entry Form ERMS: #234500

References:

Howarth S.M., and Christian-Frear, T. 1996. Porosity, Single-Phase Permeability, and Capillary Pressure Data from Preliminary Laboratory Experiments on Selected Samples from Marker Bed 139 at the Waste Isolation Pilot Plant. Albuquerque, NM: Sandia National Laboratories. ERMS #238019.

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Parameter 57: Residual Brine Saturation - Marker Bed 139

Parameter Description:

The residual brine saturation (S_{br}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves. Referred to also as S_{wr} (wetting phase) or S_{lr} (liquid phase), residual brine saturation is the point reached under high gas saturation conditions when brine is no longer continuous throughout the pore network and relative brine permeability becomes zero. It is a sampled parameter for MB139 (see CCA Appendix PA, Figure 4.2.1).

Material and Property Name(s):

S_MB139 SAT_RBRN

Computational Code: BRAGFLO

Measured Values:	0.00778	0.069	0.070	0.073	0.109	0.174

Units: None

Distribution Type: Student's-t

Data: Site-Specific Experimental Data

Residual brine saturation parameter values for the marker beds are based on curve fit parameter values predicted from laboratory measurements of capillary pressure. The parameter records package associated with this parameter is: Anhydrite Two-Phase Parameters, Appendix E for SAND94-0472 (SNL 1996).

Discussion:

Parameter values are based on curve fit capillary pressure data measured using a mercury injection technique. The two-phase flow program reports the results of curve-fitted measurements of capillary pressure on six MB samples (Howarth and Christian-Frear 1996). Specimens were collected from intact MB139 core samples taken from the experimental area of the repository.

Parameter Data Entry Form ERMS: #234506

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References:

Howarth S.M., and Christian-Frear, T. 1996. Porosity, Single-Phase Permeability, and Capillary Pressure Data from Preliminary Laboratory Experiments on Selected Samples from Marker Bed 139 at the Waste Isolation Pilot Plant. Albuquerque, NM: Sandia National Laboratories. ERMS #238019.

SNL 1996. Anyhydrite Two Phase Parameters, Appendix E for SAND94-0472. ERMS 230643. Sandia National Laboratories. Albuquerque, NM

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Parameter 58: Pore Distribution - Marker Bed 139

Parameter(s) Description:

The Brooks-Corey pore size distribution parameter (□) is used to calculate capillary pressure and relative permeabilities for gas and brine flow in the two-phase flow model. It is a sampled parameter for MB139 (see CCA Appendix PA, Figure 4.2.1).

Material and Property Name(s):

S_MB139 PORE_DIS

Computational Code: BRAGFLO

Measured Values:	0.491	0.558	0.652	0.655	0.665	0.842

Units: None

Distribution Type: Student's-t

Data: Site-Specific Experimental Data

Pore size distribution parameter values for all anhydrite units are based on curve fit values predicted from laboratory measurements of capillary pressure. The parameter records package associated with this parameter is retained in Anhydrite Two-Phase Parameters, Appendix E for SAND94-0472 (SNL 1996).

Discussion:

Curve fit parameter values are derived from six specimens cut from intact MB139 core samples collected from the northern experimental area of the repository. Reported data and parameters are based on mercury injection capillary pressure tests (Howarth and Christian-Frear 1996).

Parameter Data Entry Form ERMS: #234859

References:

Howarth S.M., and Christian-Frear, T. 1996. Porosity, Single-Phase Permeability, and Capillary Pressure Data from Preliminary Laboratory Experiments on Selected Samples from Marker Bed 139 at the Waste Isolation Pilot Plant. Albuquerque, NM: Sandia National Laboratories. (ERMS #238019).

SNL 1996. Anyhydrite Two Phase Parameters, Appendix E for SAND94-0472. ERMS 230643. Sandia National Laboratories. Albuquerque, NM

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Parameter 59: Initial Pressure - Salado Halite

Parameter Description:

The initial brine far-field (undisturbed) pore pressure in the Salado halite is applied at an elevation consistent with the intersection of MB139 (see CCA Appendix PA, Figure 4.2.1).

Material and Property Name(s):

S_HALITE PRESSURE

Computational Code: BRAGFLO

minimum	maximum
1.10×10^7	1.39×10^7

Units: Pascals

Distribution Type: Uniform

Data: Site-Specific Experimental Data

Two hydraulic tests were performed in boreholes in undisturbed halite in the underground WIPP repository. Both tests were performed in the area where Room Q would later be mined. The tests were undertaken in April-July, 1989. Pressure, fluid volume, temperature, axial test-tool movement, and radial borehole closure were measured during the hydraulic tests in undisturbed rock. The following parameter records package is associated with the tests: Halite Pressure (SNL 1996).

Discussion:

It was assumed that Darcy flow and borehole closure were the only forms of pressure/flow transmission during the hydraulic tests in undisturbed halite. The uncertainty associated with the estimated parameter values is high. The distribution is based on the two data points provided in the data package and the calculated median is 1.247×10^7 pascals. See Martell, M (1996) and Tierney, M (1996).

Parameter Data Entry Form ERMS: #234394

References:

Martell, M. 1996. Memo: M. Martell to file, 3/25/96, Support Documentation (Salado, Non-Salado, and Shaft Seals) to Request the Need or Intended Use of a WIPP Parameter. Sandia National Laboratories. Carlsbad, NM. ERMS 235597

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SNL 1996. Halite Pressure. ERMS 231221. Sandia National Laboratories. Albuquerque, NM.

Tierney, M. 1996. Memo: M. Tierney to Distribution, 3/21/96, Distributions. Sandia National Laboratories. Carlsbad, NM. ERMS 235268

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Parameter 60: Initial Pressure - Castile Brine Reservoir

Parameter Description:

Initial brine pore pressure in the Castile brine reservoir (see CCA Appendix PA, Figure 4.2.1).

Material and Property Name(s):

CASTILER PRESSURE

Computational Code: BRAGFLO

Mode	minimum	maximum
1.27×10^{7}	1.11×10^{7}	1.70×10^{7}

Units: Pascals

Distribution Type: Triangular

Data: Site-Specific Experimental Data and Professional Judgment

The parameter records package associated with this parameter is as follows: Castile Brine Reservoir Pressure (SNL 1996).

Discussion:
All pressure measurements were adjusted to reflect formation pressure of the WIPP-12 reservoir. Pressure adjustments were made as follows:

$$P_a = P + \rho\, g\, (h - 140)\; 1 \times 10^{-6}$$

where:
- P_a = adjusted pressure (megapascals)
- P = measured/estimated pressure (megapascals)
- ρ = assumed density (kilograms per cubic meter)
- g = gravitational constant (9.8 Newtons per kilogram)
- h = brine reservoir elevation (meters above sea level)

Observed (measured and interpreted) Castile brine reservoir fluid pressures were compared with their corresponding lithostatic pressures; four locations (shown in Table 12) were found to best represent the formation pressure. The measured values in Table 12 are adjusted to reflect formation pressure at the depth of WIPP-12, which is representative of the depth of the BRAGFLO Castile Brine Reservoir. The pressure adjustment requires an assumption about pressure variation with depth in the Castile. Two bounding cases were used, hydrostatic and 85 percent of lithostatic; the adjusted pressure was calculated using the equation provided above. A brine density of 1,240 kg/m^3 (Reeves et al. 1989) was assumed for the hydrostatic

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variation; an average formation density of 2,040 kg/m^3 (Sandia WIPP Project 1992) was assumed for the lithostatic variation. The best-measured value (that is, the mode) is the brine reservoir pressure reported for WIPP-12 (12.7 megapascals). The maximum brine reservoir pressure is 85 percent of lithostatic at WIPP-12 depth (17 megapascals). The minimum value is the lowest measured hydrostatic pressure (11.1 megapascals). Freeze and Larson (1996), attached to CCA Appendix MASS, Section 18 , provide more detail.

Parameter Data Entry Form ERMS: #231612

References:

Freeze, Geoff, and Larson, K. 1996. Memorandum to Martin Tierney Re: Initial Pressure in the Castile Brine Reservoir, March 20, 1996. ERMS #237148.

Reeves, M., Freeze, G.A., Kelley, V.A., Pickens, J.F., Upton, D.T., and Davies, P.B. 1989. Regional Double-Porosity Solute Transport in the Culebra Dolomite under Brine-Reservoir-Breach Release Conditions: An Analysis of Parameter Sensitivity and Importance. SAND89-7069. Albuquerque, NM: Sandia National Laboratories. ERMS #224048.

SNL 1996. Castile Brine Reservoir Pressure. ERMS 231072. Sandia National Laboratories. Albuquerque, NM

Sandia WIPP Project. 1992. Preliminary Performance Assessment for the Waste Isolation Pilot Plant, December 1992: Volume 3, Model Parameters. SAND92-0700/3. Albuquerque, NM: Sandia National Laboratories. ERMS #223529.

Table 12. Measured Castile Brine Reservoir Formation Pressures

Location	Pressure at Reservoir Depth (megapascals)	Pressure at WIPP-12 Depth with Hydrostatic Adjustment (megapascals)	Pressure at WIPP-12 Depth with 85% Lithostatic Adjustment (megapascals)
WIPP-12	12.7[1]	12.7	12.7
ERDA-6	14.1[2]	15.5	16.4
Belco	14.3[2]	14.5	14.5
Gulf Covington	13.6[2]	12.1	11.1

[1] from Reeves et al. 1989, Appendix A
[2] from Popielak et al. 1983, Table H.1

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Parameter 61: Log of Intrinsic Permeability - Castile Brine Reservoir

Parameter Description:

The log of the intrinsic permeability of the Castile Brine Reservoir. It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Property Name(s):

CASTILER PRMX_LOG
CASTILER PRMY_LOG
CASTILER PRMZ_LOG

Computational Code: BRAGFLO

Mode	minimum	maximum
-11.80	-14.70	-9.80

Units: Log (meters squared)

Distribution Type: Triangular

Data: Site-Specific Experimental Data and Professional Judgment

Although several shorter flow tests were conducted to measure permeability of Castile brine reservoirs, only one test is considered representative of the long-term behavior of the brine reservoir behavior: the WIPP-12 Flow Test 3 (24,800 bbl produced, nine months recovery). The Graph Theoretic Field Model (GTFM) analysis of WIPP-12 Flow Test 3 (Reeves et al. 1989) is considered better than the Horner analysis because it considers the effects of pre-test borehole pumping history. The GTFM interpreted hydraulic conductivity from WIPP-12 Flow Test 3 therefore provides the basis for the mean permeability for the Castile brine reservoir. The other values from WIPP-12 and ERDA-6 were used to establish the permeability distribution.

Professional judgment was used to better define the data mean and range because of the shortage of directly relevant data points. The parameter records package associated with this parameter is as follows: Castile Brine Reservoir Permeability (SNL 1996).

The GTFM analysis from WIPP-12 Flow Test 3 consists of a match to pressure response data and a match to flow rate data. The late time match to the pressure data are controlled primarily by the formation pressure and is not very sensitive to the hydraulic conductivity or the specific storage. To match the flow rate data, the GTFM interpreted hydraulic conductivity (K) is strongly correlated with the specified specific storage (S_s), where:

$$S_s = \rho\, g\, (C_R + \Phi\beta)$$

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For Castile brine reservoir properties, specific storage is proportional to the bulk rock compressibility (C_R). The correlation between K and S_s is such that their product is approximately a constant. For example, if the assumed specific storage (or rock compressibility) in GTFM is reduced by an order of magnitude, the interpreted hydraulic conductivity must increase by an order of magnitude to produce the same flow rate. The new combination of K and S_s will produce a different early-time pressure response, but will not impact the late-time match. For the GTFM analyses of the WIPP-12 Flow Tests, a rock compressibility of 1×10^{-9} pascals^{-1} was assumed. Because the mean rock compressibility for the Castile brine reservoir is 1×10^{-10} pascals^{-1}, the hydraulic conductivity required to reproduce the WIPP-12 flow is approximately 1×10^{-5} m/s (permeability of -11.81 log (square meters)). For all triangular distributions, the mode is the best estimate. GTFM analysis determines a hydraulic conductivity (with units of meters per second) based on pressure change, flow rate, and assumptions about fluid and formation properties. Conversions from meters per second to square meters were based on a conversion factor of 1.7×10^{-7} m^2 per (meters per second). The conversion factor is based on the assumed GTFM fluid properties. (Popielak et. al. 1983)

Parameter Data Entry Form ERMS: #231613

References:

Popielak, R.S., Beauheim, R.L., Black, S.R., Coons, W.E., Ellingson, C.T., and Olsen, R.L. 1983. Brine Reservoirs in the Castile Formation, Waste Isolation Pilot Plant (WIPP) Project, Southeastern New Mexico. DOE Report TME-3153.

Reeves, M., Freeze, G.A., Kelley, V.A., Pickens, J.F., Upton, D.T., and Davies, P.B. 1989. Regional Double-Porosity Solute Transport in the Culebra Dolomite under Brine-Reservoir-Breach Release Conditions: An Analysis of Parameter Sensitivity and Importance. SAND89-7069. Albuquerque, NM: Sandia National Laboratories. ERMS #224048.

SNL 1996. Castile Brine Reservoir Permeability. ERMS 231070. Sandia National Laboratories. Albuquerque, NM

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Parameter 62: Rock Compressibility - Castile Brine Reservoir

Parameter Description:

The rock (or bulk) compressibility of the Castile Brine Reservoir is used to calculate the pore compressibility, which is required for running BRAGFLO (see CCA Appendix PA, Figure 4.2.1). Pore compressibility is used to predict the effect of material compressibility on porosity and mass storage in the equation of state for flow through porous media as follows:

$$\phi = \phi_o \exp\left(c_p\left(p - p_o\right)\right)$$

where,

ϕ = porosity of solid matrix (cubic meters per cubic meters)
ϕ_o = porosity at reference pressure p_o
c_p = pore compressibility (pascals^{-1})
p = pore pressure (pascals)
p_o = reference pore pressure (pascals)

The rock compressibility is divided by effective porosity to calculate pore compressibility.

Material and Property Name(s):

CASTILER COMP_RCK

Computational Code: BRAGFLO

mode	minimum	maximum
4.00×10^{-11}	2.00×10^{-11}	1.00×10^{-10}

Units: Pascals^{-1}

Distribution Type: Triangular

Data: Site-Specific Experimental Data and Professional Judgment

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

In CCA Appendix PAR, parameter values were based on an analysis of data from WIPP-12. Rock compressibility values were determined by calculating the bulk modulus of anhydrite from the acoustic log of the Castile Anhydrite III unit found in WIPP-12. The DOE chose to use the acoustic log because it measures compressive wave travel time over short distances through relatively intact, undisturbed rock, then uses a correlation between wave velocity and

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elastic rock properties to estimate bulk modulus. Various laboratory compression tests on anhydrite from other WIPP locations produced similar results for the bulk modulus (Popielak et al., 1983).

The estimated bulk modulus, K, for the intact Anhydrite III at WIPP-12 was 6.9×10^{10} pascals (10×10^{6} psi). Assuming uniaxial strain, the rock compressibility (C_R) can be estimated from the bulk modulus (K) and the shear modulus (G) of the rock:

$$C_R = \frac{1}{K + 4G/3}$$

No estimates for shear modulus for Anhydrite III were available. Beauheim et al. (1991) reported a value for G that was approximately 1/3 of K for Salado anhydrite. Using this estimate for G, the calculated intact rock compressibility is 1×10^{-11} pascals^{-1}.

The bulk modulus may be 2 to 10 times smaller for fractured rock (Popielak et al. 1983), corresponding to a 2 to 10 times increase in compressibility (assuming G changes accordingly). Beauheim et al. (1991) suggest that fracturing might result in a fourfold increase in rock compressibility. Using these adjustments for fractured rock, the calculated rock compressibility ranges from 2×10^{-11} pascals^{-1} to 1×10^{-10} pascals^{-1}, with an average value of 5×10^{-11} pascals^{-1}.

Hydraulic testing was performed in transition-zone (disturbed) Salado anhydrite and halite. Interpreted rock compressibilities for transition zone anhydrite ranged from 5×10^{-12} pascals^{-1} to 3×10^{-9} pascals^{-1}. Freeze and Cherry (1979) report a range for rock compressibility for fractured or jointed rock of 1×10^{-8} to 1×10^{-10} pascals^{-1} (DOE 1996).

Subsequent to the CCA PA calculations, EPA reviewed the CCA, and supporting information and references, and concluded that the compressibility parameter for the Castile Formation brine reservoir was not consistent with available information (EPA, 1998). Subsequent to the CCA, the field test data for the WIPP-12 borehole was re-examined and arrived at a revised range for rock compressibility. EPA regarded the re-analysis as a better estimate of the rock compressibility parameter than the value used in the CCA.

The Sandia National Laboratories Technical Library and Records Center undertook a key word-based (Castile rock compressibility) literature and records search to identify documentation/research that addresses the brine reservoir rock compressibility. Titles of all recent documents identified by the search were reviewed for relevancy; following this, abstracts and/or complete documents were reviewed to determine if information more recent than that cited in the CCA or PAVT was available. The literature and records search and review did not identify new information that would offer further support of, or otherwise refute the distributions and parameter ranges presented above. Consequently, rock compressibility is treated as a sampled variable having a triangular distribution and a revised range of 2×10^{-11} to 1×10^{-10} Pa^{-1} and a revised mode of 4×10^{-11} Pa^{-1}. See also Hansen and Leigh (2003)

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Parameter Data Entry Form ERMS: #522016

References:

Beauheim, R.L., Saulnier, G.J., Jr., and Avis, J.D. 1991. Interpretation of Brine-Permeability Tests of the Salado Formation at the Waste Isolation Pilot Plant: First Interim Report. SAND90-0083. Albuquerque, NM: Sandia National Laboratories. ERMS #226003.

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office. Vols 1-XXI.

Freeze, R.A., and Cherry, J.A. 1979. Groundwater. Prentice-Hall, Inc., Englewood Cliffs, NJ.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582

Popielak, R.S., Beauheim, R.L., Black, S.R., Coons, W.E., Ellingson, C.T., and Olsen, R.L. 1983. Brine Reservoirs in the Castile Formation, Waste Isolation Pilot Plant (WIPP) Project, Southeastern New Mexico. DOE Report TME-3153.

Reeves, M., Freeze, G.A., Kelley, V.A., Pickens, J.F., Upton, D.T., and Davies, P.B. 1989. Regional Double-Porosity Solute Transport in the Culebra Dolomite Under Brine-Reservoir-Breach Release Conditions: An Analysis of Parameter Sensitivity and Importance. SAND89-7069. Albuquerque, NM: Sandia National Laboratories. ERMS #224048.

U.S. Environmental Protection Agency (EPA). 1998. Response to Comments, Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with 40 CFR 191 Disposal Regulations: Certification Decision. Docket No. A-93-02, V-C-1. U.S. Environmental Protection Agency. Washington D.C.

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Parameter 63: Log of Intrinsic Permeability - Intrusion Borehole Filled With Silty Sand

Parameter Description:

This parameter represents the log of the intrinsic permeability of the silty-sand-filled borehole in the human-intrusion scenario (see CCA Appendix PA, Figure 4.2.1). This permeability is representative of degraded concrete or material which may sluff into the borehole or spall from the sides. It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Property Name(s):

BH_SAND PRMX_LOG
BH_SAND PRMY_LOG
BH_SAND PRMZ_LOG

Computational Code: BRAGFLO

minimum	maximum
-16.30	-11.00

Units: Log (meters squared)

Distribution Type: Uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

In CCA Appendix PAR, this parameter represented the permeability of the silty-sand-filled borehole in the human-intrusion scenario. The permeability was representative of degraded concrete or material which may sluff into the borehole or spall from the sides. Three plug configurations with different permeabilities were associated with each configuration. Borehole materials and plug configurations were based on a review of regulations and practices, and the permeability predictions are based on models and data for steel corrosion and concrete alteration found in the literature (Thompson et al. 1996). Wherever possible, the predictions were calibrated by comparing predicted behavior to field data (Thompson et al. 1996).

The three plug configurations consisted of: a continuous concrete plug through the Salado and

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Castile which was assigned a probability of 0.015 (see Section 6.4.7.2.1), a two-plug configuration (a lower plug located between the Castile brine reservoir and underlying formations and an upper plug located in the Rustler immediately above the Salado), which was assigned a probability of 0.696 (see Section 6.4.7.2.2), and a three-plug configuration (two plugs same as two-plug configuration and third plug located in the Castile above the brine reservoir and below the waste-disposal panel) which was assigned a probability of 0.289 (see Section 6.4.7.2.3).

The plugs were initially expected to have a tight permeability of 5×10^{-17} m^2 (Thompson et al. 1996). The continuous concrete plug was assumed not to degrade and had a permeability of 5×10^{-17} m^2 for the entire regulatory period. For the two-plug configuration, the permeability between the repository and the surface is 5×10^{-17} m^2 for the first 200 years and 10^{-14} to 10^{-11} m^2 after that; the permeability between the Castile and the repository is 10^{-14} to 10^{-11} m^2 up to 1,200 years and 10^{-15} to 10^{-12} m^2 after that. The three-plug configuration had the same material properties as the corresponding regions in the two-plug configuration and the third plug was assumed to behave as the lower plug in the two-plug configuration (DOE 1996).

Subsequent to the CCA PA calculations, EPA questioned the range of borehole sand permeabilities and the assumption that concrete borehole plugs would degrade to a more permeable material. The EPA (1997a) concluded that the lower bound for long-term borehole sand permeability proposed (10^{-14} m^2) should be closer to that of an undegraded borehole plug (5×10^{-17} m^2). The lower value was of interest to EPA because a lower permeability could result in increased gas pressures with consequent increases in brine and spallings releases during a human intrusion event.

The EPA also investigated drilling practices used in the petroleum industry and found literature values for cement permeability ranging from 9×10^{-21} to 1×10^{-16} m^2 (EPA 1997b). The EPA also found that filter cake and compacted, clay-based drilling muds could yield permeabilities of less than 9.9×10^{-22} m^2. In their considerations, the EPA noted that drilling mud used in the Delaware Basin boreholes might not have the permeability of clay-based solids; however, they noted that natural cuttings could contribute to lower borehole permeabilities than those assumed by the DOE. The EPA also postulated that the effective average permeability over an abandoned borehole could remain in the range of 9×10^{-21} to 1×10^{-16} m^2 over a period of hundreds of years or more if complete degradation does not occur throughout a plug configuration or if natural materials or mud were to provide additional layers with sealing properties.

With these findings, the EPA decided that the borehole sand permeabilities assigned in the CCA, while consistent with the broad range of available data, did not adequately represent the total range of permeability conditions that could exist (EPA 1998). As a result, lower borehole sand permeabilities values are used. (Hansen and Leigh 2003)

Parameter Data Entry Form ERMS: #522016

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References:

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582

Thompson, T.W., Coons, W.E., Krumhansl, J.L., and Hansen, F.D. 1996. Inadvertent Intrusion Borehole Permeability, Final Draft, July 8, 1996.

U.S. Department of Energy (DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. Carlsbad, NM: United States Department of Energy, Waste Isolation Pilot Plant, Carlsbad Area Office. Vols 1-XXI.

U.S. Environmental Protection Agency (EPA). 1997a. Technical Support Document for Section 194.23:Parameter Justification Report. Docket No. A-93-02, III-B-14, U.S. Environmental Protection Agency. Washington D.C.

U.S. Environmental Protection Agency (EPA). 1997b. Compliance Application Review Documents for the Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations: Proposed Certification Decision. Docket No. A-93-02, III-B-2. U.S. Environmental Protection Agency. Washington D.C.

U.S. Environmental Protection Agency (EPA). 1998. Technical Support Document for Section 194.23:Parameter Justification Report. Docket No. A-93-02, V-B-14. U.S. Environmental Protection Agency. Washington, D.C. ERMS #525158.

Information Only

Parameter 64: Log of Intrinsic Permeability - Disturbed Rock Zone

Parameter Description:

This parameter represents the log of the intrinsic permeability of the disturbed rock zone (DRZ), 0-10,000 yrs (see CCA Appendix PA, Figure 4.2.1). It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Property Name(s):

DRZ_1 PRMX_LOG
DRZ_1 PRMY_LOG
DRZ_1 PRMZ_LOG

Computational Code: BRAGFLO

minimum	maximum
-19.40	-12.50

Units: Log (meters squared)

Distribution Type: Uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

The grid used in CCA calculations implemented a DRZ of constant permeability (10^{-15} m^2) over a region 12 m above and 2.23 m below the disposal rooms. The grid was continuous above panel closure systems, such that the same permeability and thickness existed above and below the simulated panel closures. A more realistic representation of the DRZ over disposal rooms would include high permeability near the free surface of rooms, and reduction of permeability as a function of depth into the surrounding rock. Generally speaking, the DRZ extends greater distances above a room than below, and is relatively shallow into the ribs.

Subsequent to the CCA PA calculations, the EPA determined an alternate lower bound for DRZ permeability from measured gas permeability in anhydrite cores from MB139 (Howarth 1996; Beauheim 1996; Howarth and Christain-Frear 1996). The EPA concluded that a value of -19.4 for the log of the permeability was a more appropriate lower bound for the range of likely values. The EPA selected a value of -12.5 as an upper bound on the log of DRZ

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permeability based upon a sensitivity analysis (EPA 1998). The EPA also assigned a uniform distribution for the range of -19.4 to -12.5 based on the supposition that all the values are equally likely. The geometric dimensions of the DRZ are the same in the CCA and the PAVT. The DOE has adopted this revised range for the DRZ permeability (Hansen and Leigh 2003).

Parameter Data Entry Form ERMS: #522016

References:

Beauheim, R.L. 1996. "Salado Package #16, (X, Y, Z) DRZ Permeability." Revision 1. Records Package. Sandia National Laboratories. Albuquerque, NM. ERMS #232038.

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582

Howarth, S.M. 1996. "[Salado Package #13], Salado Anhydrite Permeability in the X-Direction." Records Package. Sandia National Laboratories. Albuquerque, NM. ERMS #230603.

Howarth, S.M., and Christain-Frear, T. 1996. Porosity, Single-Phase Permeability, and Capillary Pressure Data from Preliminary Laboratory Experiments on Selected Samples from Marker Bed 139 at the Waste Isolation Pilot Plant. SAND94-0472 (Draft). Sandia National Laboratories. Albuquerque, NM. ERMS #238367.

U.S. Environmental Protection Agency (EPA). 1998. Technical Support Document for Section 194.23:Parameter Justification Report. Docket No. A-93-02, V-B-14. U.S. Environmental Protection Agency. Washington, D.C.

Information Only

Parameter 65: Log of Intrinsic Permeability – Concrete Plug

Parameter Description:

This parameter represents the log of the intrinsic permeability of the concrete plug, at the surface of the repository and in the Rustler (see CCA Appendix PA Figure 4.2.1). It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Property Name(s):

CONC_PLG PRMX_LOG
CONC_PLG PRMY_LOG
CONC_PLG PRMZ_LOG

Computational Code: BRAGFLO

minimum	maximum
-19.00	-17.00

Units: Log (meters squared)

Distribution Type: Uniform

Data: Site-Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records package: Analysis Reports Relating to Analysis Plan AP-086 (Chavez, 2001), specifically Summary of parameter changes adopted from the Performance Assessment Verification Test for the Technical Baseline Migration (Hansen, 2002).

Discussion:

In preparation for the CCA, DOE developed a set of assumed plug configurations for boreholes drilled and abandoned in the future. Each assumed plug configuration involved several materials with varying degrees of integrity over the lifetime of the repository. One material used in the CCA PA borehole models was a concrete material. The DOE assumed that initially, the concrete plugs would be effective in limiting fluid flow in the borehole. However, for purposes of the CCA PA calculation, some plugs above the repository were assumed to degrade after 200 years of emplacement. From that point on, the borehole was assumed to be filled with a silty, sand-like material containing degraded concrete, corrosion products resulting from degradation of the casing, and material that sloughs off of the walls of the borehole.

In CCA Appendix PAR, borehole concrete permeability was set at a constant 5×10^{-17} m^2,

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based on results reported by Thompson et al. (1996). This value was directly measured for a concrete borehole plug at the WIPP site (Christensen and Hunter 1980).

Subsequent to the CCA PA calculations, EPA required the DOE to consider a range of values for the borehole concrete permeability (EPA 1998). The lower bound of the range chosen by EPA, – 1×10^{-19} m^2 – is more than two orders of magnitude lower than the lowest value measured for a WIPP borehole plug grout (5×10^{-17} m^2) as reported by Christensen and Hunter (1980). The EPA considered this to be a more conservative lower bound because a less permeable borehole plug may result in higher repository gas pressures and hence greater releases during a human intrusion event. The EPA chose an upper bound, 1×10^{-17} m^2, which was equal to the permeability of the concrete in the shaft seal systems. The EPA specified a uniform distribution over the permeability range (from 10^{-19} to 10^{-17}) (Froehlich 1997). The DOE has adopted this revised range for the borehole concrete permeability. (Hansen and Leigh 2003)

Parameter Data Entry Form ERMS: #522016

References:

Christensen, C.L. and Hunter, T.O. 1980. The Bell Canyon Test Results. SAND80-2414C. Sandia National Laboratories. Albuquerque, New Mexico.

Chavez, M. J. 2001. Analyisis Reports Relating to Analysis Plan AP-086, (Parameter Data Entry Forms). ERMS 520523. Sandia National Laboratories. Carlsbad, NM.

Hansen, C. W. 2002. Summary of Parameter changes Adopted from the Performance Assessment Verifiction Test for the Technical Baseline Migration (TBM). ERMS 522016. Sandia National Laboratories. Albuquerque, NM.

Froehlich, G. 1997. "PAV1 Parameter Values." Memorandum to C. Lattier. ERMS #246087. Sandia National Laboratories. Albuquerque, NM.

Hansen, C., Leigh, C. 2003. A Reconciliation of the CCA and PAVT Parameter Baselines, Rev. 3. Carlsbad, NM. Sandia National Laboratories. ERMS #528582

Thompson, T.W., Coons, W.E., Krumhansl, J.L., and Hansen, F.D. 1996. Inadvertent Intrusion Borehole Permeability. Final Draft. Sandia National Laboratories. Carlsbad, NM.

U.S. Environmental Protection Agency (EPA). 1998. Technical Support Document for Section 194.23:Parameter Justification Report. Docket No. A-93-02, V-B-14. U.S. Environmental Protection Agency. Washington, D.C. ERMS #525158.

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Parameter 66: Residual Brine Saturation – Upper Portion of Simplified Shaft

Parameter Description:

The residual brine saturation (S_{br}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves (see CCA Appendix PA, Figure 4.2.1). Referred to also as S_{wr} (wetting phase) or S_{lr} (liquid phase), residual brine saturation is the point reached under high gas saturation conditions when brine is no longer continuous throughout the pore network and relative brine permeability becomes zero.

Material and Property Name(s):

SHFTU SAT_RBRN

Computational Code: BRAGFLO

Value	0	0.20	0.60
Percentiles	0	.50	1

Units: None

Distribution Type: Cumulative

Data: General Literature Data

A discussion of the data associated with this parameter may be found in the following parameter records packages: CRA Parameter Package (Stein, 2003a) and Analysis Reports for AP-094 (Stein, 2003b).

Discussion:

The values sampled for the material SHFTU are assigned to the other shaft seal materials (SHFTL_T1, SHFTL_T2, and CONC_MON). These distributions are the same as were used for the material SALT_T1 in shaft seal model (James and Stein 2002, 2003).

