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to: WIPP Records Center

from: Seth King

subject: Actinide Solubility and Colloidal Contributions for CRA-2019 for Appendix SOTERM

The purpose of this memo is to provide source term calculations for incorporation into Appendix SOTERM for the CRA-2019. A hypothetical source term is calculated using median distribution values for PA sampled parameters. In addition to parameter value changes, the equation for microbial concentrations has changed from previous CRA calculations (Sarathi 2019a).

Construction of Source Terms

Because PA does not differentiate dissolved from colloidal species for transport in the Salado, the total source term in the Salado is the sum of both components. To model transport within the Culebra, however, this simplification was replaced by separating the mobilized actinides delivered to the Culebra by Salado transport codes into five components (dissolved, humic, microbial, mineral-fragment, and intrinsic colloids) to account for differences in their transport behavior. This is important because transport within the repository occurs through, at most, hundreds of meters of poorly defined waste undergoing decomposition, whereas transport through the Culebra occurs over kilometers in a relatively homogeneous (compared to waste) fractured dolomite.

The parameters required to construct the source term were as follows:

1. Solubilities for four oxidation states in Salado and Castile brines, the two brine end members. (SOLMODx:SOLyOH for oxidation state x and brine y).

2. Uncertainty distributions to be applied to the median solubilities for oxidation states III and IV. (SOLMODx:SOLVAR for oxidation state x)

3. A scheme for assigning sampled oxidation states ("low" or "high") (GLOBAL:OXSTAT).

4. Colloidal concentrations or proportionality constants for each actinide (Am, Np, Pu, Th, and U) and an associated oxidation state for each of four colloid types (z:CONCINT, z:CONCMIN for actinide z and PHUMOXx:PHUMyIM for oxidation state x and brine y).

5. Caps on the actinide concentrations that may be applied to two types of colloids (microbial and humic) (z:CAPMIC and z:CAPHUM for activide z).

6. Cm solubilities are not calculated, it is assigned the source term calculated for Am (i.e., it has the same solubility/speciation as Am up to its inventory limit).

The parameters used are presented in Table 1.

Cm and Np are not explicitly transported in NUTS, although they are implicitly lumped with other modeled isotopes. They are however, included in the PANEL calculations for use with the DBR calculations in PA.

These parameters are combined into a single maximum concentration for each modeled actinide in the PA calculations. The term "total mobilized concentration" is used for the combined concentrations of dissolved and colloidal species. The combined concentrations are not necessarily the actual concentrations, because the concentration may be lower as a result of inventory limits. Both NUTS and PANEL assume that the actinide concentrations specified by the total mobilized concentrations are attained instantaneously if sufficient inventory is available. When the inventory is insufficient, the actual mobilized concentration will be lower and is said to be inventory limited. The calculation of the total mobilized concentration is performed by PANEL for each of 100 sampled vectors per replicate for all 3 replicates. A similar methodology to generate the combined maximum concentrations was used for the CCA PA, the CCA PAVT, the CRA-2004 PA, the CRA-2004 PABC, the CRA-2009 PA, the CRA-2009 PABC and the CRA-2014 PA.

For each actinide, the baseline solubility is determined by the oxidation state and source brine. The mineral and intrinsic concentrations are constants pulled from the parameters database (Param_DB) for each actinide. The dissolved concentration (mol/L), the humic concentration (mol/L), the microbial concentration (mol/L), the sum of colloidal concentrations (mol/L) and the total mobile concentration (mol/L) need to be calculated. To calculate the dissolved concentration a solubility uncertainty parameter is sampled from a given distribution; the distribution parameters are dependent on the given oxidation state. For the results displayed here the median value for the solubility uncertainty will be used. The dissolved concentration can then be calculated using the formula:

$$Dissolved = Baseline\ Solubility \times 10^{Sampled\ Solubility\ Uncertainty}$$

The humic concentration can then be calculated with the formula:

$$Humic = \min(Dissolved * PHUM, CAPHUM)$$

Where *PHUM* is the proportionality constant of humic colloids (PHUMSIM or PHUMCIM), and *CAPHUM* is the maximum concentration of actinide with mobile humic colloids. The microbial concentration is calculated using the formula:

$$Microbial = \min(Dissolved * PROPMIC, CAPMIC)$$

Where *PROPMIC* is the proportionality constant of microbial colloids and *CAPMIC* is the maximum concentration of actinide on microbe colloids. Note that this equation has changed from the 2014 calculation. For more details on this change see Sarathi (2019a).

