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Comparison of Toxicological and Radiological Aspects of K Basins Sludge

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Abstract: The composition of various K Basins sludge is evaluated for its toxicological and radiological impacts downwind from accidents. It is shown that the radiological risk evaluation guidelines are always more limiting than the toxicological risk evaluation guidelines.

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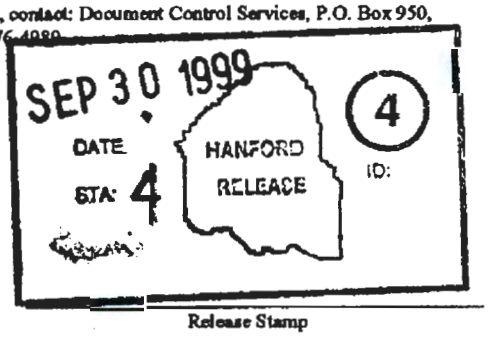

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Comparison of Toxicological and Radiological Aspects of K-Basins Sludge

by Paul D. Rittmann, PhD CHP September 21, 1999

The sludge at K basins contains more than just radioactive material. It also contains a variety of potentially toxic chemicals. DOE-RL has provided risk acceptance guidelines for both. For evaluation of accident consequences, it can be shown that the radiological doses are substantially closer to these guidelines than are the toxicological air concentrations.

The approach followed in this report is very similar to that followed in HNF-SD-SNF-TI-059. First, the composition of K basins sludge is described. Second, concentration-weighted risk guidelines (CWRG) are computed. Finally, the radiological and the toxicological consequences of postulated accidents are compared using a ratioing approach in which doses and air concentrations are divided by the corresponding DOE-RL guidance. It is shown that the radiological guidelines are always more limiting than the toxicological guidelines. For this reason, the accident analyses need only examine the radiological effects. The peer review checklist is included as Appendix A.

The DOE-recommended risk evaluation guidelines (Sellers 1997) for radiological consequences and for toxicological exposures are shown in Tables 1 and 2 below.

Table 1. Radiological Risk Evaluation Guidelines for the Spent Nuclear Fuel Project.

Frequency	Onsite	Offsite
Anticipated 10^{+0} to 10^{-2}/yr	1.0 rem (0.01 Sv)	0.5 rem (0.005 Sv)
Unlikely 10^{-2} to 10^{-4}/yr	10 rem (0.1 Sv)	5.0 rem (0.05 Sv)
Extremely unlikely 10^{-4} to 10^{-6}/yr	25 rem (0.25 Sv)	5.0 rem (0.05 Sv)

1 Sv = 100 rem
The doses are 50 year committed effective dose equivalents.
Onsite values are "risk evaluation guidelines", while offsite values are "accident release limits" (Sellers 1997).

Table 2. Toxicological Air Concentration Guidelines for the Spent Nuclear Fuel Project.

Frequency	Onsite	Offsite
Anticipated 10^{+0} to 10^{-2}/yr	≤ERPG-1	≤PEL-TWA
Unlikely 10^{-2} to 10^{-4}/yr	≤ERPG-2	≤ERPG-1
Extremely unlikely 10^{-4} to 10^{-6}/yr	≤ERPG-3	≤ERPG-2

ERPG = emergency response planning guideline.
PEL = permissible exposure limit.
TWA = time-weighted average.

The following are definitions for ERPGs and the PEL-TWA (AIHA 1991).

- The ERPG-1 value is the maximum airborne concentration to which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.

- The ERPG-2 value is the maximum airborne concentration to which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

- The ERPG-3 value is the maximum airborne concentration to which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

- The PEL-TWA value is the employees' average airborne exposure in any 8-hour work shift of a 40-hour work week that shall not be exceeded.

PEL-TWA use for emergency response is not strictly appropriate because the PEL-TWA is designed to control relatively long-term worker exposure rather than the short term exposure to the public that would be expected for accident response. The lower of the ERPG-1 and the PEL-TWA should be used for the offsite exposure for high frequency events. Use of the limits that are at or below the ERPG-1 accident category provides an additional level of conservatism. However, it will be shown that radiological effects are more important than toxicological effects, so this refinement is not needed.

No published ERPG values exist for a number of chemicals found in sludge. Therefore ERPG values developed by Craig to fill these gaps were employed (Craig 1997). These interim ERPG values are known as temporary emergency exposure limits or TEELs. Values for compounds that have been found in K basins sludge are listed in Table 3 below. In addition, values for

plutonium and americium are assumed to be the same as those for uranium. This assumption has no effect on the conclusions, but illustrates how little these elements contribute to the overall toxicity of the mixtures.

Table 3. Air Concentration Guidelines for Sludge Chemicals

Analyte	PEL-TWA	ERPG-1	ERPG-2	ERPG-3
Ag_2O	0.01	0.3	0.5	10
Al_2O_3	10	15	15	25
Am	0.05	0.6	0.6	10
B_2O_3	10	30	50	250
BaO	0.5	1.5	2.5	12.5
BeO	0.002	0.01	0.025	0.1
BiO	NA	NA	NA	NA
CO	39.9	228	399	570
CaO	5	6	10	25
CdO	0.005	0.03	4	9
Cr_2O_3	0.5	1.5	2.5	25
CuO	1	3	5	100
Fe_2O_3	10	15	25	2500
MgO	10	30	50	250
MnO_2	0.2	3	5	500
Na_2O	10	30	50	250
NiO	1	3	5	20
PO_3	1	3	100	500
PbO	0.05	0.15	0.25	100
Pu	0.05	0.6	0.6	10
Se	0.2	0.6	1	1
SiO_2	0.1	0.3	0.5	25
Sm_2O_3	NA	NA	NA	NA
Sr	10	30	50	500
Tl_2O_3	2	2	2	20
UO	0.05	0.6	0.6	10
ZnO	10	15	15	500
ZrO_2	5	10	25	50
PCB	0.001	0.003	0.005	500

The air concentration guidelines are given in units of mg/m^3. Values are from Craig 1997. Values for Am and Pu are assumed to be the same as UO. The assumed compounds are from HNF-SD-SNF-TI-009 Volume 2.

Composition of K Basins Sludge

In HNF-SD-SNF-TI-009 Volume 2, sludge characterization is presented for several locations ranging from the basin floor to fuel washing. For convenience, two broad categories will be used in this report, (1) the general sludge associated with material on the basin and pit floors, and (2) the canister sludge associated with the canisters and fuel washing. Sludge volumes are much larger in KE than KW, thus more characterization data exists for KE. In particular, the general sediments in KE basin have been analyzed, while that in KW has not. It is assumed that the composition of the KW general sludge is bounded by that found in KE. Canister sludges for both basins have been analyzed.

The average composition of KE basin general sludge is given in Table 4. This composition is assumed for both KE and KW Basin (HNF-SD-SNF-TI-009 Volume 2) except that KW has no PCBs. The composition was determined using a method that quantifies the elements without identifying chemical compounds. The assumed chemical forms are oxides, except for PCBs. The additional mass associated with the oxides were included in the values listed in HNF-SD-SNF-TI-009.

The mass densities of americium (Am) and strontium (Sr) shown in Table 4 are calculated from the radiological composition. The calculation first multiplies the activity concentration (μCi/g) by the dry density (g/cc) to convert the activity concentration to volume units (μCi/cc). Then the activity per unit volume is divided by the specific activity of the isotope to obtain the mass densities shown in Table 4. Values for specific activities are shown in the notes to Table 4. In all cases, the mass density associated with the isotopes is an insignificant addition to the total mass as well as the chemical toxicity of the mixture. The mass of Cs-137 was not calculated because no air concentration guidelines exist for cesium compounds based on toxicological considerations. The plutonium mass was not calculated because it is given in HNF-SD-SNF-TI-009 Volume 2.

Note that the radioactive composition of K basins sludge that is used for safety basis calculations is the bounding SNF composition as stated in HNF-SD-SNF-TI-009 Volume 2, Section 3.5. The bounding composition has the most conservative value for inhalation dose per unit mass inhaled, or unit dose (UD).

The dry density and wet density of the settled material are shown in Table 4. The dry density is used to covert the radiological composition from activity per unit mass to activity per unit volume. The volumes of sludge shown in Table 4 are those estimated for KE Basin. The KW Basin volumes are much smaller.

Characterization data for the KE Basin includes only the "Main Basin Floor", the "Weasel Pit", the "North Loadout Pit", and a few canisters. Compositions for the "Tech View Pit" and "Elevator Pit" are assumed to be bounded by the sludge composition of the "Weasel Pit", and are therefore not shown.

In the absence of characterization data for the KW basin, it is assumed that the sludge composition is the same as in KE (Table 4), except that KW has no PCBs (HNF-SD-SNF-TI-009). For KW the composition of the "Discharge Chute" is also assumed to have the same composition as the "Weasel Pit".

The comparison between radiological and toxicological risk of the sludge mixtures depends entirely on the relative amounts of the chemicals in each type of sludge. Thus the cases where the same composition is assumed will also have the same comparison ratio between radiological and toxicological risk.