A literature search was conducted to obtain residual liquid saturation values for consolidated geologic materials, concrete, and asphalt in support of the CCA. Residual liquid saturations for geologic materials were found in four references (Brooks and Corey 1964; Lappala et al. 1987; Parker et al. 1987; and Rawls et al. 1982). Brooks and Corey (1964) determined residual saturations for five unconsolidated samples based on measured values of liquid saturation as a function of capillary pressure. Lappala et al. (1987) determined residual moisture content for 11 soils by obtaining best fits to measured moisture content versus pressure head data using three models. The residual moisture contents determined for each soil using the three models were averaged and divided by the reported porosity to obtain a

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residual liquid saturation for each soil. Parker et al. (1987) fit their saturation-pressure relationship to observed data to obtain residual saturations for a sandy and clayey porous media. Residual water contents reported by Rawls et al. (1982) for 11 soil texture classes were divided by the reported porosity to obtain residual saturations.

Mayer et al. (1992) reported a residual liquid saturation for normal concrete of 0.30. Data regarding residual liquid saturations in asphalt materials were not found in the literature.

The literature values of residual liquid saturation for geologic materials and concrete fall within the range of 0.0 to 0.6 with all but two values falling within the range of 0.0 to 0.4. It was recommended that a value of 0.2 be used for the residual liquid saturation of all seal components.

Parameter Data Entry Form ERMS: #527670

References:

Brooks, R.H., and Corey, A.T. 1964. Hydraulic Properties of Porous Media. Hydrology Paper No. 3. Fort Collins, CO: Colorado State University.

James, S.J., and Stein, J. 2002. Analysis Plan for the Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment. AP-094. Carlsbad, NM: Sandia National Laboratories. ERMS #524958.

James, S.J., Stein, J. 2003. Analysis Report for: Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment, Rev. 1. January 23, 2003. Carlsbad, NM: Sandia National Laboratories. ERMS #525203.

Lappala, E.G., Healy, R.W., and Weeks, E.P. 1987. Documentation of Computer Program VS2D to Solve the Equations of Fluid Flow in Variably Saturated Porous Media. Water-Resources Investigations Report 83-4099. Denver, CO: U.S. Geological Survey. Tech Library books collection: PC173.4.P67L31987.

Mayer, G., Jacobs, F., and Wittmann, F.H. 1992. "Experimental Determination and Numerical Simulation of the Permeability of Cementitious Materials," Nuclear Engineering and Design. Vol. 138, no. 2, 171-177.

Parker, J.C., Lenhard, R.J., and Kuppusamy, T. 1987. "A Parametric Model for Constitutive Properties Governing Multiphase Flow in Porous Media," Water Resources Research. Vol. 23, no. 4, 618-624.

Rawls, W.J., Brakensiek, D.L., and Saxton, K.E. 1982. "Estimation of Soil Water Properties," Transactions of the ASAE. St. Joseph, MI: American Society of Agricultural Engineers. 1316-1328.

Stein, J. S. 2003a. CRA (Compliance Recertification Application) Parameter Package. ERMS

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526660. Sandia National Laboratories. Carlsbad, NM.

Stein, J. S. 2003b. Analysis Reports for AP-094. ERMS 525186. Sandia National Laboratories. Carlsbad, NM.

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Parameter 67: Residual Gas Saturation – Upper Portion Simplified Shaft

Parameter Description:

The residual (critical) gas saturation (S_{gr}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves (see CCA Appendix PA, Figure 4.2.1). S_{gr} corresponds to the degree of waste-generated gas saturation necessary to create an incipient interconnected pathway in porous material; a condition required for porous rock to be permeable to gas.

Material and Property Name(s):

SHFTU SAT_RGAS

Computational Code: BRAGFLO

minimum	maximum
0	0.40

Units: None

Distribution Type: Uniform

Data: General Literature Data

A discussion of the data associated with this parameter may be found in the following parameter records packages: CRA Parameter Package (Stein, 2003a) and Analysis Reports for AP-094 (Stein, 2003b).

Discussion:

The values sampled for the material SHFTU are assigned to the other shaft seal materials (SHFTL_T1, SHFTL_T2, and CONC_MON). These distributions are the same as were used for the material SALT_T1 in shaft seal model (James and Stein 2002; 2003).

A literature search was conducted to obtain residual saturation values for consolidated geologic materials, concrete, and asphalt in support of the CCA.

A single value of 0.18 was found for normal concrete (Mayer et al. 1992). Based on this value, a distribution was assumed for the seal components. The recommended value was 0.2, and the recommended range was 0.0 to 0.4 with a uniform distribution for all shaft seal materials.

Parameter Data Entry Form ERMS: #527671

Information Only

References:

James, S.J., and Stein, J. 2002. Analysis Plan for the Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment. AP-094. Carlsbad, NM: Sandia National Laboratories. ERMS #524958.

James, S.J., Stein, J. 2003. Analysis Report for: Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment, Rev. 1. January 23, 2003. Carlsbad, NM: Sandia National Laboratories. ERMS #525203.

Mayer, G., Jacobs, F., and Wittmann, F.H. 1992. "Experimental Determination and Numerical Simulation of the Permeability of Cementitious Materials," Nuclear Engineering and Design. Vol. 138, no. 2, 171-177.

Stein, J. S. 2003a. CRA (Compliance Recertification Application) Parameter Package. ERMS 526660. Sandia National Laboratories. Carlsbad, NM.

Stein, J. S. 2003b. Analysis Reports for AP-094. ERMS 525186. Sandia National Laboratories. Carlsbad, NM.

Information Only

Parameter 68: Log of Intrinsic Permeability – Upper Portion of Simplified Shaft

Parameter Description:

This parameter describes the permeability distribution for the shaft in the non-Salado formations (see CCA Appendix PA, Figure 4.2.1). It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Property Name(s):

SHFTU PRMX_LOG

Computational Code: BRAGFLO

Value	-20.5	-20.0	-19.5	-19.0	-18.5	-18.0	-17.5	-17.0	-16.5
Percentiles	0	0.03	0.11	0.24	0.43	0.65	0.89	0.99	1

Units: Log (meters squared)

Distribution Type: Cumulative

Data:

A discussion of the data associated with this parameter may be found in the following parameter records packages: CRA Parameter Package (Stein, 2003a) and Analysis Reports for AP-094 (Stein, 2003b).

Discussion:

The simplified shaft seal model (James and Stein 2002; 2003) was developed by combining the effects of the many different materials used in the baseline shaft seal model and representing these effects with fewer materials.

The permeability of the non-Salado portion of the simplified shaft was obtained by calculating the effective permeability of the materials above the Salado in the baseline shaft seal model (EARTH and CLAY_RUS). A cumulative distribution was fit to the resulting equivalent permeability data (James and Stein 2003).

Parameter Data Entry Form ERMS: #527656

References:

James, S.J., and Stein, J. 2002. Analysis Plan for the Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment. AP-094. Carlsbad, NM: Sandia National Laboratories. ERMS #524958.

Information Only

James, S.J., Stein, J. 2003. Analysis Report for: Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment, Rev. 1. January 23, 2003. Carlsbad, NM: Sandia National Laboratories. ERMS #525203.

Stein, J. S. 2003a. CRA (Compliance Recertification Application) Parameter Package. ERMS 526660. Sandia National Laboratories. Carlsbad, NM.

Stein, J. S. 2003b. Analysis Reports for AP-094. ERMS 525186. Sandia National Laboratories. Carlsbad, NM.

Information Only

Parameter 69: Log of Intrinsic Permeability – Lower Portion of Simplified Shaft (0-200 yrs)

Parameter Description:
This parameter describes the permeability distributions for the portion of the shaft in the Salado for the first 200 years of operation (see CCA Appendix PA, Figure 4.2.1). It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Property Name(s):

SHFTL_T1 PRMX_LOG

Computational Code: BRAGFLO

Value	-20.0	-19.5	-19.0	-18.5	-18.0	-17.5	-17.0	-16.5
Percentiles	0	0.01	0.10	0.31	0.64	0.87	0.99	1

Units: Log (meters squared)

Distribution Type: Cumulative

Data: Site- Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records packages: CRA Parameter Package (Stein, 2003a) and Analysis Reports for AP-094 (Stein, 2003b).

Discussion:

The simplified shaft seal model (James and Stein 2002; 2003) was developed by combining the effects of the many different materials used in the baseline shaft seal model and representing these effects with fewer materials.

An analysis of the equivalent permeability data from the baseline shaft model used in the CCA indicates that the distributions for 0–10, 10–25, and 25–50 years are nearly identical (with mean equivalent permeabilities decreasing by 5 and 42 percent at 10 and 25 years, respectively). After 50 years, permeability progressively decreases between time intervals 25–50, 50–100, 100–200, and 200–400 years (with mean equivalent permeabilities decreasing by 133 percent, 604 percent, and 2507 percent at 50, 100, and 200 years, respectively). The final change occurs at 400 years and results in a very slight increase in effective permeability (mean equivalent permeability increases by 31 percent) because of increases in concrete permeability assumed for the 400–10,000 year period.

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To capture the time-dependent behavior of the Salado composite material, there is a single permeability change at 200 years. A conservative choice for the distribution of the first 200 years is to average the distributions for the 0–10, 10–25, and 25–50 year intervals. Note that the 50–100 and 100–200 year intervals are not used. From 200 to 10,000 years, the distribution is defined as the average of the distributions from the baseline shaft seal model for the 200–400 and 400–10,000 year intervals. Because only the highest permeability data from the first 50 years is used to constrain the model for 200 years, this approach overestimates the permeability during the first 200 years and is thereby conservative. The permeability distributions can be implemented in PA by fitting a cumulative distribution to the data (James and Stein 2003).

Parameter Data Entry Form ERMS: #527672

References:

James, S.J., and Stein, J. 2002. Analysis Plan for the Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment. AP-094. Carlsbad, NM: Sandia National Laboratories. ERMS #524958.

James, S.J., Stein, J. 2003. Analysis Report for: Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment, Rev. 1. January 23, 2003. Carlsbad, NM: Sandia National Laboratories. ERMS #525203.

Stein, J. S. 2003a. CRA (Compliance Recertification Application) Parameter Package. ERMS 526660. Sandia National Laboratories. Carlsbad, NM.

Stein, J. S. 2003b. Analysis Reports for AP-094. ERMS 525186. Sandia National Laboratories. Carlsbad, NM.

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Parameter 70: Log of Intrinsic Permeability – Lower Portion of Simplified Shaft (200-10,000 yrs)

Parameter Description:

This parameter describes the permeability distributions for the portion of the shaft in the Salado for the 200 to 10,000 years of operation (see CCA Appendix PA, Figure 4.2.1). It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Property Name(s):

SHFTL_T2 PRMX_LOG

Computational Code: BRAGFLO

Value	-22.5	-22.0	-21.5	-21.0	-20.5	-20.0	-19.5	-19.0	-18.5	-18.0
Percentiles	0	0.02	0.08	0.17	0.31	0.53	0.70	0.87	0.97	1

Units: Log (meters squared)

Distribution Type: Cumulative

Data: Site- Specific Experimental Data

A discussion of the data associated with this parameter may be found in the following parameter records packages: CRA Parameter Package (Stein, 2003a) and Analysis Reports for AP-094 (Stein, 2003b).

Discussion:

The simplified shaft seal model (James and Stein 2002; 2003) was developed by combining the effects of the many different materials used in the baseline shaft seal model and representing these effects with fewer materials.

An analysis of the equivalent permeability data from the baseline shaft model used in the CCA indicates that the distributions for 0–10, 10–25, and 25–50 years are nearly identical (with mean equivalent permeabilities decreasing by 5 and 42 percent at 10 and 25 years, respectively). After 50 years, permeability progressively decreases between time intervals 25–50, 50–100, 100–200, and 200–400 years (with mean equivalent permeabilities decreasing by 133, 604, and 2507 percent at 50, 100, and 200 years, respectively). The final change occurs at 400 years and results in a very slight increase in effective permeability (mean equivalent permeability increases by 31 percent) because of increases in concrete permeability assumed for the 400–10,000 year period.

To capture the time-dependent behavior of the Salado composite material from 200 to 10,000

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years, the distribution is defined as the average of the distributions from the baseline shaft seal model for the 200–400 and 400–10,000 year intervals. Because only the highest permeability data from the first 50 years is used to constrain the model for 200 years, this approach overestimates the permeability during the first 200 years and is thereby conservative. The permeability distributions are implemented in PA by fitting a cumulative distribution to the data. (James and Stein 2003)

Parameter Data Entry Form ERMS: #527682

References:

James, S.J., and Stein, J. 2002. Analysis Plan for the Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment. AP-094. Carlsbad, NM: Sandia National Laboratories. ERMS #524958.

James, S.J., Stein, J. 2003. Analysis Report for: Development of a Simplified Shaft Seal Model for the WIPP Performance Assessment, Rev. 1. January 23, 2003. Carlsbad, NM: Sandia National Laboratories. ERMS #525203.

Stein, J. S. 2003a. CRA (Compliance Recertification Application) Parameter Package. ERMS 526660. Sandia National Laboratories. Carlsbad, NM.

Stein, J. S. 2003b. Analysis Reports for AP-094. ERMS 525186. Sandia National Laboratories. Carlsbad, NM.

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Parameter 71: Microbial Gas Generation Rates

Parameter Description:

This parameter defines microbial gas generation rates for the BRAGFLO model.

Material and Property Name(s):

WAS_AREA BIOGENFC

Computational Code: BRAGFLO

minimum	maximum
0	1

Units: None

Distribution Type: Uniform

Data: Analysis

This parameter is a multiplicative factor in determining the effective microbial-gas-generation rates . The parameter, WAS_AREA:BIOGENFC, was created with a uniform distribution from 0 to 1. (Nemer et al. 1005)

Discussion:

The conditions inside the WIPP are likely to be quite different from the conditions represented in experiemtns, which are designed to promote microbial growth. In the WIPP the following uncertanties may cause microbial action to be reduced from the observed in the experiments (Brush, 2004):

1. Whether microbes will survive for a significant fraction of the 10,000-year regulatory period
2. Whether sufficient H2O will be present
3. Whether sufficient quantities of biodegradable subsrtrates will be present
4. Whether sufficient electron acceptors will be present and available
5. Whether enough nutrients will be present and available

Due to these and other uncertanties an additional sampled parameter was added to these calculations. This additional parameter is a multiplicative factor in determining the effective microbial-gas-generation rates. For this analysis, a parameter BIOGENFC was created with a uniform distribution from 0 to 1. A uniform distribution was chosen to reflect the fact that we

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have no quantitative data on the effect of items 1-5 above on the probability of attaining the BNL gas generation rates. BIOGENFC was manually added to the MATSET output file as a property of the material, WAS_AREA. This is required so that the POSTLHS modeling step can use the parameter. BIOGENFC and its distribution (uniform from 0 to 1) were also manually substituted for a place-holder parameter. (Nemer et al. 1005)

Parameter Data Entry Form ERMS: #539565

References:

Nemer, Martin et al.. 2005. "Analysis Report for BRAGFLO Preliminary Modeling Results With New Gas Generation Rates Based Upon Recent Experimental Results." Carlsbad, NM. Sandia National Laboratories. ERMS #539437..

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Parameter 72: Blank Placeholder

Blank Placeholder – see description of Parameter 2

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Parameter 73: Blank Placeholder

Blank Placeholder – see description of Parameter 2

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Parameter 74: Blank Placeholder

Blank Placeholder – see description of Parameter 2

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Parameter 75: Blank Placeholder

Blank Placeholder – see description of Parameter 2

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Table 13. Borehole, Blowout and Drill Mud Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3470	BLOWOUT	Material for direct brine release calculations	GAS_MIN	Gas rate cut-off	Constant	mscf/day	1.00E+02
3250	BLOWOUT	Material for direct brine release calculations	HREPO	Height of repository at burial time in CUTTINGS model	Constant	m	3.96E+00
3471	BLOWOUT	Material for direct brine release calculations	MAXFLOW	Maximum blowout flow	Constant	s	3.888E+05
3472	BLOWOUT	Material for direct brine release calculations	MINFLOW	Minimum blowout flow	Constant	s	2.59E+05
3246	BLOWOUT	Material for direct brine release calculations	PARTDIA	Waste Particle Diameter in CUTTINGS Model	Log uniform	m	2.80E-03
3456	BLOWOUT	Material for direct brine release calculations	RE_CAST	External drainage radius for the Castile formation	Constant	m	1.14E+02
3253	BLOWOUT	Material for direct brine release calculations	RGAS	Gas Constant for Hydrogen	Constant	N*m/kg/K	4.12E+03
3247	BLOWOUT	Material for direct brine release calculations	RHOS	Waste Particle Density in CUTTINGS_S Model	Constant	kg/m^3	2.65E+03
3473	BLOWOUT	Material for direct brine release calculations	THCK_CAS	Thickness of the Castile Brine Reservoir	Constant	m	1.26E+02
3258	BLOWOUT	Material for direct brine release calculations	TREPO	Temperature of repository in CUTTINGS model	Constant	K	3.00E+02
23	BOREHOLE	Borehole and Fill	CAP_MOD	Model number, capillary pressure model	Constant	NONE	2.00E+00
3242	BOREHOLE	Borehole and Fill	COLDIA	Drill collar diameter in CUTTINGS model	Constant	m	2.03E-01
25	BOREHOLE	Borehole and Fill	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	2.64E-09
26	BOREHOLE	Borehole and Fill	DIAMMOD	Modern or current diameter	Constant	m	3.11E-01
27	BOREHOLE	Borehole and Fill	DOMEGA	Drill string angular velocity (0)	Cumulative	rad/s	7.8E+00
3122	BOREHOLE	Borehole and Fill	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3244	BOREHOLE	Borehole and Fill	L1	Drill collar length in CUTTINGS model	Constant	m	1.83E+02
29	BOREHOLE	Borehole and Fill	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3120	BOREHOLE	Borehole and Fill	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	5.60E-01
3121	BOREHOLE	Borehole and Fill	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.46E-01
3241	BOREHOLE	Borehole and Fill	PIPED	Drill pipe diameter in CUTTINGS model	Constant	m	1.14E-01

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Table 13. Borehole, Blowout and Drill Mud Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
32	BOREHOLE	Borehole and Fill	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
30	BOREHOLE	Borehole and Fill	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	9.40E-01
31	BOREHOLE	Borehole and Fill	POROSITY	Effective porosity	Constant	NONE	5.00E-02
34	BOREHOLE	Borehole and Fill	PRMX_LOG	Log of intrinsic permeability, X-direction	Normal	$log(m^2)$	-1.25E+01
35	BOREHOLE	Borehole and Fill	PRMY_LOG	Log of intrinsic permeability, Y-direction	Normal	$log(m^2)$	-1.25E+01
36	BOREHOLE	Borehole and Fill	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Normal	$log(m^2)$	-1.25E+01
40	BOREHOLE	Borehole and Fill	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
41	BOREHOLE	Borehole and Fill	SAT_RBRN	Residual Brine Saturation	Constant	NONE	2.00E-01
42	BOREHOLE	Borehole and Fill	SAT_RGAS	Residual Gas Saturation	Constant	NONE	2.00E-01
2254	BOREHOLE	Borehole and Fill	TAUFAIL	Effective shear strength for erosion (rfail)	Log uniform	Pa	1.96E+00
3414	BOREHOLE	Borehole and Fill	WUF	Unit of Waste	Constant	Curies	2.32E+00
171	DRILLMUD	Drilling Mud	DNSFLUID	Brine Density	Cumulative	kg/m^3	1.21E+03
172	DRILLMUD	Drilling Mud	VISCO	Viscosity	Cumulative	Pa*s	9.17E-03
173	DRILLMUD	Drilling Mud	YLDSTRSS	Yield Stress Point	Cumulative	Pa	4.40E+00

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Table 14. Borehole (Concrete Plug) Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3150	CONC_PLG	Concrete Plug, surface and Rustler	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
3148	CONC_PLG	Concrete Plug, surface and Rustler	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	3.80E-10
3156	CONC_PLG	Concrete Plug, surface and Rustler	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3151	CONC_PLG	Concrete Plug, surface and Rustler	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3157	CONC_PLG	Concrete Plug, surface and Rustler	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
3158	CONC_PLG	Concrete Plug, surface and Rustler	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
3155	CONC_PLG	Concrete Plug, surface and Rustler	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
3154	CONC_PLG	Concrete Plug, surface and Rustler	*PORE_DIS*	*Brooks-Corey pore distribution parameter*	*Constant*	NONE	9.40E-01
3147	CONC_PLG	Concrete Plug, surface and Rustler	POROSITY	Effective porosity	Constant	NONE	3.20E-01
3192	CONC_PLG	Concrete Plug, surface and Rustler	PRMY_LOG	Log of intrinsic permeability, Y-direction	Uniform	$log(m^2)$	-1.80E+01
3193	CONC_PLG	Concrete Plug, surface and Rustler	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Uniform	$log(m^2)$	-1.80E+01
3149	CONC_PLG	Concrete Plug, surface and Rustler	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
3152	CONC_PLG	Concrete Plug, surface and Rustler	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
3153	CONC_PLG	Concrete Plug, surface and Rustler	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00

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Table 15. Borehole (Open) Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3138	BH_OPEN	Borehole Unrestricted	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
3136	BH_OPEN	Borehole Unrestricted	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
3144	BH_OPEN	Borehole Unrestricted	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3139	BH_OPEN	Borehole Unrestricted	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3145	BH_OPEN	Borehole Unrestricted	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
3146	BH_OPEN	Borehole Unrestricted	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
3143	BH_OPEN	Borehole Unrestricted	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
3142	BH_OPEN	Borehole Unrestricted	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
3135	BH_OPEN	Borehole Unrestricted	POROSITY	Effective porosity	Constant	NONE	3.20E-01
3134	BH_OPEN	Borehole Unrestricted	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$log(m^2)$	-9.00E+00
3186	BH_OPEN	Borehole Unrestricted	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$log(m^2)$	-9.00E+00
3187	BH_OPEN	Borehole Unrestricted	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$log(m^2)$	-9.00E+00
3137	BH_OPEN	Borehole Unrestricted	RELP_MOD	Model number, relative permeability model	Constant	NONE	5.00E+00
3140	BH_OPEN	Borehole Unrestricted	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
3141	BH_OPEN	Borehole Unrestricted	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00

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Table 16. Borehole (Silty Sand) Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3162	BH_SAND	Borehole filled with silty sand	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
3160	BH_SAND	Borehole filled with silty sand	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
3168	BH_SAND	Borehole filled with silty sand	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3163	BH_SAND	Borehole filled with silty sand	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3169	BH_SAND	Borehole filled with silty sand	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
3170	BH_SAND	Borehole filled with silty sand	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
3167	BH_SAND	Borehole filled with silty sand	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
3166	BH_SAND	Borehole filled with silty sand	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	9.40E-01
3159	BH_SAND	Borehole filled with silty sand	POROSITY	Effective porosity	Constant	NONE	3.20E-01
3184	BH_SAND	Borehole filled with silty sand	PRMX_LOG	Log of intrinsic permeability, X-direction	Uniform	$\log(m^2)$	Sampled Value
3190	BH_SAND	Borehole filled with silty sand	PRMY_LOG	Log of intrinsic permeability, Y-direction	Uniform	$\log(m^2)$	Applied Value See BH_SAND PRMX_LOG
3191	BH_SAND	Borehole filled with silty sand	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Uniform	$\log(m^2)$	Applied Value See BH_SAND PRMX_LOG
3161	BH_SAND	Borehole filled with silty sand	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
3164	BH_SAND	Borehole filled with silty sand	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
3165	BH_SAND	Borehole filled with silty sand	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00

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Table 17. Borehole (Creep) Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3174	BH_CREEP	Creep Borehole Fill	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
3172	BH_CREEP	Creep Borehole Fill	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
3180	BH_CREEP	Creep Borehole Fill	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3175	BH_CREEP	Creep Borehole Fill	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3181	BH_CREEP	Creep Borehole Fill	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
3182	BH_CREEP	Creep Borehole Fill	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
3179	BH_CREEP	Creep Borehole Fill	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
3178	BH_CREEP	Creep Borehole Fill	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	9.40E-01
3171	BH_CREEP	Creep Borehole Fill	POROSITY	Effective porosity	Constant	NONE	3.20E-01
3183	BH_CREEP	Creep Borehole Fill	PRMX_LOG	Log of intrinsic permeability, X-direction	Uniform	$log(m^2)$	-1.35E+01
3188	BH_CREEP	Creep Borehole Fill	PRMY_LOG	Log of intrinsic permeability, Y-direction	Uniform	$log(m^2)$	-1.35E+01
3189	BH_CREEP	Creep Borehole Fill	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Uniform	$log(m^2)$	-1.35E+01
3173	BH_CREEP	Creep Borehole Fill	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
3176	BH_CREEP	Creep Borehole Fill	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
3177	BH_CREEP	Creep Borehole Fill	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00

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Table 18. DRSPALL Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3675	SPALLMOD	Material developed for DRSPALL	ANNUROUG	Absolute wall roughness of wellbore annulus	Constant	m	5.00E-05
3662	SPALLMOD	Material developed for DRSPALL	BIOTBETA	Biot's beta for waste	Constant	NONE	1.00E+00
3652	SPALLMOD	Material developed for DRSPALL	COHESION	Cohesion of waste	Constant	Pa	1.40E+05
3677	SPALLMOD	Material developed for DRSPALL	DDZPERM	Permeability of drilling-damaged zone (DDZ)	Constant	m2	1.00E-14
3659	SPALLMOD	Material developed for DRSPALL	DDZTHICK	Thickness of drilling-damaged zone (DDZ)	Constant	m	1.60E-01
3674	SPALLMOD	Material developed for DRSPALL	DRILRATE	Drill penetration rate through Salado	Constant	m/s	4.45E-03
3668	SPALLMOD	Material developed for DRSPALL	DRZPERM	DRZ Permeability for DRSPALL	Constant	m^2	1.00E-15
3654	SPALLMOD	Material developed for DRSPALL	FFSTRESS	Isotropic in-situ stress in waste area	Constant	Pa	1.49E+07
3657	SPALLMOD	Material developed for DRSPALL	FRICTANG	Friction angle of waste	Constant	deg	4.58E+01
3671	SPALLMOD	Material developed for DRSPALL	MUDPRATE	Typical volumetric mud pumping rate for drilling in Salado	Constant	(m3)/s	2.02E-02
3673	SPALLMOD	Material developed for DRSPALL	MUDSOLMX	Solids volume fraction in drill mud that causes choking of flow	Constant	NONE	6.15E-01
3670	SPALLMOD	Material developed for DRSPALL	MUDSOLVE	Exponent on mud slurry viscosity power law	Constant	NONE	-1.50E+00
3667	SPALLMOD	Material developed for DRSPALL	PARTDIAM	Particle diameter of disaggregated waste	Loguniform	m	1.00E-02
3660	SPALLMOD	Material developed for DRSPALL	PIPEID	Inner diameter of drill pipe (where OD = 0.1143 m)	Constant	m	9.72E-02
3663	SPALLMOD	Material developed for DRSPALL	PIPEROUG	Absolute wall roughness of drill pipe	Constant	m	5.00E-05
3672	SPALLMOD	Material developed for DRSPALL	POISRAT	Poisson's ratio for waste	Constant	NONE	3.80E-01
3651	SPALLMOD	Material developed for DRSPALL	REFPRS	Atmospheric pressure at sea level	Constant	Pa	1.02E+05
3666	SPALLMOD	Material developed for DRSPALL	REPIPERM	Waste permeability to gas local to intrusion borehole	Loguniform	m2	2.40E-13

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Table 18. DRSPALL Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3655	SPALLMOD	Material developed for DRSPALL	REPOSTOP	Elevation of roof in excavated area	Constant	m	3.85E+02
3664	SPALLMOD	Material developed for DRSPALL	SALTDENS	Density of solid cuttings from the Salado	Constant	kg/m3	2.18E+03
3669	SPALLMOD	Material developed for DRSPALL	SHAPEFAC	Shape factor for disaggregated waste particles	Constant	NONE	1.00E-01
3661	SPALLMOD	Material developed for DRSPALL	STPDVOLR	Mud ejection rate that turns off drilling	Constant	$(m^3)/s$	1.00E+03
3656	SPALLMOD	Material developed for DRSPALL	STPPVOLR	Mud ejection rate that turns off mud pump	Constant	$(m^3)/s$	1.00E+03
3658	SPALLMOD	Material developed for DRSPALL	SURFELEV	Elevation of land surface at WIPP site	Constant	m	1.04E+03
3676	SPALLMOD	Material developed for DRSPALL	TENSLSTR	Tensile strength of waste	Uniform	Pa	1.45E+05

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Table 19. Shaft Material Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3051	CONC_MON	Concrete Monolith	CAP_MOD	Model number, capillary pressure model	Constant	NONE	2.00E+00
3052	CONC_MON	Concrete Monolith	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	6.00E-11
3053	CONC_MON	Concrete Monolith	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3054	CONC_MON	Concrete Monolith	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3055	CONC_MON	Concrete Monolith	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	5.60E-01
3056	CONC_MON	Concrete Monolith	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.46E-01
3124	CONC_MON	Concrete Monolith	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
3057	CONC_MON	Concrete Monolith	PORE_DIS	Brooks-Corey pore distribution parameter	Cumulative	NONE	9.40E-01
3058	CONC_MON	Concrete Monolith	POROSITY	Effective porosity	Constant	NONE	5.00E-02
3059	CONC_MON	Concrete Monolith	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$\log(m^2)$	-1.40E+01
3060	CONC_MON	Concrete Monolith	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$\log(m^2)$	-1.40E+01
3061	CONC_MON	Concrete Monolith	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$\log(m^2)$	-1.40E+01
3062	CONC_MON	Concrete Monolith	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
3115	CONC_MON	Concrete Monolith	SAT_IBRN	Initial Brine Saturation	Constant	NONE	1.00E+00
3063	CONC_MON	Concrete Monolith	SAT_RBRN	Residual Brine Saturation	Cumulative	NONE	2.00E-01
3064	CONC_MON	Concrete Monolith	SAT_RGAS	Residual Gas Saturation	Uniform	NONE	2.00E-01
3562	SHFTL_T1	Lower portion of simplified shaft from 0 - 200 years	COMP_POR	Pore volume compressibility	Constant	Pa^{-1}	4.28E-09
3563	SHFTL_T1	Lower portion of simplified shaft from 0 - 200 years	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3564	SHFTL_T1	Lower portion of simplified shaft from 0 - 200 years	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3565	SHFTL_T1	Lower portion of simplified shaft from 0 - 200 years	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	5.60E-01
3566	SHFTL_T1	Lower portion of simplified shaft from 0 - 200 years	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.46E-01
3567	SHFTL_T1	Lower portion of simplified shaft from 0 - 200 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
3568	SHFTL_T1	Lower portion of simplified shaft from 0 - 200 years	POROSITY	Effective porosity	Constant	NONE	1.13E-01