The sum of the colloidal concentrations can be calculated with:

$$Sum\ Colloidal = Humic + Microbial + Mineral + Intrinsic$$

The total mobile concentration can then be calculated as the sum of the concentrations:

$$Total\ Mobile = Dissolved + Sum\ Colloidal$$

For actinides with more than one oxidation state, the oxidation state is specified by the sampled oxidation-state parameter GLOBAL:OXSTAT. OXSTAT is sampled from a uniform distribution between 0 and 1. If the value of OXSTAT is less than or equal to 0.5 then the lower oxidation state is used, otherwise the higher oxidation state is used.

Table 1 Data from the WIPP PA Database for the calculation of concentrations+*

Material	Property	CRA14	CRA19
SOLMOD3	SOLSOH	2.590E-06	1.630E-07
SOLMOD4	SOLSOH	6.050E-08	5.450E-08
SOLMOD5	SOLSOH	2.770E-07	4.020E-07
SOLMOD6	SOLSOH	1.000E-03	1.000E-03
SOLMOD3	SOLCOH	1.480E-06	1.780E-07
SOLMOD4	SOLCOH	7.020E-08	5.440E-08
SOLMOD5	SOLCOH	8.760E-07	1.200E-06
SOLMOD6	SOLCOH	1.000E-03	1.000E-03
AM	CONCMIN	2.600E-08	2.600E-08
NP	CONCMIN	2.600E-08	2.600E-08
PU	CONCMIN	2.600E-08	2.600E-08
TH	CONCMIN	2.600E-08	2.600E-08
U	CONCMIN	2.600E-08	2.600E-08
AM	CONCINT	4.000E-09	9.500E-09
NP	CONCINT	2.000E-08	4.300E-08
PU	CONCINT	2.000E-08	4.300E-08
TH	CONCINT	2.000E-08	4.300E-08
U	CONCINT	3.000E-08	1.400E-06
PHUMOX3	PHUMSIM	1.900E-01	2.000E-01
PHUMOX4	PHUMSIM	6.300E+00	1.000E-02
PHUMOX5	PHUMSIM	9.100E-04	9.100E-04
PHUMOX6	PHUMSIM	1.200E-01	1.200E-01
PHUMOX3	PHUMCIM	1.370E+00	2.000E-01
PHUMOX4	PHUMCIM	6.300E+00	1.000E-02
PHUMOX5	PHUMCIM	7.400E-03	7.400E-03
PHUMOX6	PHUMCIM	5.100E-01	5.100E-01
AM	CAPHUM	1.100E-05	1.100E-05
NP	CAPHUM	1.100E-05	1.100E-05
PU	CAPHUM	1.100E-05	1.100E-05
TH	CAPHUM	1.100E-05	1.100E-05
U	CAPHUM	1.100E-05	1.100E-05
AM	PROPMIC	3.200E-01	3.000E-02
NP	PROPMIC	1.760E+00	2.100E-01
PU	PROPMIC	1.760E+00	2.100E-01
TH	PROPMIC	1.760E+00	2.100E-01
U	PROPMIC	1.760E+00	2.100E-01
AM	CAPMIC	3.100E-08	2.300E-09

* Median value used for Sampled Parameters

+ Oxidation states +5 and +6 are assumed to have no uncertainty and therefore the uncertainty exponential takes on a value of 0.0. These values are not included in the WIPP PA Database.

Material	Property	CRA14	CRA19
NP	CAPMIC	2.300E-06	3.800E-08
PU	CAPMIC	2.300E-06	3.800E-08
TH	CAPMIC	2.300E-06	3.800E-08
U	CAPMIC	2.300E-06	3.800E-08
SOLMOD3	SOLVAR*	-8.743E-01*	3.464E-01*
SOLMOD4	SOLVAR*	1.029E+00*	-9.960E-02*
SOLMOD5	SOLVAR+	0.000E+00+	0.000E+00+
SOLMOD6	SOLVAR+	0.000E+00+	0.000E+00+