Table 4. KE Basin General Sludge Composition (2 pages)

Analyte	Weasel Pit	Main Basin Floor	Tech View Pit	North Loadout Pit	Elevator Pit
Mass Densities (g/cc) of KE Basin Sludges					
Ag_2O	0.000017	0.000007	0.000017	nd	0.000017
Al_2O_3	0.062895	0.041372	0.062895	0.014103	0.062895
Am	0.000022	0.000066	0.000022	0.000005	0.000022
B_2O_3	0.000406	0.000303	0.000406	nd	0.000406
BaO	0.000379	0.000111	0.000379	0.000065	0.000379
BeO	0.000045	0.000052	0.000045	0.000016	0.000045
BiO	nd	nd	nd	nd	nd
CO	0.007600	0.006030	0.007600	nd	0.007600
CaO	0.015968	0.003087	0.015968	0.003699	0.015968
CdO	0.000050	0.000060	0.000050	0.000051	0.000050
Cr_2O_3	0.001333	0.000303	0.001333	0.000122	0.001333
CuO	0.000433	0.000289	0.000433	0.000239	0.000433
Fe_2O_3	0.403050	0.128683	0.403050	0.037761	0.403050
MgO	0.002863	0.001052	0.002863	0.000622	0.002863
MnO	0.000583	0.000245	0.000583	0.000323	0.000583
Na_2O	0.000966	0.001533	0.000966	nd	0.000966
NiO	nd	nd	nd	nd	nd
PO_3	nd	nd	nd	nd	nd
PbO	0.000475	0.000183	0.000475	0.000105	0.000475
Pu	0.000076	0.000102	0.000076	0.000060	0.000076
Se	0.000173	0.000063	0.000173	nd	0.000173
SiO_2	0.235325	0.073942	0.235325	0.297060	0.235325

Table 4. KE Basin General Sludge Composition (2 pages)

Analyte	Weasel Pit	Main Basin Floor	Tech View Pit	North Loadout Pit	Elevator Pit
Sm_2O_3	0.000201	0.000073	0.000201	0.000042	0.000201
Sr	0.000015	0.000018	0.000015	nd	0.000015
Tl_2O_3	0.000344	0.000136	0.000344	0.000105	0.000344
UO	0.063422	0.038469	0.063422	0.015223	0.063422
ZnO	0.001168	0.000436	0.001168	nd	0.001168
ZrO_2	0.000673	0.000224	0.000673	nd	0.000673
PCB	0.000225	0.000083	0.000225	nd	0.000225
Other	0.062079	0.056651	0.062079	nd	0.062079
Total:	0.86079	0.35357	0.86079	0.36960	0.86079
Dry Density:	0.931	0.375	0.931	0.370	0.931
Wet Density:	1.56	1.32	1.56	1.27	1.56
Miscellaneous Characteristics of KE Basin Sludges					
Volume, m^3:	10.10	21.50	0.40	6.30	1.40
Volume, L:	10,100	21,500	400	6,300	1,400
Wet Sludge, MT:	15.76	28.38	0.62	8.00	2.18
Dry Sludge, MT:	9.40	8.06	0.37	2.33	1.30
Uranium, kg:	559.83	722.84	22.17	83.87	77.6
Radiological Composition (μCi/g) of KE Basin Sludges					
Sr-90	223.55	302.20	223.55	0.00	223.55
Cs-137	293.54	310.24	293.54	37.84	293.54
Pu-239	5.37	19.88	5.37	10.05	5.37
Am-241	8.17	28.11	8.17	7.27	8.17

Notes: Listed data comes from HNF-SD-SNF-TI-009 Rev 2. Data not given in the document is indicated by "nd". The specific activities needed to convert activity into mass for an isotope are listed below.

Sr-90:	139.03 Ci/g
Cs-137:	86.55 Ci/g
Pu-239:	0.06197 Ci/g
Am-241:	3.4314 Ci/g

Compositions for the "Tech View Pit" and "Elevator Pit" are assumed to be bounded by the composition measured for the "Weasel Pit".

Table 5. KE Basin Canister and Fuel Sludge Composition (2 pages)

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Mass Densities (g/cc) of KE Basin Sludges					
Ag2O	0.000094	0.000094	nd	nd	nd
Al_2O_3	0.170042	0.170042	0.025395	0.213762	nd
Am	0.000107	0.000107	0.000073	0.000002	0.000077
B_2O_3	0.000939	0.000939	nd	nd	nd
BaO	0.000162	0.000162	nd	nd	nd
BeO	0.000198	0.000198	nd	nd	nd
BiO	0.000413	0.000413	nd	nd	nd
CO	0.009904	0.009904	0.007600	nd	0.007600
CaO	0.001624	0.001624	nd	0.014884	nd
CdO	0.000084	0.000084	nd	nd	nd
Cr_2O_3	0.000577	0.000577	nd	nd	nd
CuO	0.000481	0.000481	nd	nd	nd
Fe_2O_3	0.109399	0.109399	0.004348	0.028622	nd
MgO	0.002350	0.002350	nd	nd	nd
MnO	0.000456	0.000456	nd	nd	nd
Na_2O	0.000806	0.000806	nd	nd	nd
NiO	0.000253	0.000253	nd	nd	nd
PO_3	0.002017	0.002017	nd	nd	nd
PbO	0.000413	0.000413	nd	nd	nd
Pu	0.001536	0.001536	0.008681	0.001794	0.033569
Se	nd	nd	nd	nd	nd
SiO_2	0.039261	0.039261	0.348580	nd	nd
Sm_2O_3	nd	nd	nd	nd	nd
Sr	0.000020	0.000020	0.000033	0.000001	0.000046
Tl_2O_3	nd	nd	nd	nd	nd
UO	0.531651	0.531651	1.906871	0.673135	9.828354
ZnO	0.000590	0.000590	nd	nd	nd
ZrO_2	0.000496	0.000496	nd	nd	0.692665
PCB	0.000002	0.000002	nd	nd	nd

Table 5. KE Basin Canister and Fuel Sludge Composition (2 pages)

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Other	0.010235	0.010235	0.017895	0.036809	0.056162
Total, g/cc:	0.88411	0.88411	2.31948	0.96901	10.61847
Dry Density:	0.884	0.884	2.312	0.969	10.611
Wet Density:	1.62	1.62	3.00	1.50	11.02
Miscellaneous Characteristics of KE Basin Sludges					
Volume, m^3:	3.00	0.40	0.518	0.061	0.149
Volume, L:	3,000	400	518	61	149
Wet Sludge, MT:	4.86	0.65	1.55	0.09	1.64
Dry Sludge, MT:	2.65	0.35	1.20	0.06	1.58
Uranium, kg:	1,408.97	187.86	880.43	26.14	1,464.42
Radiological Composition (μCi/g) of KE Basin Sludges					
Sr-90	1,053.40	1,053.40	3,851.61	1,767.75	4,045.39
Cs-137	806.35	806.35	3,443.33	1,410.00	5,342.20
Pu-239	108.70	108.70	232.67	114.50	195.91
Am-241	138.34	138.34	210.50	93.40	168.01

Notes: Listed data comes from HNF-SD-SNF-TI-009 Rev 2. Data not given in the document is indicated by "nd". The specific activities needed to convert activity into mass for an isotope are listed below.

Sr-90:	139.03 Ci/g
Cs-137:	86.55 Ci/g
Pu-239:	0.06197 Ci/g
Am-241:	3.4314 Ci/g

Table 6. KW Basin Canister and Fuel Sludge Composition (2 pages)

Analyte	Canister Sludge Cans		Fuel Wash Sludge		
	Full	Empty	Internal	Coating	Pieces
Mass Densities (g/cc) of KW Basin Sludges					
Ag_2O	nd	nd	nd	nd	nd
Al_2O_3	0.117661	0.117661	0.129080	0.544151	nd
Am	0.000083	0.000083	0.000052	0.000001	0.000076
B_2O_3	nd	nd	nd	nd	nd
BaO	0.000565	0.000565	nd	nd	nd
BeO	0.000274	0.000274	nd	nd	nd
BiO	nd	nd	nd	nd	nd
CO	0.005844	0.005844	nd	nd	nd
CaO	nd	nd	nd	0.004574	nd
CdO	nd	nd	nd	nd	nd
Cr_2O_3	0.000935	0.000935	nd	nd	nd
CuO	nd	nd	nd	nd	nd
Fe_2O_3	0.209042	0.209042	0.004031	0.306839	nd
MgO	nd	nd	nd	nd	nd
MnO	0.000733	0.000733	nd	nd	nd
Na_2O	nd	nd	nd	nd	nd
NiO	0.000659	0.000659	nd	nd	nd
PO_3	nd	nd	nd	nd	nd
PbO	nd	nd	nd	nd	nd
Pu	0.005648	0.005648	0.006865	0.000073	0.034805
Se	nd	nd	nd	nd	nd
SiO_2	nd	nd	0.194161	0.028835	0.000000
Sm_2O_3	nd	nd	nd	nd	nd
Sr	0.000046	0.000046	0.000018	nd	0.000058
Tl_2O_3	nd	nd	nd	nd	nd
UO	1.497660	1.497660	1.888783	0.022194	9.828354
ZnO	0.001537	0.001537	nd	nd	nd
ZrO_2	0.001186	0.001186	nd	nd	0.692665
PCB	0.000015	0.000015	nd	nd	nd

Table 6. KW Basin Canister and Fuel Sludge Composition (2 pages)

Analyte	Canister Sludge Cans		Fuel Wash Sludge		
	Full	Empty	Internal	Coating	Pieces
Other	0.055248	0.055248	0.017895	0.036809	0.056162
Total:	1.89714	1.89714	2.24088	0.94348	10.61212
Dry Density:	2.053	2.053	2.31	0.97	10.612
Wet Density:	2.68	2.68	3.00	1.50	11.02
Unlisted:	0.15586	0.15586	0.06912	0.02652	-0.00012
Miscellaneous Characteristics of KW Basin Sludges					
Volume, m^3:	1.01	0.13	0.518	0.405	0.149
Volume, L:	1,010	135	518	405	149
Wet Sludge, MT:	2.71	0.36	1.55	0.61	1.64
Dry Sludge, MT:	2.07	0.28	1.20	0.39	1.58
Uranium, kg:	1,329.96	177.33	880.43	26.14	1,464.42
Radiological Composition (μCi/g) of KW Basin Sludges					
Sr-90	3,096.25	3,096.25	2,116.08	92.90	5,065.27
Cs-137	1,898.75	1,898.75	2,210.00	57.70	6,505.54
Pu-239	175.03	175.03	184.00	4.62	203.12
Am-241	136.66	136.66	148.00	4.38	165.58

Notes: Listed data comes from HNF-SD-SNF-TI-009 Rev 2. Data not given in the document is indicated by "nd". The specific activities needed to convert activity into mass for an isotope are listed below.