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Table 19. Shaft Material Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3569	SHFTL_T1	Lower portion of simplified shaft from 0 - 200 years	PRMX_LOG	Log of intrinsic permeability, X-direction	Cumulative	log(m^2)	Sampled Value
3570	SHFTL_T1	Lower portion of simplified shaft from 0 - 200 years	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
3571	SHFTL_T1	Lower portion of simplified shaft from 0 - 200 years	SAT_IBRN	Initial Brine Saturation	Constant	NONE	5.34E-01
3572	SHFTL_T2	Lower portion of simplified shaft from 200 - 10,000 years	COMP_POR	Pore volume compressibility	Constant	Pa^{-1}	4.28E-09
3573	SHFTL_T2	Lower portion of simplified shaft from 200 - 10,000 years	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3574	SHFTL_T2	Lower portion of simplified shaft from 200 - 10,000 years	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3575	SHFTL_T2	Lower portion of simplified shaft from 200 - 10,000 years	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	5.60E-01
3576	SHFTL_T2	Lower portion of simplified shaft from 200 - 10,000 years	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.46E-01
3577	SHFTL_T2	Lower portion of simplified shaft from 200 - 10,000 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
3578	SHFTL_T2	Lower portion of simplified shaft from 200 - 10,000 years	POROSITY	Effective porosity	Constant	NONE	1.13E-01
3579	SHFTL_T2	Lower portion of simplified shaft from 200 - 10,000 years	PRMX_LOG	Log of intrinsic permeability, X-direction	Cumulative	log(m^2)	Sampled Value
3580	SHFTL_T2	Lower portion of simplified shaft from 200 - 10,000 years	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
3581	SHFTL_T2	Lower portion of simplified shaft from 200 - 10,000 years	SAT_IBRN	Initial Brine Saturation	Constant	NONE	5.34E-01
3550	SHFTU	Upper portion of simplified shaft	COMP_POR	Pore volume compressibility	Constant	Pa^{-1}	2.05E-08
3551	SHFTU	Upper portion of simplified shaft	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3552	SHFTU	Upper portion of simplified shaft	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3553	SHFTU	Upper portion of simplified shaft	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	5.60E-01
3554	SHFTU	Upper portion of simplified shaft	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.46E-01
3555	SHFTU	Upper portion of simplified shaft	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
3556	SHFTU	Upper portion of simplified shaft	POROSITY	Effective porosity	Constant	NONE	2.91E-01
3557	SHFTU	Upper portion of simplified shaft	PRMX_LOG	Log of intrinsic permeability, X-direction	Cumulative	log(m^2)	Sampled Value
3558	SHFTU	Upper portion of simplified shaft	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
3559	SHFTU	Upper portion of simplified shaft	SAT_IBRN	Initial Brine Saturation	Constant	NONE	7.96E-01
3560	SHFTU	Upper portion of simplified shaft	SAT_RBRN	Residual Brine Saturation	Cumulative	NONE	Sampled Value
3561	SHFTU	Upper portion of simplified shaft	SAT_RGAS	Residual Gas Saturation	Uniform	NONE	Sampled Value

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Table 20. Panel Closure Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3514	CONC_PCS	Concrete portion of PCS	CAP_MOD	Model number, capillary pressure model	Constant	NONE	2.00E+00
3515	CONC_PCS	Concrete portion of PCS	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	6.00E-11
3517	CONC_PCS	Concrete portion of PCS	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3518	CONC_PCS	Concrete portion of PCS	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3519	CONC_PCS	Concrete portion of PCS	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	5.60E-01
3520	CONC_PCS	Concrete portion of PCS	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.46E-01
3521	CONC_PCS	Concrete portion of PCS	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
3522	CONC_PCS	Concrete portion of PCS	PORE_DIS	Brooks-Corey pore distribution parameter	Cumulative	NONE	Sampled Value
3523	CONC_PCS	Concrete portion of PCS	POROSITY	Effective porosity	Constant	NONE	5.00E-02
3525	CONC_PCS	Concrete portion of PCS	PRMX_LOG	Log of intrinsic permeability, X-direction	Triangular	$\log(m^2)$	Sampled Value
3526	CONC_PCS	Concrete portion of PCS	PRMY_LOG	Log of intrinsic permeability, Y-direction	Triangular	$\log(m^2)$	Applied Value See CONC_PCS PRMX_LOG
3527	CONC_PCS	Concrete portion of PCS	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Triangular	$\log(m^2)$	Applied Value See CONC_PCS PRMX_LOG
3529	CONC_PCS	Concrete portion of PCS	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
3531	CONC_PCS	Concrete portion of PCS	SAT_RBRN	Residual Brine Saturation	Cumulative	NONE	Sampled Value
3532	CONC_PCS	Concrete portion of PCS	SAT_RGAS	Residual Gas Saturation	Uniform	NONE	Sampled Value
3533	DRZ_PCS	DRZ directly above concrete portion of panel closure	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
3534	DRZ_PCS	DRZ directly above concrete portion of panel closure	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	7.41E-10
3535	DRZ_PCS	DRZ directly above concrete portion of panel closure	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3536	DRZ_PCS	DRZ directly above concrete portion of panel closure	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3537	DRZ_PCS	DRZ directly above concrete portion of panel closure	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00

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Table 20. Panel Closure Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3538	DRZ_PCS	DRZ directly above concrete portion of panel closure	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
3539	DRZ_PCS	DRZ directly above concrete portion of panel closure	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
3540	DRZ_PCS	DRZ directly above concrete portion of panel closure	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
3541	DRZ_PCS	DRZ directly above concrete portion of panel closure	POROSITY	Effective porosity	Cumulative	NONE	1.29E-02
3542	DRZ_PCS	DRZ directly above concrete portion of panel closure	PRMX_LOG	Log of intrinsic permeability, X-direction	Triangular	$log(m^2)$	Sampled Value
3543	DRZ_PCS	DRZ directly above concrete portion of panel closure	PRMY_LOG	Log of intrinsic permeability, Y-direction	Triangular	$log(m^2)$	Applied Value See DRZ_PCS PRMX_LOG
3544	DRZ_PCS	DRZ directly above concrete portion of panel closure	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Triangular	$log(m^2)$	Applied Value See DRZ_PCS PRMX_LOG
3546	DRZ_PCS	DRZ directly above concrete portion of panel closure	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
3547	DRZ_PCS	DRZ directly above concrete portion of panel closure	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00

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Table 21. Santa Rosa Formation Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
336	SANTAROS	Santa Rosa Formation	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
337	SANTAROS	Santa Rosa Formation	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	1.00E-08
2768	SANTAROS	Santa Rosa Formation	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
339	SANTAROS	Santa Rosa Formation	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2769	SANTAROS	Santa Rosa Formation	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2770	SANTAROS	Santa Rosa Formation	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
342	SANTAROS	Santa Rosa Formation	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
340	SANTAROS	Santa Rosa Formation	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	6.44E-01
341	SANTAROS	Santa Rosa Formation	POROSITY	Effective porosity	Constant	NONE	1.75E-01
343	SANTAROS	Santa Rosa Formation	PRESSURE	Brine far-field pore pressure	Constant	Pa	1.01E+05
344	SANTAROS	Santa Rosa Formation	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$log(m^2)$	-1.00E+01
345	SANTAROS	Santa Rosa Formation	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$log(m^2)$	-1.00E+01
346	SANTAROS	Santa Rosa Formation	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$log(m^2)$	-1.00E+01
349	SANTAROS	Santa Rosa Formation	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
350	SANTAROS	Santa Rosa Formation	SAT_IBRN	Initial Brine Saturation	Constant	NONE	8.36E-02
351	SANTAROS	Santa Rosa Formation	SAT_RBRN	Residual Brine Saturation	Constant	NONE	8.36E-02
352	SANTAROS	Santa Rosa Formation	SAT_RGAS	Residual Gas Saturation	Constant	NONE	7.71E-02

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Table 22. Dewey Lake Formation

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
153	DEWYLAKE	Dewey Lake Red Beds	CAP_MOD	Model number, capillary pressure model	Constant	NONE	2.00E+00
154	DEWYLAKE	Dewey Lake Red Beds	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	1.00E-08
2696	DEWYLAKE	Dewey Lake Red Beds	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
156	DEWYLAKE	Dewey Lake Red Beds	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2697	DEWYLAKE	Dewey Lake Red Beds	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	2.60E-01
2698	DEWYLAKE	Dewey Lake Red Beds	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.48E-01
159	DEWYLAKE	Dewey Lake Red Beds	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
157	DEWYLAKE	Dewey Lake Red Beds	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	6.44E-01
158	DEWYLAKE	Dewey Lake Red Beds	POROSITY	Effective porosity	Student	NONE	1.43E-01
161	DEWYLAKE	Dewey Lake Red Beds	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$\log(m^2)$	-1.63E+01
162	DEWYLAKE	Dewey Lake Red Beds	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$\log(m^2)$	-1.63E+01
163	DEWYLAKE	Dewey Lake Red Beds	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$\log(m^2)$	-1.63E+01
166	DEWYLAKE	Dewey Lake Red Beds	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
167	DEWYLAKE	Dewey Lake Red Beds	SAL_USAT	Average saturation, unsaturated zones	Constant	NONE	8.36E-02
168	DEWYLAKE	Dewey Lake Red Beds	SAT_IBRN	Initial Brine Saturation	Constant	NONE	1.00E+00
169	DEWYLAKE	Dewey Lake Red Beds	SAT_RBRN	Residual Brine Saturation	Constant	NONE	8.36E-02
170	DEWYLAKE	Dewey Lake Red Beds	SAT_RGAS	Residual Gas Saturation	Constant	NONE	7.71E-02

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Table 23. Forty-Niner Member of the Rustler Formation Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
2085	FORTYNIN	Forty Niner Member	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
2238	FORTYNIN	Forty Niner Member	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
2715	FORTYNIN	Forty Niner Member	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
2239	FORTYNIN	Forty Niner Member	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2716	FORTYNIN	Forty Niner Member	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2717	FORTYNIN	Forty Niner Member	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
2718	FORTYNIN	Forty Niner Member	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
2087	FORTYNIN	Forty Niner Member	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
2088	FORTYNIN	Forty Niner Member	POROSITY	Effective porosity	Student	NONE	8.20E-02
2899	FORTYNIN	Forty Niner Member	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$\log(m^2)$	-3.50E+01
2900	FORTYNIN	Forty Niner Member	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$\log(m^2)$	-3.50E+01
2901	FORTYNIN	Forty Niner Member	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$\log(m^2)$	-3.50E+01
2093	FORTYNIN	Forty Niner Member	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
2240	FORTYNIN	Forty Niner Member	SAT_RBRN	Residual Brine Saturation	Constant	NONE	2.00E-01
2094	FORTYNIN	Forty Niner Member	SAT_RGAS	Residual Gas Saturation	Constant	NONE	2.00E-01

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Table 24. Magenta Member of the Rustler Formation Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
2097	MAGENTA	Magenta Member	CAP_MOD	Model number, capillary pressure model	Constant	NONE	2.00E+00
3016	MAGENTA	Magenta Member	COMP_RCK	Bulk Compressibility	Student	Pa^{-1}	2.64E-10
2725	MAGENTA	Magenta Member	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
2098	MAGENTA	Magenta Member	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2726	MAGENTA	Magenta Member	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	2.60E-01
2727	MAGENTA	Magenta Member	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.48E-01
2728	MAGENTA	Magenta Member	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
2099	MAGENTA	Magenta Member	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	6.44E-01
2100	MAGENTA	Magenta Member	POROSITY	Effective porosity	Student	NONE	1.38E-01
2101	MAGENTA	Magenta Member	PRESSURE	Brine far-field pore pressure	Constant	Pa	9.47E+05
2102	MAGENTA	Magenta Member	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$\log(m^2)$	-1.52E+01
2103	MAGENTA	Magenta Member	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$\log(m^2)$	-1.52E+01
2104	MAGENTA	Magenta Member	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$\log(m^2)$	-1.52E+01
2106	MAGENTA	Magenta Member	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
2241	MAGENTA	Magenta Member	SAT_RBRN	Residual Brine Saturation	Constant	NONE	8.36E-02
2107	MAGENTA	Magenta Member	SAT_RGAS	Residual Gas Saturation	Constant	NONE	7.71E-02

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Table 25. Tamarisk Member of the Rustler Formation Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
2183	TAMARISK	Tamarisk Member	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
2243	TAMARISK	Tamarisk Member	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
2793	TAMARISK	Tamarisk Member	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
2244	TAMARISK	Tamarisk Member	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2794	TAMARISK	Tamarisk Member	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2795	TAMARISK	Tamarisk Member	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
2796	TAMARISK	Tamarisk Member	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
2185	TAMARISK	Tamarisk Member	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
2186	TAMARISK	Tamarisk Member	POROSITY	Effective porosity	Student	NONE	6.40E-02
2914	TAMARISK	Tamarisk Member	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$\log(m^2)$	-3.50E+01
2915	TAMARISK	Tamarisk Member	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$\log(m^2)$	-3.50E+01
2916	TAMARISK	Tamarisk Member	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$\log(m^2)$	-3.50E+01
2191	TAMARISK	Tamarisk Member	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
2245	TAMARISK	Tamarisk Member	SAT_RBRN	Residual Brine Saturation	Constant	NONE	2.00E-01
2192	TAMARISK	Tamarisk Member	SAT_RGAS	Residual Gas Saturation	Constant	NONE	2.00E-01

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Table 26. Culebra Member of the Rustler Formation Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3487	CULEBRA	Culebra member of the Rustler formation	APOROS	Culebra Advective Porosity	Log uniform	NONE	Sampled Value
119	CULEBRA	Culebra member of the Rustler formation	CAP_MOD	Model number, capillary pressure model	Constant	NONE	2.00E+00
120	CULEBRA	Culebra member of the Rustler formation	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	1.00E-10
3483	CULEBRA	Culebra member of the Rustler formation	DISP_L	Longitudinal dispersivity	Constant	m	0.00E+00
3484	CULEBRA	Culebra member of the Rustler formation	DISPT_L	Transverse dispersivity	Constant	m	0.00E+00
843	CULEBRA	Culebra member of the Rustler formation	DNSGRAIN	Material Grain Density	Constant	kg/m^3	2.82E+03
3486	CULEBRA	Culebra member of the Rustler formation	DPOROS	Diffusive Porosity for Culebra Dolomite	Cumulative	NONE	Sampled Value
3474	CULEBRA	Culebra member of the Rustler formation	DTORT	Diffusive Tortuosity	Constant	NONE	1.10E-01
861	CULEBRA	Culebra member of the Rustler formation	FTORT	Fracture Tortuosity	Constant	NONE	1.00E+00
3485	CULEBRA	Culebra member of the Rustler formation	HMBLKLT	Culebra Half Matrix-Block Length	Uniform	m	Sampled Value
2691	CULEBRA	Culebra member of the Rustler formation	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
3419	CULEBRA	Culebra member of the Rustler formation	MINP_FAC	Mining Transmissivity Multiplier	Uniform	NONE	Sampled Value
137	CULEBRA	Culebra member of the Rustler formation	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2692	CULEBRA	Culebra member of the Rustler formation	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	2.60E-01
2693	CULEBRA	Culebra member of the Rustler formation	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.48E-01
141	CULEBRA	Culebra member of the Rustler formation	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
139	CULEBRA	Culebra member of the Rustler formation	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	6.44E-01

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Table 26. Culebra Member of the Rustler Formation Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
140	CULEBRA	Culebra member of the Rustler formation	POROSITY	Effective porosity	Constant	NONE	1.51E-01
142	CULEBRA	Culebra member of the Rustler formation	PRESSURE	Brine far-field pore pressure	Constant	Pa	9.14E+05
143	CULEBRA	Culebra member of the Rustler formation	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	log(m^2)	-1.31E+01
144	CULEBRA	Culebra member of the Rustler formation	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	log(m^2)	-1.31E+01
145	CULEBRA	Culebra member of the Rustler formation	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	log(m^2)	-1.31E+01
148	CULEBRA	Culebra member of the Rustler formation	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
149	CULEBRA	Culebra member of the Rustler formation	SAT_IBRN	Initial Brine Saturation	Constant	NONE	1.00E+00
150	CULEBRA	Culebra member of the Rustler formation	SAT_RBRN	Residual Brine Saturation	Constant	NONE	8.36E-02
151	CULEBRA	Culebra member of the Rustler formation	SAT_RGAS	Residual Gas Saturation	Constant	NONE	7.71E-02
3469	CULEBRA	Culebra member of the Rustler formation	SKIN_RES	Skin Resistance	Constant	NONE	0.00E+00

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Table 27. Los Medanos (Unnamed Lower) Member of the Rustler Formation Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
2217	UNNAMED	Unnamed Lower Member of Rustler Formation	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
2218	UNNAMED	Unnamed Lower Member of Rustler Formation	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
2799	UNNAMED	Unnamed Lower Member of Rustler Formation	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
2247	UNNAMED	Unnamed Lower Member of Rustler Formation	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2800	UNNAMED	Unnamed Lower Member of Rustler Formation	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2801	UNNAMED	Unnamed Lower Member of Rustler Formation	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
2802	UNNAMED	Unnamed Lower Member of Rustler Formation	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
2219	UNNAMED	Unnamed Lower Member of Rustler Formation	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
2220	UNNAMED	Unnamed Lower Member of Rustler Formation	POROSITY	Effective porosity	Student	NONE	1.81E-01
2911	UNNAMED	Unnamed Lower Member of Rustler Formation	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$log(m^2)$	-3.50E+01
2912	UNNAMED	Unnamed Lower Member of Rustler Formation	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$log(m^2)$	-3.50E+01
2913	UNNAMED	Unnamed Lower Member of Rustler Formation	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$log(m^2)$	-3.50E+01
2225	UNNAMED	Unnamed Lower Member of Rustler Formation	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
2248	UNNAMED	Unnamed Lower Member of Rustler Formation	SAT_RBRN	Residual Brine Saturation	Constant	NONE	2.00E-01
2226	UNNAMED	Unnamed Lower Member of Rustler Formation	SAT_RGAS	Residual Gas Saturation	Constant	NONE	2.00E-01

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Table 28. Salado Formation – Intact Halite – Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
540	S_HALITE	Salado halite, intact	CAP_MOD	Model number, capillary pressure model	Constant	NONE	2.00E+00
541	S_HALITE	Salado halite, intact	COMP_RCK	Bulk Compressibility	Uniform	Pa^{-1}	Sampled Value
2778	S_HALITE	Salado halite, intact	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
542	S_HALITE	Salado halite, intact	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2779	S_HALITE	Salado halite, intact	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	5.60E-01
2780	S_HALITE	Salado halite, intact	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.46E-01
545	S_HALITE	Salado halite, intact	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
543	S_HALITE	Salado halite, intact	PORE_DIS	Brooks-Corey pore distribution parameter	Cumulative	NONE	7.00E-01
544	S_HALITE	Salado halite, intact	POROSITY	Effective porosity	Cumulative	NONE	Sampled Value
546	S_HALITE	Salado halite, intact	PRESSURE	Brine far-field pore pressure	Uniform	Pa	Sampled Value
547	S_HALITE	Salado halite, intact	PRMX_LOG	Log of intrinsic permeability, X-direction	Uniform	$\log(m^2)$	Sampled Value
548	S_HALITE	Salado halite, intact	PRMY_LOG	Log of intrinsic permeability, Y-direction	Uniform	$\log(m^2)$	Applied Value See S_HALITE PRMX_LOG
549	S_HALITE	Salado halite, intact	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Uniform	$\log(m^2)$	Applied Value See S_HALITE PRMX_LOG
553	S_HALITE	Salado halite, intact	RELP_MOD	Model number, relative permeability model	Delta	NONE	4.00E+00
555	S_HALITE	Salado halite, intact	SAT_RBRN	Residual Brine Saturation	Uniform	NONE	3.00E-01
556	S_HALITE	Salado halite, intact	SAT_RGAS	Residual Gas Saturation	Uniform	NONE	2.00E-01

Table 29. Salado Formation – Brine – Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
48	BRINESAL	Salado Brine	COMPRES	Brine Compressibility	Constant	Pa^{-1}	3.10E-10
49	BRINESAL	Salado Brine	DNSFLUID	Brine Density	Constant	kg/m^3	1.22E+03
50	BRINESAL	Salado Brine	REF_PRES	Reference pressure for porosity	Constant	Pa	1.01E+05
51	BRINESAL	Salado Brine	REF_TEMP	Reference Temperature	Constant	K	3.00E+02
55	BRINESAL	Salado Brine	VISCO	Viscosity	Constant	Pa*s	2.10E-03
57	BRINESAL	Salado Brine	WTF	Mass fraction of salt in brine	Student	NONE	3.24E-01

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Table 30. Salado Formation – Marker Bed 138 – Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
559	S_MB138	Salado marker bed 138, intact and fractured	CAP_MOD	Model number, capillary pressure model	Constant	NONE	2.00E+00
560	S_MB138	Salado marker bed 138, intact and fractured	COMP_RCK	Bulk Compressibility	Student	Pa^{-1}	2.23E-11
2169	S_MB138	Salado marker bed 138, intact and fractured	DPHIMAX	Incremental increase in porosity relative to intact conditions	Constant	NONE	3.90E-02
2810	S_MB138	Salado marker bed 138, intact and fractured	IFRX	Index for fracture perm. enhancement in X-direction	Constant	NONE	1.00E+00
2813	S_MB138	Salado marker bed 138, intact and fractured	IFRY	Index for fracture perm. enhancement in Y-direction	Constant	NONE	1.00E+00
2816	S_MB138	Salado marker bed 138, intact and fractured	IFRZ	Index for fracture perm. enhancement in Z-direction	Constant	NONE	0.00E+00
2170	S_MB138	Salado marker bed 138, intact and fractured	KMAXLOG	Log of Maximum Permeability in Altered Anhydrite Flow Model Anhydrites	Constant	$\log(m^2)$	-9.00E+00
2783	S_MB138	Salado marker bed 138, intact and fractured	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
561	S_MB138	Salado marker bed 138, intact and fractured	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2784	S_MB138	Salado marker bed 138, intact and fractured	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	2.60E-01
2785	S_MB138	Salado marker bed 138, intact and fractured	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.48E-01
563	S_MB138	Salado marker bed 138, intact and fractured	PF_DELTA	Incremental pressure for full fracture development	Constant	Pa	3.80E+06
565	S_MB138	Salado marker bed 138, intact and fractured	PI_DELTA	Fracture initiation pressure increment	Constant	Pa	2.00E+05
568	S_MB138	Salado marker bed 138, intact and fractured	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
566	S_MB138	Salado marker bed 138, intact and fractured	PORE_DIS	Brooks-Corey pore distribution parameter	Student	NONE	6.44E-01
567	S_MB138	Salado marker bed 138, intact and fractured	POROSITY	Effective porosity	Student	NONE	1.10E-02
570	S_MB138	Salado marker bed 138, intact and fractured	PRMX_LOG	Log of intrinsic permeability, X-direction	Student	$\log(m^2)$	-1.89E+01
571	S_MB138	Salado marker bed 138, intact and fractured	PRMY_LOG	Log of intrinsic permeability, Y-direction	Student	$\log(m^2)$	-1.89E+01

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Table 30. Salado Formation – Marker Bed 138 – Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
572	S_MB138	Salado marker bed 138, intact and fractured	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Student	$\log(m^2)$	-1.89E+01
575	S_MB138	Salado marker bed 138, intact and fractured	RELP_MOD	Model number, relative permeability model	Delta	NONE	4.00E+00
577	S_MB138	Salado marker bed 138, intact and fractured	SAT_RBRN	Residual Brine Saturation	Student	NONE	8.36E-02
578	S_MB138	Salado marker bed 138, intact and fractured	SAT_RGAS	Residual Gas Saturation	Student	NONE	5.495E-02
580	S_MB139	Salado marker bed 139, intact and fractured	COMP_RCK	Bulk Compressibility	Student	Pa^{-1}	Sampled Value

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Table 31. Salado Formation – Marker Bed 139 – Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3185	CONC_PLG	Concrete Plug, surface and Rustler	PRMX_LOG	Log of intrinsic permeability, X-direction	Uniform	log(m^2)	-1.8E+01
2905	S_MB139	Salado marker bed 139, intact and fractured	BKLINK	Klinkenberg B Correction Parameters for H2 gas	Constant	Pa	2.71E-01
579	S_MB139	Salado marker bed 139, intact and fractured	CAP_MOD	Model number, capillary pressure model	Constant	NONE	2.00E+00
2177	S_MB139	Salado marker bed 139, intact and fractured	DPHIMAX	Incremental increase in porosity relative to intact conditions	Constant	NONE	3.90E-02
2903	S_MB139	Salado marker bed 139, intact and fractured	EXPKLINK	Klinkenberg b correction parameters for H2 gas	Constant	NONE	-3.41E-01
2811	S_MB139	Salado marker bed 139, intact and fractured	IFRX	Index for fracture perm. enhancement in X-direction	Constant	NONE	1.00E+00
2814	S_MB139	Salado marker bed 139, intact and fractured	IFRY	Index for fracture perm. enhancement in Y-direction	Constant	NONE	1.00E+00
2817	S_MB139	Salado marker bed 139, intact and fractured	IFRZ	Index for fracture perm. enhancement in Z-direction	Constant	NONE	0.00E+00
2178	S_MB139	Salado marker bed 139, intact and fractured	KMAXLOG	Log of Maximum Permeability in Altered Anhydrite Flow Model Anhydrites	Constant	log(m^2)	-9.00E+00
2788	S_MB139	Salado marker bed 139, intact and fractured	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
582	S_MB139	Salado marker bed 139, intact and fractured	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2789	S_MB139	Salado marker bed 139, intact and fractured	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	2.60E-01
2790	S_MB139	Salado marker bed 139, intact and fractured	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.48E-01
2180	S_MB139	Salado marker bed 139, intact and fractured	PF_DELTA	Incremental pressure for full fracture development	Constant	Pa	3.80E+06
586	S_MB139	Salado marker bed 139, intact and fractured	PI_DELTA	Fracture initiation pressure increment	Constant	Pa	2.00E+05
589	S_MB139	Salado marker bed 139, intact and fractured	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
587	S_MB139	Salado marker bed 139, intact and fractured	PORE_DIS	Brooks-Corey pore distribution parameter	Student	NONE	6.436E-01
588	S_MB139	Salado marker bed 139, intact and fractured	POROSITY	Effective porosity	Student	NONE	1.10E-02

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Table 31. Salado Formation – Marker Bed 139 – Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
591	S_MB139	Salado marker bed 139, intact and fractured	PRMX_LOG	Log of intrinsic permeability, X-direction	Student	log(m^2)	-1.889E+01
592	S_MB139	Salado marker bed 139, intact and fractured	PRMY_LOG	Log of intrinsic permeability, Y-direction	Student	log(m^2)	-1.89E+01
593	S_MB139	Salado marker bed 139, intact and fractured	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Student	log(m^2)	-1.89E+01
596	S_MB139	Salado marker bed 139, intact and fractured	RELP_MOD	Model number, relative permeability model	Delta	NONE	4.0E+00
598	S_MB139	Salado marker bed 139, intact and fractured	SAT_RBRN	Residual Brine Saturation	Student	NONE	8.362E-02
599	S_MB139	Salado marker bed 139, intact and fractured	SAT_RGAS	Residual Gas Saturation	Student	NONE	5.495E-02

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Table 32. Salado Formation – Anhydrite a and b, Intact and Fractured – Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
520	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	CAP_MOD	Model number, capillary pressure model	Constant	NONE	2.00E+00
521	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	COMP_RCK	Bulk Compressibility	Student	Pa^{-1}	2.23E-11
2158	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	DPHIMAX	Incremental increase in porosity relative to intact conditions	Constant	NONE	2.39E-01
2812	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	IFRX	Index for fracture perm. enhancement in X-direction	Constant	NONE	1.00E+00
2815	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	IFRY	Index for fracture perm. enhancement in Y-direction	Constant	NONE	1.00E+00
2818	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	IFRZ	Index for fracture perm. enhancement in Z-direction	Constant	NONE	0.00E+00
2159	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	KMAXLOG	Log of Maximum Permeability in Altered Anhydrite Flow Model Anhydrites	Constant	$\log(m^2)$	-9.00E+00
2773	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
522	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2774	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	2.60E-01
2775	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.48E-01
524	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	PF_DELTA	Incremental pressure for full fracture development	Constant	Pa	3.80E+06
526	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	PI_DELTA	Fracture initiation pressure increment	Constant	Pa	2.00E+05
529	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
527	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	PORE_DIS	Brooks-Corey pore distribution parameter	Student	NONE	6.44E-01
528	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	POROSITY	Effective porosity	Student	NONE	1.10E-02
531	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	PRMX_LOG	Log of intrinsic permeability, X-direction	Student	$\log(m^2)$	-1.89E+01
532	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	PRMY_LOG	Log of intrinsic permeability, Y-direction	Student	$\log(m^2)$	-1.89E+01

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Table 32. Salado Formation – Anhydrite a and b, Intact and Fractured – Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
533	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Student	$\log(m^2)$	-1.89E+01
536	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	RELP_MOD	Model number, relative permeability model	Delta	NONE	4.00E+00
538	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	SAT_RBRN	Residual Brine Saturation	Student	NONE	8.36E-02
539	S_ANH_AB	Salado anhydrite beds A and B, intact and fracture	SAT_RGAS	Residual Gas Saturation	Student	NONE	5.495E-02

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Table 33. Disturbed Rock Zone Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
174	DRZ_0	Disturbed rock zone; time period -5 to 0 years	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
175	DRZ_0	Disturbed rock zone; time period -5 to 0 years	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	7.41E-10
2701	DRZ_0	Disturbed rock zone; time period -5 to 0 years	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
176	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2702	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2703	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
179	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
177	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
178	DRZ_0	Disturbed rock zone; time period -5 to 0 years	POROSITY	Effective porosity	Cumulative	NONE	1.29E-02
181	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$\log(m^2)$	-1.70E+01
182	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$\log(m^2)$	-1.70E+01
183	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$\log(m^2)$	-1.70E+01
186	DRZ_0	Disturbed rock zone; time period -5 to 0 years	RELP_MOD	Model number, relative permeability model	Delta	NONE	4.00E+00
188	DRZ_0	Disturbed rock zone; time period -5 to 0 years	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
189	DRZ_0	Disturbed rock zone; time period -5 to 0 years	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00
190	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
191	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	7.41E-10
3116	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00

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Table 33. Disturbed Rock Zone Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
193	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
3128	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
3129	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
196	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
194	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
195	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	POROSITY	Effective porosity	Cumulative	NONE	1.29E-02
198	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	PRMX_LOG	Log of intrinsic permeability, X-direction	Uniform	$\log(m^2)$	Sampled Value
199	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	Uniform	$\log(m^2)$	Applied Value See DRZ-1 PRMX_LOG
200	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Uniform	$\log(m^2)$	Applied Value See DRZ_1 PRMX_LOG
203	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	RELP_MOD	Model number, relative permeability model	Delta	NONE	4.00E+00
205	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
206	DRZ_1	Disturbed rock zone; time period 0 to 10,000 years	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00

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Table 34. Waste Area and Waste Material Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
651	WAS_AREA	Waste emplacement area and waste	ABSROUGH	Absolute roughness of material	Uniform	m	2.50E-02
652	WAS_AREA	Waste emplacement area and waste	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
653	WAS_AREA	Waste emplacement area and waste	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
2041	WAS_AREA	Waste emplacement area and waste	DCELLCHW	Average density of cellulosics in CH waste	Constant	kg/m^3	6.00E+01
2274	WAS_AREA	Waste emplacement area and waste	DCELLRHW	Average density of cellulosics in RH waste	Constant	kg/m^3	9.30E+00
1992	WAS_AREA	Waste emplacement area and waste	DIRNCCHW	Bulk density of iron containers, CH waste	Constant	kg/m^3	1.70E+02
1993	WAS_AREA	Waste emplacement area and waste	DIRNCRHW	Bulk density of iron containers, RH waste	Constant	kg/m^3	5.40E+02
2040	WAS_AREA	Waste emplacement area and waste	DIRONCHW	Average density of iron-based material in CH waste	Constant	kg/m^3	1.10E+02
2044	WAS_AREA	Waste emplacement area and waste	DIRONRHW	Average density of iron-based material in RH waste	Constant	kg/m^3	5.90E+01
2043	WAS_AREA	Waste emplacement area and waste	DPLASCHW	Average density of plastics in CH waste	Constant	kg/m^3	4.30E+01
2275	WAS_AREA	Waste emplacement area and waste	DPLASRHW	Average density of plastics in CH waste	Constant	kg/m^3	8.00E+00
1995	WAS_AREA	Waste emplacement area and waste	DPLSCCHW	Bulk density of plastic liners, CH waste	Constant	kg/m^3	1.70E+01
2228	WAS_AREA	Waste emplacement area and waste	DPLSCRHW	Bulk density of plastic liners, RH waste	Constant	kg/m^3	3.10E+00
2042	WAS_AREA	Waste emplacement area and waste	DRUBBCHW	Average density of rubber in CH waste	Constant	kg/m^3	1.30E+01
2046	WAS_AREA	Waste emplacement area and waste	DRUBBRHW	Average density of rubber in RH waste	Constant	kg/m^3	6.70E+00
2804	WAS_AREA	Waste emplacement area and waste	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
658	WAS_AREA	Waste emplacement area and waste	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2805	WAS_AREA	Waste emplacement area and waste	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00