Example Calculation

As an example, the Pu concentration in the Salado brine will be calculated assuming the high oxidation state Pu(IV) was sampled from GLOBAL:OXSTAT. The sampled value for solubility uncertainty will use the median value of -0.0996. The median brine solubility uses the SOLMOD*oxs* material where *oxs* is the oxidation state (in this case SOLMOD4) and the Salado brine corresponds to the property SOLSOH, giving the value 5.45×10^{-8} mol/L. The humic proportionality constant, PHUMOX4:PHUMSIM, is 0.01 mol/mol, the microbial proportionality constant, PU:PROPMIC, is 0.21 mol/mol, the humic cap, PU:CAPHUM, is 1.1×10^{-5} mol/L, the microbe cap, PU:CAPMIC, is 3.8×10^{-8} mol/L, the concentration of the actinide on mineral fragments, PU:CONCMIN, is 2.6×10^{-8} mol/L, and the intrinsic-colloid concentration, PU:CONCINT, is 4.3×10^{-8} mol/L.

In this case, the maximum dissolved concentration of Pu(IV) used in the PA would be:

$$Dissolved = Baseline\ Solubility \times 10^{Sampled\ Solubility\ Uncertainty}$$
$$= (5.45 \times 10^{-8}) \times (10^{-0.0996}) = 4.33 \times 10^{-8} \frac{mol}{L}$$

The maximum humic-complexed Pu would be:

$$Humic = \min(Dissolved * PHUM, CAPHUM)$$
$$= \min\left((4.33 \times 10^{-8}) \times (0.01), 1.1 \times 10^{-5}\right) = 4.33 \times 10^{-10} \frac{mol}{L}$$

The maximum microbial-mobilized Pu would be:

$$Microbial = \min(Dissolved * PROPMIC, CAPMIC)$$
$$= \min\left((4.33 \times 10^{-8}) \times (0.21), 3.8 \times 10^{-8}\right) = 9.1 \times 10^{-9} \frac{mol}{L}$$

The total mobilized concentration of Pu(IV) would then be the sum of the dissolved and colloidal contributions:

$$Total\ Mobile = Dissolved + (Humic + Microbial + Mineral + Intrinsic)$$
$$= 4.33 \times 10^{-8} + 4.33 \times 10^{-10} + 9.1 \times 10^{-9} + 2.6 \times 10^{-8} + 4.3 \times 10^{-8}$$
$$= 1.22 \times 10^{-7} \frac{mol}{L}$$

Solubility calculations are performed for Am(III), Th(IV), and Np(V) and the oxidation-state analogy is used to apply the values calculated for these elements/oxidation states to other actinide elements in the same oxidation states (if any). The total mobilized concentration and mobile fractions for Cm are set equal to the values for Am. In addition, the PA groups radioisotopes with similar decay and transport properties for the NUTS and SECOTP2D (component radionuclide transport in fractures or granular aquifers) transport calculations. For example, the U solubility is decreased to account for the shared solubility with the low-activity ^{238}U, which is not explicitly modeled, enabling NUTS to properly represent the effect of the U isotopes on compliance using the single lumped isotope ^{234}U.

Calculated Solubilities

Table 3 shows the dissolved and colloidal components of the source term and the total mobile actinide concentrations obtained when median parameter values are used. For conservatism, 1× minimum brine volume was used because total mobilized concentration for a radionuclide decreases as the brine volume increases (Sarathi 2019b).

Table 2 Actinide Solubility and Colloidal Contributions for CRA-2019[1]

An	Brine	Baseline Solubility[+]	Uncertainty Exponent[*]	Dissolved	Mineral	Intrinsic	Humic	Microbial (Corrected)	Sum Colloidal	Total Mobile[◊]
		mol/L	log10()	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L
Am(III)	Castile (ERD A-6)	1.78E-07	3.46E-01	3.95E-07	2.60E-08	9.50E-09	7.90E-08	2.30E-09	1.17E-07	5.12E-07
Am(III)	Salado (GWB)	1.63E-07	3.46E-01	3.62E-07	2.60E-08	9.50E-09	7.24E-08	2.30E-09	1.10E-07	4.72E-07
Np(IV)	Castile (ERD A-6)	5.44E-08	-9.96E-02	4.33E-08	2.60E-08	4.30E-08	4.33E-10	9.08E-09	7.85E-08	1.22E-07
Np(IV)	Salado (GWB)	5.45E-08	-9.96E-02	4.33E-08	2.60E-08	4.30E-08	4.33E-10	9.10E-09	7.85E-08	1.22E-07
Np(V)	Castile (ERD A-6)	1.20E-06	0.00E+00	1.20E-06	2.60E-08	4.30E-08	8.88E-09	3.80E-08	1.16E-07	1.32E-06
Np(V)	Salado (GWB)	4.02E-07	0.00E+00	4.02E-07	2.60E-08	4.30E-08	3.66E-10	3.80E-08	1.07E-07	5.09E-07
Pu(III)	Castile (ERD A-6)	1.78E-07	3.46E-01	3.95E-07	2.60E-08	4.30E-08	7.90E-08	3.80E-08	1.86E-07	5.81E-07
Pu(III)	Salado (GWB)	1.63E-07	3.46E-01	3.62E-07	2.60E-08	4.30E-08	7.24E-08	3.80E-08	1.79E-07	5.41E-07
Pu(IV)	Castile (ERD A-6)	5.44E-08	-9.96E-02	4.33E-08	2.60E-08	4.30E-08	4.33E-10	9.08E-09	7.85E-08	1.22E-07
Pu(IV)	Salado (GWB)	5.45E-08	-9.96E-02	4.33E-08	2.60E-08	4.30E-08	4.33E-10	9.10E-09	7.85E-08	1.22E-07