Sr-90:	139.03 Ci/g
Cs-137:	86.55 Ci/g
Pu-239:	0.06197 Ci/g
Am-241:	3.4314 Ci/g

Concentration-Weighted Risk Guidelines

The method used to calculate toxicological air concentrations in relation to the DOE-RL acceptance guideline is summarized in the discussion below, taken from HNF-SD-SNF-TI-059.

For toxic chemicals the accumulated dose is not computed. Rather, the air concentration is determined and compared with guidelines. Health effects from exposure to contaminated air depend on the chemical, the air concentration, and the exposure time. For corrosive chemicals, the air concentration alone determines the amount of damage. Noncorrosive chemicals are carcinogens or have toxic effects based on the amount accumulated in the body. For noncorrosive chemicals the health effects depend on exposure time.

For accidents with release durations less than the transition times associated with each receptor distance, the puff model is appropriate for calculating air concentrations. The peak air concentration is calculated using the following equation:

$$C_{puff} = (M)(\chi/Q)$$

where

C_{puff} = peak concentration at a downwind receptor location, grams per cubic meter

M = mass of the toxic chemical released, grams

χ/Q = puff release air transport factor, per cubic meter.

For accidents with release durations greater than the transition times, the plume model is appropriate for calculating air concentrations. The average air concentration during plume passage is calculated using the following equation:

$$C_{plume} = (M)(\chi/Q')/T_{rel}$$

where

C_{plume} = average plume concentration at a downwind receptor location, grams per cubic meter

M = mass of the toxic chemical released, grams

χ/Q' = continuous release air transport factor, seconds per cubic meter

T_{rel} = release duration, seconds.

For short release durations, the air concentrations can become quite large for brief periods. To accommodate this effect in a conservative way, the concept of an averaging period has been developed. One calculates the average concentration during some minimum period and compares this concentration with the concentration guideline. The averaging time used in the present calculations is 15 minutes, based on the following guidance from WSRC-MS-92-206, Rev 2, *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities* (Craig et al. 1995):

> 4.2 Exposure time: Concentrations for comparison with the guidelines must be calculated as the peak 15-minute average concentrations, which are then compared with the guideline concentration limits. This is applicable for all chemicals for which the toxic effect is immediate (i.e., concentration-dependent). If it is known that the toxic effects of a chemical are not concentration-dependent, but depend on the total quantity of chemical taken up by the body (i.e., dose-dependent), then the peak 1-hour concentration may be used. Concentration dependent chemicals are defined as fast-acting chemicals whose toxic effects are immediate, and correlate more closely to concentration than dose. Included in this category are sensory irritants and chemicals which are corrosive or vesicant in their action. Any chemical which has been assigned an OSHA PEL-STEL or PEL-C, or an ACGIH TLV-STEL or TLV-C value must be considered concentration-dependent. In contrast, the effects of dose-dependent chemicals are a function of both concentration and duration of exposure. However, a chemical may elicit concentration-dependent effects at high levels and dose-dependent effects at lower concentrations.

Since the exposure averaging time (15 minutes or 900 seconds) is greater than all the transition times computed in HNF-SD-SNF-TI-059, puff releases are eliminated from further consideration. Air concentrations from accidents with release durations less than 15 minutes are calculated using the plume equation with the release time set to 900 seconds. This is summarized in the modified equation below.

$$C_{ave} = (M)(\chi/Q')/\max(T_{rel}, T_{ave})$$

where

C_{ave} = average concentration of a chemical at a downwind receptor location, grams per cubic meter

M = mass of the toxic chemical released, grams

χ/Q' = continuous release air transport factor, seconds per cubic meter

T_{rel} = release duration, seconds

T_{ave} = exposure averaging period, 900 seconds.

When more than one chemical is released, a sum-of-fractions method is used to evaluate concentrations against the risk guidelines. The sum-of-fractions method was adapted from American Conference of Governmental Industrial Hygienists (ACGIH) and Occupational Safety and Health Administration (OSHA) methods for adding combined exposures to compounds with similar health effects:

$$SOF = \sum_K (C_K)/(CG_K)$$

where

SOF = sum-of-fractions for a mixture of chemicals in air

C_K = calculated average air concentration for the Kth chemical, grams per cubic meter

CG_K = concentration guide for the Kth chemical, grams of chemical per cubic meter of air

When the formula for average air concentration at the downwind receptor location is substituted into the SOF formula, the result is shown below. The sum over ratios of mass fraction divided by concentration guideline has been written as CWRG. The inverse of a CWRG is a composition-weighted concentration guideline for sludge, i.e., an effective concentration guideline for K basins sludge.

$$SOF = \sum_K (M)(MF_K)(\chi/Q')/\max(T_{rel}, T_{ave})/(CG_K)$$

$$SOF = (M)(CWRG)(\chi/Q')/\max(T_{rel}, T_{ave})$$

$$CWRG = \sum_K (MF_K)/(CG_K)$$

where

SOF = sum-of-fractions for a mixture of chemicals (eg., sludge) suspended in air

M = total mass of sludge (a mixture of chemicals) released into the air as respirable particles, grams

MF_K = mass fractions for a mixture of chemicals, i.e., mass of the Kth chemical per gram of total sludge

χ/Q' = continuous release air transport factor, seconds per cubic meter

T_{rel} = release duration, seconds

T_{ave} = exposure averaging period, 900 seconds.

CWRG = composition-weighted risk guideline, cubic meters per gram of sludge

CG_K = concentration guide for the Kth chemical, grams of chemical per cubic meter of air.

The normalized composition of sludge (MF_K) is listed in Tables 7, 8, and 9. The values in these tables were computed from those shown in Tables 4, 5, and 6 by dividing the total concentration into the concentrations of each component. Note that the total density of the components is used rather than the wet or dry bulk density to calculate the mass fractions. In some cases the total of the numbers in a column is less than 1.00. This happens because the "Other" component is not shown in the tables.

Note that one more refinement will be included for long duration releases to ensure the comparison of toxicological and radiological risk can be considered bounding. In the event that the release duration is greater than the time characteristic of the risk evaluation guideline (1 hour or 8 hours), then the concentration guideline should be reduced. This approach is based on the observation that the total amount inhaled is related to the health effects on individuals downwind. Mathematically, one changes the definition of the concentration guideline to that shown below.

$$\text{If } T_{rel} < T_{guide}, \text{ then } CG'_K = CG_K$$
$$\text{If } T_{rel} > T_{guide}, \text{ then } CG'_K = (CG_K)(T_{guide})/(T_{rel})$$
$$\text{or, } \quad CG'_K = (CG_K)\cdot\min[1,(T_{guide})/(T_{rel})]$$

With this revised definition of concentration guides for long duration releases, it is necessary to revise the formula for sum-of-fractions. The formula below shows the results of the revision. Note that the main effect of the revision is to limit the release duration (T_{rel}) to the time inherent in the risk evaluation guideline (T_{guide}). For release durations less than T_{ave}, the formula uses the minimum averaging time. For release durations longer than T_{ave} but shorter than T_{guide}, the formula uses the release duration. For release durations longer than T_{guide}, the formula uses the guideline time.

$$SOF = (M)(CWRG)(\chi/Q')/\min[T_{guide},\max(T_{rel},T_{ave})]$$

This equation should be used when it is necessary to determine the toxicological consequences of accidental releases from K basins. Sum-of-fractions that are less than one indicate that risk evaluation guidelines are met. Sum-of-fractions that are greater than one indicate that risk evaluation guidelines are exceeded and some type of control must be added to lower the probability of the accident.

Table 7. Normalized KE Basin General Sludge (g/g sludge)