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Table 34. Waste Area and Waste Material Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
2806	WAS_AREA	Waste emplacement area and waste	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
661	WAS_AREA	Waste emplacement area and waste	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
659	WAS_AREA	Waste emplacement area and waste	PORE_DIS	Brooks-Corey pore distribution parameter	Cumulative	NONE	2.89E+00
660	WAS_AREA	Waste emplacement area and waste	POROSITY	Effective porosity	Constant	NONE	8.48E-01
663	WAS_AREA	Waste emplacement area and waste	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$log(m^2)$	-1.26E+01
664	WAS_AREA	Waste emplacement area and waste	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$log(m^2)$	-1.26E+01
665	WAS_AREA	Waste emplacement area and waste	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$log(m^2)$	-1.26E+01
2823	WAS_AREA	Waste emplacement area and waste	PROBDEG	Probability of plastics and rubber biodegradation in event of microbial gas generation	Delta	NONE	1.25E+00
3549	WAS_AREA	Waste emplacement area and waste	PTHRESH	Capillary threshold displacement pressure	Constant	Pa	8.00E+06
668	WAS_AREA	Waste emplacement area and waste	RELP_MOD	Model number, relative permeability model	Constant	NONE	1.20E+01
669	WAS_AREA	Waste emplacement area and waste	SAT_IBRN	Initial Brine Saturation	Constant	NONE	1.50E-02
670	WAS_AREA	Waste emplacement area and waste	SAT_RBRN	Residual Brine Saturation	Uniform	NONE	2.76E-01
671	WAS_AREA	Waste emplacement area and waste	SAT_RGAS	Residual Gas Saturation	Uniform	NONE	7.5E-02
2231	WAS_AREA	Waste emplacement area and waste	SAT_WICK	Index for computing wicking	Uniform	NONE	5.0E-01e
2232	WAS_AREA	Waste emplacement area and waste	VOLCHW	BIR total volume of CH waste	Constant	m^3	1.69E+05
2233	WAS_AREA	Waste emplacement area and waste	VOLRHW	BIR total volume of RH waste	Constant	m^3	7.08E+03

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Table 35. Waste Chemistry Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3447	AM	Americium	CAPMIC	Maximum Concentration of Actinide on Microbe Colloids	Constant	moles/liter	1.00E+00
3310	AM	Americium	CONCINT	Actinide Concentration with Mobile Actinide Intrinsic Colloids	Constant	moles/liter	0.00E+00
3441	AM	Americium	CONCMIN	Actinide Concentration with Mobile Mineral Fragment Colloids	Constant	moles/liter	2.60E-08
3311	AM	Americium	PROPMIC	Moles of Actinide Mobilized on Microbe Colloids per Moles Dissolved	Constant	NONE	3.60E+00
3444	AM+3	Americium III	MD0	Molecular diffusion in pure fluid	Constant	m^2/s	3.00E-10
3482	AM+3	Americium III	MKD_AM	Matrix Partition Coefficient for Americium	Log uniform	m^3/kg	Sampled Value
3458	NP	Neptunium	CAPHUM	Maximum Concentration of Actinide with Mobile Humic Colloids	Constant	moles/liter	1.10E-05
3313	NP	Neptunium	CAPMIC	Maximum Concentration of Actinide on Microbe Colloids	Constant	moles/liter	2.70E-03
3312	NP	Neptunium	CONCINT	Actinide Concentration with Mobile Actinide Intrinsic Colloids	Constant	moles/liter	0.00E+00
3439	NP	Neptunium	CONCMIN	Actinide Concentration with Mobile Mineral Fragment Colloids	Constant	moles/liter	2.60E-08
3314	NP	Neptunium	PROPMIC	Moles of Actinide Mobilized on Microbe Colloids per Moles Dissolved	Constant	NONE	1.20E+01
3429	PHUMOX3	Proportionality Constant, +3 State, Humic Colloids	PHUMCIM	Proportionality Const., Humic Colloids, Castile Brine, MgO controls pH	Cumulative	NONE	Sampled Value
3433	PHUMOX3	Proportionality Constant, +3 State, Humic Colloids	PHUMSIM	Proportionality Const. Of Actinides in Salado Brine w/Humic Colloids, Inorganic	Constant	NONE	1.90E-01
3430	PHUMOX4	Proportionality constant with humic colloids for a	PHUMCIM	Proportionality Const., Humic Colloids, Castile Brine, MgO controls pH	Constant	NONE	6.30E+00

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Table 35. Waste Chemistry Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3434	PHUMOX4	Proportionality constant with humic colloids for a	PHUMSIM	Proportionality Const. Of Actinides in Salado Brine w/Humic Colloids, Inorganic	Constant	NONE	6.30E+00
3431	PHUMOX5	Proportionality constant with humic colloids for a	PHUMCIM	Proportionality Const., Humic Colloids, Castile Brine, MgO controls pH	Constant	NONE	7.40E-03
3435	PHUMOX5	Proportionality constant with humic colloids for a	PHUMSIM	Proportionality Const. Of Actinides in Salado Brine w/Humic Colloids, Inorganic	Constant	NONE	9.10E-04
3432	PHUMOX6	Proportionality constant with humic colloids for a	PHUMCIM	Proportionality Const., Humic Colloids, Castile Brine, MgO controls pH	Constant	NONE	5.10E-01
3436	PHUMOX6	Proportionality constant with humic colloids for a	PHUMSIM	Proportionality Const. Of Actinides in Salado Brine w/Humic Colloids, Inorganic	Constant	NONE	1.20E-01
3459	PU	Plutonium	CAPHUM	Maximum Concentration of Actinide with Mobile Humic Colloids	Constant	moles/liter	1.10E-05
3315	PU	Plutonium	CAPMIC	Maximum Concentration of Actinide on Microbe Colloids	Constant	moles/liter	6.80E-05
3316	PU	Plutonium	CONCINT	Actinide Concentration with Mobile Actinide Intrinsic Colloids	Constant	moles/liter	1.00E-09
3440	PU	Plutonium	CONCMIN	Actinide Concentration with Mobile Mineral Fragment Colloids	Constant	moles/liter	2.60E-08
3317	PU	Plutonium	PROPMIC	Moles of Actinide Mobilized on Microbe Colloids per Moles Dissolved	Constant	NONE	3.00E-01
3442	PU+3	Plutonium III	MD0	Molecular diffusion in pure fluid	Constant	m^2/s	3.00E-10
3480	PU+3	Plutonium III	MKD_PU	Matrix Partition Coefficient for Plutonium	Log uniform	m^3/kg	Sampled Value
3443	PU+4	Plutonium IV	MD0	Molecular diffusion in pure fluid	Constant	m^2/s	1.53E-10
3481	PU+4	Plutonium IV	MKD_PU	Matrix Partition Coefficient for Plutonium	Log uniform	m^3/kg	Sampled Value
3263	SOLAM3	Solubility Multiplier for Am+3	SOLCIM	Solubility Mult. in Castile Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	None (see PPR-04-2002, ERMS #524651)	Sampled Value
3262	SOLAM3	Solubility Multiplier for Am+3	SOLSIM	Solubility Mult. in Salado Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	None (see PPR-04-2002, ERMS #524651)	Sampled Value
3628	SOLMOD3	Oxidation state III model	SOLCOC	Solubility in Castile Brine with Organics included Controlled by Mg(OH)2/CaCO3	Constant	moles/liter	1.77E-07
3629	SOLMOD3	Oxidation state III model	SOLCOH	Solubility in Castile Brine with Organics included Controlled by Mg(OH)2/Hydromagnisite buffer(5424)	Constant	moles/liter	2.88E-07

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Table 35. Waste Chemistry Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3630	SOLMOD3	Oxidation state III model	SOLSOC	Solubility in Salado Brine with Organics included Controlled by Mg(OH)2/CaCO3	Constant	moles/liter	3.07E-07
3631	SOLMOD3	Oxidation state III model	SOLSOH	Solubility in Salado Brine with Organics included Controlled by Mg(OH)2/Hydromagnisite buffer(5424)	Constant	moles/liter	3.87E-07
3632	SOLMOD4	Oxidation state IV model	SOLCOC	Solubility in Castile Brine with Organics included Controlled by Mg(OH)2/CaCO3	Constant	moles/liter	5.84E-09
3633	SOLMOD4	Oxidation state IV model	SOLCOH	Solubility in Castile Brine with Organics included Controlled by Mg(OH)2/Hydromagnisite buffer(5424)	Constant	moles/liter	6.77E-08
3634	SOLMOD4	Oxidation state IV model	SOLSOC	Solubility in Salado Brine with Organics included Controlled by Mg(OH)2/CaCO3	Constant	moles/liter	1.24E-08
3635	SOLMOD4	Oxidation state IV model	SOLSOH	Solubility in Salado Brine with Organics included Controlled by Mg(OH)2/Hydromagnisite buffer(5424)	Constant	moles/liter	5.64E-08
3636	SOLMOD5	Oxidation state V model	SOLCOC	Solubility in Castile Brine with Organics included Controlled by Mg(OH)2/CaCO3	Constant	moles/liter	2.13E-05
3637	SOLMOD5	Oxidation state V model	SOLCOH	Solubility in Castile Brine with Organics included Controlled by Mg(OH)2/Hydromagnisite buffer(5424)	Constant	moles/liter	8.24E-07
3638	SOLMOD5	Oxidation state V model	SOLSOC	Solubility in Salado Brine with Organics included Controlled by Mg(OH)2/CaCO3	Constant	moles/liter	9.72E-07
3639	SOLMOD5	Oxidation state V model	SOLSOH	Solubility in Salado Brine with Organics included Controlled by Mg(OH)2/Hydromagnisite buffer(5424)	Constant	moles/liter	3.55E-07
3640	SOLMOD6	Oxidation state VI model	SOLCOC	Solubility in Castile Brine with Organics included Controlled by Mg(OH)2/CaCO3	Constant	moles/liter	8.80E-06
3641	SOLMOD6	Oxidation state VI model	SOLCOH	Solubility in Castile Brine with Organics included Controlled by Mg(OH)2/Hydromagnisite buffer(5424)	Constant	moles/liter	1.00E-03
3642	SOLMOD6	Oxidation state VI model	SOLSOC	Solubility in Salado Brine with Organics included Controlled by Mg(OH)2/CaCO3	Constant	moles/liter	8.70E-06
3643	SOLMOD6	Oxidation state VI model	SOLSOH	Solubility in Salado Brine with Organics included Controlled by Mg(OH)2/Hydromagnisite buffer(5424)	Constant	moles/liter	1.00E-03
3264	SOLPU3	Solubility Multiplier for Pu+3	SOLCIM	Solubility Mult. in Castile Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	moles/liter	-9.00E-02
3265	SOLPU3	Solubility Multiplier for Pu+3	SOLSIM	Solubility Mult. in Salado Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	moles/liter	-9.00E-02
3389	SOLPU4	Solubility Multiplier for Pu+4	SOLCIM	Solubility Mult. in Castile Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	moles/liter	-9.00E-02

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Table 35. Waste Chemistry Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3266	SOLPU4	Solubility Multiplier for Pu+4	SOLSIM	Solubility Mult. in Salado Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	moles/liter	-9.00E-02
3627	SOLTH4	Solubility Multiplier for Th+4	SOLCIM	Solubility Mult. in Castile Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	moles/liter	-9.00E-02
3393	SOLTH4	Solubility Multiplier for Th+4	SOLSIM	Solubility Mult. in Salado Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	moles/liter	-9.00E-02
3626	SOLU4	Solubility Multiplier for U+4	SOLCIM	Solubility Mult. in Castile Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	moles/liter	-9.00E-02
3390	SOLU4	Solubility Multiplier for U+4	SOLSIM	Solubility Mult. in Salado Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	moles/liter	-9.00E-02
3392	SOLU6	Solubility Multiplier for U+6	SOLCIM	Solubility Mult. in Castile Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	moles/liter	-9.00E-02
3391	SOLU6	Solubility Multiplier for U+6	SOLSIM	Solubility Mult. in Salado Brine, Inorganic Chem Controlled by Mg(OH)2-MgCO3	Cumulative	moles/liter	-9.00E-02
3461	TH	Thorium	CAPHUM	Maximum Concentration of Actinide with Mobile Humic Colloids	Constant	moles/liter	1.10E-05
3318	TH	Thorium	CAPMIC	Maximum Concentration of Actinide on Microbe Colloids	Constant	moles/liter	1.90E-03
3319	TH	Thorium	CONCINT	Actinide Concentration with Mobile Actinide Intrinsic Colloids	Constant	moles/liter	0.00E+00
3437	TH	Thorium	CONCMIN	Actinide Concentration with Mobile Mineral Fragment Colloids	Constant	moles/liter	2.60E-08
3320	TH	Thorium	PROPMIC	Moles of Actinide Mobilized on Microbe Colloids per Moles Dissolved	Constant	NONE	3.10E+00
3449	TH+4	Thorium IV	MD0	Molecular diffusion in pure fluid	Constant	m^2/s	1.53E-10
3478	TH+4	Thorium IV	MKD_TH	Matrix Partition Coefficient for Thorium	Log uniform	m^3/kg	2.6E+00
3460	U	Uranium	CAPHUM	Maximum Concentration of Actinide with Mobile Humic Colloids	Constant	moles/liter	1.10E-05
3308	U	Uranium	CAPMIC	Maximum Concentration of Actinide on Microbe Colloids	Constant	moles/liter	2.10E-03
3307	U	Uranium	CONCINT	Actinide Concentration with Mobile Actinide Intrinsic Colloids	Constant	moles/liter	0.00E+00
3438	U	Uranium	CONCMIN	Actinide Concentration with Mobile Mineral Fragment Colloids	Constant	moles/liter	2.60E-08
3309	U	Uranium	PROPMIC	Moles of Actinide Mobilized on Microbe Colloids per Moles Dissolved	Constant	NONE	2.10E-03
3446	U+4	Uranium IV	MD0	Molecular diffusion in pure fluid	Constant	m^2/s	1.53E-10

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Table 35. Waste Chemistry Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3479	U+4	Uranium IV	MKD_U	Matrix Partition Coefficient for Uranium	Log uniform	m^3/kg	2.6E+00
3448	U+6	Uranium VI	MD0	Molecular diffusion in pure fluid	Constant	m^2/s	4.26E-10
3475	U+6	Uranium VI	MKD_U	Matrix Partition Coefficient for Uranium	Log uniform	m^3/kg	7.7E-04

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Table 36. Radionuclide Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
2	AM241	Americium 241	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.41E-01
3363	AM241	Americium 241	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
3	AM241	Americium 241	HALFLIFE	Halflife	Constant	s	1.36E+10
3223	AM243	Americium 243	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.43E-01
3365	AM243	Americium 243	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
6	AM243	Americium 243	HALFLIFE	Halflife	Constant	s	2.33E+11
106	CF252	Californium 252	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.52E-01
3330	CF252	Californium 252	EPAREL	EPA Release Limit	Constant	Curies/wuf	0.00E+00
107	CF252	Californium 252	HALFLIFE	Halflife	Constant	s	8.33E+07
3231	CM243	Curium 243	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.43E-01
3366	CM243	Curium 243	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
3277	CM243	Curium 243	HALFLIFE	Halflife	Constant	s	8.99E+08
110	CM244	Curium 244	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.44E-01
3331	CM244	Curium 244	EPAREL	EPA Release Limit	Constant	Curies/wuf	0.00E+00
111	CM244	Curium 244	HALFLIFE	Halflife	Constant	s	5.72E+08
3232	CM245	Curium 245	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.45E-01
3367	CM245	Curium 245	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
3278	CM245	Curium 245	HALFLIFE	Halflife	Constant	s	2.68E+11
3233	CM248	Curium 248	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.48E-01
3368	CM248	Curium 248	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
115	CM248	Curium 248	HALFLIFE	Halflife	Constant	s	1.07E+13
116	CS137	Cesium 137	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	1.37E-01
3369	CS137	Cesium 137	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+03
117	CS137	Cesium 137	HALFLIFE	Halflife	Constant	s	9.47E+08
246	NP237	Neptunium 237	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.37E-01
3370	NP237	Neptunium 237	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
247	NP237	Neptunium 237	HALFLIFE	Halflife	Constant	s	6.75E+13

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Table 36. Radionuclide Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
250	PA231	Protactinium 231	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.31E-01
3371	PA231	Protactinium 231	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
251	PA231	Protactinium 231	HALFLIFE	Halflife	Constant	s	1.03E+12
283	PB210	Lead 210	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.10E-01
3372	PB210	Lead 210	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
284	PB210	Lead 210	HALFLIFE	Halflife	Constant	s	7.04E+08
287	PM147	Promethium 147	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	1.47E-01
3341	PM147	Promethium 147	EPAREL	EPA Release Limit	Constant	Curies/wuf	0.00E+00
288	PM147	Promethium 147	HALFLIFE	Halflife	Constant	s	8.28E+07
291	PU238	Plutonium 238	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.38E-01
3373	PU238	Plutonium 238	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
292	PU238	Plutonium 238	HALFLIFE	Halflife	Constant	s	2.77E+09
295	PU239	Plutonium 239	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.39E-01
3374	PU239	Plutonium 239	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
296	PU239	Plutonium 239	HALFLIFE	Halflife	Constant	s	7.59E+11
299	PU240	Plutonium 240	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.40E-01
3375	PU240	Plutonium 240	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
300	PU240	Plutonium 240	HALFLIFE	Halflife	Constant	s	2.06E+11
303	PU241	Plutonium 241	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.41E-01
3348	PU241	Plutonium 241	EPAREL	EPA Release Limit	Constant	Curies/wuf	0.00E+00
304	PU241	Plutonium 241	HALFLIFE	Halflife	Constant	s	4.54E+08
307	PU242	Plutonium 242	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.42E-01
3376	PU242	Plutonium 242	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
308	PU242	Plutonium 242	HALFLIFE	Halflife	Constant	s	1.22E+13
311	PU244	Plutonium 244	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.44E-01
3377	PU244	Plutonium 244	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
312	PU244	Plutonium 244	HALFLIFE	Halflife	Constant	s	2.61E+15
314	RA226	Radium 226	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.26E-01
3378	RA226	Radium 226	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
315	RA226	Radium 226	HALFLIFE	Halflife	Constant	s	5.05E+10
318	RA228	Radium 228	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.28E-01
3352	RA228	Radium 228	EPAREL	EPA Release Limit	Constant	Curies/wuf	0.00E+00
319	RA228	Radium 228	HALFLIFE	Halflife	Constant	s	2.11E+08
516	SR90	Strontium 90	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	8.99E-02
3380	SR90	Strontium 90	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+03
517	SR90	Strontium 90	HALFLIFE	Halflife	Constant	s	9.19E+08
603	TH229	Thorium 229	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.29E-01
3381	TH229	Thorium 229	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
604	TH229	Thorium 229	HALFLIFE	Halflife	Constant	s	2.32E+11
607	TH230	Thorium 230	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.30E-01
3382	TH230	Thorium 230	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+01
608	TH230	Thorium 230	HALFLIFE	Halflife	Constant	s	2.43E+12
611	TH232	Thorium 232	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.32E-01

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Table 36. Radionuclide Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3383	TH232	Thorium 232	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+01
612	TH232	Thorium 232	HALFLIFE	Halflife	Constant	s	4.43E+17
632	U233	Uranium 233	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.33E-01
3384	U233	Uranium 233	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
633	U233	Uranium 233	HALFLIFE	Halflife	Constant	s	5.00E+12
636	U234	Uranium 234	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.34E-01
3385	U234	Uranium 234	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
637	U234	Uranium 234	HALFLIFE	Halflife	Constant	s	7.72E+12
640	U235	Uranium 235	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.35E-01
3386	U235	Uranium 235	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
641	U235	Uranium 235	HALFLIFE	Halflife	Constant	s	2.22E+16
644	U236	Uranium 236	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.36E-01
3387	U236	Uranium 236	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
645	U236	Uranium 236	HALFLIFE	Halflife	Constant	s	7.39E+14
647	U238	Uranium 238	ATWEIGHT	Atomic Weight in kg/mole	Constant	kg/mole	2.38E-01
3388	U238	Uranium 238	EPAREL	EPA Release Limit	Constant	Curies/wuf	1.00E+02
648	U238	Uranium 238	HALFLIFE	Halflife	Constant	s	1.41E+17

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Table 37. Isotope Inventory

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
4	AM241	Americium 241	INVCHD	Inventory of Contact Handled Design	Constant	Curies	4.42E+05
5	AM241	Americium 241	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.58E+04
3504	AM241L	Americium 241 Lumped with Plutonium 241	INVCHD	Inventory of Contact Handled Design	Constant	Curies	4.59E+05
3509	AM241L	Americium 241 Lumped with Plutonium 241	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.66E+04
3415	AM243	Americium 243	INVCHD	Inventory of Contact Handled Design	Constant	Curies	2.10E+01
3416	AM243	Americium 243	INVRHD	Inventory of Remote Handled Design	Constant	Curies	7.42E-01
108	CF252	Californium 252	INVCHD	Inventory of Contact Handled Design	Constant	Curies	4.64E-05
109	CF252	Californium 252	INVRHD	Inventory of Remote Handled Design	Constant	Curies	3.95E-06
3410	CM243	Curium 243	INVCHD	Inventory of Contact Handled Design	Constant	Curies	1.82E-01
3411	CM243	Curium 243	INVRHD	Inventory of Remote Handled Design	Constant	Curies	2.25E-01
112	CM244	Curium 244	INVCHD	Inventory of Contact Handled Design	Constant	Curies	2.43E+03
113	CM244	Curium 244	INVRHD	Inventory of Remote Handled Design	Constant	Curies	7.94E+01
3412	CM245	Curium 245	INVCHD	Inventory of Contact Handled Design	Constant	Curies	8.59E-03
3413	CM245	Curium 245	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.06E-02
2265	CM248	Curium 248	INVCHD	Inventory of Contact Handled Design	Constant	Curies	9.14E-02
2266	CM248	Curium 248	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.83E-03
2037	CS137	Cesium 137	INVCHD	Inventory of Contact Handled Design	Constant	Curies	4.61E+03
118	CS137	Cesium 137	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.74E+05
248	NP237	Neptunium 237	INVCHD	Inventory of Contact Handled Design	Constant	Curies	9.25E+00
249	NP237	Neptunium 237	INVRHD	Inventory of Remote Handled Design	Constant	Curies	8.22E-01
2267	PA231	Protactinium 231	INVCHD	Inventory of Contact Handled Design	Constant	Curies	1.21E+00
2268	PA231	Protactinium 231	INVRHD	Inventory of Remote Handled Design	Constant	Curies	6.55E-04
285	PB210	Lead 210	INVCHD	Inventory of Contact Handled Design	Constant	Curies	4.94E+00
286	PB210	Lead 210	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.42E-05
2038	PM147	Promethium 147	INVCHD	Inventory of Contact Handled Design	Constant	Curies	3.86E-04
289	PM147	Promethium 147	INVRHD	Inventory of Remote Handled Design	Constant	Curies	7.47E-02
293	PU238	Plutonium 238	INVCHD	Inventory of Contact Handled Design	Constant	Curies	1.25E+06
294	PU238	Plutonium 238	INVRHD	Inventory of Remote Handled Design	Constant	Curies	2.80E+03
3506	PU238L	Plutonium 238 Equals Plutonium 238 Inventory	INVCHD	Inventory of Contact Handled Design	Constant	Curies	1.25E+06

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Table 37. Isotope Inventory — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3511	PU238L	Plutonium 238 Equals Plutonium 238 Inventory	INVRHD	Inventory of Remote Handled Design	Constant	Curies	2.80E+03
297	PU239	Plutonium 239	INVCHD	Inventory of Contact Handled Design	Constant	Curies	6.59E+05
298	PU239	Plutonium 239	INVRHD	Inventory of Remote Handled Design	Constant	Curies	5.37E+03
3505	PU239L	Plutonium 239 Lumped with Plutonium 240 and Pluton	INVCHD	Inventory of Contact Handled Design	Constant	Curies	7.66E+05
3510	PU239L	Plutonium 239 Lumped with Plutonium 240 and Pluton	INVRHD	Inventory of Remote Handled Design	Constant	Curies	7.05E+03
301	PU240	Plutonium 240	INVCHD	Inventory of Contact Handled Design	Constant	Curies	1.07E+05
302	PU240	Plutonium 240	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.67E+03
305	PU241	Plutonium 241	INVCHD	Inventory of Contact Handled Design	Constant	Curies	5.14E+05
306	PU241	Plutonium 241	INVRHD	Inventory of Remote Handled Design	Constant	Curies	2.39E+04
309	PU242	Plutonium 242	INVCHD	Inventory of Contact Handled Design	Constant	Curies	2.66E+01
310	PU242	Plutonium 242	INVRHD	Inventory of Remote Handled Design	Constant	Curies	4.74E-01
2269	PU244	Plutonium 244	INVCHD	Inventory of Contact Handled Design	Constant	Curies	1.32E-06
2270	PU244	Plutonium 244	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.10E-03
316	RA226	Radium 226	INVCHD	Inventory of Contact Handled Design	Constant	Curies	6.28E+00
317	RA226	Radium 226	INVRHD	Inventory of Remote Handled Design	Constant	Curies	4.99E-05
2271	RA228	Radium 228	INVCHD	Inventory of Contact Handled Design	Constant	Curies	7.63E+00
2272	RA228	Radium 228	INVRHD	Inventory of Remote Handled Design	Constant	Curies	2.51E-01
2039	SR90	Strontium 90	INVCHD	Inventory of Contact Handled Design	Constant	Curies	2.68E+04
518	SR90	Strontium 90	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.15E+05
605	TH229	Thorium 229	INVCHD	Inventory of Contact Handled Design	Constant	Curies	5.25E+00
606	TH229	Thorium 229	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.39E-01
609	TH230	Thorium 230	INVCHD	Inventory of Contact Handled Design	Constant	Curies	1.69E-01
610	TH230	Thorium 230	INVRHD	Inventory of Remote Handled Design	Constant	Curies	6.67E-03
3508	TH230L	Thorium 230 Lumped with Thorium 229	INVCHD	Inventory of Contact Handled Design	Constant	Curies	5.42E+00
3513	TH230L	Thorium 230 Lumped with Thorium 229	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.46E-01
613	TH232	Thorium 232	INVCHD	Inventory of Contact Handled Design	Constant	Curies	6.61E+00
614	TH232	Thorium 232	INVRHD	Inventory of Remote Handled Design	Constant	Curies	2.18E-01
634	U233	Uranium 233	INVCHD	Inventory of Contact Handled Design	Constant	Curies	1.24E+03
635	U233	Uranium 233	INVRHD	Inventory of Remote Handled Design	Constant	Curies	3.41E+01
638	U234	Uranium 234	INVCHD	Inventory of Contact Handled Design	Constant	Curies	2.97E+02
639	U234	Uranium 234	INVRHD	Inventory of Remote Handled Design	Constant	Curies	2.20E+01
3507	U234L	Uranium 234 Lumped with Uranium 233	INVCHD	Inventory of Contact Handled Design	Constant	Curies	1.54E+03
3512	U234L	Uranium 234 Lumped with Uranium 233	INVRHD	Inventory of Remote Handled Design	Constant	Curies	5.61E+01
642	U235	Uranium 235	INVCHD	Inventory of Contact Handled Design	Constant	Curies	1.34E+00
643	U235	Uranium 235	INVRHD	Inventory of Remote Handled Design	Constant	Curies	9.42E-01

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Table 37. Isotope Inventory — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
2216	U236	Uranium 236	INVCHD	Inventory of Contact Handled Design	Constant	Curies	2.31E-01
646	U236	Uranium 236	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.42E+00
649	U238	Uranium 238	INVCHD	Inventory of Contact Handled Design	Constant	Curies	2.44E+01
650	U238	Uranium 238	INVRHD	Inventory of Remote Handled Design	Constant	Curies	1.30E+02

Table 38. Waste Container Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3106	REFCON	Reference Constant	ASDRUM	Surface area of corrodible metal per drum	Constant	m^2	6.00E+00
3132	REFCON	Reference Constant	DRROOM	Number of drums, per room, in ideal packing	Constant	NONE	6.80E+03

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Table 39. Stoichiometric Gas Generation Model Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
2907	STEEL	Generic steel in waste	CORRMCO2	Inundated corrosion rate for steel without CO2 present	Uniform	m/s	1.585E-14
2910	STEEL	Generic steel in waste	HUMCORR	Humid corrosion rate for steel	Constant	m/s	0.00E+00
2898	STEEL	Generic steel in waste	STOIFX	Stoichiometric factor - X	Constant	NONE	1.00E+00
2909	SULFATE	Sulfate	QINIT	Initial quantity of material in waste	Constant	moles	4.61E+06
2041	WAS_AREA	Waste emplacement area and waste	DCELLCHW	Average density of cellulosics in CH waste	Constant	kg/m^3	6.00E+01
2274	WAS_AREA	Waste emplacement area and waste	DCELLRHW	Average density of cellulosics in RH waste	Constant	kg/m^3	9.30E+00
1992	WAS_AREA	Waste emplacement area and waste	DIRNCCHW	Bulk density of iron containers, CH waste	Constant	kg/m^3	1.70E+02
1993	WAS_AREA	Waste emplacement area and waste	DIRNCRHW	Bulk density of iron containers, RH waste	Constant	kg/m^3	5.40E+02
2040	WAS_AREA	Waste emplacement area and waste	DIRONCHW	Average density of iron-based material in CH waste	Constant	kg/m^3	1.10E+02
2044	WAS_AREA	Waste emplacement area and waste	DIRONRHW	Average density of iron-based material in RH waste	Constant	kg/m^3	5.90E+01
2043	WAS_AREA	Waste emplacement area and waste	DPLASCHW	Average density of plastics in CH waste	Constant	kg/m^3	4.30E+01
2275	WAS_AREA	Waste emplacement area and waste	DPLASRHW	Average density of plastics in RH waste	Constant	kg/m^3	8.00E+00
1995	WAS_AREA	Waste emplacement area and waste	DPLSCCHW	Bulk density of plastic liners, CH waste	Constant	kg/m^3	1.70E+01
2228	WAS_AREA	Waste emplacement area and waste	DPLSCRHW	Bulk density of plastic liners, RH waste	Constant	kg/m^3	3.10E+00
2042	WAS_AREA	Waste emplacement area and waste	DRUBBCHW	Average density of rubber in CH waste	Constant	kg/m^3	1.30E+01
2046	WAS_AREA	Waste emplacement area and waste	DRUBBRHW	Average density of rubber in RH waste	Constant	kg/m^3	6.70E+00
656	WAS_AREA	Waste emplacement area and waste	GRATMICH	Humid biodegredation rate for cellulose	Uniform	moles/(kg*s)	5.136E-10
657	WAS_AREA	Waste emplacement area and waste	GRATMICI	Inundated biodegradation rate for cellulose	Uniform	moles/(kg*s)	2.939E-10