[1] Spreadsheet used to obtain final results stored at nfs/DATA/CVSLIB/WIPP_EXTERNAL/APPENDIXSOTERM
[+] For conservatism, the baseline solubility is calculated using the minimum brine volume.
[*] The median distribution value is used for sampled parameters
[◊] = Dissolved + (Mineral + Intrinsic + Humic + Microbial)

An	Brine	Baseline Solubility[+]	Uncertainty Exponent[*]	Dissolved	Mineral	Intrinsic	Humic	Microbial (Corrected)	Sum Colloidal	Total Mobile[◊]
		mol/L	log10()	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L	mol/L
Th(IV)	Castile (ERD A-6)	**5.44E-08**	-9.96E-02	4.33E-08	2.60E-08	4.30E-08	4.33E-10	9.08E-09	7.85E-08	**1.22E-07**
Th(IV)	Salado (GWB)	**5.45E-08**	-9.96E-02	4.33E-08	2.60E-08	4.30E-08	4.33E-10	9.10E-09	7.85E-08	**1.22E-07**
U(IV)	Castile (ERD A-6)	**5.44E-08**	-9.96E-02	4.33E-08	2.60E-08	1.40E-06	4.33E-10	9.08E-09	1.44E-06	**1.48E-06**
U(IV)	Salado (GWB)	**5.45E-08**	-9.96E-02	4.33E-08	2.60E-08	1.40E-06	4.33E-10	9.10E-09	1.44E-06	**1.48E-06**
U(VI)	Castile (ERD A-6)	**1.00E-03**	0.00E+00	1.00E-03	2.60E-08	1.40E-06	1.10E-05	3.80E-08	1.25E-05	**1.01E-03**
U(VI)	Salado (GWB)	**1.00E-03**	0.00E+00	1.00E-03	2.60E-08	1.40E-06	1.10E-05	3.80E-08	1.25E-05	**1.01E-03**

Table 3 Concentrations (mol/L) of Dissolved, Colloidal, and Total Mobile Actinides Obtained Using Median Parameter Values for the CRA-2019 PA.

Actinide Oxidation State and Brine	CRA-2019 PA Concentrations (mol/L)
Pu(III), dissolved, Salado brine	3.62×10^{-7}
Pu(III), colloidal, Salado brine	1.79×10^{-7}
Pu(III), total mobile, Salado brine	5.41×10^{-7}
Pu(III), dissolved, Castile brine	3.95×10^{-7}
Pu(III), colloidal, Castile brine	1.86×10^{-7}
Pu(III), total mobile, Castile brine	5.81×10^{-7}
Am(III), dissolved, Salado brine	3.62×10^{-7}
Am(III), colloidal, Salado brine	1.10×10^{-7}
Am(III), total mobile, Salado brine	4.72×10^{-7}
Am(III), dissolved, Castile brine	3.95×10^{-7}
Am(III), colloidal, Castile brine	1.17×10^{-7}
Am(III), total mobile, Castile brine	5.12×10^{-7}
Th(IV), dissolved, Salado brine	4.33×10^{-8}