Analyte	Weasel Pit	Main Basin Floor	Tech View Pit	North Loadout Pit	Elevator Pit
Ag_2O	1.975 E-05	1.980 E-05	1.975 E-05	0.000	1.975 E-05
Al_2O_3	7.307 E-02	1.170 E-01	7.307 E-02	3.816 E-02	7.307 E-02
Am	2.601 E-05	1.868 E-04	2.601 E-05	1.336 E-05	2.601 E-05
B_2O_3	4.717 E-04	8.570 E-04	4.717 E-04	0.000	4.717 E-04
BaO	4.403 E-04	3.139 E-04	4.403 E-04	1.759 E-04	4.403 E-04
BeO	5.228 E-05	1.471 E-04	5.228 E-05	4.329 E-05	5.228 E-05
BiO	0.000	0.000	0.000	0.000	0.000
CO	8.829 E-03	1.705 E-02	8.829 E-03	0.000	8.829 E-03
CaO	1.855 E-02	8.731 E-03	1.855 E-02	1.001 E-02	1.855 E-02
CdO	5.809 E-05	1.697 E-04	5.809 E-05	1.380 E-04	5.809 E-05
Cr_2O_3	1.549 E-03	8.570 E-04	1.549 E-03	3.301 E-04	1.549 E-03
CuO	5.030 E-04	8.174 E-04	5.030 E-04	6.466 E-04	5.030 E-04
Fe_2O_3	4.682 E-01	3.640 E-01	4.682 E-01	1.022 E-01	4.682 E-01
MgO	3.326 E-03	2.975 E-03	3.326 E-03	1.683 E-03	3.326 E-03
MnO	6.773 E-04	6.929 E-04	6.773 E-04	8.739 E-04	6.773 E-04
Na_2O	1.122 E-03	4.336 E-03	1.122 E-03	0.000	1.122 E-03
NiO	0.000	0.000	0.000	0.000	0.000
PO_3	0.000	0.000	0.000	0.000	0.000
PbO	5.518 E-04	5.176 E-04	5.518 E-04	2.841 E-04	5.518 E-04
Pu	8.829 E-05	2.885 E-04	8.829 E-05	1.623 E-04	8.829 E-05
Se	2.010 E-04	1.782 E-04	2.010 E-04	0.000	2.010 E-04
SiO_2	2.734 E-01	2.091 E-01	2.734 E-01	8.037 E-01	2.734 E-01
Sm_2O_3	2.335 E-04	2.065 E-04	2.335 E-04	1.136 E-04	2.335 E-04
Sr	1.756 E-05	4.957 E-05	1.756 E-05	0.000	1.756 E-05
Tl_2O_3	3.996 E-04	3.846 E-04	3.996 E-04	2.841 E-04	3.996 E-04
UO	7.368 E-02	1.088 E-01	7.368 E-02	4.119 E-02	7.368 E-02
ZnO	1.357 E-03	1.233 E-03	1.357 E-03	0.000	1.357 E-03
ZrO_2	7.818 E-04	6.335 E-04	7.818 E-04	0.000	7.818 E-04
PCB	2.614 E-04	2.347 E-04	2.614 E-04	0.000	2.614 E-04
Total:	0.9278811	0.8397755	0.9278811	1	0.9278811

The above mass ratios are computed from the mass concentrations and total shown in Table 4. The total mass concentration has been divided into the concentration of each component. The totals are not 1.00 because the component "Other" has been omitted.

Table 8. Normalized KE Basin Canister and Fuel Sludge (g/g sludge)

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Ag2O	1.063 E-04	1.063 E-04	0.000	0.000	0.000
Al2O3	1.923 E-01	1.923 E-01	1.095 E-02	2.206 E-01	0.000
Am	1.209 E-04	1.209 E-04	3.167 E-05	1.660 E-06	7.290 E-06
B2O3	1.062 E-03	1.062 E-03	0.000	0.000	0.000
BaO	1.832 E-04	1.832 E-04	0.000	0.000	0.000
BeO	2.240 E-04	2.240 E-04	0.000	0.000	0.000
BiO	4.671 E-04	4.671 E-04	0.000	0.000	0.000
CO	1.120 E-02	1.120 E-02	3.277 E-03	0.000	7.157 E-04
CaO	1.837 E-03	1.837 E-03	0.000	1.536 E-02	0.000
CdO	9.501 E-05	9.501 E-05	0.000	0.000	0.000
Cr2O3	6.526 E-04	6.526 E-04	0.000	0.000	0.000
CuO	5.441 E-04	5.441 E-04	0.000	0.000	0.000
Fe2O3	1.237 E-01	1.237 E-01	1.875 E-03	2.954 E-02	0.000
MgO	2.658 E-03	2.658 E-03	0.000	0.000	0.000
MnO	5.158 E-04	5.158 E-04	0.000	0.000	0.000
Na2O	9.117 E-04	9.117 E-04	0.000	0.000	0.000
NiO	2.862 E-04	2.862 E-04	0.000	0.000	0.000
PO3	2.281 E-03	2.281 E-03	0.000	0.000	0.000
PbO	4.671 E-04	4.671 E-04	0.000	0.000	0.000
Pu	1.737 E-03	1.737 E-03	3.743 E-03	1.851 E-03	3.161 E-03
Se	0.000	0.000	0.000	0.000	0.000
SiO2	4.441 E-02	4.441 E-02	1.503 E-01	0.000	0.000
Sm2O3	0.000	0.000	0.000	0.000	0.000
Sr	2.273 E-05	2.273 E-05	1.430 E-05	7.756 E-07	4.332 E-06
Tl2O3	0.000	0.000	0.000	0.000	0.000
UO	6.013 E-01	6.013 E-01	8.221 E-01	6.947 E-01	9.256 E-01
ZnO	6.673 E-04	6.673 E-04	0.000	0.000	0.000
ZrO2	5.610 E-04	5.610 E-04	0.000	0.000	6.523 E-02
PCB	2.036 E-06	2.036 E-06	0.000	0.000	0.000
Total:	0.988423	0.988423	0.992285	0.962014	0.994711

The above mass ratios are computed from the mass concentrations and total shown in Table 5. The total mass concentration has been divided into the concentration of each component. The totals are not 1.00 because the component "Other" has been omitted.

Table 9. Normalized KW Basin Canister and Fuel Sludge (g/g sludge)

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Ag2O	0.000	0.000	0.000	0.000	0.000
Al2O3	6.202 E-02	6.202 E-02	5.760 E-02	5.768 E-01	0.000
Am	4.353 E-05	4.353 E-05	2.303 E-05	5.315 E-07	7.190 E-06
B2O3	0.000	0.000	0.000	0.000	0.000
BaO	2.978 E-04	2.978 E-04	0.000	0.000	0.000
BeO	1.444 E-04	1.444 E-04	0.000	0.000	0.000
BiO	0.000	0.000	0.000	0.000	0.000
CO	3.080 E-03	3.080 E-03	0.000	0.000	0.000
CaO	0.000	0.000	0.000	4.848 E-03	0.000
CdO	0.000	0.000	0.000	0.000	0.000
Cr2O3	4.928 E-04	4.928 E-04	0.000	0.000	0.000
CuO	0.000	0.000	0.000	0.000	0.000
Fe2O3	1.102 E-01	1.102 E-01	1.799 E-03	3.252 E-01	0.000
MgO	0.000	0.000	0.000	0.000	0.000
MnO	3.864 E-04	3.864 E-04	0.000	0.000	0.000
Na2O	0.000	0.000	0.000	0.000	0.000
NiO	3.474 E-04	3.474 E-04	0.000	0.000	0.000
PO3	0.000	0.000	0.000	0.000	0.000
PbO	0.000	0.000	0.000	0.000	0.000
Pu	2.977 E-03	2.977 E-03	3.064 E-03	7.737 E-05	3.280 E-03
Se	0.000	0.000	0.000	0.000	0.000
SiO2	0.000	0.000	8.664 E-02	3.056 E-02	0.000
Sm2O3	0.000	0.000	0.000	0.000	0.000
Sr	2.434 E-05	2.434 E-05	8.127 E-06	2.782 E-07	5.428 E-06
Tl2O3	0.000	0.000	0.000	0.000	0.000
UO	7.894 E-01	7.894 E-01	8.429 E-01	2.352 E-02	9.261 E-01
ZnO	8.102 E-04	8.102 E-04	0.000	0.000	0.000
ZrO2	6.252 E-04	6.252 E-04	0.000	0.000	6.527 E-02
PCB	7.907 E-06	7.907 E-06	0.000	0.000	0.000
Total:	0.970878	0.970878	0.992014	0.960986	0.994708

The above mass ratios are computed from the mass concentrations and total shown in Table 6. The total mass concentration has been divided into the concentration of each component. The totals are not 1.00 because the component "Other" has been omitted.

Note that the released material is assumed to have the same composition as sludge. If an accident results in additional chemicals besides the materials in sludge, then a new CWRG must be generated.

The toxicological calculations addressed in this report use the above equation. The calculations for toxic chemical releases should be carried out using the steps shown below.

1. Determine the accident frequency range for the event.

2. Determine the quantity of material released into the air as respirable particles. It is also important to estimate the time required to release this material. If the duration exceeds 15 minutes, then the 15-minute period during the release that contains the greatest amount released must be used in the calculation of the Sum-of-fractions.

3. Determine the SOF by multiplying the mass released by the air transport factor and the CWRG, and dividing by the appropriate time interval. If the SOF is greater than 1.0, then controls must be established to lower the probability of the accident or the mass released.

Using the mass fractions shown in Tables 7, 8, and 9, and the concentration guidelines shown in Table 3, the CWRGs for K basins sludge are calculated and listed in Table 10. The contribution of the TRU to the CWRG is included by assuming that americium and plutonium are chemically similar to uranium in the body. By this assumption, the concentration guides for uranium are also used for americium and plutonium. The values for CWRG are given in more detail in Appendix B. Appendix B lists the contribution of each chemical to the total CWRG. In Appendix B the effective concentration limit is also shown. Last in the tables is the percent contribution of each compound to the total. From the percentages, it is evident that silicon oxide (as finely divided particulate, assumed respirable, and not agglomerated) is the main contributor to the toxicity of the general basin sludge.

Comparison of Toxicological and Radiological

Because any environmental release of sludge could have toxicological and radiological effects, both should be computed for comparison with consequence guidelines. A comparison will be presented in this section by using a ratio of radiological and toxicological ratios. The radiological (or toxicological) ratio shows the importance of a given release by comparing the resulting dose (or air concentration) with the risk evaluation guidelines. The ratio of these radiological and toxicological ratios simplifies the comparison so that a broader variety of accident conditions can be evaluated.