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Table 40. Predisposal Cavities (Waste Area) Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
76	CAVITY_1	Cavity for Waste Areas	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
77	CAVITY_1	Cavity for Waste Areas	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
2612	CAVITY_1	Cavity for Waste Areas	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
78	CAVITY_1	Cavity for Waste Areas	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2613	CAVITY_1	Cavity for Waste Areas	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2614	CAVITY_1	Cavity for Waste Areas	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
81	CAVITY_1	Cavity for Waste Areas	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
79	CAVITY_1	Cavity for Waste Areas	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
80	CAVITY_1	Cavity for Waste Areas	POROSITY	Effective porosity	Constant	NONE	1.00E+00
82	CAVITY_1	Cavity for Waste Areas	PRESSURE	Brine far-field pore pressure	Constant	Pa	1.01E+05
83	CAVITY_1	Cavity for Waste Areas	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$\log(m^2)$	-1.00E+01
84	CAVITY_1	Cavity for Waste Areas	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$\log(m^2)$	-1.00E+01
85	CAVITY_1	Cavity for Waste Areas	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$\log(m^2)$	-1.00E+01
88	CAVITY_1	Cavity for Waste Areas	RELP_MOD	Model number, relative permeability model	Constant	NONE	1.10E+01
3099	CAVITY_1	Cavity for Waste Areas	SAT_IBRN	Initial Brine Saturation	Constant	NONE	0.00E+00
89	CAVITY_1	Cavity for Waste Areas	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
90	CAVITY_1	Cavity for Waste Areas	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00
91	CAVITY_2	Cavity for Non-waste Areas	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
92	CAVITY_2	Cavity for Non-waste Areas	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
2616	CAVITY_2	Cavity for Non-waste Areas	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
93	CAVITY_2	Cavity for Non-waste Areas	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2617	CAVITY_2	Cavity for Non-waste Areas	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2618	CAVITY_2	Cavity for Non-waste Areas	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
96	CAVITY_2	Cavity for Non-waste Areas	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
94	CAVITY_2	Cavity for Non-waste Areas	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
95	CAVITY_2	Cavity for Non-waste Areas	POROSITY	Effective porosity	Constant	NONE	1.00E+00
97	CAVITY_2	Cavity for Non-waste Areas	PRESSURE	Brine far-field pore pressure	Constant	Pa	1.01E+05
98	CAVITY_2	Cavity for Non-waste Areas	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$\log(m^2)$	-1.00E+01
99	CAVITY_2	Cavity for Non-waste Areas	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$\log(m^2)$	-1.00E+01

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Table 40. Predisposal Cavities (Waste Area) Parameters — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
100	CAVITY_2	Cavity for Non-waste Areas	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	log(m²)	-1.00E+01
103	CAVITY_2	Cavity for Non-waste Areas	RELP_MOD	Model number, relative permeability model	Constant	NONE	1.10E+01
3100	CAVITY_2	Cavity for Non-waste Areas	SAT_IBRN	Initial Brine Saturation	Constant	NONE	0.00E+00
104	CAVITY_2	Cavity for Non-waste Areas	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
105	CAVITY_2	Cavity for Non-waste Areas	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00
2049	CAVITY_3	Cavity for Shaft	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
2051	CAVITY_3	Cavity for Shaft	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
2620	CAVITY_3	Cavity for Shaft	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
2234	CAVITY_3	Cavity for Shaft	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2621	CAVITY_3	Cavity for Shaft	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2622	CAVITY_3	Cavity for Shaft	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
2623	CAVITY_3	Cavity for Shaft	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
2052	CAVITY_3	Cavity for Shaft	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
2053	CAVITY_3	Cavity for Shaft	POROSITY	Effective porosity	Constant	NONE	1.00E+00
3101	CAVITY_3	Cavity for Shaft	PRESSURE	Brine far-field pore pressure	Constant	Pa	1.01E+05
2054	CAVITY_3	Cavity for Shaft	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	log(m²)	-1.00E+01
2055	CAVITY_3	Cavity for Shaft	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	log(m²)	-1.00E+01
2056	CAVITY_3	Cavity for Shaft	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	log(m²)	-1.00E+01
2058	CAVITY_3	Cavity for Shaft	RELP_MOD	Model number, relative permeability model	Constant	NONE	1.10E+01
3102	CAVITY_3	Cavity for Shaft	SAT_IBRN	Initial Brine Saturation	Constant	NONE	0.00E+00
2235	CAVITY_3	Cavity for Shaft	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
2059	CAVITY_3	Cavity for Shaft	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00
2060	CAVITY_4	Cavity for Borehole	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
2062	CAVITY_4	Cavity for Borehole	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
2625	CAVITY_4	Cavity for Borehole	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
2236	CAVITY_4	Cavity for Borehole	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2626	CAVITY_4	Cavity for Borehole	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2627	CAVITY_4	Cavity for Borehole	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
2628	CAVITY_4	Cavity for Borehole	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
2063	CAVITY_4	Cavity for Borehole	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
2064	CAVITY_4	Cavity for Borehole	POROSITY	Effective porosity	Constant	NONE	1.00E+00
3103	CAVITY_4	Cavity for Borehole	PRESSURE	Brine far-field pore pressure	Constant	Pa	1.01E+05
2065	CAVITY_4	Cavity for Borehole	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	log(m²)	-1.00E+01
2066	CAVITY_4	Cavity for Borehole	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	log(m²)	-1.00E+01
2067	CAVITY_4	Cavity for Borehole	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	log(m²)	-1.00E+01
2069	CAVITY_4	Cavity for Borehole	RELP_MOD	Model number, relative permeability model	Constant	NONE	1.10E+01
3104	CAVITY_4	Cavity for Borehole	SAT_IBRN	Initial Brine Saturation	Constant	NONE	0.00E+00
2237	CAVITY_4	Cavity for Borehole	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
2070	CAVITY_4	Cavity for Borehole	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00

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Table 41. Operations Region Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
7	OPS_AREA	Operations Region	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
8	OPS_AREA	Operations Region	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
2604	OPS_AREA	Operations Region	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
9	OPS_AREA	Operations Region	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2605	OPS_AREA	Operations Region	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2606	OPS_AREA	Operations Region	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
12	OPS_AREA	Operations Region	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
10	OPS_AREA	Operations Region	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
11	OPS_AREA	Operations Region	POROSITY	Effective porosity	Constant	NONE	1.80E-01
13	OPS_AREA	Operations Region	PRESSURE	Brine far-field pore pressure	Constant	Pa	1.01E+05
14	OPS_AREA	Operations Region	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$\log(m^2)$	-1.10E+01
15	OPS_AREA	Operations Region	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$\log(m^2)$	-1.10E+01
16	OPS_AREA	Operations Region	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$\log(m^2)$	-1.10E+01
19	OPS_AREA	Operations Region	RELP_MOD	Model number, relative permeability model	Constant	NONE	1.10E+01
20	OPS_AREA	Operations Region	SAT_IBRN	Initial Brine Saturation	Constant	NONE	0.00E+00
21	OPS_AREA	Operations Region	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
22	OPS_AREA	Operations Region	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00

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Table 42. Area Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
207	EXP_AREA	Experimental Area	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
208	EXP_AREA	Experimental Area	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
2711	EXP_AREA	Experimental Area	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
209	EXP_AREA	Experimental Area	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2712	EXP_AREA	Experimental Area	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2713	EXP_AREA	Experimental Area	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
212	EXP_AREA	Experimental Area	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
210	EXP_AREA	Experimental Area	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
211	EXP_AREA	Experimental Area	POROSITY	Effective porosity	Constant	NONE	1.80E-01
213	EXP_AREA	Experimental Area	PRESSURE	Brine far-field pore pressure	Constant	Pa	1.01E+05
214	EXP_AREA	Experimental Area	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$\log(m^2)$	-1.10E+01
215	EXP_AREA	Experimental Area	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$\log(m^2)$	-1.10E+01
216	EXP_AREA	Experimental Area	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$\log(m^2)$	-1.10E+01
219	EXP_AREA	Experimental Area	RELP_MOD	Model number, relative permeability model	Constant	NONE	1.10E+01
220	EXP_AREA	Experimental Area	SAT_IBRN	Initial Brine Saturation	Constant	NONE	0.00E+00
221	EXP_AREA	Experimental Area	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
222	EXP_AREA	Experimental Area	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00

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Table 43. Castile Formation Parameters

Parameter Id#	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
229	IMPERM_Z	Impermeable Zones	CAP_MOD	Model number, capillary pressure model	Constant	NONE	1.00E+00
230	IMPERM_Z	Impermeable Zones	COMP_RCK	Bulk Compressibility	Constant	Pa^{-1}	0.00E+00
2720	IMPERM_Z	Impermeable Zones	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0
231	IMPERM_Z	Impermeable Zones	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2721	IMPERM_Z	Impermeable Zones	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	0.00E+00
2722	IMPERM_Z	Impermeable Zones	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	0.00E+00
234	IMPERM_Z	Impermeable Zones	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
232	IMPERM_Z	Impermeable Zones	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
233	IMPERM_Z	Impermeable Zones	POROSITY	Effective porosity	Constant	NONE	5.00E-03
236	IMPERM_Z	Impermeable Zones	PRMX_LOG	Log of intrinsic permeability, X-direction	Constant	$\log(m^2)$	-3.50E+01
237	IMPERM_Z	Impermeable Zones	PRMY_LOG	Log of intrinsic permeability, Y-direction	Constant	$\log(m^2)$	-3.50E+01
238	IMPERM_Z	Impermeable Zones	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Constant	$\log(m^2)$	-3.50E+01
241	IMPERM_Z	Impermeable Zones	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
243	IMPERM_Z	Impermeable Zones	SAT_RBRN	Residual Brine Saturation	Constant	NONE	0.00E+00
244	IMPERM_Z	Impermeable Zones	SAT_RGAS	Residual Gas Saturation	Constant	NONE	0.00E+00

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Table 44. Castile Brine Reservoir Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
60	CASTILER	Castile Brine Reservoir	CAP_MOD	Model number, capillary pressure model	Constant	NONE	2.00E+00
61	CASTILER	Castile Brine Reservoir	COMP_RCK	Bulk Compressibility	Triangular	Pa^{-1}	Sampled Value
2608	CASTILER	Castile Brine Reservoir	KPT	Flag for Permeability Determined Threshold	Constant	NONE	0.00E+00
62	CASTILER	Castile Brine Reservoir	PC_MAX	Maximum allowable capillary pressure	Constant	Pa	1.00E+08
2609	CASTILER	Castile Brine Reservoir	PCT_A	Threshold Pressure Linear Parameter	Constant	Pa	5.60E-01
2610	CASTILER	Castile Brine Reservoir	PCT_EXP	Threshold pressure exponential parameter	Constant	NONE	-3.46E-01
65	CASTILER	Castile Brine Reservoir	PO_MIN	Minimum brine pressure for capillary model KPC=3	Constant	Pa	1.01E+05
63	CASTILER	Castile Brine Reservoir	PORE_DIS	Brooks-Corey pore distribution parameter	Constant	NONE	7.00E-01
64	CASTILER	Castile Brine Reservoir	POROSITY	Effective porosity	Student	NONE	8.70E-03
66	CASTILER	Castile Brine Reservoir	PRESSURE	Brine far-field pore pressure	Triangular	Pa	1.27E+07
67	CASTILER	Castile Brine Reservoir	PRMX_LOG	Log of intrinsic permeability, X-direction	Triangular	$log(m^2)$	-1.18E+01
68	CASTILER	Castile Brine Reservoir	PRMY_LOG	Log of intrinsic permeability, Y-direction	Triangular	$log(m^2)$	-1.18E+01
69	CASTILER	Castile Brine Reservoir	PRMZ_LOG	Log of intrinsic permeability, Z-direction	Triangular	$log(m^2)$	-1.18E+01
72	CASTILER	Castile Brine Reservoir	RELP_MOD	Model number, relative permeability model	Constant	NONE	4.00E+00
73	CASTILER	Castile Brine Reservoir	SAT_IBRN	Initial Brine Saturation	Constant	NONE	1.00E+00
74	CASTILER	Castile Brine Reservoir	SAT_RBRN	Residual Brine Saturation	Constant	NONE	2.00E-01
75	CASTILER	Castile Brine Reservoir	SAT_RGAS	Residual Gas Saturation	Constant	NONE	2.00E-01

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Table 45. Reference Constants

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3503	REFCON	Reference Constant	ABERM	Area of Berm Placed Over Waste Panel	Constant	m^2	6.29E+05
2833	REFCON	Reference Constant	ACF_CH4	Acentric Factors - CH4	Constant	NONE	1.00E-02
2832	REFCON	Reference Constant	ACF_CO2	Acentric Factors - CO2	Constant	NONE	2.31E-01
2831	REFCON	Reference Constant	ACF_H2	Acentric Factors - H2	Constant	NONE	0.00E+00
2835	REFCON	Reference Constant	ACF_H2S	Acentric Factors - H2S	Constant	NONE	1.00E-01
2834	REFCON	Reference Constant	ACF_N2	Acentric Factors - N2	Constant	NONE	4.50E-02
2836	REFCON	Reference Constant	ACF_O2	Acentric Factors - O2	Constant	NONE	1.90E-02
3489	REFCON	Reference Constant	AREA_CH	Area For CH Waste Disposal in CDFGF Model	Constant	m^2	1.12E+05
3496	REFCON	Reference Constant	AREA_RH	Area For RH Waste Disposal in CDFGF Model	Constant	m^2	1.58E+04
3488	REFCON	Reference Constant	AREA_ZRO	Area in Waste Panels Not Used For Disposal (CCDFGF Model)	Constant	m^2	4.13E+03
2890	REFCON	Reference Constant	ATMPA	Conversion from std. atmosphere to Pa	Constant	Pa/atm	1.01E+05
3109	REFCON	Reference Constant	AVOGADRO	Avogadro's number	Constant	$mole^{-1}$	6.02E+23
3590	REFCON	Reference Constant	BIP_11	H2:H2 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3591	REFCON	Reference Constant	BIP_12	H2:CO2 - Binary Interaction Parameter	Constant	NONE	-3.43E-01
3592	REFCON	Reference Constant	BIP_13	H2:CH4 - Binary Interaction Parameter	Constant	NONE	-2.22E-02
3593	REFCON	Reference Constant	BIP_14	H2:N2 - Binary Interaction Parameter	Constant	NONE	9.78E-02
3594	REFCON	Reference Constant	BIP_15	H2:H2S - Binary Interaction Parameter	Constant	NONE	0.00E+00
3595	REFCON	Reference Constant	BIP_16	H2:O2 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3596	REFCON	Reference Constant	BIP_21	CO2:H2 - Binary Interaction Parameter	Constant	NONE	-3.43E-01
3597	REFCON	Reference Constant	BIP_22	CO2:CO2 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3598	REFCON	Reference Constant	BIP_23	CO2:CH4 - Binary Interaction Parameter	Constant	NONE	9.33E-02
3599	REFCON	Reference Constant	BIP_24	CO2:N2 - Binary Interaction Parameter	Constant	NONE	-3.15E-02
3600	REFCON	Reference Constant	BIP_25	CO2:H2S - Binary Interaction Parameter	Constant	NONE	9.89E-02

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Table 45. Reference Constants — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3601	REFCON	Reference Constant	BIP_26	CO2:O2 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3602	REFCON	Reference Constant	BIP_31	CH4:H2 - Binary Interaction Parameter	Constant	NONE	-2.22E-02
3603	REFCON	Reference Constant	BIP_32	CH4:CO2 - Binary Interaction Parameter	Constant	NONE	9.33E-02
3604	REFCON	Reference Constant	BIP_33	CH4:CH4 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3605	REFCON	Reference Constant	BIP_34	CH4:N2 - Binary Interaction Parameter	Constant	NONE	2.78E-02
3606	REFCON	Reference Constant	BIP_35	CH4:H2S - Binary Interaction Parameter	Constant	NONE	8.50E-02
3607	REFCON	Reference Constant	BIP_36	CH4:O2 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3608	REFCON	Reference Constant	BIP_41	N2:H2 - Binary Interaction Parameter	Constant	NONE	9.78E-02
3609	REFCON	Reference Constant	BIP_42	N2:CO2 - Binary Interaction Parameter	Constant	NONE	-3.15E-02
3610	REFCON	Reference Constant	BIP_43	N2:CH4 - Binary Interaction Parameter	Constant	NONE	2.78E-02
3611	REFCON	Reference Constant	BIP_44	N2:N2 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3612	REFCON	Reference Constant	BIP_45	N2:H2S - Binary Interaction Parameter	Constant	NONE	1.70E-01
3613	REFCON	Reference Constant	BIP_46	N2:O2 - Binary Interaction Parameter	Constant	NONE	-7.80E-03
3614	REFCON	Reference Constant	BIP_51	H2S:H2 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3615	REFCON	Reference Constant	BIP_52	H2S:CO2 - Binary Interaction Parameter	Constant	NONE	9.89E-02
3616	REFCON	Reference Constant	BIP_53	H2S:CH4 - Binary Interaction Parameter	Constant	NONE	8.50E-02
3617	REFCON	Reference Constant	BIP_54	H2S:N2 - Binary Interaction Parameter	Constant	NONE	1.70E-01
3618	REFCON	Reference Constant	BIP_55	H2S:H2S - Binary Interaction Parameter	Constant	NONE	0.00E+00
3619	REFCON	Reference Constant	BIP_56	H2S:O2 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3620	REFCON	Reference Constant	BIP_61	O2:H2 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3621	REFCON	Reference Constant	BIP_62	O2:CO2 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3622	REFCON	Reference Constant	BIP_63	O2:CH4 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3623	REFCON	Reference Constant	BIP_64	O2:N2 - Binary Interaction Parameter	Constant	NONE	-7.80E-03
3624	REFCON	Reference Constant	BIP_65	O2:H2S - Binary Interaction Parameter	Constant	NONE	0.00E+00
3625	REFCON	Reference Constant	BIP_66	O2:O2 - Binary Interaction Parameter	Constant	NONE	0.00E+00
3111	REFCON	Reference Constant	CITOBQ	Curie to Becquerel Conversion	Constant	Bq/Curies	3.70E+10
2882	REFCON	Reference Constant	DARM2	Conversion from darcy to m^2	Constant	m^2/darcy	9.87E-13

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Table 45. Reference Constants — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
2887	REFCON	Reference Constant	DAYSEC	Conversion from days to seconds	Constant	s/day	8.64E+04
2881	REFCON	Reference Constant	FTM	Conversion from feet to meter	Constant	m/ft	3.05E-01
3647	REFCON	Reference Constant	FVRW	Fraction of Emplaced RH Volume Occupied by RH Waste in CCDFGF Model	Constant	NONE	1.00E+00
3492	REFCON	Reference Constant	FVW	Fraction of Repository Volume Occupied By Waste In CCDFGF Model	Constant	NONE	3.86E-01
2889	REFCON	Reference Constant	GRAVACC	Standard gravitational acceleration	Constant	m/s^2	9.81E+00
3502	REFCON	Reference Constant	HRH	Emplaced Height of Remote Handled Waste in CCDFGF Model	Constant	m	5.09E-01
3589	REFCON	Reference Constant	MW_CELL	Carbon Normalized Molecular Weight of Cellulose	Constant	kg/mole	2.70E-02
3585	REFCON	Reference Constant	MW_CH4	Molecular Weight of CH4	Constant	kg/mole	1.60E-02
3584	REFCON	Reference Constant	MW_CO2	Molecular Weight of CO2	Constant	kg/mole	4.40E-02
2865	REFCON	Reference Constant	MW_FE	Molecular Weight - FE	Constant	kg/mole	5.58E-02
2858	REFCON	Reference Constant	MW_H2	Molecular Weight - H2	Constant	kg/mole	2.02E-03
2864	REFCON	Reference Constant	MW_H2O	Molecular Weight - H2O	Constant	kg/mole	1.80E-02
3587	REFCON	Reference Constant	MW_H2S	Molecular Weight of H2S	Constant	kg/mole	3.41E-02
3586	REFCON	Reference Constant	MW_N2	Molecular Weight of N2	Constant	kg/mole	2.80E-02
3583	REFCON	Reference Constant	MW_NACL	Molecular Weight of NaCl	Constant	kg/mole	5.84E-02
3588	REFCON	Reference Constant	MW_O2	Molecular Weight of O2	Constant	kg/mole	3.20E-02
2894	REFCON	Reference Constant	OMEGAA	Constants for RKS EOS	Constant	NONE	4.27E-01
2895	REFCON	Reference Constant	OMEGAB	Constants for RDS EOS	Constant	NONE	8.66E-02
2839	REFCON	Reference Constant	PC_CH4	Critical Pressure of CH4	Constant	Pa	4.62E+06
2838	REFCON	Reference Constant	PC_CO2	Critical Pressure of CO2	Constant	Pa	7.38E+06
2837	REFCON	Reference Constant	PC_H2	Critical Pressure of H2	Constant	Pa	2.05E+06
2841	REFCON	Reference Constant	PC_H2S	Critical Pressure of H2S	Constant	Pa	9.01E+06
2840	REFCON	Reference Constant	PC_N2	Critical Pressure of N2	Constant	Pa	3.39E+06
2842	REFCON	Reference Constant	PC_O2	Critical Pressure of O2	Constant	Pa	5.08E+06
2896	REFCON	Reference Constant	PI	Mathematical constant: PI	Constant	NONE	3.14E+00
2892	REFCON	Reference Constant	PSIPA	Conversion from psi to pascal	Constant	$Pa*in^2/lb$	6.89E+03
2893	REFCON	Reference Constant	R	Gas constant R	Constant	J/mole*K	8.31E+00

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Table 45. Reference Constants — Continued

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3112	REFCON	Reference Constant	SECYR	Seconds to years Conversion	Constant	yr/s	3.17E-08
2827	REFCON	Reference Constant	TC_CH4	Critical temperature: Methane (CH4)	Constant	K	1.91E+02
2826	REFCON	Reference Constant	TC_CO2	Critical temperature: Carbon Dioxide (CO2)	Constant	K	3.04E+02
2825	REFCON	Reference Constant	TC_H2	Critical temperature: Hydrogen (H2)	Constant	K	4.36E+01
2829	REFCON	Reference Constant	TC_H2S	Critical temperature: Hydrogen Sulfide (H2S)	Constant	K	3.74E+02
2828	REFCON	Reference Constant	TC_N2	Critical temperature: Nitrogen (N2)	Constant	K	1.26E+02
2830	REFCON	Reference Constant	TC_O2	Critical temperature: Oxygen (O2)	Constant	K	1.55E+02
3490	REFCON	Reference Constant	VOLWP	Uncompacted Volume of Waste Panels In CCDFGF Model	Constant	m^3	4.36E+05
3107	REFCON	Reference Constant	VPANLEX	Excavated volume of one panel	Constant	m^3	4.61E+04
3108	REFCON	Reference Constant	VREPOS	Excavated storage volume of repository	Constant	m^3	4.38E+05
3105	REFCON	Reference Constant	VROOM	Volume of one room in repository	Constant	m^3	3.64E+03
2888	REFCON	Reference Constant	YRSEC	Conversion from mean solar or tropical year to seconds	Constant	s/yr	3.16E+07

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Table 46. Global Parameters

Parameter Id #	Material	Material Description	Property	Property Description	Distribution Type	Units	Value
3501	GLOBAL	Information that applies globally	FPICD	PIC multiplicative factor for human intrusion by drilling	Constant	NONE	1.00E+00
3500	GLOBAL	Information that applies globally	FPICM	PIC multiplicative factor for human intrusion by mining	Constant	NONE	1.00E+00
3494	GLOBAL	Information that applies globally	LAMBDAD	Drilling Rate Per Unit Area	Constant	$(km^{-2})(yr^{-1})$	5.85E-03
3497	GLOBAL	Information that applies globally	MINERT	Mining rate from 40 CFR 194	Constant	yr^{-1}	1.00E-04
3644	GLOBAL	Information that applies globally	ONEPLG	Probability of having Plug Pattern 1	Constant	NONE	1.50E-02
3495	GLOBAL	Information that applies globally	PLGPAT	Index for Plugging Pattern After Drilling Intrusion	Delta	NONE	0.00E+00
3491	GLOBAL	Information that applies globally	TA	Time Active Institutional Controls at WIPP Site Are Effective	Constant	yr	1.00E+02
3646	GLOBAL	Information that applies globally	THREEPLG	Probability of having Plug Pattern 3	Constant	NONE	2.89E-01
3499	GLOBAL	Information that applies globally	TPICD	Time over which passive institutional controls reduce rate of drilling	Constant	yr	6.00E+02
3498	GLOBAL	Information that applies globally	TPICM	Time over which passive institutional controls reduce rate of mining	Constant	yr	6.00E+02
3645	GLOBAL	Information that applies globally	TWOPLG	Probability of having Plug Pattern 2	Constant	NONE	6.96E-01

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Table 47. Reference Thicknesses for Hydrostratigraphic Units in BRAGFLO

Hydrostratigraphic Unit	Total Hydrostratigraphic Unit Thickness (meters)	Geologic Units Combined as Units Above Dewey Lake	Geologic Unit Thickness (meters)
Units above Dewey Lake	15.76[1]	Surficial Sediments Mescalero Caliche Gatuña Santa Rosa	0 - 3 0 – 4.6[2] 0 – [2.7 – 9.0][3] 0 – [0.6 – 64.0][4]
Dewey Lake	149.3		
Forty-niner	17.3		
Magenta	8.5		
Tamarisk	24.8		
Culebra	7.7		
Unnamed lower Member	36.0		
Impure Halite	600.3		
Marker Bed 138			
Anhydrite Layers and b	0.27		
Marker Bed 139	0.85		
Castile	78.5		

[1] Thicknesses of supra-Dewey Lake hydrostratigraphic unit relates to the ranges of total thickness of geologic units as determined for the following quadrants of the land withdrawal area:

Northwest – 6.0 m (H-6) – 22 m (WIPP-13)
Southwest – 6.0 m (P-6) – 12 m (H-14)
Southeast – 11.3 m (ERDA-9) – 47 m (H-15)
Northeast – 21 m (WIPP-21) – 67 m (H-5)

Source: Sanchez and McCasland, 1994, Assessment of Solid Waste Management Units: NMED/DOE/AIP-94/1, New Mexico Environment Department, Santa Fe, New Mexico, p. 4-1 – 4-28.

[2] Mescalero caliche engulfs local bedrock; thickness of unit is accounted for in bedrock unit thickness of geologic units above Dewey Lake.

[3] Gatuña thickness is variable; generally thickest on west half of land withdrawal area and absent on east side. Range includes AIS shaft (2.7 m) and H-14 (9.0 m).

[4] Santa Rosa is generally absent on west half of land withdrawal area; thickens to east. Range includes AIS shaft (0.6 m) and H-5 (64 m).

Table 48. EPAUNI RH Input (RH Total)

StreamRH	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234	Cs-137	Sr-90	U-233
RH-Total	7078	1.38E+04	1.09E+03	3.81E+03	5.24E+03	1.58E+03	1.31E+05	3.04E+01	4.26E+05	3.22E+05	1.27E+02

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Table 49. EPAUNI CH Input (Stream Totals)

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
AE-T001	189.43	6.84E+01	0.00E+00	1.47E+01	1.73E+02	1.02E+02	1.97E+02	1.09E-02
AE-T003	44.05	5.95E+00	0.00E+00	2.01E+00	5.46E+01	2.11E+01	1.11E+02	9.55E-05
AW-N026.82	0.21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AW-N027.531	11.97	3.48E-02	0.00E+00	5.14E+01	3.90E+01	2.36E-01	2.09E-01	4.06E-04
AW-T033.1325	38.22	1.11E-01	0.00E+00	1.64E+02	1.25E+02	7.53E-01	6.67E-01	1.30E-03
AW-W049	12.81	0.00E+00	0.00E+00	0.00E+00	5.51E-01	0.00E+00	0.00E+00	0.00E+00
BCLCH-MT01	5.24	6.49E+00	0.00E+00	1.78E+03	2.87E+01	7.54E+00	3.60E+02	0.00E+00
BT-T002	18.6	8.43E-03	2.53E-03	9.30E-01	7.25E-04	1.48E-03	1.58E-01	1.99E-03
ET-C1-B55	0.84	4.83E-02	0.00E+00	1.06E-02	6.21E-02	3.10E-02	2.79E-01	2.36E-04
ET-C1-D139	0.21	6.67E-03	0.00E+00	1.47E-03	8.73E-03	4.36E-03	3.71E-02	6.18E-08
ET-C2-SEFOR	1.25	1.77E-01	0.00E+00	0.00E+00	1.37E-01	4.61E-02	5.72E-01	0.00E+00
IN-BN-510	19874.76	9.75E+03	0.00E+00	5.45E+04	2.94E+04	7.20E+03	8.89E+04	2.12E+00
IN-GEM-01	145.92	6.57E+01	0.00E+00	7.12E-01	3.18E+01	7.30E+00	3.94E+01	0.00E+00
IN-GEM-02	34.68	1.56E+01	0.00E+00	1.69E-01	7.56E+00	1.73E+00	9.36E+00	0.00E+00
IN-ICP-002	12480.6	3.89E+04	0.00E+00	2.97E+03	1.45E+04	3.81E+03	0.00E+00	1.54E+01
IN-ICP-003	5262.46	1.64E+04	0.00E+00	1.25E+03	6.10E+03	1.61E+03	0.00E+00	6.50E+00
IN-ICP-004	1084.86	3.38E+03	0.00E+00	2.58E+02	1.26E+03	3.25E+02	0.00E+00	1.36E+00
IN-ICP-005	7239.39	2.26E+04	0.00E+00	1.72E+03	8.39E+03	2.21E+03	0.00E+00	8.94E+00
IN-W157.144	745.55	7.30E+01	0.00E+00	9.08E+00	2.80E+02	6.16E+01	6.18E+02	3.53E-04
IN-W163.1007	11.47	5.47E+00	0.00E+00	2.83E+00	8.68E+01	1.91E+01	1.91E+02	1.10E-04
IN-W164.153	4.79	5.20E-02	0.00E+00	2.68E-02	8.23E-01	1.82E-01	1.81E+00	1.04E-06
IN-W167.149	383.3	1.62E+01	0.00E+00	4.36E+00	1.34E+02	2.95E+01	2.93E+02	1.69E-04
IN-W174.154	431.07	0.00E+00	0.00E+00	2.46E+03	1.79E+00	3.45E+00	0.00E+00	9.57E-02
IN-W177.156	802.9	7.24E-03	0.00E+00	5.26E+03	1.69E+00	1.00E-02	2.53E-01	2.04E-01
IN-W179.158	1995.78	4.87E-02	0.00E+00	5.22E+03	9.80E-02	4.96E-02	1.70E+00	2.03E-01
IN-W181.162	80.29	2.53E+00	0.00E+00	8.70E-01	2.72E+01	6.17E+00	8.80E+01	3.38E-05
IN-W188.160	149.11	4.64E+00	0.00E+00	2.39E+00	7.36E+01	1.62E+01	1.62E+02	9.30E-05
IN-W216.98	12743.17	1.60E+05	0.00E+00	1.95E+02	6.00E+03	1.32E+03	1.32E+04	7.59E-03
IN-W218.909	2082.75	1.61E+03	0.00E+00	1.04E+01	3.25E+02	7.38E+01	1.05E+03	4.03E-04
IN-W219.110	3.95	4.51E-01	0.00E+00	1.55E-01	4.86E+00	1.10E+00	1.57E+01	6.01E-06
IN-W219.914	1.89	7.10E-02	0.00E+00	2.44E-02	7.67E-01	1.74E-01	2.48E+00	9.47E-07
IN-W220.114	1892.55	5.65E+03	0.00E+00	1.54E+01	5.07E+02	1.08E+02	1.04E+03	5.96E-04
IN-W221.927	39.2	1.73E+00	0.00E+00	8.88E-01	2.73E+01	6.03E+00	6.02E+01	3.45E-05
IN-W222.116	259.02	6.01E+01	0.00E+00	3.01E+01	9.24E+02	2.04E+02	2.04E+03	1.17E-03
IN-W228.101	8063.41	1.46E+03	0.00E+00	9.82E+00	3.01E+02	6.66E+01	6.64E+02	3.82E-04
IN-W240.931	396.66	9.12E+01	0.00E+00	1.25E+01	3.85E+02	8.48E+01	8.48E+02	4.86E-04
IN-W243.808	773.28	9.94E+01	0.00E+00	2.20E+01	6.75E+02	1.49E+02	1.48E+03	8.54E-04
IN-W245.301	752.23	8.79E+01	0.00E+00	4.30E+01	1.32E+03	2.92E+02	2.91E+03	1.67E-03
IN-W247.810	761.81	4.26E+01	0.00E+00	2.10E+01	6.45E+02	1.42E+02	1.42E+03	8.14E-04
IN-W249.527	6.68	0.00E+00	0.00E+00	1.47E+03	1.14E+01	0.00E+00	0.00E+00	5.71E-02
IN-W263.520	280.07	4.24E-02	0.00E+00	3.69E+02	1.90E+01	3.02E-02	1.48E+00	1.43E-02
IN-W267.1005	11.47	9.86E+00	0.00E+00	5.09E+00	1.56E+02	3.44E+01	3.44E+02	1.98E-04