Actinide Oxidation State and Brine	CRA-2019 PA Concentrations (mol/L)
Th(IV), colloidal, Salado brine	7.85×10^{-8}
Th(IV), total mobile, Salado brine	1.22×10^{-7}
Th(IV), dissolved, Castile brine	4.33×10^{-8}
Th(IV), colloidal, Castile brine	7.85×10^{-8}
Th(IV), total mobile, Castile brine	1.22×10^{-7}
U(IV), dissolved, Salado brine	4.33×10^{-8}
U(IV), colloidal, Salado brine	1.44×10^{-6}
U(IV), total mobile, Salado brine	1.48×10^{-6}
U(IV), dissolved, Castile brine	4.33×10^{-8}
U(IV), colloidal, Castile brine	1.44×10^{-6}
U(IV), total mobile, Castile brine	1.48×10^{-6}
Pu(IV), dissolved, Salado brine	4.33×10^{-8}
Pu(IV), colloidal, Salado brine	7.85×10^{-8}
Pu(IV), total mobile, Salado brine	1.22×10^{-7}
Pu(IV), dissolved, Castile brine	4.33×10^{-8}
Pu(IV), colloidal, Castile brine	7.85×10^{-8}
Pu(IV), total mobile, Castile brine	1.22×10^{-7}
U(VI), dissolved, Salado brine	1.00×10^{-3}
U(VI), colloidal, Salado brine	1.25×10^{-5}
U(VI), total mobile, Salado brine	1.01×10^{-3}
U(VI), dissolved, Castile brine	1.00×10^{-3}
U(VI), colloidal, Castile brine	1.25×10^{-5}
U(VI), total mobile, Castile brine	1.01×10^{-3}

References

Domski, P.S. 2019. "Th(IV), Np(V), and Am(III) Baseline Solubilities and Th(IV) and Am(III) Solubility Uncertainties for the CRA-2019 PA". ERMS 571169. Sandia National Laboratories, Carlsbad, New Mexico

Sarathi, R.S. 2019a. Memo: Explanation of CAPMIC definition and usage in PA calculations. ERMS 570685. Sandia National Laboratories. Carlsbad, NM.

Sarathi, R.S. 2019b Analysis Package for Actinide Mobilization and Salado Transport in the 2019 Compliance Recertification Application Performance Assessment (CRA-2019 PA). ERMS 571371. Sandia National Laboratories. Carlsbad, NM.

U.S. Department of Energy (DOE). 2014. *Title 40 CFR Part 191 Subparts B and C Compliance Recertification Application 2014, Appendix SOTERM-2014*. DOE/WIPP 14-3503. Carlsbad, NM: Carlsbad Field Office.

WIPP PA Parameter Database. http://bto.sandia.gov

ParamsDB values

Material	Property	CRA-2014	CRA-2019
SOLMOD3	SOLSOH	2.590E-06	1.630E-07
SOLMOD4	SOLSOH	6.050E-08	5.450E-08
SOLMOD5	SOLSOH	2.770E-07	4.020E-07
SOLMOD6	SOLSOH	1.000E-03	1.000E-03
SOLMOD3	SOLCOH	1.480E-06	1.780E-07
SOLMOD4	SOLCOH	7.020E-08	5.440E-08
SOLMOD5	SOLCOH	8.760E-07	1.200E-06
SOLMOD6	SOLCOH	1.000E-03	1.000E-03
AM	CONCMIN	2.600E-08	2.600E-08
NP	CONCMIN	2.600E-08	2.600E-08
PU	CONCMIN	2.600E-08	2.600E-08
TH	CONCMIN	2.600E-08	2.600E-08
U	CONCMIN	2.600E-08	2.600E-08
AM	CONCINT	4.000E-09	9.500E-09
NP	CONCINT	2.000E-08	4.300E-08
PU	CONCINT	2.000E-08	4.300E-08
TH	CONCINT	2.000E-08	4.300E-08
U	CONCINT	3.000E-08	1.400E-06
PHUMOX3	PHUMSIM	1.900E-01	2.000E-01
PHUMOX4	PHUMSIM	6.300E+00	1.000E-02
PHUMOX5	PHUMSIM	9.100E-04	9.100E-04
PHUMOX6	PHUMSIM	1.200E-01	1.200E-01
PHUMOX3	PHUMCIM	1.370E+00	2.000E-01
PHUMOX4	PHUMCIM	6.300E+00	1.000E-02
PHUMOX5	PHUMCIM	7.400E-03	7.400E-03
PHUMOX6	PHUMCIM	5.100E-01	5.100E-01
AM	CAPHUM	1.100E-05	1.100E-05
NP	CAPHUM	1.100E-05	1.100E-05
PU	CAPHUM	1.100E-05	1.100E-05
TH	CAPHUM	1.100E-05	1.100E-05
U	CAPHUM	1.100E-05	1.100E-05
AM	PROPMIC	3.200E-01	3.000E-02
NP	PROPMIC	1.760E+00	2.100E-01
PU	PROPMIC	1.760E+00	2.100E-01
TH	PROPMIC	1.760E+00	2.100E-01
U	PROPMIC	1.760E+00	2.100E-01
AM	CAPMIC	3.100E-08	2.300E-09
NP	CAPMIC	2.300E-06	3.800E-08
PU	CAPMIC	2.300E-06	3.800E-08
TH	CAPMIC	2.300E-06	3.800E-08
U	CAPMIC	2.300E-06	3.800E-08
SOLMOD3	SOLVAR*	-8.743E-01	3.464E-01
SOLMOD4	SOLVAR*	1.029E+00	-9.960E-02
SOLMOD5	SOLVAR	0.000E+00	0.000E+00
SOLMOD6	SOLVAR	0.000E+00	0.000E+00