Table 10. CWRG Values for KE Basin Sludge (m^3/g)

	PEL-TWA	ERPG-1	ERPG-2	ERPG-3
KE Basin General Sludge				
Weasel Pit	4,590	1,170	754	23.1
Main Basin Floor	4,690	1,020	680	26.3
Tech View Pit	4,590	1,170	754	23.1
North Loadout Pit	8,940	2,770	1,690	38.8
Elevator Pit	4,590	1,170	754	23.1
KE Basin Canister and Fuel Wash Sludge				
Canister Sludge -- Full	12,701	1,210	1,120	72.3
Canister Sludge -- Empty	12,701	1,210	1,120	72.3
Fuel Washing Sludge -- Internal	18,022	1,880	1,680	89.0
Fuel Washing Sludge -- Coating	13,958	1,180	1,180	79.1
Fuel Washing Sludge -- Pieces	18,588	1,550	1,550	94.2
KW Basin Canister and Fuel Wash Sludge				
Canister Sludge -- Full	15,950	1,350	1,340	83.3
Canister Sludge -- Empty	15,950	1,350	1,340	83.3
Fuel Washing Sludge -- Internal	17,790	1,700	1,590	90.4
Fuel Washing Sludge -- Coating	869	202	152	27.0
Fuel Washing Sludge -- Pieces	18,600	1,560	1,550	94.2

Note: Contributions from americium and plutonium are included by assuming the concentration guide for these elements is the same as that for uranium. Details are provided in Appendix B.

The formulas used to calculate the radiological and toxicological significance of airborne releases from K basins are shown below. For the purposes of comparison, the radiological consequence formula has been written as the dose equivalent divided by the radiological risk evaluation guideline. Both radiological and toxicological consequences are thereby reduced to unitless, risk-based ratios. The utility of risk-based ratios is that an accident with a ratio greater than 1.0 requires additional controls to lessen either the severity or probability of the accident.

$$\text{Radiological ratio} = (M)(\chi/Q')(BR)(UD)/(RRG)$$

$$\text{Toxicological ratio} = (M)(\chi/Q')(CWRG)/\min[T_{guide}, \max(T_{rel}, T_{ave})]$$

where

M = mass of K basin sludge released into the air as respirable particles, grams

χ/Q' = air transport factor, s/m^3 (HNF-SD-SNF-TI-059)

BR = average inhalation rate during the release, m^3/s

UD = committed effective dose equivalent per gram inhaled, 438,000 rem/g (HNF-SD-SNF-TI-059)

RRG = radiological risk evaluation guideline, rem (Table 1)

CWRG = composition-weighted risk guidelines for sludge, m^3 per gram of sludge (Table 10)

T_{guide} = time period characteristic of the toxicological risk guideline, seconds

T_{rel} = release duration, seconds

T_{ave} = exposure averaging period, 900 seconds.

Note that the same air transport factors are always used in both the radiological and toxicological calculations. When the ratio of radiological to toxicological is computed, the quantity released (M) and the air transport factors (χ/Q') cancel out. The resulting simplified ratio is shown below.

$$W = \frac{\text{Radiological ratio}}{\text{Toxicological ratio}} = \frac{(BR)\ (UD)\ \min(T_{guide}, \max(T_{rel}, T_{ave}))}{(RRG)\ (CWRG)}$$

To minimize this ratio, the shortest time possible should be selected for the release duration. This shortest time is the exposure averaging time, 15 minutes (900 seconds). The numerator is then 131,000 rem·m^3)/g. Values for the denominator come from Tables 1 and 10, and depends on the location of the receptor (onsite or offsite) and the accident probability. Values for the above ratios of radiological to toxicological consequences were computed for each case. Results are shown in Table 11. The radiological ratios are greater than the toxicological ratios for any mass released and any release duration, i.e., W is always greater than 1.0 for K basins sludge.

Table 11. "W" Ratios for K Basins Sludge

	Anticipated	Unlikely	Extremely Unlikely
KE Basin General Sludge			
Weasel Pit			
Onsite:	112	17	227
Offsite:	57	22	35
Main Basin Floor			
Onsite:	129	19	200
Offsite:	56	26	39
Tech View Pit			
Onsite:	112	17	227
Offsite:	57	22	35
North Loadout Pit			
Onsite:	47	7.8	135
Offsite:	29	9.5	16
Elevator Pit			
Onsite:	112	17	227
Offsite:	57	22	35
KE Basin Canister and Fuel Wash Sludge			
Canister Sludge -- Full			
Onsite:	109	12	73
Offsite:	21	22	23
Canister Sludge -- Empty			
Onsite:	109	12	73
Offsite:	21	22	23
Fuel Washing Sludge -- Internal			
Onsite:	70	7.8	59
Offsite:	15	14	16
Fuel Washing Sludge -- Coating			
Onsite:	111	11	66
Offsite:	19	22	22
Fuel Washing Sludge -- Pieces			

Table 11. "W" Ratios for K Basins Sludge

	Anticipated	Unlikely	Extremely Unlikely
Onsite:	84	8.5	56
Offsite:	14	17	17
KW Basin Canister and Fuel Wash Sludge			
Canister Sludge -- Full			
Onsite:	97	10	63
Offsite:	16	19	20
Canister Sludge -- Empty			
Onsite:	97	10	63
Offsite:	16	19	20
Fuel Washing Sludge -- Internal			
Onsite:	77	8.3	58
Offsite:	15	15	17
Fuel Washing Sludge -- Coating			
Onsite:	649	86	195
Offsite:	302	130	172
Fuel Washing Sludge -- Pieces			
Onsite:	84	8.5	56
Offsite:	14	17	17

The quantity "W" is the radiological risk ratio divided by the toxicological risk ratio.

The assumed release duration is at most 15 minutes. Larger release durations increase the ratios shown above due to smaller toxicological consequences.

The preferential release of specific constituents in the sludge rather than the complete composition could affect the above ratios by changing the CWRG values. Apart from this caveat, it can be stated that for all accidents involving sludge, the radiological risk guidelines are more limiting than the toxicological guidelines. In other words, if the radiological risk is brought within radiological guidelines, the toxicological risk is below toxicological guidelines with margin.

REFERENCES

AIHA, 1991, *Emergency Response Planning Guidelines*, American Industrial Hygiene Association, Akron, Ohio.

Craig, D. K., 1995, *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities*, WSRC-MS-92-206, Rev. 2, Westinghouse Savannah River Company, Aiken, South Carolina.

Craig, D. K., 1997, *ERPGs and TEELs for Chemicals of Concern at SRS: Rev. 12 (July 9, 1997)*, PEC-CAT-97-0044A

HNF-SD-SNF-TI-009, 1998, *105-K Basin Material Design Basis Feed Description for Spent Nuclear Fuel Project Facilities, Volume 2, SLUDGE*, Rev 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.

HNF-SD-SNF-TI-059, 1999, *A Discussion on the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, Rev 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.

Sellers, E. D., 1997, *Risk Evaluation Guidelines (REGs) to Ensure Inherently Safer Designs* (Letter 97-SFD-034 to H. J. Hatch, Fluor Daniel Hanford, Incorporated, May 23), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Appendix A. Peer Reviewer Checklist

PEER REVIEW CHECKLIST

Document Reviewed: SNF-5066 Revision 0, *Comparison of Toxicological and Radiological Aspects of K-Basins Sludge*

Scope of Review: whole thing

Yes	No	N/A	
[X]	[ ]	[ ]	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
[X]	[ ]	[ ]	Problem completely defined.
[ ]	[ ]	[X]	Accident scenarios developed in a clear and logical manner.
[X]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[ ]	[ ]	[X]	Computer codes and data files documented.
[X]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[ ]	[ ]	[ ] ①	Data checked for consistency with original source information as applicable.
[X]	[ ]	[ ]	Mathematical derivations checked including dimensional consistency of results.
[X]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[X]	[ ]	[ ]	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[ ]	[ ]	[X]	Software input correct and consistent with document reviewed.
[ ]	[ ]	[X]	Software output consistent with input and with results reported in document reviewed.
[X]	[ ]	[ ]	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[ ]	[ ]	[X]	Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[X]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[ ]	[ ]	[X]	Format consistent with appropriate NRC Regulatory Guide or other standards
[ ]	[ ]	[X]	Review calculations, comments, and/or notes are attached.
[X]	[ ]		**Document approved.**

Peer Reviewer:

JAY LAVENDER 9/21/99

Signature Date

① DID NOT REVIEW HNF-SD-SNF-TI-009

Appendix B: Tables Showing Calculation of CWRG Numbers

Table B-1. CWRG for the PEL-TWA Guideline -- KE Basin General Sludge

Analyte	Weasel Pit	Main Basin Floor	Tech View Pit	North Loadout Pit	Elevator Pit
Mass Fractions Divided by the PEL-TWA Guideline (m^3/g)					
Ag_2O	1.975	1.980	1.975	NA	1.975
Al_2O_3	7.307	11.70	7.307	3.816	7.307
Am	0.520	3.736	0.520	0.267	0.520
B_2O_3	0.047	0.086	0.047	NA	0.047
BaO	0.881	0.628	0.881	0.352	0.881
BeO	26.14	73.54	26.14	21.64	26.14
BiO	NA	NA	NA	NA	NA
CO	0.221	0.427	0.221	NA	0.221
CaO	3.710	1.746	3.710	2.002	3.710
CdO	11.62	33.94	11.62	27.60	11.62
Cr_2O_3	3.097	1.714	3.097	0.660	3.097
CuO	0.503	0.817	0.503	0.647	0.503
Fe_2O_3	46.82	36.40	46.82	10.22	46.82
MgO	0.333	0.298	0.333	0.168	0.333
MnO	3.386	3.465	3.386	4.370	3.386
Na_2O	0.112	0.434	0.112	NA	0.112
NiO	NA	NA	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	11.04	10.35	11.04	5.682	11.04
Pu	1.766	5.770	1.766	3.247	1.766
Se	1.005	0.891	1.005	NA	1.005
SiO_2	2,734	2,091	2,734	8,037	2,734
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.002	0.005	0.002	NA	0.002
Tl_2O_3	0.200	0.192	0.200	0.142	0.200
UO	1,474	2,176	1,474	824	1,474
ZnO	0.136	0.123	0.136	NA	0.136
ZrO_2	0.156	0.127	0.156	NA	0.156
PCB	261.4	234.7	261.4	NA	261.4
Total CWRG:	4,590	4,690	4,590	8,942	4,590
1/CWRG, mg/m^3:	0.218	0.213	0.218	0.112	0.218