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
IN-W309.609	7730.78	5.53E+02	0.00E+00	8.60E+01	2.63E+03	5.77E+02	5.79E+03	3.34E-03
IN-W315.601	34.41	2.19E+03	0.00E+00	9.04E-01	2.84E+01	6.42E+00	9.15E+01	3.51E-05
IN-W319.584	4.79	1.52E+00	0.00E+00	7.87E-01	2.40E+01	5.31E+00	5.31E+01	3.05E-05
IN-W321.1023	11.47	1.32E+01	0.00E+00	6.80E+00	2.09E+02	4.60E+01	4.59E+02	2.64E-04
IN-W322.851	1.89	0.00E+00	0.00E+00	0.00E+00	9.12E+00	1.89E+00	0.00E+00	0.00E+00
IN-W322.952	1.66	0.00E+00	0.00E+00	0.00E+00	2.43E+01	5.04E+00	0.00E+00	0.00E+00
IN-W323.562	1.89	4.47E-02	0.00E+00	1.22E+00	2.49E-01	0.00E+00	1.56E+00	4.76E-05
IN-W323.951	0.21	5.28E-02	0.00E+00	1.45E-02	2.97E-01	0.00E+00	1.84E+00	5.64E-07
IN-W332.661	4.79	0.00E+00	0.00E+00	1.52E+01	1.19E-01	0.00E+00	0.00E+00	5.90E-04
IN-W337.673	0.21	0.00E+00	0.00E+00	0.00E+00	3.04E+00	6.30E-01	0.00E+00	0.00E+00
IN-W337.957	1.89	0.00E+00	0.00E+00	0.00E+00	9.12E+00	1.89E+00	0.00E+00	0.00E+00
IN-W342.652	1.89	4.55E+00	0.00E+00	0.00E+00	4.02E-02	1.04E-17	0.00E+00	0.00E+00
IN-W342.953	0.42	3.04E+00	0.00E+00	0.00E+00	2.69E-02	6.98E-18	0.00E+00	0.00E+00
IN-W347.818	153.9	2.64E+00	0.00E+00	0.00E+00	7.65E+01	1.36E+02	0.00E+00	3.58E-08
IN-W348.1012	22.94	2.45E+01	0.00E+00	1.25E+01	3.85E+02	8.50E+01	8.49E+02	4.87E-04
IN-W353.917	0.21	0.00E+00	0.00E+00	0.00E+00	2.50E-02	0.00E+00	0.00E+00	0.00E+00
IN-W357.1022	4.79	4.77E-02	0.00E+00	2.46E-02	7.52E-01	1.66E-01	1.66E+00	9.54E-07
IN-W358.854	1.89	0.00E+00	0.00E+00	3.92E+02	1.88E+00	3.63E+00	0.00E+00	8.00E-03
IN-W358.855	3.33	0.00E+00	0.00E+00	2.09E+03	1.00E+01	1.93E+01	0.00E+00	4.27E-02
IN-W358.948	0.21	0.00E+00	0.00E+00	4.36E+02	2.09E+00	4.02E+00	0.00E+00	8.90E-03
IN-W361.1021	11.47	4.65E+00	0.00E+00	2.38E+00	7.30E+01	1.61E+01	1.61E+02	9.25E-05
IN-W362.1020	45.88	6.02E+01	0.00E+00	3.11E+01	9.54E+02	2.10E+02	2.10E+03	1.21E-03
IN-W363.1019	4.79	2.83E+00	0.00E+00	1.46E+00	4.49E+01	9.85E+00	9.86E+01	5.68E-05
IN-W364.1011	4.79	4.67E+00	0.00E+00	2.41E+00	7.37E+01	1.63E+01	1.63E+02	9.35E-05
IN-W365.1010	11.47	3.52E+02	0.00E+00	1.91E+00	5.88E+01	1.29E+01	1.29E+02	7.44E-05
IN-W366.841	16.26	4.38E+00	0.00E+00	1.63E+00	4.97E+01	1.09E+01	1.10E+02	6.33E-05
IN-W372.832	1.89	4.55E+00	0.00E+00	0.00E+00	4.02E-02	1.04E-17	0.00E+00	0.00E+00
IN-W375.1096	199.78	1.16E+00	0.00E+00	6.00E-01	1.84E+01	4.07E+00	4.06E+01	2.33E-05
KN-B234TRU	310.5	1.08E+02	0.00E+00	1.84E+01	2.19E+02	7.36E+01	3.85E+02	1.47E-03
LA-IT-00-01	9.78	2.35E+00	1.63E+00	4.16E+00	5.85E-01	8.16E-03	9.85E-08	3.55E-04
LA-OS-00-01	50.2	3.77E+03	0.00E+00	1.34E+05	8.90E+02	0.00E+00	0.00E+00	3.81E-01
LA-PX-00-01	0.62	1.62E-02	0.00E+00	8.01E-03	9.05E-02	2.13E-02	1.63E-01	1.40E-07
LA-SL-00-01	0.42	0.00E+00	0.00E+00	1.69E-01	1.53E-01	0.00E+00	0.00E+00	1.39E-05
LA-TA-03-12	221.33	1.91E-01	0.00E+00	3.91E+00	4.36E-01	1.52E-01	9.66E-01	3.82E-04
LA-TA-03-13	46.38	2.46E-01	0.00E+00	1.24E+01	6.81E-01	1.60E-01	1.28E+00	5.33E-04
LA-TA-03-19	179.85	5.18E-01	0.00E+00	1.85E+01	1.33E+00	3.85E-01	1.98E+00	1.79E-03
LA-TA-03-20	30.07	2.64E-01	0.00E+00	8.78E+00	5.86E-01	2.07E-01	1.62E+00	6.89E-04
LA-TA-03-24	29.95	3.71E-01	0.00E+00	3.42E+01	1.09E+00	3.31E-01	1.68E+00	3.41E-03
LA-TA-03-26	24.27	1.69E-02	0.00E+00	1.41E+00	2.64E+00	4.33E-02	1.47E-01	1.01E-03
LA-TA-03-28	5.84	0.00E+00	0.00E+00	4.88E-01	2.47E-01	0.00E+00	0.00E+00	4.52E-05
LA-TA-03-30	0.83	7.12E-01	0.00E+00	3.48E-01	5.03E+00	1.46E+00	7.70E+00	3.10E-05

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
LA-TA-03-31	0.21	1.10E+00	0.00E+00	4.40E-01	2.14E+00	5.20E-03	2.30E-02	1.96E-03
LA-TA-03-40	266.02	0.00E+00	0.00E+00	2.75E-02	5.47E-02	0.00E+00	0.00E+00	2.64E-06
LA-TA-03-42	299.98	1.69E-05	0.00E+00	6.89E-04	3.42E-03	4.51E-05	1.61E-04	6.61E-08
LA-TA-21-06	226.38	1.64E-01	0.00E+00	7.58E+01	9.57E-01	2.93E-01	1.66E+00	7.01E-03
LA-TA-21-12	263.95	6.09E-01	0.00E+00	4.57E+02	3.32E+00	9.94E-01	5.70E+00	4.23E-02
LA-TA-21-13	16.22	1.24E+00	0.00E+00	0.00E+00	2.94E-01	0.00E+00	0.00E+00	0.00E+00
LA-TA-21-14	7.9	1.24E-04	0.00E+00	8.72E+00	4.49E+00	5.25E-05	2.31E-03	1.78E-04
LA-TA-21-15	3.54	8.78E-02	0.00E+00	2.40E-02	1.39E+00	2.38E-01	9.37E-01	2.13E-06
LA-TA-21-16	71.67	1.05E+00	0.00E+00	3.70E-01	1.06E+01	2.54E+00	9.89E+00	3.55E-05
LA-TA-21-40	1022.49	1.22E-04	0.00E+00	1.65E+00	3.33E-01	3.70E-04	1.85E-03	1.18E-04
LA-TA-21-41	41.51	0.00E+00	0.00E+00	0.00E+00	7.09E-01	0.00E+00	0.00E+00	0.00E+00
LA-TA-21-42	690.71	1.70E-02	0.00E+00	5.36E-01	1.64E-01	1.12E-02	6.01E-02	5.34E-05
LA-TA-21-43	2533.7	2.54E+03	0.00E+00	6.14E+01	1.77E+03	0.00E+00	9.99E-03	1.47E+01
LA-TA-21-44	137.73	7.63E-02	0.00E+00	6.53E+01	1.29E+02	2.60E-01	5.69E+00	1.33E-03
LA-TA-48-01	0.62	8.50E-02	2.62E+01	1.40E-02	1.18E-01	4.24E-01	5.56E-01	1.06E-06
LA-TA-49-01	96.22	7.84E-03	0.00E+00	1.31E+02	7.44E+01	2.19E-02	1.09E-01	3.39E-01
LA-TA-50-10	1.04	3.27E-02	0.00E+00	1.27E-02	4.59E-02	0.00E+00	0.00E+00	1.84E-07
LA-TA-50-11	8.57	4.67E-02	0.00E+00	1.67E-02	4.66E-01	1.04E-01	5.50E-01	1.25E-05
LA-TA-50-15	159.12	1.07E-01	0.00E+00	1.92E+00	3.40E-01	7.65E-02	4.67E-01	1.21E-04
LA-TA-50-17	174.7	1.45E+01	0.00E+00	1.26E+00	1.47E+01	3.47E-04	3.45E-02	3.54E-04
LA-TA-50-18	98.41	1.07E+00	0.00E+00	2.06E-01	2.97E+00	5.36E-06	1.26E-03	1.98E-05
LA-TA-50-19	1179.79	3.41E-01	0.00E+00	9.18E-02	3.95E-01	4.59E-03	1.56E-02	3.56E-05
LA-TA-50-20	0.62	9.37E-03	0.00E+00	0.00E+00	9.74E-03	0.00E+00	0.00E+00	0.00E+00
LA-TA-50-40	24.53	3.55E-03	0.00E+00	1.24E-03	1.06E-02	4.97E-03	5.00E-02	9.31E-08
LA-TA-50-41	35.91	2.56E-03	0.00E+00	1.25E-03	4.70E-02	1.10E-02	8.91E-02	4.84E-08
LA-TA-55-19	2576.98	5.56E+00	0.00E+00	1.31E+00	2.10E+01	5.94E+00	4.00E+01	1.33E-03
LA-TA-55-20	450.87	6.92E+01	0.00E+00	1.35E+01	4.57E+02	1.10E+02	9.06E+02	6.79E-02
LA-TA-55-21	98.99	8.93E-01	2.27E-03	2.16E-01	4.52E+00	1.09E+00	1.04E+01	7.73E-06
LA-TA-55-22	14.18	2.32E+00	0.00E+00	1.22E+00	1.59E+01	3.74E+00	3.22E+01	4.36E-05
LA-TA-55-23	12.48	2.14E+00	0.00E+00	1.02E+00	1.09E+01	2.71E+00	3.17E+01	3.31E-05
LA-TA-55-24	1.25	6.98E-01	0.00E+00	1.60E-01	5.72E+00	1.34E+00	1.51E+01	2.79E-06
LA-TA-55-25	22.64	3.57E+00	0.00E+00	9.33E-01	2.84E+01	6.67E+00	7.73E+01	1.63E-05
LA-TA-55-28	3.74	1.26E+00	0.00E+00	5.17E-01	8.72E+00	2.07E+00	2.51E+01	1.06E-05
LA-TA-55-30	2713.31	3.36E+01	1.77E-05	5.07E+00	1.17E+02	2.84E+01	1.50E+02	6.34E-04
LA-TA-55-32	4.78	3.05E+00	0.00E+00	3.46E+01	1.13E+01	3.51E+00	2.29E+01	3.50E-03
LA-TA-55-33	6.66	4.64E-01	0.00E+00	8.93E-02	1.49E+00	4.78E-01	3.22E+00	6.39E-06
LA-TA-55-34	205.67	3.43E+01	0.00E+00	6.34E+00	1.77E+02	4.52E+01	2.98E+02	2.58E-03
LA-TA-55-38	744.3	1.26E+02	0.00E+00	2.39E+00	4.48E+01	1.21E+01	7.92E+01	1.66E-03
LA-TA-55-39	2.91	9.97E+00	0.00E+00	2.01E+00	7.61E+01	1.72E+01	1.59E+02	5.93E-05
LA-TA-55-41	35.38	2.92E+02	0.00E+00	3.37E+00	7.64E+01	1.84E+01	1.62E+02	1.31E-04
LA-TA-55-43	64.9	7.76E-02	0.00E+00	2.73E+02	1.42E-01	5.00E-02	1.76E+00	7.24E-03
LA-TA-55-44	230.66	1.02E+00	0.00E+00	6.43E+02	2.63E+00	7.34E-01	5.20E+00	4.82E-02

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
LA-TA-55-48	23.34	3.02E-01	0.00E+00	2.97E+02	2.06E-01	1.03E-01	2.91E+00	1.92E-02
LA-TA-55-49	18.3	1.67E+01	0.00E+00	3.34E+03	3.09E+01	8.73E+00	6.35E+01	2.39E-01
LA-TA-55-53	174.68	6.22E+01	0.00E+00	5.57E+00	2.14E+02	5.01E+01	2.81E+02	3.70E-04
LA-TA-55-56	685.19	5.12E+01	0.00E+00	1.86E+02	2.77E+02	6.98E+01	5.82E+02	8.49E-03
LA-TA-55-60	211.31	3.71E-02	0.00E+00	6.49E-02	7.20E-02	2.57E-02	4.74E-01	4.64E-06
LA-TA-55-61	226.49	3.01E-02	0.00E+00	2.99E-01	1.39E-01	4.74E-02	4.61E-01	1.94E-05
LA-TA-55-62	73.58	7.64E-03	0.00E+00	2.84E-03	2.33E-02	1.12E-02	1.24E-01	1.94E-07
LA-TA-55-63	5.66	4.64E-03	0.00E+00	1.92E-03	7.47E-02	1.74E-02	1.22E-01	9.32E-08
LL-M001	31.11	8.06E+01	9.43E+01	7.65E+01	6.41E+01	2.88E+01	8.81E+02	0.00E+00
LL-T001	276.82	2.52E+02	0.00E+00	0.00E+00	3.86E+02	1.75E+02	5.40E+03	0.00E+00
LL-T002	1507.73	2.70E+03	0.00E+00	4.83E+02	3.75E+03	1.55E+03	4.77E+04	0.00E+00
LL-T003	761.83	1.03E+02	0.00E+00	5.35E+01	7.56E+01	6.11E+01	1.87E+03	0.00E+00
LL-T004	23.43	6.58E+01	0.00E+00	1.11E+01	4.83E+01	3.89E+01	1.19E+03	0.00E+00
LL-T005	852.06	4.18E+02	3.39E+03	1.36E+02	1.87E+02	1.53E+02	4.62E+03	0.00E+00
LL-W018	2.11	2.19E-02	0.00E+00	0.00E+00	1.85E-02	4.28E-02	1.25E+00	0.00E+00
LL-W019	15.3	1.90E+01	0.00E+00	0.00E+00	1.21E+01	1.01E+01	3.08E+02	0.00E+00
LL-W034	20.98	9.44E+00	7.59E+01	3.15E+00	4.20E+00	3.36E+00	1.04E+02	0.00E+00
MC-W001	2.5	1.56E-01	0.00E+00	0.00E+00	6.06E-02	0.00E+00	1.88E-01	0.00E+00
MU-W002	1.46	2.17E+00	0.00E+00	0.00E+00	5.26E-02	0.00E+00	0.00E+00	2.67E-12
NT-JAS-01	681.4	9.20E+01	0.00E+00	4.78E+01	6.76E+01	5.46E+01	1.67E+03	0.00E+00
NT-W001	626.75	3.06E+02	2.30E+00	1.33E+02	2.84E+03	1.90E+01	1.63E+02	1.15E-02
NT-W021	5.67	3.20E+00	0.00E+00	9.60E-01	3.22E+01	7.38E+00	8.39E+01	4.65E-05
OR-W201	86.24	3.04E+03	1.14E+02	2.05E+03	1.54E+03	1.52E+03	6.26E+04	3.10E+01
OR-W202	417.76	6.77E+02	2.38E+03	5.92E+03	3.95E+02	3.83E+02	2.01E+03	3.22E-01
OR-W203	142.79	1.47E+00	8.27E+01	8.51E-01	1.77E-02	1.04E+00	5.10E+00	4.39E-05
OR-W204	27.5	3.67E-01	3.43E-04	9.59E-01	3.02E-01	2.05E-01	0.00E+00	4.97E-05
PA-A015	14.19	0.00E+00	0.00E+00	0.00E+00	3.43E-01	0.00E+00	0.00E+00	0.00E+00
RF-MT0001	8.15	1.95E+03	0.00E+00	8.38E+00	1.96E+02	4.49E+01	6.45E+02	2.99E-04
RF-MT0002	0.63	1.50E+02	0.00E+00	6.43E-01	1.51E+01	3.45E+00	4.95E+01	2.30E-05
RF-MT0003	1.67	3.01E-01	0.00E+00	1.47E-01	3.45E+00	7.90E-01	1.13E+01	5.27E-06
RF-MT0007	0.83	1.69E+00	0.00E+00	0.00E+00	4.30E-01	9.83E-02	1.31E+00	0.00E+00
RF-MT0089	0.42	2.92E-03	0.00E+00	1.47E-03	3.45E-02	7.89E-03	1.13E-01	5.26E-08
RF-MT0090	2.5	1.34E+01	0.00E+00	2.08E+00	8.86E+01	2.01E+01	1.13E+02	7.45E-05
RF-MT0091	148.83	7.50E+02	0.00E+00	2.11E+02	5.92E+03	1.35E+03	9.33E+03	1.06E-02
RF-MT0092	21.47	1.09E+02	0.00E+00	2.66E+01	8.48E+02	1.97E+02	1.29E+03	9.48E-04
RF-MT0093	23.35	1.49E+02	0.00E+00	2.74E+01	9.15E+02	2.16E+02	1.10E+03	9.78E-04
RF-MT0097	1.46	7.28E+00	0.00E+00	1.21E+00	4.78E+01	9.82E+00	6.01E+01	4.30E-05
RF-MT0099	0.63	4.39E-03	0.00E+00	2.21E-03	5.17E-02	1.18E-02	1.70E-01	7.89E-08
RF-MT0290	18.97	1.09E+01	0.00E+00	5.47E+00	1.28E+02	2.93E+01	4.21E+02	1.95E-04
RF-MT-0292	23.97	1.37E+01	0.00E+00	6.91E+00	1.62E+02	3.70E+01	5.32E+02	2.47E-04
RF-MT-0299	31.06	3.30E+03	0.00E+00	1.77E+02	4.15E+03	9.50E+02	1.37E+04	6.33E-03
RF-MT0302	0.42	3.94E-02	0.00E+00	7.02E-03	1.79E-01	4.11E-02	5.32E-01	1.71E-05

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RF-MT0320	7.09	5.06E+01	0.00E+00	7.27E+00	1.74E+02	3.99E+01	5.35E+02	2.72E-04
RF-MT0321	36.9	2.96E+01	0.00E+00	1.92E+00	4.97E+01	1.13E+01	1.33E+02	2.21E-03
RF-MT-0328	2.61	1.59E+00	0.00E+00	2.09E-01	4.90E+00	1.12E+00	1.61E+01	2.80E-04
RF-MT0330	4.38	1.91E+01	0.00E+00	2.55E+00	1.11E+02	2.72E+01	1.69E+02	9.13E-05
RF-MT-0331	24.6	1.29E+02	0.00E+00	1.77E+01	5.41E+02	1.21E+02	1.09E+03	2.14E-02
RF-MT0332	1.46	1.02E-02	0.00E+00	5.16E-03	1.21E-01	2.76E-02	3.97E-01	1.84E-07
RF-MT-0335	0.83	1.36E+00	0.00E+00	2.37E-01	6.23E+00	1.43E+00	1.62E+01	5.51E-04
RF-MT0336	14.29	1.03E+02	0.00E+00	1.57E+01	4.42E+02	1.01E+02	9.50E+02	2.38E-03
RF-MT0337	13.97	6.07E+01	0.00E+00	8.63E+00	2.70E+02	6.07E+01	4.64E+02	4.16E-03
RF-MT0339	215.3	1.25E+02	0.00E+00	1.95E+01	4.90E+02	1.11E+02	1.39E+03	1.48E-02
RF-MT-0342	0.42	8.09E-01	0.00E+00	1.97E-01	5.47E+00	1.23E+00	1.23E+01	6.55E-05
RF-MT0371	20.43	2.96E+02	0.00E+00	4.56E+01	1.07E+03	2.44E+02	3.51E+03	2.92E-03
RF-MT-0372	1.46	1.07E+00	0.00E+00	3.21E-01	7.46E+00	1.71E+00	2.17E+01	2.51E-04
RF-MT0373	3.96	2.12E+01	0.00E+00	3.30E+00	1.40E+02	3.18E+01	1.79E+02	1.18E-04
RF-MT0374	0.63	5.76E-01	0.00E+00	1.18E-01	2.77E+00	6.33E-01	9.07E+00	7.54E-06
RF-MT0376	0.21	4.74E-01	0.00E+00	9.53E-02	2.76E+00	6.41E-01	6.69E+00	1.85E-05
RF-MT0377	74.42	2.73E+02	0.00E+00	5.49E+01	1.29E+03	2.94E+02	4.22E+03	1.22E-02
RF-MT0378	0.63	2.69E+00	0.00E+00	7.59E-01	1.78E+01	4.07E+00	5.84E+01	2.71E-05
RF-MT0419	4.79	5.67E+00	0.00E+00	7.09E-01	1.66E+01	3.80E+00	5.46E+01	2.53E-05
RF-MT0420	0.83	9.86E-01	0.00E+00	1.23E-01	2.88E+00	6.60E-01	9.49E+00	4.40E-06
RF-MT0423	1.04	9.86E+00	0.00E+00	1.00E+00	4.16E+01	9.23E+00	3.76E+01	3.58E-05
RF-MT0425	0.21	2.47E-01	0.00E+00	3.08E-02	7.21E-01	1.65E-01	2.37E+00	1.10E-06
RF-MT-0438	0.63	2.17E+00	0.00E+00	4.04E-01	1.28E+01	2.90E+00	2.35E+01	2.76E-05
RF-MT0440	2.29	7.49E-01	0.00E+00	1.45E-01	4.64E+00	1.08E+00	9.68E+00	1.70E-04
RF-MT0442	0.83	2.88E-01	0.00E+00	6.27E-02	1.59E+00	3.63E-01	3.59E+00	9.71E-05
RF-MT0443	19.39	2.49E+00	0.00E+00	1.03E+00	2.47E+01	5.65E+00	7.49E+01	1.95E-04
RF-MT0444	44.44	2.58E+01	0.00E+00	4.98E+00	1.17E+02	2.68E+01	3.83E+02	2.00E-04
RF-MT0480	112.89	7.22E+01	0.00E+00	1.34E+01	3.17E+02	7.24E+01	9.48E+02	2.81E-03
RF-MT0488	406.67	9.39E+01	0.00E+00	1.64E+01	3.84E+02	8.80E+01	1.26E+03	2.45E-02
RF-MT0490	1.89	4.93E-01	0.00E+00	1.23E-01	2.93E+00	6.71E-01	9.00E+00	1.56E-05
RF-MT-0491	0.63	4.85E-02	0.00E+00	5.62E-03	1.33E-01	3.03E-02	4.21E-01	2.21E-06
RF-MT0523A	10.84	3.81E+01	0.00E+00	4.47E+00	1.05E+02	2.40E+01	3.43E+02	4.16E-04
RF-MT0523B	10.84	3.81E+01	0.00E+00	4.47E+00	1.05E+02	2.40E+01	3.43E+02	4.16E-04
RF-MT0523C	10.84	3.81E+01	0.00E+00	4.47E+00	1.05E+02	2.40E+01	3.43E+02	4.16E-04
RF-MT0523D	10.84	3.81E+01	0.00E+00	4.47E+00	1.05E+02	2.40E+01	3.43E+02	4.16E-04
RF-MT0523E	10.84	3.81E+01	0.00E+00	4.47E+00	1.05E+02	2.40E+01	3.43E+02	4.16E-04
RF-MT0531	0.21	1.46E-03	0.00E+00	7.36E-04	1.72E-02	3.94E-03	5.67E-02	2.63E-08
RF-MT0532E	15.63	1.34E+02	0.00E+00	9.57E+00	2.29E+02	5.23E+01	7.31E+02	1.45E-03
RF-MT0532F	15.63	1.34E+02	0.00E+00	9.57E+00	2.29E+02	5.23E+01	7.31E+02	1.45E-03
RF-MT0541	4.38	5.43E+00	0.00E+00	1.38E-01	3.25E+00	7.42E-01	1.07E+01	4.94E-06
RF-MT0545	0.21	1.33E-02	0.00E+00	6.68E-03	1.57E-01	3.58E-02	5.15E-01	2.39E-07
RF-MT0800	62.48	1.17E+03	0.00E+00	3.31E+00	7.75E+01	1.77E+01	2.55E+02	6.02E-04

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RF-MT0801	101.83	1.26E+02	0.00E+00	3.22E+00	7.56E+01	1.73E+01	2.48E+02	1.15E-04
RF-MT0803	2.29	2.85E+00	0.00E+00	7.25E-02	1.70E+00	3.88E-01	5.58E+00	2.59E-06
RF-MT0806	0.21	1.11E+00	0.00E+00	1.74E-01	7.39E+00	1.67E+00	9.43E+00	6.21E-06
RF-MT0807	84.18	1.46E+01	0.00E+00	1.34E+00	3.14E+01	7.19E+00	1.03E+02	4.79E-05
RF-MT0816	0.42	1.44E+00	0.00E+00	1.89E-01	4.43E+00	1.01E+00	1.46E+01	6.75E-06
RF-MT-0823	0.21	7.34E-01	0.00E+00	8.60E-02	2.02E+00	4.62E-01	6.60E+00	8.00E-06
RF-MT0827	9.9	3.41E+01	0.00E+00	4.49E+00	1.05E+02	2.41E+01	3.46E+02	1.60E-04
RF-MT0831	59.92	6.00E+01	0.00E+00	1.31E+01	3.03E+02	6.94E+01	9.70E+02	1.27E-02
RF-MT0832	166.26	3.76E+02	0.00E+00	4.07E+01	1.01E+03	2.30E+02	2.96E+03	3.00E-02
RF-MT0833	100.26	1.11E+02	0.00E+00	1.17E+01	2.83E+02	6.48E+01	8.64E+02	8.04E-03
RF-MT0855	1.67	1.25E-02	0.00E+00	6.31E-03	1.48E-01	3.38E-02	4.86E-01	2.25E-07
RF-MT0857	0.21	1.11E+00	0.00E+00	1.73E-01	7.37E+00	1.67E+00	9.41E+00	6.19E-06
RF-MT0H61	7.71	4.12E+01	0.00E+00	6.43E+00	2.73E+02	6.20E+01	3.49E+02	2.30E-04
RF-MT2116	2.08	4.71E+00	0.00E+00	5.10E-01	1.26E+01	2.88E+00	3.71E+01	3.76E-04
RF-MT3010	42.81	1.82E+01	0.00E+00	4.06E+00	9.61E+01	2.20E+01	3.05E+02	4.46E-04
RF-MT3011	420.26	1.61E+02	0.00E+00	2.75E+01	6.45E+02	1.48E+02	2.12E+03	7.48E-03
RF-MT420P	160.94	1.20E+03	0.00E+00	1.67E+02	6.35E+03	1.45E+03	8.30E+03	1.60E-02
RF-MT532A	27.5	2.35E+02	0.00E+00	1.68E+01	4.03E+02	9.20E+01	1.29E+03	2.55E-03
RF-MT532B	123.42	1.06E+03	0.00E+00	7.56E+01	1.81E+03	4.13E+02	5.77E+03	1.14E-02
RF-MT532C	247.47	2.12E+03	0.00E+00	1.52E+02	3.63E+03	8.28E+02	1.16E+04	2.29E-02
RF-MT532D	1.56	1.34E+01	0.00E+00	9.57E-01	2.29E+01	5.23E+00	7.30E+01	1.45E-04
RF-TT0069	0.21	8.59E-02	0.00E+00	1.59E-02	3.73E-01	8.53E-02	1.23E+00	7.41E-05
RF-TT0200	0.63	4.46E+00	0.00E+00	6.42E-01	1.53E+01	3.52E+00	4.72E+01	2.40E-05
RF-TT0299	0.21	2.21E+01	0.00E+00	1.19E+00	2.79E+01	6.38E+00	9.16E+01	4.25E-05
RF-TT0300	42.32	1.26E+02	0.00E+00	3.33E+01	7.87E+02	1.81E+02	2.19E+03	9.40E-03
RF-TT0301	5.84	1.74E+01	0.00E+00	4.60E+00	1.09E+02	2.50E+01	3.02E+02	1.30E-03
RF-TT0302	9.28	8.77E-01	0.00E+00	1.56E-01	3.99E+00	9.14E-01	1.18E+01	3.80E-04
RF-TT0303	1.25	5.69E+00	0.00E+00	9.76E-01	2.29E+01	5.23E+00	7.51E+01	1.07E-03
RF-TT0310	3.13	1.87E+01	0.00E+00	4.58E+00	1.03E+02	2.43E+01	2.75E+02	3.49E-04
RF-TT0312	57.95	4.77E+02	0.00E+00	8.27E+01	2.25E+03	5.10E+02	5.79E+03	4.72E-03
RF-TT0317	0.21	1.87E-01	0.00E+00	8.99E-02	2.11E+00	4.82E-01	6.92E+00	3.21E-06
RF-TT0320	26.27	1.88E+02	0.00E+00	2.70E+01	6.45E+02	1.48E+02	1.98E+03	1.01E-03
RF-TT0330	15.95	6.95E+01	0.00E+00	9.31E+00	4.03E+02	9.92E+01	6.14E+02	3.32E-04
RF-TT-0331	69.21	3.62E+02	0.00E+00	4.99E+01	1.52E+03	3.41E+02	3.07E+03	6.01E-02
RF-TT-0334	4.07	8.63E+01	0.00E+00	3.61E+01	8.45E+02	1.93E+02	2.78E+03	1.29E-03
RF-TT0335	94.4	1.54E+02	0.00E+00	2.68E+01	7.05E+02	1.62E+02	1.83E+03	6.23E-02
RF-TT0336	22.52	1.63E+02	0.00E+00	2.48E+01	6.96E+02	1.59E+02	1.50E+03	3.75E-03
RF-TT0337	47.46	2.06E+02	0.00E+00	2.93E+01	9.17E+02	2.06E+02	1.58E+03	1.41E-02
RF-TT0338	142.93	8.31E+02	0.00E+00	1.03E+02	3.45E+03	7.77E+02	6.79E+03	1.13E-02
RF-TT0340	7.3	4.18E+00	0.00E+00	2.10E+00	4.92E+01	1.13E+01	1.62E+02	7.51E-05
RF-TT0342	20.85	4.05E+01	0.00E+00	9.87E+00	2.74E+02	6.14E+01	6.14E+02	3.28E-03
RF-TT0360	0.63	3.65E+00	0.00E+00	5.33E-01	1.30E+01	3.01E+00	3.85E+01	2.54E-05