* Median values used for sampled parameters

Note SOLMOD5:SOLVAR and SOLMOD6:SOLVAR do not have values in ParamsDB, they take on hard-coded values of 0 to represent no uncertainty.

CRA-2019

An	Brine	Baseline Solubility	Uncertainty Exponent	Dissolved	Mineral	Intrinsic	Humic	Microbial (Corrected)	Sum Colloidal	Total Mobile
Am(III)	Castile	1.780E-07	3.464E-01	3.952E-07	2.600E-08	9.500E-09	7.90333E-08	2.3E-09	1.168E-07	5.120E-07
Am(III)	Salado	1.630E-07	3.464E-01	3.619E-07	2.600E-08	9.500E-09	7.23732E-08	2.3E-09	1.102E-07	4.720E-07
Np(IV)	Castile	5.440E-08	-9.960E-02	4.325E-08	2.600E-08	4.300E-08	4.32513E-10	9.08277E-09	7.852E-08	1.218E-07
Np(IV)	Salado	5.450E-08	-9.960E-02	4.333E-08	2.600E-08	4.300E-08	4.33308E-10	9.09946E-09	7.853E-08	1.219E-07
Np(V)	Castile	1.200E-06	0.000E+00	1.200E-06	2.600E-08	4.300E-08	8.88E-09	0.000000038	1.159E-07	1.316E-06
Np(V)	Salado	4.020E-07	0.000E+00	4.020E-07	2.600E-08	4.300E-08	3.6582E-10	0.000000038	1.074E-07	5.094E-07
Pu(III)	Castile	1.780E-07	3.464E-01	3.952E-07	2.600E-08	4.300E-08	7.90333E-08	0.000000038	1.860E-07	5.812E-07
Pu(III)	Salado	1.630E-07	3.464E-01	3.619E-07	2.600E-08	4.300E-08	7.23732E-08	0.000000038	1.794E-07	5.412E-07
Pu(IV)	Castile	5.440E-08	-9.960E-02	4.325E-08	2.600E-08	4.300E-08	4.32513E-10	9.08277E-09	7.852E-08	1.218E-07
Pu(IV)	Salado	5.450E-08	-9.960E-02	4.333E-08	2.600E-08	4.300E-08	4.33308E-10	9.09946E-09	7.853E-08	1.219E-07
Th(IV)	Castile	5.440E-08	-9.960E-02	4.325E-08	2.600E-08	4.300E-08	4.32513E-10	9.08277E-09	7.852E-08	1.218E-07
Th(IV)	Salado	5.450E-08	-9.960E-02	4.333E-08	2.600E-08	4.300E-08	4.33308E-10	9.09946E-09	7.853E-08	1.219E-07
U(IV)	Castile	5.440E-08	-9.960E-02	4.325E-08	2.600E-08	1.400E-06	4.32513E-10	9.08277E-09	1.436E-06	1.479E-06
U(IV)	Salado	5.450E-08	-9.960E-02	4.333E-08	2.600E-08	1.400E-06	4.33308E-10	9.09946E-09	1.436E-06	1.479E-06
U(VI)	Castile	1.000E-03	0.000E+00	1.000E-03	2.600E-08	1.400E-06	0.000011	0.000000038	1.246E-05	1.012E-03
U(VI)	Salado	1.000E-03	0.000E+00	1.000E-03	2.600E-08	1.400E-06	0.000011	0.000000038	1.246E-05	1.012E-03