Table B-1. CWRG for the PEL-TWA Guideline -- KE Basin General Sludge

Analyte	Weasel Pit	Main Basin Floor	Tech View Pit	North Loadout Pit	Elevator Pit
Percent Contributions to the CWRG for the PEL-TWA Guideline					
Ag_2O	0.043%	0.042%	0.043%	NA	0.043%
Al_2O_3	0.159%	0.249%	0.159%	0.043%	0.159%
Am	0.011%	0.080%	0.011%	0.003%	0.011%
B_2O_3	0.001%	0.002%	0.001%	NA	0.001%
BaO	0.019%	0.013%	0.019%	0.004%	0.019%
BeO	0.570%	1.568%	0.570%	0.242%	0.570%
BiO	NA	NA	NA	NA	NA
CO	0.005%	0.009%	0.005%	NA	0.005%
CaO	0.081%	0.037%	0.081%	0.022%	0.081%
CdO	0.253%	0.724%	0.253%	0.309%	0.253%
Cr_2O_3	0.067%	0.037%	0.067%	0.007%	0.067%
CuO	0.011%	0.017%	0.011%	0.007%	0.011%
Fe_2O_3	1.020%	0.776%	1.020%	0.114%	1.020%
MgO	0.007%	0.006%	0.007%	0.002%	0.007%
MnO	0.074%	0.074%	0.074%	0.049%	0.074%
Na_2O	0.002%	0.009%	0.002%	NA	0.002%
NiO	NA	NA	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	0.240%	0.221%	0.240%	0.064%	0.240%
Pu	0.038%	0.123%	0.038%	0.036%	0.038%
Se	0.022%	0.019%	0.022%	NA	0.022%
SiO_2	59.56%	44.59%	59.56%	89.88%	59.56%
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	NA	0.000%
Tl_2O_3	0.004%	0.004%	0.004%	0.002%	0.004%
UO	32.11%	46.39%	32.11%	9.212%	32.11%
ZnO	0.003%	0.003%	0.003%	NA	0.003%
ZrO_2	0.003%	0.003%	0.003%	NA	0.003%
PCB	5.695%	5.005%	5.695%	NA	5.695%

Note: The Am and Pu numbers use the PEL-TWA for uranium.

Table B-2. CWRG for the ERPG-1 Guideline -- KE Basin General Sludge

Analyte	Weasel Pit	Main Basin Floor	Tech View Pit	North Loadout Pit	Elevator Pit
Mass Fractions Divided by the ERPG-1 Guideline (m^3/g)					
Ag_2O	0.066	0.066	0.066	NA	0.066
Al_2O_3	4.871	7.801	4.871	2.544	4.871
Am	0.043	0.311	0.043	0.022	0.043
B_2O_3	0.016	0.029	0.016	NA	0.016
BaO	0.294	0.209	0.294	0.117	0.294
BeO	5.228	14.71	5.228	4.329	5.228
BiO	NA	NA	NA	NA	NA
CO	0.039	0.075	0.039	NA	0.039
CaO	3.092	1.455	3.092	1.668	3.092
CdO	1.936	5.657	1.936	4.600	1.936
Cr_2O_3	1.032	0.571	1.032	0.220	1.032
CuO	0.168	0.272	0.168	0.216	0.168
Fe_2O_3	31.22	24.26	31.22	6.811	31.22
MgO	0.111	0.099	0.111	0.056	0.111
MnO	0.226	0.231	0.226	0.291	0.226
Na_2O	0.037	0.145	0.037	NA	0.037
NiO	NA	NA	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	3.679	3.450	3.679	1.894	3.679
Pu	0.147	0.481	0.147	0.271	0.147
Se	0.335	0.297	0.335	NA	0.335
SiO_2	911.3	697.1	911.3	2,679	911.3
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.001	0.002	0.001	NA	0.001
Tl_2O_3	0.200	0.192	0.200	0.142	0.200
UO	122.8	181.3	122.8	68.65	122.8
ZnO	0.090	0.082	0.090	NA	0.090
ZrO_2	0.078	0.063	0.078	NA	0.078
PCB	87.13	78.25	87.13	NA	87.13
Total CWRG:	1,174	1,017	1,174	2,771	1,174
1/CWRG, mg/m^3:	0.852	0.983	0.852	0.361	0.852

Table B-2. CWRG for the ERPG-1 Guideline -- KE Basin General Sludge

Analyte	Weasel Pit	Main Basin Floor	Tech View Pit	North Loadout Pit	Elevator Pit
Percent Contributions to the CWRG for the ERPG-1 Guideline					
Ag_2O	0.006%	0.006%	0.006%	NA	0.006%
Al_2O_3	0.415%	0.767%	0.415%	0.092%	0.415%
Am	0.004%	0.031%	0.004%	0.001%	0.004%
B_2O_3	0.001%	0.003%	0.001%	NA	0.001%
BaO	0.025%	0.021%	0.025%	0.004%	0.025%
BeO	0.445%	1.446%	0.445%	0.156%	0.445%
BiO	NA	NA	NA	NA	NA
CO	0.003%	0.007%	0.003%	NA	0.003%
CaO	0.263%	0.143%	0.263%	0.060%	0.263%
CdO	0.165%	0.556%	0.165%	0.166%	0.165%
Cr_2O_3	0.088%	0.056%	0.088%	0.008%	0.088%
CuO	0.014%	0.027%	0.014%	0.008%	0.014%
Fe_2O_3	2.659%	2.385%	2.659%	0.246%	2.659%
MgO	0.009%	0.010%	0.009%	0.002%	0.009%
MnO	0.019%	0.023%	0.019%	0.011%	0.019%
Na_2O	0.003%	0.014%	0.003%	NA	0.003%
NiO	NA	NA	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	0.313%	0.339%	0.313%	0.068%	0.313%
Pu	0.013%	0.047%	0.013%	0.010%	0.013%
Se	0.029%	0.029%	.0.029%	NA	0.029%
SiO_2	77.61%	68.53%	77.61%	96.69%	77.61%
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	NA	0.000%
Tl_2O_3	0.017%	0.019%	0.017%	0.005%	0.017%
UO	10.46%	17.83%	10.46%	2.477%	10.46%
ZnO	0.008%	0.008%	0.008%	NA	0.008%
ZrO_2	0.007%	0.006%	0.007%	NA	0.007%
PCB	7.421%	7.693%	7.421%	NA	7.421%

Note: The Am and Pu numbers use the ERPG-1 for uranium.

Table B-3. CWRG for the ERPG-2 Guideline -- KE Basin General Sludge

Analyte	Weasel Pit	Main Basin Floor	Tech View Pit	North Loadout Pit	Elevator Pit
Mass Fractions Divided by the ERPG-2 Guideline (m^3/g)					
Ag_2O	0.039	0.040	0.039	NA	0.039
Al_2O_3	4.871	7.801	4.871	2.544	4.871
Am	0.043	0.311	0.043	0.022	0.043
B_2O_3	0.009	0.017	0.009	NA	0.009
BaO	0.176	0.126	0.176	0.070	0.176
BeO	2.091	5.883	2.091	1.732	2.091
BiO	NA	NA	NA	NA	NA
CO	0.022	0.043	0.022	NA	0.022
CaO	1.855	0.873	1.855	1.001	1.855
CdO	0.015	0.042	0.015	0.034	0.015
Cr_2O_3	0.619	0.343	0.619	0.132	0.619
CuO	0.101	0.163	0.101	0.129	0.101
Fe_2O_3	18.73	14.56	18.73	4.087	18.73
MgO	0.067	0.060	0.067	0.034	0.067
MnO	0.135	0.139	0.135	0.175	0.135
Na_2O	0.022	0.087	0.022	NA	0.022
NiO	NA	NA	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	2.207	2.070	2.207	1.136	2.207
Pu	0.147	0.481	0.147	0.271	0.147
Se	0.201	0.178	0.201	NA	0.201
SiO_2	546.8	418.3	546.8	1,607	546.8
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000	0.001	0.000	NA	0.000
Tl_2O_3	0.200	0.192	0.200	0.142	0.200
UO	122.8	181.3	122.8	68.65	122.8
ZnO	0.090	0.082	0.090	NA	0.090
ZrO_2	0.031	0.025	0.031	NA	0.031
PCB	52.28	46.95	52.28	NA	52.28
Total CWRG:	754	680	754	1,688	754
1/CWRG, mg/m^3:	1.327	1.470	1.327	0.593	1.327