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RF-TT0368	12.51	7.30E+01	0.00E+00	1.07E+01	2.61E+02	6.03E+01	7.71E+02	5.07E-04
RF-TT0370	17.09	1.40E+02	0.00E+00	2.31E+01	5.81E+02	1.33E+02	1.64E+03	8.67E-03
RF-TT0371	0.21	3.02E+00	0.00E+00	4.65E-01	1.09E+01	2.49E+00	3.58E+01	2.98E-05
RF-TT0372	0.42	3.06E-01	0.00E+00	9.16E-02	2.13E+00	4.88E-01	6.20E+00	7.17E-05
RF-TT0374	10.74	9.89E+00	0.00E+00	2.03E+00	4.75E+01	1.09E+01	1.56E+02	1.29E-04
RF-TT0375A	2.3	5.63E-02	0.00E+00	2.66E-02	6.22E-01	1.42E-01	2.05E+00	9.49E-07
RF-TT0375B	2.3	5.63E-02	0.00E+00	2.66E-02	6.22E-01	1.42E-01	2.05E+00	9.49E-07
RF-TT0376	11.46	2.61E+01	0.00E+00	5.24E+00	1.52E+02	3.52E+01	3.68E+02	1.02E-03
RF-TT0377	3.23	1.19E+01	0.00E+00	2.39E+00	5.59E+01	1.28E+01	1.83E+02	5.29E-04
RF-TT0391	0.42	3.53E+00	0.00E+00	4.01E-01	1.69E+01	3.81E+00	3.83E+01	1.43E-05
RF-TT0392	0.21	1.25E+00	0.00E+00	2.52E-01	8.83E+00	2.01E+00	1.33E+01	9.17E-06
RF-TT0393	11.05	9.38E+01	0.00E+00	1.76E+01	4.11E+02	9.41E+01	1.35E+03	6.27E-04
RF-TT0398	0.42	2.20E+00	0.00E+00	4.64E-01	1.65E+01	3.74E+00	2.51E+01	1.67E-05
RF-TT0409	0.21	2.23E+00	0.00E+00	2.17E-01	8.52E+00	1.93E+00	9.65E+00	8.37E-06
RF-TT0412	0.21	2.23E+00	0.00E+00	2.17E-01	8.52E+00	1.93E+00	9.65E+00	8.37E-06
RF-TT0414	6.46	6.91E+01	0.00E+00	6.71E+00	2.64E+02	5.97E+01	2.99E+02	2.59E-04
RF-TT0430	0.21	9.95E-03	0.00E+00	5.01E-03	1.17E-01	2.68E-02	3.85E-01	1.79E-07
RF-TT0431	22.2	2.55E+00	0.00E+00	1.19E+00	2.80E+01	6.40E+00	8.89E+01	2.58E-04
RF-TT0438	70.32	2.44E+02	0.00E+00	4.54E+01	1.43E+03	3.26E+02	2.64E+03	3.10E-03
RF-TT0440	60.17	1.97E+01	0.00E+00	3.79E+00	1.22E+02	2.84E+01	2.54E+02	4.47E-03
RF-TT0441	143.32	1.10E+02	0.00E+00	2.10E+01	4.96E+02	1.13E+02	1.59E+03	5.32E-03
RF-TT0442	47.35	1.63E+01	0.00E+00	3.56E+00	9.03E+01	2.06E+01	2.04E+02	5.51E-03
RF-TT0443	1.46	1.88E-01	0.00E+00	7.79E-02	1.86E+00	4.26E-01	5.65E+00	1.47E-05
RF-TT0479	1.04	2.16E+00	0.00E+00	1.09E+00	2.54E+01	5.82E+00	8.36E+01	3.88E-05
RF-TT0480	294.34	1.88E+02	0.00E+00	3.50E+01	8.25E+02	1.89E+02	2.47E+03	7.33E-03
RF-TT0481	0.21	1.33E-01	0.00E+00	2.48E-02	5.84E-01	1.34E-01	1.75E+00	5.19E-06
RF-TT0483	0.83	2.66E-01	0.00E+00	1.34E-01	3.13E+00	7.17E-01	1.03E+01	1.72E-02
RF-TT0484	9.8	1.85E+00	0.00E+00	5.55E-01	1.30E+01	2.98E+00	4.28E+01	1.31E-04
RF-TT0485	5.42	1.82E-01	0.00E+00	3.43E-02	8.02E-01	1.84E-01	2.64E+00	2.79E-04
RF-TT0486	14.38	1.08E+00	0.00E+00	2.03E-01	4.76E+00	1.09E+00	1.56E+01	2.35E-04
RF-TT0487	2.19	4.95E+00	0.00E+00	5.36E-01	1.33E+01	3.03E+00	3.90E+01	3.95E-04
RF-TT0489	9.38	1.49E+00	0.00E+00	3.10E-01	7.26E+00	1.66E+00	2.39E+01	1.12E-04
RF-TT0490	252.23	6.58E+01	0.00E+00	1.64E+01	3.91E+02	8.95E+01	1.20E+03	2.09E-03
RF-TT0491	27.79	2.15E+00	0.00E+00	2.50E-01	5.90E+00	1.35E+00	1.87E+01	9.84E-05
RF-TT0492	1.89	6.03E-01	0.00E+00	1.50E-01	3.50E+00	8.02E-01	1.15E+01	5.34E-06
RF-TT0523A	1.46	5.13E+00	0.00E+00	6.02E-01	1.41E+01	3.23E+00	4.62E+01	5.60E-05
RF-TT0523B	1.46	5.13E+00	0.00E+00	6.02E-01	1.41E+01	3.23E+00	4.62E+01	5.60E-05
RF-TT0523C	1.46	5.13E+00	0.00E+00	6.02E-01	1.41E+01	3.23E+00	4.62E+01	5.60E-05
RF-TT0523D	1.46	5.13E+00	0.00E+00	6.02E-01	1.41E+01	3.23E+00	4.62E+01	5.60E-05
RF-TT0523E	1.46	5.13E+00	0.00E+00	6.02E-01	1.41E+01	3.23E+00	4.62E+01	5.60E-05
RF-TT0532A	16.05	1.37E+02	0.00E+00	9.83E+00	2.35E+02	5.37E+01	7.50E+02	1.49E-03
RF-TT0532B	16.05	1.37E+02	0.00E+00	9.83E+00	2.35E+02	5.37E+01	7.50E+02	1.49E-03

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RF-TT0541	0.21	1.19E-01	0.00E+00	6.01E-02	1.41E+00	3.22E-01	4.63E+00	2.15E-06
RF-TT0545	0.42	2.66E-02	0.00E+00	1.34E-02	3.13E-01	7.17E-02	1.03E+00	4.78E-07
RF-TT0601	2.71	1.58E+01	0.00E+00	2.31E+00	5.65E+01	1.31E+01	1.67E+02	1.10E-04
RF-TT0802	56.43	1.89E+03	0.00E+00	1.87E+02	4.41E+03	1.00E+03	1.44E+04	6.69E-03
RF-TT0809	4.07	1.36E+02	0.00E+00	1.35E+01	3.18E+02	7.24E+01	1.04E+03	4.82E-04
RF-TT0821	237.15	2.93E+02	0.00E+00	5.43E+01	1.38E+03	3.16E+02	3.42E+03	1.63E-01
RF-TT0822	222.17	3.13E+02	0.00E+00	3.77E+01	9.24E+02	2.10E+02	2.72E+03	1.57E-01
RF-TT0823	0.21	7.34E-01	0.00E+00	8.60E-02	2.02E+00	4.62E-01	6.60E+00	8.00E-06
RF-TT0824	1025.18	5.64E+02	0.00E+00	1.00E+02	2.41E+03	5.52E+02	7.46E+03	5.55E-02
RF-TT0825	566.73	5.51E+02	0.00E+00	7.82E+01	1.96E+03	4.47E+02	5.33E+03	7.54E-02
RF-TT0832	151.04	3.41E+02	0.00E+00	3.69E+01	9.16E+02	2.09E+02	2.69E+03	2.73E-02
RF-TT0854	2.19	7.28E-02	0.00E+00	3.66E-02	8.58E-01	1.96E-01	2.82E+00	5.82E-04
RF-TT0886	0.21	1.33E-02	0.00E+00	6.67E-03	1.56E-01	3.58E-02	5.14E-01	2.38E-07
RF-TT2216	3.13	7.06E+00	0.00E+00	7.65E-01	1.90E+01	4.32E+00	5.57E+01	5.64E-04
RF-TT3010	519.26	2.21E+02	0.00E+00	4.93E+01	1.17E+03	2.67E+02	3.70E+03	5.41E-03
RF-TT3011	1763.69	6.74E+02	0.00E+00	1.16E+02	2.71E+03	6.19E+02	8.89E+03	3.14E-02
RF-TT301U	15.63	6.34E+01	0.00E+00	1.51E+01	3.63E+02	8.44E+01	1.08E+03	6.97E-04
RF-TT310P	2.71	2.13E+01	0.00E+00	3.93E+00	1.22E+02	2.65E+01	2.26E+02	1.44E-04
RF-TT338S	0.42	3.74E-01	0.00E+00	1.80E-01	4.21E+00	9.64E-01	1.38E+01	6.42E-06
RF-TT390P	0.42	3.59E+00	0.00E+00	4.88E-01	2.05E+01	4.31E+00	3.45E+01	4.62E-05
RF-TT391P	22.72	1.92E+02	0.00E+00	2.19E+01	9.21E+02	2.07E+02	2.09E+03	7.81E-04
RF-TT392P	65.24	3.91E+02	0.00E+00	7.89E+01	2.76E+03	6.29E+02	4.15E+03	2.87E-03
RF-TT393R	12.51	5.59E+01	0.00E+00	1.34E+01	4.22E+02	9.68E+01	6.71E+02	6.53E-04
RF-TT394P	0.62	8.14E+00	0.00E+00	8.29E-01	3.26E+01	6.91E+00	4.83E+01	3.67E-05
RF-TT395P	0.83	1.09E+01	0.00E+00	1.11E+00	4.36E+01	9.23E+00	6.46E+01	4.91E-05
RF-TT396P	0.21	2.72E+00	0.00E+00	2.77E-01	1.09E+01	2.31E+00	1.61E+01	1.23E-05
RF-TT398P	43.15	2.28E+02	0.00E+00	4.80E+01	1.71E+03	3.87E+02	2.59E+03	1.72E-03
RF-TT398R	69.83	2.44E+03	0.00E+00	8.92E+01	2.76E+03	6.26E+02	5.05E+03	3.19E-03
RF-TT411R	7.71	8.25E+01	0.00E+00	8.01E+00	3.15E+02	7.13E+01	3.57E+02	3.10E-04
RF-TT429R	2.08	1.97E+02	0.00E+00	1.72E+00	7.30E+01	1.62E+01	6.23E+01	6.13E-05
RF-TT433X	0.63	6.19E+01	0.00E+00	4.76E-01	2.10E+01	4.21E+00	2.47E+01	1.70E-05
RF-TT436R	7.09	4.43E+02	0.00E+00	6.89E+00	2.75E+02	6.21E+01	4.77E+02	2.46E-04
RF-TT454X	0.42	2.60E+01	0.00E+00	4.05E-01	1.62E+01	3.66E+00	2.81E+01	1.45E-05
RL-T101	567.94	0.00E+00	0.00E+00	2.46E+01	8.75E+02	1.96E+02	3.97E+03	1.99E-10
RL-T102	200.12	0.00E+00	0.00E+00	3.13E-04	1.12E-02	2.50E-03	5.04E-02	1.15E-06
RL-T103	99.63	5.03E+01	0.00E+00	2.98E+01	3.82E+02	8.50E+01	2.11E+03	0.00E+00
RL-T104	4.99	0.00E+00	0.00E+00	4.47E-04	1.59E-02	3.58E-03	7.22E-02	3.26E-08
RL-T105	80.4	1.37E-02	0.00E+00	1.69E-01	6.04E+00	1.35E+00	2.73E+01	4.48E-05
RL-T106	8.11	0.00E+00	0.00E+00	1.66E-01	5.90E+00	1.32E+00	2.67E+01	0.00E+00
RL-T107	6156.09	3.95E+00	0.00E+00	9.75E+04	1.63E+04	3.64E+03	7.33E+04	8.43E-01
RL-T108	192.62	0.00E+00	0.00E+00	1.68E+01	9.28E+00	2.08E+00	4.20E+01	2.93E-05
RL-T109	19.72	7.32E-02	0.00E+00	3.46E-01	1.23E+01	2.76E+00	5.57E+01	2.33E-02

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RL-T110	494.03	2.77E+00	0.00E+00	6.60E+01	1.41E+03	3.17E+02	6.40E+03	1.36E+00
RL-T112	137.74	6.08E+01	0.00E+00	2.79E+01	1.87E+02	4.19E+01	8.47E+02	7.36E-01
RL-T113	42.8	0.00E+00	0.00E+00	5.39E-02	6.16E-01	1.38E-01	2.79E+00	0.00E+00
RL-T114	19.58	0.00E+00	0.00E+00	2.63E+00	9.36E+01	2.10E+01	4.24E+02	0.00E+00
RL-T115	1025.43	1.57E+02	0.00E+00	8.52E+01	1.23E+03	2.76E+02	6.24E+03	4.13E-01
RL-T116	11.02	0.00E+00	0.00E+00	4.32E+00	1.53E+02	3.44E+01	6.96E+02	5.62E-02
RL-T118	261.96	3.79E+01	0.00E+00	3.45E+01	1.52E+02	3.41E+01	6.89E+02	8.33E-01
RL-T120	133.81	6.60E+00	0.00E+00	3.62E+00	4.50E+01	1.00E+01	2.42E+02	5.65E-07
RL-T122	29.3	0.00E+00	0.00E+00	1.53E-01	5.42E+00	1.22E+00	2.46E+01	1.46E+00
RL-T123	0.62	0.00E+00	0.00E+00	4.48E-01	1.59E+01	3.58E+00	7.24E+01	5.97E-02
RL-T125	15.18	1.07E+02	0.00E+00	1.11E+02	3.33E+02	1.72E+02	1.13E+04	0.00E+00
RL-T127	283.6	3.23E+02	0.00E+00	2.79E+01	9.95E+02	2.23E+02	4.50E+03	8.00E-02
RL-T128	0.42	7.08E-01	0.00E+00	6.78E-07	2.42E-05	5.41E-06	1.09E-04	0.00E+00
RL-T129	28.75	0.00E+00	0.00E+00	1.29E+02	1.37E+01	3.05E+00	6.16E+01	7.68E-03
RL-T130	0.21	0.00E+00	0.00E+00	8.15E-04	2.91E-02	6.51E-03	1.31E-01	8.30E-05
RL-T131	30.16	8.15E-01	0.00E+00	4.45E-01	5.54E+00	1.23E+00	2.96E+01	8.23E-03
RL-T132	28.7	0.00E+00	0.00E+00	7.86E+01	2.81E+03	6.29E+02	1.27E+04	2.45E-01
RL-T133	0.21	2.71E-03	0.00E+00	1.26E-03	4.61E-02	1.03E-02	1.80E-01	0.00E+00
RL-T134	0.21	0.00E+00	0.00E+00	3.39E-03	1.21E-01	2.70E-02	5.47E-01	0.00E+00
RL-T135	0.42	0.00E+00	0.00E+00	1.59E-02	5.66E-01	1.27E-01	2.56E+00	4.15E-03
RL-T137	151.63	6.30E+02	0.00E+00	3.47E+02	4.31E+03	9.60E+02	2.33E+04	6.23E-03
RL-T140	138.11	9.93E+02	0.00E+00	3.30E+02	4.17E+03	1.03E+03	1.98E+04	2.62E+01
RL-T143	403.71	0.00E+00	0.00E+00	1.89E+00	6.74E+01	1.51E+01	3.05E+02	3.86E-02
RL-T145	711.19	0.00E+00	0.00E+00	5.39E+00	1.92E+02	4.29E+01	8.68E+02	8.96E-02
RL-W407	348.21	2.88E+01	0.00E+00	8.23E+00	3.14E+02	7.02E+01	9.42E+02	0.00E+00
RL-W408	3.8	1.18E-04	0.00E+00	4.86E-05	1.78E-03	3.99E-04	6.80E-03	0.00E+00
RL-W415	59.94	1.87E-03	0.00E+00	7.66E-04	2.81E-02	6.29E-03	1.07E-01	0.00E+00
RL-W418	12.3	9.95E-03	0.00E+00	3.21E-03	1.21E-01	2.70E-02	3.99E-01	0.00E+00
RL-W438	3.79	1.18E-04	0.00E+00	4.84E-05	1.77E-03	3.97E-04	6.77E-03	0.00E+00
RL-W444	744.95	6.17E+01	0.00E+00	1.76E+01	6.71E+02	1.50E+02	2.02E+03	0.00E+00
RL-W447	9.87	7.09E-03	0.00E+00	2.91E-03	1.06E-01	2.39E-02	4.07E-01	0.00E+00
RL-W448	1.68	5.24E-05	0.00E+00	2.15E-05	7.87E-04	1.76E-04	3.01E-03	0.00E+00
RL-W449	1.05	1.28E+00	0.00E+00	7.87E-04	2.25E-02	5.04E-03	5.46E-02	0.00E+00
RL-W450	0.84	7.91E-04	0.00E+00	3.24E-04	1.19E-02	2.66E-03	4.54E-02	0.00E+00
RL-W451	0.42	1.13E-04	0.00E+00	4.62E-05	1.69E-03	3.79E-04	6.47E-03	0.00E+00
RL-W452	7.6	6.14E-03	0.00E+00	1.99E-03	7.45E-02	1.67E-02	2.46E-01	0.00E+00
RL-W453	0.21	1.96E-03	0.00E+00	5.60E-04	2.14E-02	4.78E-03	6.41E-02	0.00E+00
RL-W454	0.21	2.74E-02	0.00E+00	7.83E-03	2.99E-01	6.69E-02	8.96E-01	0.00E+00
RL-W455	0.21	6.53E-03	0.00E+00	2.11E-03	7.91E-02	1.77E-02	2.62E-01	0.00E+00
RL-W456	9.03	9.36E-01	0.00E+00	2.76E-01	1.05E+01	2.35E+00	3.23E+01	0.00E+00
RL-W457	0.63	9.11E-02	0.00E+00	2.68E-02	1.02E+00	2.28E-01	3.13E+00	0.00E+00
RL-W458	0.21	1.96E-01	0.00E+00	1.37E-01	4.19E-01	2.34E-01	1.26E+01	0.00E+00

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RL-W459	6.12	1.75E+00	0.00E+00	1.41E+00	1.04E+01	3.19E+00	1.25E+02	0.00E+00
RL-W460	0.21	1.74E-02	0.00E+00	4.96E-03	1.89E-01	4.24E-02	5.68E-01	0.00E+00
RL-W461	0.42	3.41E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RL-W462	0.21	4.13E-03	0.00E+00	1.44E-03	5.35E-02	1.20E-02	1.86E-01	0.00E+00
RL-W463	0.42	2.55E-02	0.00E+00	7.28E-03	2.78E-01	6.22E-02	8.33E-01	0.00E+00
RL-W464	0.42	1.18E-02	0.00E+00	3.35E-03	1.28E-01	2.86E-02	3.84E-01	0.00E+00
RL-W465	0.84	7.12E-02	0.00E+00	2.27E-02	8.52E-01	1.91E-01	2.78E+00	0.00E+00
RL-W466	14.07	1.01E+00	0.00E+00	3.09E-01	1.17E+01	2.62E+00	3.70E+01	0.00E+00
RL-W467	1.26	4.72E-02	0.00E+00	1.59E-02	5.96E-01	1.33E-01	2.03E+00	0.00E+00
RL-W468	0.21	2.35E-04	0.00E+00	8.19E-05	3.05E-03	6.83E-04	1.06E-02	0.00E+00
RL-W469	1.26	1.09E-01	0.00E+00	3.29E-02	1.24E+00	2.79E-01	3.90E+00	0.00E+00
RL-W470	0.21	1.48E+00	0.00E+00	1.53E+00	4.60E+00	2.38E+00	1.57E+02	0.00E+00
RL-W474	1.89	2.61E-01	0.00E+00	1.69E-01	1.05E-02	9.00E-03	0.00E+00	0.00E+00
RL-W476	4.78	1.96E-01	0.00E+00	6.08E-02	2.30E+00	5.17E-01	7.08E+00	0.00E+00
RL-W480	0.42	3.01E-02	0.00E+00	9.74E-03	3.65E-01	8.19E-02	1.21E+00	0.00E+00
RL-W481	0.63	4.73E-02	0.00E+00	1.53E-02	5.73E-01	1.28E-01	1.90E+00	0.00E+00
RL-W482	2.5	6.29E+01	0.00E+00	5.09E+00	7.29E-02	1.36E-01	2.52E+03	0.00E+00
RL-W483	1.04	4.70E+00	0.00E+00	3.95E-01	4.72E-03	9.66E-03	1.88E+02	0.00E+00
RL-W484	0.84	4.19E-02	0.00E+00	3.18E-03	6.59E-02	1.58E-02	1.56E-01	0.00E+00
RL-W485	0.21	2.77E-03	0.00E+00	4.50E-04	7.13E-03	1.71E-03	0.00E+00	0.00E+00
RL-W486	0.21	1.17E-03	0.00E+00	1.90E-04	3.01E-03	7.19E-04	0.00E+00	0.00E+00
RL-W487	0.21	1.41E-01	0.00E+00	2.44E-02	4.31E-01	1.19E-01	1.45E+00	0.00E+00
RL-W488	0.21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RL-W489	0.21	3.55E-02	0.00E+00	2.30E-02	5.58E-01	1.27E-01	2.34E+00	0.00E+00
RL-W490	1.9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RL-W491	0.21	1.38E-02	0.00E+00	1.94E-02	5.85E-02	1.29E-02	8.50E-01	0.00E+00
RL-W492	0.21	8.01E-04	0.00E+00	4.78E-04	1.17E-02	2.65E-03	4.89E-02	0.00E+00
RL-W493	0.21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RL-W494	77.49	3.10E+01	0.00E+00	2.77E+01	2.95E-01	2.53E-01	1.96E+03	0.00E+00
RL-W495	0.42	5.53E-01	0.00E+00	7.53E-02	2.83E-03	2.26E-03	3.57E+01	0.00E+00
RL-W496	0.21	3.62E+00	0.00E+00	8.67E-01	9.30E-03	7.49E-03	2.31E+02	0.00E+00
RL-W497	0.21	2.74E-01	0.00E+00	1.71E-01	5.58E-01	2.54E-01	6.05E+00	0.00E+00
RL-W498	508.95	5.61E-01	0.00E+00	1.81E-01	6.80E+00	1.52E+00	2.25E+01	0.00E+00
RL-W499	0.21	7.06E-06	0.00E+00	2.28E-06	8.55E-05	1.92E-05	2.83E-04	0.00E+00
RL-W500	0.21	5.11E-04	0.00E+00	2.83E-04	3.49E-03	7.78E-04	1.99E-02	0.00E+00
RL-W501	38.91	2.62E+01	0.00E+00	4.51E+00	7.98E+01	2.20E+01	2.69E+02	0.00E+00
RL-W502	3.15	3.76E-03	0.00E+00	1.22E-03	4.56E-02	1.02E-02	1.51E-01	0.00E+00
RL-W503	0.42	2.12E-01	0.00E+00	1.25E-01	1.61E+00	3.58E-01	8.88E+00	0.00E+00
RL-W504	0.21	1.41E-01	0.00E+00	2.44E-02	4.31E-01	1.19E-01	1.45E+00	0.00E+00
RL-W505	0.21	2.73E-03	0.00E+00	1.28E-03	4.66E-02	1.04E-02	1.82E-01	0.00E+00
RL-W506	0.63	1.38E-03	0.00E+00	5.03E-04	1.53E-02	3.43E-03	5.45E-02	0.00E+00
RL-W507	0.63	1.36E-04	0.00E+00	4.40E-05	1.65E-03	3.69E-04	5.46E-03	0.00E+00

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RL-W508	0.63	2.62E+00	0.00E+00	1.44E+00	1.79E+01	3.99E+00	9.68E+01	0.00E+00
RL-W509	4.83	3.47E+01	0.00E+00	1.15E+01	1.46E+02	3.59E+01	6.94E+02	0.00E+00
RL-W510	3.36	2.10E+00	0.00E+00	1.18E+00	1.45E+01	3.23E+00	8.26E+01	0.00E+00
RL-W511	52.92	3.48E+02	0.00E+00	5.69E+01	1.94E+03	4.26E+02	4.50E+03	3.44E-04
RL-W512	31.29	3.61E+02	0.00E+00	3.84E+01	1.17E+03	2.92E+02	2.30E+03	0.00E+00
RL-W513	6266.68	2.45E+04	0.00E+00	1.11E+04	1.36E+04	6.79E+03	2.60E+05	0.00E+00
RL-W514	0.42	5.91E-04	0.00E+00	1.79E-04	6.77E-03	1.52E-03	2.13E-02	0.00E+00
RL-W515	8.02	2.18E-02	0.00E+00	7.02E-03	2.64E-01	5.90E-02	8.71E-01	0.00E+00
RL-W516	26.6	3.02E-02	0.00E+00	9.75E-03	3.65E-01	8.19E-02	1.21E+00	0.00E+00
RL-W517	0.21	2.51E-10	0.00E+00	8.72E-11	3.25E-09	7.27E-10	1.13E-08	0.00E+00
RL-W518	0.84	9.74E-01	0.00E+00	3.67E-01	4.66E+00	1.13E+00	2.43E+01	0.00E+00
RL-W519	1.68	1.46E-01	0.00E+00	4.35E-02	1.65E+00	3.69E-01	5.13E+00	0.00E+00
RL-W520	0.42	1.30E-02	0.00E+00	4.90E-03	1.81E-01	4.05E-02	6.58E-01	0.00E+00
RL-W521	0.21	2.78E-04	0.00E+00	8.99E-05	3.37E-03	7.56E-04	1.12E-02	0.00E+00
RL-W522	2.31	8.29E+00	0.00E+00	3.34E+00	2.23E+01	6.41E+00	1.62E+02	0.00E+00
RL-W523	0.21	3.06E+00	0.00E+00	1.27E+00	1.48E+00	9.03E-01	3.21E+01	0.00E+00
RL-W524	2.73	1.20E+01	0.00E+00	4.86E+00	1.36E+01	5.29E+00	1.53E+02	0.00E+00
RL-W525	0.63	9.59E-01	0.00E+00	3.29E-01	1.61E+00	5.35E-01	1.20E+01	0.00E+00
RL-W526	14.35	2.19E+00	0.00E+00	1.19E+00	1.72E+01	3.86E+00	8.73E+01	0.00E+00
RL-W527	0.21	2.18E-01	0.00E+00	1.72E-01	1.82E+00	4.34E-01	1.02E+01	0.00E+00
RL-W528	5.26	2.01E+02	0.00E+00	7.31E+01	5.80E+01	5.58E+01	1.56E+03	0.00E+00
RL-W529	1.9	9.37E-02	0.00E+00	5.14E-02	6.40E-01	1.42E-01	3.44E+00	0.00E+00
RL-W530	0.42	1.06E+00	0.00E+00	5.96E-01	7.31E+00	1.63E+00	4.18E+01	0.00E+00
RL-W531	5.47	1.11E+02	0.00E+00	5.98E+01	3.16E+01	2.29E+01	1.11E+03	0.00E+00
RL-W532	30.4	2.01E-01	0.00E+00	6.50E-02	2.44E+00	5.46E-01	8.06E+00	0.00E+00
RL-W533	3.8	1.03E-01	0.00E+00	5.61E-02	6.98E-01	1.55E-01	3.73E+00	0.00E+00
RL-W534	0.21	5.62E-06	0.00E+00	1.81E-06	6.81E-05	1.53E-05	2.25E-04	0.00E+00
RL-W535	23.75	4.64E+01	0.00E+00	1.79E+01	8.73E+01	2.68E+01	6.86E+02	0.00E+00
RL-W536	6.51	8.30E-01	0.00E+00	2.41E-01	3.03E+00	6.90E-01	1.57E+01	3.20E-06
RL-W537	5.04	3.16E+01	0.00E+00	5.44E+00	1.86E+02	4.10E+01	4.39E+02	2.72E-05
RL-W538	1.68	7.13E-05	0.00E+00	2.30E-05	8.65E-04	1.94E-04	2.86E-03	0.00E+00
RL-W539	0.42	6.87E-03	0.00E+00	2.59E-03	9.56E-02	2.14E-02	3.48E-01	0.00E+00
RL-W540	30.87	2.52E+01	0.00E+00	1.14E+01	3.44E+01	1.19E+01	3.34E+02	0.00E+00
RL-W541	0.63	2.08E-02	0.00E+00	7.47E-03	2.77E-01	6.20E-02	9.80E-01	0.00E+00
RL-W542	3.99	1.15E+00	0.00E+00	5.55E-01	7.01E+00	1.63E+00	4.02E+01	0.00E+00
RL-W543	4.01	3.33E-03	0.00E+00	1.08E-03	4.06E-02	9.10E-03	1.35E-01	0.00E+00
RL-W544	0.21	8.74E-02	0.00E+00	4.41E-02	4.62E-01	1.16E-01	2.68E+00	0.00E+00
RL-W545	3.8	2.01E-02	0.00E+00	6.48E-03	2.43E-01	5.45E-02	8.04E-01	0.00E+00
RL-W546	0.84	8.79E-04	0.00E+00	2.84E-04	1.07E-02	2.39E-03	3.52E-02	0.00E+00
RL-W547	56.14	2.25E-05	0.00E+00	7.26E-06	2.72E-04	6.10E-05	9.00E-04	0.00E+00
RL-W548	0.42	1.85E-05	0.00E+00	6.30E-06	2.35E-04	5.27E-05	8.06E-04	0.00E+00
RL-W549	4	5.68E+00	0.00E+00	2.53E+00	1.21E+01	3.62E+00	1.02E+02	0.00E+00