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An	Brine	Baseline Solubility	Uncertainty Exponent	Dissolved	Mineral	Intrinsic	Humic	Microbial (Corrected)	Sum Colloidal	Total Mobile	Microbial (UnCorrected)	Sum Colloidal (UC)	Total Mobile (UC)
Am(III)	Castile	1.480E-06	-8.743E-01	1.977E-07	2.600E-08	4.000E-09	2.70796E-07	0.000000031	3.318E-07	5.295E-07	0	3.008E-07	4.985E-07
Am(III)	Salado	2.590E-06	-8.743E-01	3.459E-07	2.600E-08	4.000E-09	6.57224E-08	0.000000031	1.267E-07	4.726E-07	0	9.572E-08	4.416E-07
Np(IV)	Castile	7.020E-08	1.029E+00	7.498E-07	2.600E-08	2.000E-08	4.72398E-06	1.31971E-06	6.090E-06	6.840E-06	0	4.770E-06	5.520E-06
Np(IV)	Salado	6.050E-08	1.029E+00	6.462E-07	2.600E-08	2.000E-08	4.07123E-06	1.13736E-06	5.255E-06	5.901E-06	0	4.117E-06	4.763E-06
Np(V)	Castile	8.760E-07	0.000E+00	8.760E-07	2.600E-08	2.000E-08	6.4824E-09	1.54176E-06	1.594E-06	2.470E-06	1.37152E-06	1.424E-06	2.300E-06
Np(V)	Salado	2.770E-07	0.000E+00	2.770E-07	2.600E-08	2.000E-08	2.5207E-10	4.8752E-07	5.338E-07	8.108E-07	4.8752E-07	5.338E-07	8.108E-07
Pu(III)	Castile	1.480E-06	-8.743E-01	1.977E-07	2.600E-08	2.000E-08	2.70796E-07	3.47884E-07	6.647E-07	8.623E-07	3.47884E-07	6.647E-07	8.623E-07
Pu(III)	Salado	2.590E-06	-8.743E-01	3.459E-07	2.600E-08	2.000E-08	6.57224E-08	6.08797E-07	7.205E-07	1.066E-06	6.08797E-07	7.205E-07	1.066E-06
Pu(IV)	Castile	7.020E-08	1.029E+00	7.498E-07	2.600E-08	2.000E-08	4.72398E-06	1.31971E-06	6.090E-06	6.840E-06	0	4.770E-06	5.520E-06
Pu(IV)	Salado	6.050E-08	1.029E+00	6.462E-07	2.600E-08	2.000E-08	4.07123E-06	1.13736E-06	5.255E-06	5.901E-06	0	4.117E-06	4.763E-06
Th(IV)	Castile	7.020E-08	1.029E+00	7.498E-07	2.600E-08	2.000E-08	4.72398E-06	1.31971E-06	6.090E-06	6.840E-06	0	4.770E-06	5.520E-06
Th(IV)	Salado	6.050E-08	1.029E+00	6.462E-07	2.600E-08	2.000E-08	4.07123E-06	1.13736E-06	5.255E-06	5.901E-06	0	4.117E-06	4.763E-06
U(IV)	Castile	7.020E-08	1.029E+00	7.498E-07	2.600E-08	3.000E-08	4.72398E-06	-0.87434	-8.743E-01	-8.743E-01	0	4.780E-06	5.530E-06
U(IV)	Salado	6.050E-08	1.029E+00	6.462E-07	2.600E-08	3.000E-08	4.07123E-06	-0.87434	-8.743E-01	-8.743E-01	0	4.127E-06	4.773E-06
U(VI)	Castile	1.000E-03	0.000E+00	1.000E-03	2.600E-08	3.000E-08	0.000011	0.0000023	1.336E-05	1.013E-03	0	1.106E-05	1.011E-03
U(VI)	Salado	1.000E-03	0.000E+00	1.000E-03	2.600E-08	3.000E-08	0.000011	0.0000023	1.336E-05	1.013E-03	0	1.106E-05	1.011E-03

Note, the "uncorrected" forumla was used in CRA-2014, these are the values you will find referenced. See Sarathi 2019 - Memo: Explanation of CAPMIC definition and usage in PA Calculations. ERMS 570685. for more details.