Table B-3. CWRG for the ERPG-2 Guideline -- KE Basin General Sludge

Analyte	Weasel Pit	Main Basin Floor	Tech View Pit	North Loadout Pit	Elevator Pit
Percent Contributions to the CWRG for the ERPG-2 Guideline					
Ag_2O	0.005%	0.006%	0.005%	NA	0.005%
Al_2O_3	0.646%	1.147%	0.646%	0.151%	0.646%
Am	0.006%	0.046%	0.006%	0.001%	0.006%
B_2O_3	0.001%	0.003%	0.001%	NA	0.001%
BaO	0.023%	0.018%	0.023%	0.004%	0.023%
BeO	0.278%	0.865%	0.278%	0.103%	0.278%
BiO	NA	NA	NA	NA	NA
CO	0.003%	0.006%	0.003%	NA	0.003%
CaO	0.246%	0.128%	0.246%	0.059%	0.246%
CdO	0.002%	0.006%	0.002%	0.002%	0.002%
Cr_2O_3	0.082%	0.050%	0.082%	0.008%	0.082%
CuO	0.013%	0.024%	0.013%	0.008%	0.013%
Fe_2O_3	2.486%	2.141%	2.486%	0.242%	2.486%
MgO	0.009%	0.009%	0.009%	0.002%	0.009%
MnO	0.018%	0.020%	0.018%	0.010%	0.018%
Na_2O	0.003%	0.013%	0.003%	NA	0.003%
NiO	NA	NA	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	0.293%	0.304%	0.293%	0.067%	0.293%
Pu	0.020%	0.071%	0.020%	0.016%	0.020%
Se	0.027%	0.026%	0.027%	NA	0.027%
SiO_2	72.56%	61.50%	72.56%	95.25%	72.56%
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	NA	0.000%
Tl_2O_3	0.027%	0.028%	0.027%	0.008%	0.027%
UO	16.30%	26.66%	16.30%	4.068%	16.30%
ZnO	0.012%	0.012%	0.012%	NA	0.012%
ZrO_2	0.004%	0.004%	0.004%	NA	0.004%
PCB	6.938%	6.904%	6.938%	NA	6.938%

Note: The Am and Pu numbers use the ERPG-2 for uranium.

Table B-4. CWRG for the ERPG-3 Guideline -- KE Basin General Sludge

Analyte	Weasel Pit	Main Basin Floor	Tech View Pit	North Loadout Pit	Elevator Pit
Mass Fractions Divided by the ERPG-3 Guideline (m^3/g)					
Ag_2O	0.002	0.002	0.002	NA	0.002
Al_2O_3	2.923	4.680	2.923	1.526	2.923
Am	0.0026	0.0187	0.0026	0.0013	0.0026
B_2O_3	0.002	0.003	0.002	NA	0.002
BaO	0.035	0.025	0.035	0.014	0.035
BeO	0.523	1.471	0.523	0.433	0.523
BiO	NA	NA	NA	NA	NA
CO	0.015	0.030	0.015	NA	0.015
CaO	0.742	0.349	0.742	0.400	0.742
CdO	0.006	0.019	0.006	0.015	0.006
Cr_2O_3	0.062	0.034	0.062	0.013	0.062
CuO	0.005	0.008	0.005	0.006	0.005
Fe_2O_3	0.187	0.146	0.187	0.041	0.187
MgO	0.013	0.012	0.013	0.007	0.013
MnO	0.0014	0.0014	0.0014	0.0017	0.0014
Na_2O	0.0045	0.0173	0.0045	NA	0.0045
NiO	NA	NA	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	0.0055	0.0052	0.0055	0.0028	0.0055
Pu	0.0088	0.0288	0.0088	0.0162	0.0088
Se	0.201	0.178	0.201	NA	0.201
SiO_2	10.935	8.365	10.935	32.149	10.935
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.0000	0.0001	0.0000	NA	0.0000
Tl_2O_3	0.020	0.019	0.020	0.014	0.020
UO	7.368	10.88	7.368	4.119	7.368
ZnO	0.0027	0.0025	0.0027	NA	0.0027
ZrO_2	0.016	0.013	0.016	NA	0.016
PCB	0.0005	0.0005	0.0005	NA	0.0005
Total CWRG:	23.1	26.3	23.1	38.8	23.1
1/CWRG, mg/m^3:	43.3	38.0	43.3	25.8	43.3

Table B-4. CWRG for the ERPG-3 Guideline -- KE Basin General Sludge

Analyte	Weasel Pit	Main Basin Floor	Tech View Pit	North Loadout Pit	Elevator Pit
Percent Contributions to the CWRG for the ERPG-3 Guideline					
Ag_2O	0.009%	0.008%	0.009%	NA	0.009%
Al_2O_3	12.66%	17.79%	12.66%	3.938%	12.66%
Am	0.011%	0.071%	0.011%	0.003%	0.011%
B_2O_3	0.008%	0.013%	0.008%	NA	0.008%
BaO	0.153%	0.095%	0.153%	0.036%	0.153%
BeO	2.265%	5.590%	2.265%	1.117%	2.265%
BiO	NA	NA	NA	NA	NA
CO	0.067%	0.114%	0.067%	NA	0.067%
CaO	3.215%	1.327%	3.215%	1.033%	3.215%
CdO	0.028%	0.072%	0.028%	0.040%	0.028%
Cr_2O_3	0.268%	0.130%	0.268%	0.034%	0.268%
CuO	0.022%	0.031%	0.022%	0.017%	0.022%
Fe_2O_3	0.811%	0.553%	0.811%	0.105%	0.811%
MgO	0.058%	0.045%	0.058%	0.017%	0.058%
MnO	0.006%	0.005%	0.006%	0.005%	0.006%
Na_2O	0.019%	0.066%	0.019%	NA	0.019%
NiO	NA	NA	NA	NA	NA
PO_5	NA	NA	NA	NA	NA
PbO	0.024%	0.020%	0.024%	0.007%	0.024%
Pu	0.038%	0.110%	0.038%	0.042%	0.038%
Se	0.871%	0.677%	0.871%	NA	0.871%
SiO_2	47.38%	31.80%	47.38%	82.94%	47.38%
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	NA	0.000%
Tl_2O_3	0.087%	0.073%	0.087%	0.037%	0.087%
UO	31.92%	41.35%	31.92%	10.63%	31.92%
ZnO	0.012%	0.009%	0.012%	NA	0.012%
ZrO_2	0.068%	0.048%	0.068%	NA	0.068%
PCB	0.002%	0.002%	0.002%	NA	0.002%

Note: The Am and Pu numbers use the ERPG-3 for uranium.

Table B-5. CWRG for the PEL-TWA Guideline -- KE Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Mass Fractions Divided by the PEL-TWA Guideline (m3/g)					
Ag_2O	10.632	10.632	NA	NA	NA
Al_2O_3	19.233	19.23	1.095	22.06	NA
Am	2.419	2.419	0.633	0.033	0.146
B_2O_3	0.106	0.106	NA	NA	NA
BaO	0.366	0.366	NA	NA	NA
BeO	111.98	111.98	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.281	0.281	0.082	NA	0.018
CaO	0.367	0.367	NA	3.072	NA
CdO	19.00	19.00	NA	NA	NA
Cr_2O_3	1.305	1.305	NA	NA	NA
CuO	0.544	0.544	NA	NA	NA
Fe_2O_3	12.37	12.37	0.187	2.95	NA
MgO	0.266	0.266	NA	NA	NA
MnO	2.579	2.579	NA	NA	NA
Na_2O	0.091	0.091	NA	NA	NA
NiO	0.286	0.286	NA	NA	NA
PO_3	2.281	2.281	NA	NA	NA
PbO	9.343	9.343	NA	NA	NA
Pu	34.75	34.75	74.85	37.03	63.23
Se	NA	NA	NA	NA	NA
SiO_2	444	444	1502.8	NA	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.002	0.002	0.001	0.000	0.000
Tl_2O_3	NA	NA	NA	NA	NA
UO	12,027	12,027	16,442	13893.3	18,512
ZnO	0.067	0.067	NA	NA	NA
ZrO_2	0.112	0.112	NA	NA	13.05
PCB	2.036	2.036	NA	NA	NA
Total CWRG:	12,701	12,701	18,022	13,958	18,588
1/CWRG, mg/m^3:	0.079	0.079	0.055	0.072	0.054

Table B-5. CWRG for the PEL-TWA Guideline -- KE Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Percent Contributions to the CWRG for the PEL-TWA Guideline					
Ag_2O	0.084%	0.084%	NA	NA	NA
Al_2O_3	0.151%	0.151%	0.006%	0.158%	NA
Am	0.019%	0.019%	0.004%	0.000%	0.001%
B_2O_3	0.001%	0.001%	NA	NA	NA
BaO	0.003%	0.003%	NA	NA	NA
BeO	0.882%	0.882%	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.002%	0.002%	0.000%	NA	0.000%
CaO	0.003%	0.003%	NA	0.022%	NA
CdO	0.150%	0.150%	NA	NA	NA
Cr_2O_3	0.010%	0.010%	NA	NA	NA
CuO	0.004%	0.004%	NA	NA	NA
Fe_2O_3	0.097%	0.097%	0.001%	0.021%	NA
MgO	0.002%	0.002%	NA	NA	NA
MnO	0.020%	0.020%	NA	NA	NA
Na_2O	0.001%	0.001%	NA	NA	NA
NiO	0.002%	0.002%	NA	NA	NA
PO_3	0.018%	0.018%	NA	NA	NA
PbO	0.074%	0.074%	NA	NA	NA
Pu	0.274%	0.274%	0.415%	0.265%	0.340%
Se	NA	NA	NA	NA	NA
SiO_2	3.50%	3.50%	8.34%	NA	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	0.000%	0.000%
Tl_2O_3	NA	NA	NA	NA	NA
UO	94.69%	94.69%	91.23%	99.53%	99.59%
ZnO	0.001%	0.001%	NA	NA	NA
ZrO_2	0.001%	0.001%	NA	NA	0.070%
PCB	0.016%	0.016%	NA	NA	NA

Note: The Am and Pu numbers use the PEL-TWA for uranium.