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RL-W550	4.41	2.84E+01	0.00E+00	4.79E+00	1.64E+02	3.62E+01	3.85E+02	1.92E-05
RL-W551	15.58	6.00E+01	0.00E+00	7.08E+00	1.85E+02	4.72E+01	4.09E+02	0.00E+00
RL-W552	0.84	1.11E-02	0.00E+00	3.92E-03	1.46E-01	3.26E-02	5.11E-01	0.00E+00
RL-W553	0.42	3.21E-04	0.00E+00	3.70E-04	1.30E-02	2.91E-03	6.46E-02	0.00E+00
RL-W554	9.5	1.70E-02	0.00E+00	5.49E-03	2.06E-01	4.62E-02	6.81E-01	0.00E+00
RL-W555	12.03	7.82E-03	0.00E+00	2.53E-03	9.49E-02	2.12E-02	3.14E-01	0.00E+00
RL-W563	0.21	1.20E-01	0.00E+00	6.33E-02	7.87E-01	1.75E-01	4.28E+00	0.00E+00
RL-W564	1.26	6.07E-02	0.00E+00	4.20E-02	5.09E-01	1.13E-01	3.29E+00	0.00E+00
RL-W565	0.21	6.78E-03	0.00E+00	2.36E-03	8.79E-02	1.97E-02	3.05E-01	0.00E+00
RL-W566	2.31	1.04E-01	0.00E+00	3.46E-02	1.29E+00	2.90E-01	4.34E+00	0.00E+00
RL-W567	0.21	4.91E+00	0.00E+00	8.84E-01	3.97E-02	3.22E-02	3.68E+02	0.00E+00
RL-W568	3.74	7.64E+01	0.00E+00	1.86E+01	1.88E+00	1.50E+00	7.60E+03	0.00E+00
RL-W569	2.1	7.74E-02	0.00E+00	1.40E-02	6.27E-04	5.10E-05	5.83E+00	0.00E+00
RL-W570	0.42	7.95E-03	0.00E+00	2.45E-03	9.32E-02	2.08E-02	2.87E-01	0.00E+00
RL-W571	12.48	1.72E+01	0.00E+00	8.32E+00	7.56E+00	3.80E+00	1.16E+03	0.00E+00
RL-W572	2.29	1.38E-02	0.00E+00	2.49E-03	4.07E-03	9.10E-05	1.04E+00	0.00E+00
RL-W573	14.98	1.84E+02	0.00E+00	3.19E+01	2.23E+00	1.68E+00	1.32E+04	0.00E+00
RL-W574	81.89	7.62E+02	0.00E+00	1.38E+02	8.52E+00	6.22E+00	5.76E+04	0.00E+00
RL-W575	284.11	5.45E+03	0.00E+00	9.29E+02	8.15E+01	4.97E+01	3.61E+05	0.00E+00
RL-W576	41.07	3.56E+02	0.00E+00	6.49E+01	4.15E+00	3.00E+00	2.71E+04	0.00E+00
RL-W579	0.42	1.06E-01	0.00E+00	1.71E-03	2.08E-02	4.67E-03	9.56E-02	0.00E+00
RL-W580	2.11	0.00E+00	0.00E+00	0.00E+00	1.66E-01	2.72E-02	0.00E+00	0.00E+00
RL-W581	0.42	1.16E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RL-W582	0.21	7.05E-03	0.00E+00	1.45E-03	5.32E-03	2.77E-03	1.55E-02	0.00E+00
RL-W583	0.21	2.76E-03	0.00E+00	7.88E-04	3.00E-02	6.73E-03	9.02E-02	0.00E+00
RL-W584	0.21	1.01E-01	0.00E+00	5.17E-02	1.75E-01	8.62E-02	4.53E-01	0.00E+00
RL-W585	0.42	2.18E-01	0.00E+00	2.75E-01	1.02E+00	5.24E-01	1.38E+01	0.00E+00
RL-W586	0.21	4.36E-05	0.00E+00	1.24E-05	4.74E-04	1.06E-04	1.42E-03	0.00E+00
RL-W587	0.42	8.83E-04	0.00E+00	2.68E-04	1.01E-02	2.27E-03	3.19E-02	0.00E+00
RL-W588	0.21	6.86E-02	0.00E+00	4.36E-02	1.48E-01	7.26E-02	3.81E-01	0.00E+00
RL-W589	0.21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RL-W590	0.62	7.86E-01	0.00E+00	9.30E-01	1.14E-02	2.04E-02	5.00E+01	0.00E+00
RL-W591	0.21	3.89E+00	0.00E+00	1.05E+00	1.41E-02	2.64E-02	3.02E+02	0.00E+00
RL-W592	2.5	2.11E+01	0.00E+00	1.15E+01	6.54E-01	8.54E-01	1.22E+03	0.00E+00
RL-W593	0.62	0.00E+00	0.00E+00	0.00E+00	2.36E-02	4.01E-02	0.00E+00	0.00E+00
RL-W594	2.5	4.64E+01	0.00E+00	2.07E+00	2.92E-02	5.42E-02	3.05E+02	0.00E+00
RL-W595	0.62	4.62E-02	0.00E+00	2.16E-01	2.00E-02	3.94E-02	3.02E+00	0.00E+00
RL-W596	9.45	1.74E-02	0.00E+00	1.68E-02	2.06E-04	3.70E-04	9.07E-01	0.00E+00
RL-W597	3.12	3.12E+01	0.00E+00	7.39E+00	3.99E-01	6.71E-01	1.69E+03	0.00E+00
RL-W598	8.74	3.43E+01	0.00E+00	4.36E+01	5.56E-01	8.37E-01	1.75E+03	0.00E+00
RL-W599	0.21	1.31E+00	0.00E+00	3.52E-01	4.70E-03	8.82E-03	1.01E+02	0.00E+00
RL-W600	0.74	1.09E-07	0.00E+00	3.11E-08	1.19E-06	2.66E-07	3.56E-06	0.00E+00

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RL-W601	1.05	1.40E-04	0.00E+00	1.61E-04	5.66E-03	1.27E-03	2.82E-02	0.00E+00
RL-W602	2.53	4.28E-01	0.00E+00	1.49E-01	5.54E+00	1.24E+00	1.92E+01	0.00E+00
RL-W603	7.6	2.72E+00	0.00E+00	9.46E-01	3.52E+01	7.89E+00	1.22E+02	0.00E+00
RL-W604	0.21	1.12E-02	0.00E+00	2.48E-03	1.71E-02	8.50E-03	1.45E-01	0.00E+00
RL-W605	0.21	4.68E-04	0.00E+00	5.39E-04	1.89E-02	4.24E-03	9.41E-02	0.00E+00
RL-W606	0.21	1.89E-04	0.00E+00	2.17E-04	7.62E-03	1.71E-03	3.80E-02	0.00E+00
RL-W607	0.21	1.90E-03	0.00E+00	4.20E-04	2.89E-03	1.44E-03	2.45E-02	0.00E+00
RL-W608	6.12	1.98E-02	0.00E+00	1.63E-02	3.76E-03	4.67E-03	3.76E-01	0.00E+00
RL-W610	3.8	3.05E+00	0.00E+00	8.72E-01	3.32E+01	7.44E+00	9.98E+01	0.00E+00
RL-W612	7.11	5.16E-03	0.00E+00	1.51E-03	5.80E-02	1.30E-02	1.70E-01	0.00E+00
RL-W615	1.89	0.00E+00	0.00E+00	0.00E+00	3.38E-01	0.00E+00	0.00E+00	0.00E+00
RL-W622	1.89	1.20E-04	0.00E+00	3.44E-05	1.31E-03	2.93E-04	3.93E-03	0.00E+00
RL-W625	0.21	1.56E-03	0.00E+00	5.23E-03	6.69E-03	6.62E-03	2.13E-01	0.00E+00
RL-W626	0.21	3.50E-01	0.00E+00	1.19E-01	2.62E-01	1.58E-01	3.72E+00	0.00E+00
RL-W627	0.21	7.30E-04	0.00E+00	1.59E-04	1.24E-06	0.00E+00	4.42E-02	0.00E+00
RL-W628	0.21	3.29E-04	0.00E+00	9.99E-05	3.78E-03	8.46E-04	1.19E-02	0.00E+00
RL-W629	0.21	1.82E-05	0.00E+00	6.87E-06	2.54E-04	5.68E-05	9.24E-04	0.00E+00
RL-W630	0.42	2.06E-01	0.00E+00	1.28E-01	2.94E+00	6.85E-01	1.00E+01	0.00E+00
RL-W631	0.42	1.12E-03	0.00E+00	1.29E-03	4.51E-02	1.01E-02	2.25E-01	0.00E+00
RL-W632	0.21	1.34E+00	0.00E+00	1.74E-01	5.96E+00	1.97E+00	7.48E+01	0.00E+00
RL-W633	0.21	6.17E-03	0.00E+00	1.01E-03	9.36E-04	8.32E-04	9.21E-02	0.00E+00
RL-W634	0.21	0.00E+00	0.00E+00	0.00E+00	1.02E-02	0.00E+00	0.00E+00	0.00E+00
RL-W635	15.39	2.38E+01	0.00E+00	3.41E+01	4.34E+00	6.53E+00	9.30E+02	0.00E+00
RL-W636	1.05	3.75E-01	0.00E+00	6.44E-02	5.67E-02	5.05E-02	5.65E+00	0.00E+00
RL-W637	0.63	6.55E-04	0.00E+00	1.64E-03	6.38E-04	6.30E-04	2.03E-02	0.00E+00
RL-W638	4.01	3.35E-02	0.00E+00	1.67E-02	6.25E-03	5.92E-03	7.56E-01	0.00E+00
RL-W639	0.63	1.32E-03	0.00E+00	4.27E-04	1.60E-02	3.58E-03	5.29E-02	0.00E+00
RL-W640	0.21	4.70E-02	0.00E+00	1.42E-02	5.39E-01	1.21E-01	1.70E+00	0.00E+00
RL-W641	5.46	2.28E+00	0.00E+00	3.12E+00	2.59E+00	1.07E+00	2.73E+01	0.00E+00
RL-W642	1.68	6.25E-02	0.00E+00	3.24E-04	3.16E-02	1.62E-04	1.18E-02	0.00E+00
RL-W643	1.68	7.02E-01	0.00E+00	9.61E-01	7.98E-01	3.30E-01	8.40E+00	0.00E+00
RL-W644	0.84	0.00E+00	0.00E+00	0.00E+00	5.49E-02	0.00E+00	0.00E+00	0.00E+00
RL-W645	1.47	8.26E-03	0.00E+00	4.32E-03	1.08E-01	2.55E-02	4.59E-01	0.00E+00
RL-W646	0.42	1.42E-02	0.00E+00	3.86E-03	2.58E-02	1.26E-02	2.23E-01	0.00E+00
RL-W647	0.21	3.59E-02	0.00E+00	5.77E-01	1.10E-01	1.75E-02	7.47E-01	0.00E+00
RL-W648	0.21	2.68E-04	0.00E+00	9.86E-04	6.01E-05	1.19E-04	2.39E-02	0.00E+00
RL-W649	1.9	9.87E-04	0.00E+00	3.63E-03	2.21E-04	4.37E-04	8.78E-02	0.00E+00
RL-W653	0.42	7.45E-05	0.00E+00	2.60E-05	9.66E-04	2.16E-04	3.35E-03	0.00E+00
RL-W654	0.21	4.39E-04	0.00E+00	1.42E-04	5.32E-03	1.19E-03	1.76E-02	0.00E+00
RL-W655	1.46	9.55E+01	0.00E+00	3.36E+01	2.11E-01	5.01E-01	4.70E+03	0.00E+00
RL-W656	3.12	3.06E+02	0.00E+00	1.51E+01	4.96E-01	5.15E-01	2.24E+04	0.00E+00
RL-W657	14.86	2.09E+02	0.00E+00	2.23E+01	2.44E-01	4.90E-01	9.91E+03	0.00E+00

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RL-W659	0.42	2.80E+01	0.00E+00	5.03E+00	4.70E-02	5.87E-02	1.12E+03	0.00E+00
RL-W660	2.08	1.45E+02	0.00E+00	6.05E+01	8.67E-01	1.56E+00	6.39E+03	0.00E+00
RL-W661	0.21	1.19E+00	0.00E+00	7.57E-02	4.18E-04	3.83E-03	7.76E+01	0.00E+00
RL-W662	0.21	6.68E-02	0.00E+00	4.51E-03	1.07E-04	1.93E-04	1.59E+00	0.00E+00
RL-W665	8.53	4.05E+02	0.00E+00	3.61E+02	1.31E+00	1.77E+00	3.16E+04	0.00E+00
RL-W666	1.46	1.10E+01	0.00E+00	8.84E-01	5.49E-02	5.82E-02	4.57E+02	0.00E+00
RL-W668	30.49	1.79E+00	0.00E+00	1.98E-02	1.03E-01	2.96E-02	7.72E-01	0.00E+00
RL-W669	1.26	5.26E-01	0.00E+00	7.21E-01	5.98E-01	2.47E-01	6.30E+00	0.00E+00
RL-W670	0.21	4.63E-02	0.00E+00	5.13E-04	2.68E-03	7.66E-04	2.00E-02	0.00E+00
RL-W671	9.45	5.40E+00	0.00E+00	2.63E-01	4.91E-03	5.14E-03	6.57E+01	0.00E+00
RL-W672	9.45	3.67E+01	0.00E+00	1.79E+00	3.35E-02	3.49E-02	4.46E+02	0.00E+00
RL-W673	49.14	3.54E+01	0.00E+00	1.72E+00	3.24E-02	3.37E-02	4.30E+02	0.00E+00
RL-W674	25.02	4.88E-02	0.00E+00	5.77E-02	8.37E+00	7.35E-02	2.26E+00	0.00E+00
RL-W675	0.21	3.78E-01	0.00E+00	4.25E-01	1.31E-01	1.14E-01	7.31E+00	0.00E+00
RL-W676	4.41	1.67E-02	0.00E+00	2.55E-03	1.47E-01	2.15E-03	2.17E-01	0.00E+00
RL-W677	3.15	3.80E+01	0.00E+00	6.32E+00	5.74E+00	5.02E+00	5.23E+02	0.00E+00
RL-W678	0.42	3.60E-02	0.00E+00	5.28E-02	5.16E-02	4.58E-02	4.10E+00	0.00E+00
RL-W679	3.8	7.49E-01	0.00E+00	1.18E-01	1.11E-01	9.86E-02	1.05E+01	0.00E+00
RL-W680	0.21	9.48E-05	0.00E+00	1.66E-04	1.74E-05	3.15E-05	4.51E-03	0.00E+00
RL-W681	0.21	2.35E-05	0.00E+00	6.73E-05	4.67E-04	2.34E-04	3.75E-03	0.00E+00
RL-W685	102.64	1.50E-01	0.00E+00	4.29E-02	1.64E+00	3.66E-01	4.91E+00	0.00E+00
RL-W689	0.21	1.13E-02	0.00E+00	7.18E-04	3.87E-04	0.00E+00	6.56E-03	0.00E+00
RL-W690	0.42	1.82E-01	0.00E+00	5.28E-02	2.03E+00	4.53E-01	5.95E+00	0.00E+00
RL-W691	0.21	4.22E-03	0.00E+00	1.23E-03	4.70E-02	1.05E-02	1.38E-01	0.00E+00
RL-W692	0.42	1.67E-01	0.00E+00	4.87E-02	1.86E+00	4.16E-01	5.45E+00	0.00E+00
RL-W693	0.62	2.07E-01	0.00E+00	6.01E-02	2.30E+00	5.15E-01	6.74E+00	0.00E+00
RL-W694	2.29	2.17E+00	0.00E+00	6.31E-01	2.43E+01	5.40E+00	7.09E+01	0.00E+00
RL-W695	0.84	3.82E-03	0.00E+00	0.00E+00	2.39E-03	0.00E+00	0.00E+00	0.00E+00
RL-W696	0.21	1.62E-03	0.00E+00	2.30E-03	2.91E-03	2.89E-03	9.73E-02	0.00E+00
RL-W697	0.21	1.15E+00	0.00E+00	4.87E+00	6.93E-03	9.57E-04	0.00E+00	0.00E+00
RL-W698	0.21	9.97E-02	0.00E+00	0.00E+00	3.29E-05	0.00E+00	0.00E+00	0.00E+00
RL-W699	0.42	8.07E-03	0.00E+00	3.24E-04	2.20E-03	2.60E-04	4.09E-01	0.00E+00
RL-W700	1.26	2.63E-03	0.00E+00	8.50E-04	3.19E-02	7.15E-03	1.06E-01	0.00E+00
RL-W702	0.21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RL-W703	0.21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RL-W704	0.42	1.75E-01	0.00E+00	2.40E-01	1.99E-01	8.25E-02	2.10E+00	0.00E+00
RL-W705	0.62	7.11E-04	0.00E+00	2.21E-04	8.36E-03	1.88E-03	2.58E-02	0.00E+00
RL-W706	0.21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RL-W707	1.87	2.55E-02	0.00E+00	7.86E-03	2.98E-01	6.68E-02	9.17E-01	0.00E+00
RL-W708	0.62	3.84E-03	0.00E+00	1.19E-03	4.52E-02	1.01E-02	1.39E-01	0.00E+00
RL-W709	0.21	1.33E+00	0.00E+00	4.10E-01	1.56E+01	3.49E+00	4.80E+01	0.00E+00
RL-W710	0.21	7.92E-05	0.00E+00	2.45E-05	9.32E-04	2.08E-04	2.87E-03	0.00E+00

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RL-W711	0.21	2.48E-02	0.00E+00	7.65E-03	2.91E-01	6.51E-02	8.94E-01	0.00E+00
RL-W712	0.21	3.20E-02	0.00E+00	9.90E-03	3.76E-01	8.42E-02	1.16E+00	0.00E+00
RL-W713	0.21	2.77E-02	0.00E+00	8.55E-03	3.24E-01	7.28E-02	1.00E+00	0.00E+00
RL-W714	0.21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RL-W715	0.42	5.04E-04	0.00E+00	1.44E-04	5.49E-03	1.23E-03	1.65E-02	0.00E+00
RL-W716	0.84	5.25E-03	0.00E+00	1.50E-03	5.72E-02	1.28E-02	1.72E-01	0.00E+00
RL-W717	0.21	1.31E-03	0.00E+00	3.75E-04	1.43E-02	3.20E-03	4.29E-02	0.00E+00
RL-W718	0.42	2.32E-04	0.00E+00	6.61E-05	2.52E-03	5.64E-04	7.56E-03	0.00E+00
RL-W719	0.42	1.04E-03	0.00E+00	2.98E-04	1.14E-02	2.55E-03	3.42E-02	0.00E+00
RL-W720	2.52	6.47E-03	0.00E+00	1.85E-03	7.04E-02	1.58E-02	2.11E-01	0.00E+00
RL-W721	2.31	4.38E-03	0.00E+00	1.25E-03	4.76E-02	1.07E-02	1.43E-01	0.00E+00
RL-W723	0.62	1.45E-02	0.00E+00	4.22E-03	1.62E-01	3.62E-02	4.74E-01	0.00E+00
RL-W724	3.33	9.65E-02	0.00E+00	2.81E-02	1.07E+00	2.41E-01	3.15E+00	0.00E+00
RL-W725	1.25	3.05E-02	0.00E+00	8.86E-03	3.39E-01	7.60E-02	9.95E-01	0.00E+00
RL-W726	1.66	2.40E-02	0.00E+00	6.99E-03	2.68E-01	5.99E-02	7.84E-01	0.00E+00
RL-W727	6.24	1.47E-01	0.00E+00	4.29E-02	1.64E+00	3.68E-01	4.81E+00	0.00E+00
RL-W728	8.32	1.34E-01	0.00E+00	3.91E-02	1.50E+00	3.35E-01	4.38E+00	0.00E+00
RL-W729	2.91	6.20E-02	0.00E+00	1.81E-02	6.90E-01	1.55E-01	2.02E+00	0.00E+00
RL-W730	85.29	3.68E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RL-W731	0.21	1.66E-05	0.00E+00	0.00E+00	4.51E-04	1.86E-06	0.00E+00	0.00E+00
RL-W732	46.16	9.33E+00	0.00E+00	7.33E+00	9.10E+01	2.02E+01	5.17E+02	0.00E+00
RL-W733	0.63	2.28E-01	0.00E+00	1.34E-01	1.38E+00	3.44E-01	7.87E+00	0.00E+00
RL-W734	0.42	7.56E-01	0.00E+00	4.47E-01	4.76E+00	1.16E+00	2.34E+01	0.00E+00
RL-W735	0.21	6.49E-01	0.00E+00	3.41E-01	3.71E+00	9.25E-01	1.82E+01	0.00E+00
RL-W736	0.21	1.21E-03	0.00E+00	7.27E-07	2.46E-03	6.38E-04	5.57E-03	0.00E+00
RL-W737	0.84	5.98E-01	0.00E+00	3.11E-01	3.52E+00	8.61E-01	1.57E+01	0.00E+00
RL-W738	2.31	2.29E+00	0.00E+00	1.07E+00	1.12E+01	2.97E+00	5.69E+01	0.00E+00
RL-W739	0.21	1.84E-01	0.00E+00	9.44E-02	1.82E+00	4.17E-01	5.17E+00	0.00E+00
RL-W740	13.23	9.13E+00	0.00E+00	3.46E+00	4.43E+01	1.16E+01	2.61E+02	0.00E+00
RL-W741	1.05	2.03E+01	0.00E+00	8.14E+00	8.63E+00	6.16E+00	1.96E+02	0.00E+00
RL-W742	0.21	6.26E-01	0.00E+00	2.45E-01	2.80E+00	6.63E-01	1.68E+01	0.00E+00
RL-W743	0.21	2.17E-03	0.00E+00	6.65E-05	1.81E-03	0.00E+00	0.00E+00	0.00E+00
RL-W744	0.21	0.00E+00	0.00E+00	0.00E+00	9.03E-02	7.72E-02	0.00E+00	0.00E+00
RL-W745	0.21	1.44E-03	0.00E+00	4.65E-04	1.75E-02	3.91E-03	5.77E-02	0.00E+00
RL-W746	0.42	5.55E-03	0.00E+00	1.79E-03	6.72E-02	1.51E-02	2.22E-01	0.00E+00
RL-W747	0.21	1.50E-02	0.00E+00	4.85E-03	1.82E-01	4.08E-02	6.02E-01	0.00E+00
RL-W748	13.23	9.45E+01	0.00E+00	1.36E+01	3.02E-01	4.99E-01	4.53E+03	0.00E+00
RL-W749	3.78	1.34E-01	0.00E+00	4.16E-02	1.58E+00	3.53E-01	4.84E+00	0.00E+00
RL-W750	0.42	1.59E+02	0.00E+00	2.06E+01	4.95E-01	8.15E-01	6.41E+03	0.00E+00
RL-W751	0.21	1.44E+02	0.00E+00	1.86E+01	4.45E-01	7.39E-01	5.78E+03	0.00E+00
RL-W752	9.87	6.26E+01	0.00E+00	8.08E+00	1.94E-01	3.21E-01	2.51E+03	0.00E+00
RL-W753	12.15	8.42E+02	0.00E+00	1.09E+02	2.61E+00	4.31E+00	3.38E+04	0.00E+00

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
RP-W754	1484.07	7.44E+01	0.00E+00	1.38E+01	1.86E+03	1.53E+02	3.12E+02	3.53E-01
RP-W755	2447.97	4.43E+02	0.00E+00	8.27E+00	1.39E+03	1.16E+02	2.33E+02	1.26E+01
SA-T001	5.41	9.07E-01	4.78E+00	1.98E-01	3.03E+00	4.73E-03	0.00E+00	4.64E-06
SA-W134	16.02	7.20E+00	1.85E-03	1.35E+00	1.38E+00	4.39E-01	5.94E+00	1.67E-01
SA-W134M	2.08	9.35E-01	2.40E-04	1.75E-01	1.80E-01	5.70E-02	7.72E-01	2.16E-02
T001-221F-HET	1963.82	9.72E+02	0.00E+00	1.38E+05	2.51E+04	6.22E+02	1.70E+04	4.92E+00
T001-221H-HET	3898.35	1.93E+03	0.00E+00	2.73E+05	4.99E+04	1.23E+03	3.37E+04	9.77E+00
T001-235F-HET	184.9	9.15E+01	0.00E+00	1.30E+04	2.36E+03	5.86E+01	1.60E+03	4.63E-01
T001-772F-HET	1468.39	7.27E+02	0.00E+00	1.03E+05	1.88E+04	4.65E+02	1.27E+04	3.68E+00
T001-773A-CLAS	22.64	1.12E+01	0.00E+00	1.59E+03	2.90E+02	7.17E+00	1.96E+02	5.67E-02
T001-773A-HET	203.2	1.01E+02	0.00E+00	1.43E+04	2.60E+03	6.44E+01	1.76E+03	5.09E-01
W006-773A-VIT	0.62	2.77E-03	0.00E+00	0.00E+00	5.37E+02	0.00E+00	0.00E+00	0.00E+00
W026-221F-HET	785.95	3.89E+02	0.00E+00	5.51E+04	1.01E+04	2.49E+02	6.79E+03	1.97E+00
W026-221H-HET	587.63	2.91E+02	0.00E+00	4.12E+04	7.52E+03	1.86E+02	5.08E+03	1.47E+00
W026-235F-HET	9.15	4.53E+00	0.00E+00	6.42E+02	1.17E+02	2.90E+00	7.91E+01	2.29E-02
W026-772F-HET	2.5	1.24E+00	0.00E+00	1.75E+02	3.19E+01	7.90E-01	2.16E+01	6.25E-03
W026-773A-HET	40.66	2.01E+01	0.00E+00	2.85E+03	5.20E+02	1.29E+01	3.51E+02	1.02E-01
W027-221F-HET	3051.42	1.97E+03	0.00E+00	1.86E+05	3.90E+04	9.64E+02	1.11E+04	1.78E+01
W027-221H-HET	1335.12	8.61E+02	0.00E+00	8.12E+04	1.71E+04	4.22E+02	4.85E+03	7.80E+00
W027-235F-HET	401.73	2.59E+02	0.00E+00	2.44E+04	5.14E+03	1.27E+02	1.46E+03	2.35E+00
W027-772F-HET	729.74	4.71E+02	0.00E+00	4.44E+04	9.33E+03	2.31E+02	2.65E+03	4.26E+00
W027-773A-HET	1088.76	7.02E+02	0.00E+00	6.62E+04	1.39E+04	3.44E+02	3.96E+03	6.36E+00
W027-999-HET	886.79	5.72E+02	0.00E+00	5.39E+04	1.13E+04	2.80E+02	3.22E+03	5.18E+00
W053-773A-VIT	0.62	0.00E+00	0.00E+00	0.00E+00	3.99E+02	0.00E+00	0.00E+00	0.00E+00
WP-INW169.001	17.01	3.31E+00	0.00E+00	4.77E-01	1.54E+01	3.44E+00	3.99E+01	1.65E-04
WP-INW198.001	44.73	3.91E+00	0.00E+00	8.32E-01	2.76E+01	6.12E+00	6.55E+01	8.18E-05
WP-INW211.001	286.23	4.39E+02	0.00E+00	7.81E+01	2.56E+03	5.68E+02	7.42E+03	1.98E-03
WP-INW216.001-A	888.3	2.51E+04	0.00E+00	4.49E+01	1.48E+03	3.30E+02	4.10E+03	2.77E-01
WP-INW216.001-B	308.7	6.90E+03	0.00E+00	1.21E+01	4.01E+02	8.90E+01	1.11E+03	2.76E-02
WP-INW218.001-A	756.76	4.57E+02	0.00E+00	7.92E+00	2.58E+02	5.74E+01	7.42E+02	3.86E-01
WP-INW218.001-B	24.99	1.50E+00	0.00E+00	2.18E-01	7.02E+00	1.56E+00	2.10E+01	3.74E-02
WP-INW222.001	30.24	1.67E+01	0.00E+00	2.35E+00	6.86E+01	1.54E+01	1.78E+02	5.74E-04
WP-INW243.001	67.2	4.30E+01	0.00E+00	5.07E+00	1.44E+02	3.24E+01	3.60E+02	8.68E-04
WP-INW247.001R1	108.36	5.25E+01	0.00E+00	1.18E+01	2.76E+02	6.30E+01	6.24E+02	7.76E-05
WP-INW276.001	10.29	3.82E+00	0.00E+00	1.15E+00	2.73E+01	6.24E+00	5.29E+01	1.67E-05
WP-INW276.002	16.17	6.21E+00	0.00E+00	1.73E+00	4.01E+01	9.36E+00	7.94E+01	2.65E-05
WP-INW276.003	185.85	2.28E+02	0.00E+00	6.43E+01	1.49E+03	3.41E+02	3.34E+03	4.49E-04
WP-INW276.004	46.62	5.76E+01	0.00E+00	1.36E+01	3.15E+02	7.20E+01	7.05E+02	1.46E-04
WP-INW296.001-A	10.92	2.37E+01	0.00E+00	3.23E+00	7.91E+01	1.80E+01	1.81E+02	3.74E-05
WP-INW296.001-B	81.06	6.78E+01	0.00E+00	1.14E+01	2.80E+02	6.36E+01	6.52E+02	3.55E-04
WP-LA-TA-55-19.01-A	5.88	1.28E+00	0.00E+00	5.30E-01	2.09E+00	5.07E-01	6.48E+00	2.64E-03
WP-LA-TA-55-19.01-B	75.2	5.06E+01	0.00E+00	1.78E+01	2.13E+02	5.22E+01	6.44E+02	8.72E-02

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Table 49. EPAUNI CH Input (Stream Totals) – Continued

Stream ID#	Volume(m3)	Am-241	Cm-244	Pu-238	Pu-239	Pu-240	Pu-241	U-234
WP-LA-TA-55-43.01	189.88	2.10E-01	0.00E+00	4.15E+02	3.23E-01	1.37E-01	5.77E+00	2.65E-02
WP-RF001.01	477	1.04E+02	0.00E+00	1.44E+01	4.10E+02	9.37E+01	6.49E+02	9.33E-03
WP-RF002.01-A	350.66	9.78E+01	0.00E+00	1.92E+01	4.62E+02	1.06E+02	1.43E+03	1.78E-02
WP-RF002.01-B	0.21	1.15E-01	0.00E+00	1.33E-02	5.00E-01	1.14E-01	8.99E-01	1.92E-07
WP-RF003.01	232.26	1.47E+03	0.00E+00	3.09E+02	8.83E+03	2.02E+03	2.36E+04	8.34E-03
WP-RF004.01	5.67	6.06E-01	0.00E+00	2.07E-01	5.09E+00	1.17E+00	1.35E+01	1.27E-04
WP-RF005.01	120.54	5.17E+03	0.00E+00	1.57E+02	4.67E+03	1.06E+03	9.40E+03	1.81E-03
WP-RF005.02	78.33	6.30E+03	0.00E+00	8.11E+01	2.79E+03	6.29E+02	4.82E+03	1.21E-03
WP-RF006.01	220.92	1.68E+03	0.00E+00	2.95E+02	7.94E+03	1.82E+03	1.22E+04	2.56E-02
WP-RF008.01	80.01	3.88E+02	0.00E+00	1.05E+02	2.32E+03	5.41E+02	8.05E+03	1.26E-03
WP-RF009.01	1299.06	6.23E+04	0.00E+00	1.29E+03	5.09E+04	1.14E+04	9.25E+04	2.07E-02
WP-RF010.01	55.5	1.43E+01	0.00E+00	3.27E+00	7.69E+01	1.76E+01	2.85E+02	7.31E-04
WP-RF029.01-A	48.88	3.55E+00	0.00E+00	6.15E-01	1.35E+01	3.10E+00	6.53E+01	7.30E-04
WP-RF029.01-B	18.8	6.88E+00	0.00E+00	4.87E-01	1.07E+01	2.45E+00	5.17E+01	2.25E-03
WP-RF118.01	1273.44	8.86E+03	0.00E+00	2.45E+03	5.14E+04	1.15E+04	1.70E+05	2.15E-01
WP-RLMPDT.001	7.35	1.84E+00	0.00E+00	7.15E-01	7.36E+00	1.92E+00	3.73E+01	2.04E-06
WP-RLNPDT.002	90.72	2.36E+01	0.00E+00	6.81E+00	7.23E+01	1.95E+01	4.28E+02	3.89E-05
WP-SR2001.001.00	61.74	4.19E-01	0.00E+00	7.83E-01	6.83E+00	1.36E+00	2.33E+01	4.48E-06
WP-SR-W027-221F-HETA	141.12	5.43E+00	0.00E+00	2.30E+00	1.96E+01	5.49E+00	1.05E+02	1.86E-01

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