Table B-6. CWRG for the ERPG-1 Guideline -- KE Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Mass Fractions Divided by the ERPG-1 Guideline (m^3/g)					
Ag_2O	0.354	0.354	NA	NA	NA
Al_2O_3	12.82	12.82	0.730	14.71	NA
Am	0.202	0.202	0.053	0.003	0.012
B_2O_3	0.035	0.035	NA	NA	NA
BaO	0.122	0.122	NA	NA	NA
BeO	22.40	22.40	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.049	0.049	0.014	NA	0.003
CaO	0.306	0.306	NA	2.560	NA
CdO	3.167	3.167	NA	NA	NA
Cr_2O_3	0.435	0.435	NA	NA	NA
CuO	0.181	0.181	NA	NA	NA
Fe_2O_3	8.249	8.249	0.125	1.969	NA
MgO	0.089	0.089	NA	NA	NA
MnO	0.172	0.172	NA	NA	NA
Na_2O	0.030	0.030	NA	NA	NA
NiO	0.095	0.095	NA	NA	NA
PO_3	0.760	0.760	NA	NA	NA
PbO	3.114	3.114	NA	NA	NA
Pu	2.896	2.896	6.238	3.086	5.269
Se	NA	NA	NA	NA	NA
SiO_2	148.0	148.0	500.9	NA	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.001	0.001	0.000	0.000	0.000
Tl_2O_3	NA	NA	NA	NA	NA
UO	1,002	1,002	1,370	1,158	1,543
ZnO	0.044	0.044	NA	NA	NA
ZrO_2	0.056	0.056	NA	NA	6.523
PCB	0.679	0.679	NA	NA	NA
Total CWRG:	1,207	1,207	1,878	1,180	1,554
1/CWRG, mg/m^3:	0.829	0.829	0.532	0.847	0.643

Table B-6. CWRG for the ERPG-1 Guideline -- KE Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Percent Contributions to the CWRG for the ERPG-1 Guideline					
Ag_2O	0.029%	0.029%	NA	NA	NA
Al_2O_3	1.063%	1.063%	0.039%	1.246%	NA
Am	0.017%	0.017%	0.003%	0.000%	0.001%
B_2O_3	0.003%	0.003%	NA	NA	NA
BaO	0.010%	0.010%	NA	NA	NA
BeO	1.856%	1.856%	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.004%	0.004%	0.001%	NA	0.000%
CaO	0.025%	0.025%	NA	0.217%	NA
CdO	0.262%	0.262%	NA	NA	NA
Cr_2O_3	0.036%	0.036%	NA	NA	NA
CuO	0.015%	0.015%	NA	NA	NA
Fe_2O_3	0.684%	0.684%	0.007%	0.167%	NA
MgO	0.007%	0.007%	NA	NA	NA
MnO	0.014%	0.014%	NA	NA	NA
Na_2O	0.003%	0.003%	NA	NA	NA
NiO	0.008%	0.008%	NA	NA	NA
PO_3	0.063%	0.063%	NA	NA	NA
PbO	0.258%	0.258%	NA	NA	NA
Pu	0.240%	0.240%	0.332%	0.261%	0.339%
Se	NA	NA	NA	NA	NA
SiO_2	12.27%	12.27%	26.67%	NA	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	0.000%	0.000%
Tl_2O_3	NA	NA	NA	NA	NA
UO	83.07%	83.07%	72.95%	98.11%	99.24%
ZnO	0.004%	0.004%	NA	NA	NA
ZrO_2	0.005%	0.005%	NA	NA	0.420%
PCB	0.056%	0.056%	NA	NA	NA

Note: The Am and Pu numbers use the ERPG-1 for uranium.

Table B-7. CWRG for the ERPG-2 Guideline -- KE Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Mass Fractions Divided by the ERPG-2 Guideline (m3/g)					
Ag_2O	0.213	0.213	NA	NA	NA
Al_2O_3	12.82	12.82	0.730	14.71	NA
Am	0.202	0.202	0.053	0.003	0.012
B_2O_3	0.021	0.021	NA	NA	NA
BaO	0.073	0.073	NA	NA	NA
BeO	8.958	8.958	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.028	0.028	0.008	NA	0.002
CaO	0.184	0.184	NA	1.536	NA
CdO	0.024	0.024	NA	NA	NA
Cr_2O_3	0.261	0.261	NA	NA	NA
CuO	0.109	0.109	NA	NA	NA
Fe_2O_3	4.950	4.950	0.075	1.181	NA
MgO	0.053	0.053	NA	NA	NA
MnO	0.103	0.103	NA	NA	NA
Na_2O	0.018	0.018	NA	NA	NA
NiO	0.057	0.057	NA	NA	NA
PO_3	0.023	0.023	NA	NA	NA
PbO	1.869	1.869	NA	NA	NA
Pu	2.896	2.896	6.238	3.086	5.269
Se	NA	NA	NA	NA	NA
SiO_2	88.8	88.8	300.6	NA	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000	0.000	0.000	0.000	0.000
Tl_2O_3	NA	NA	NA	NA	NA
UO	1,002	1,002	1,370	1,158	1,543
ZnO	0.044	0.044	NA	NA	NA
ZrO_2	0.022	0.022	NA	NA	2.609
PCB	0.407	0.407	NA	NA	NA
Total CWRG:	1,124	1,124	1,678	1,178	1,551
1/CWRG, mg/m^3:	0.889	0.889	0.596	0.849	0.645

Table B-7. CWRG for the ERPG-2 Guideline -- KE Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Percent Contributions to the CWRG for the ERPG-2 Guideline					
Ag_2O	0.019%	0.019%	NA	NA	NA
Al_2O_3	1.140%	1.140%	0.044%	1.248%	NA
Am	0.018%	0.018%	0.003%	0.000%	0.001%
B_2O_3	0.002%	0.002%	NA	NA	NA
BaO	0.007%	0.007%	NA	NA	NA
BeO	0.797%	0.797%	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.002%	0.002%	0.000%	NA	0.000%
CaO	0.016%	0.016%	NA	0.130%	NA
CdO	0.002%	0.002%	NA	NA	NA
Cr_2O_3	0.023%	0.023%	NA	NA	NA
CuO	0.010%	0.010%	NA	NA	NA
Fe_2O_3	0.440%	0.440%	0.004%	0.100%	NA
MgO	0.005%	0.005%	NA	NA	NA
MnO	0.009%	0.009%	NA	NA	NA
Na_2O	0.002%	0.002%	NA	NA	NA
NiO	0.005%	0.005%	NA	NA	NA
PO_3	0.002%	0.002%	NA	NA	NA
PbO	0.166%	0.166%	NA	NA	NA
Pu	0.258%	0.258%	0.372%	0.262%	0.340%
Se	NA	NA	NA	NA	NA
SiO_2	7.90%	7.90%	17.91%	NA	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	0.000%	0.000%
Tl_2O_3	NA	NA	NA	NA	NA
UO	89.14%	89.14%	81.66%	98.259%	99.49%
ZnO	0.004%	0.004%	NA	NA	NA
ZrO_2	0.002%	0.002%	NA	NA	0.168%
PCB	0.036%	0.036%	NA	NA	NA

Note: The Am and Pu numbers use the ERPG-2 for uranium.

Table B-8. CWRG for the ERPG-3 Guideline -- KE Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Mass Fractions Divided by the ERPG-3 Guideline (m^3/g)					
Ag_2O	0.011	0.011	NA	NA	NA
Al_2O_3	7.693	7.693	0.438	8.824	NA
Am	0.012	0.012	0.0032	0.0002	0.0007
B_2O_3	0.004	0.004	NA	NA	NA
BaO	0.015	0.015	NA	NA	NA
BeO	2.240	2.240	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.020	0.020	0.006	NA	0.0013
CaO	0.073	0.073	NA	0.614	NA
CdO	0.011	0.011	NA	NA	NA
Cr_2O_3	0.026	0.026	NA	NA	NA
CuO	0.005	0.005	NA	NA	NA
Fe_2O_3	0.049	0.049	0.0007	0.012	NA
MgO	0.011	0.011	NA	NA	NA
MnO	0.001	0.001	NA	NA	NA
Na_2O	0.004	0.004	NA	NA	NA
NiO	0.014	0.014	NA	NA	NA
PO_3	0.005	0.005	NA	NA	NA
PbO	0.005	0.005	NA	NA	NA
Pu	0.174	0.174	0.374	0.185	0.316
Se	NA	NA	NA	NA	NA
SiO_2	1.776	1.776	6.011	NA	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.0000	0.0000	0.0000	0.0000	0.0000
Tl_2O_3	NA	NA	NA	NA	NA
UO	60.13	60.13	82.21	69.47	92.56
ZnO	0.0013	0.0013	NA	NA	NA
ZrO_2	0.011	0.011	NA	NA	1.305
PCB	0.0000	0.0000	NA	NA	NA
Total CWRG:	72.3	72.3	89.0	79.1	94.2
1/CWRG, mg/m^3:	13.8	13.8	11.2	12.6	10.6

Table B-8. CWRG for the ERPG-3 Guideline -- KE Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Percent Contributions to the CWRG for the ERPG-3 Guideline					
Ag_2O	0.015%	0.015%	NA	NA	NA
Al_2O_3	10.64%	10.64%	0.492%	11.16%	NA
Am	0.017%	0.017%	0.004%	0.000%	0.001%
B_2O_3	0.006%	0.006%	NA	NA	NA
BaO	0.020%	0.020%	NA	NA	NA
BeO	3.098%	3.098%	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.027%	0.027%	0.006%	NA	0.001%
CaO	0.102%	0.102%	NA	0.777%	NA
CdO	0.015%	0.015%	NA	NA	NA
Cr_2O_3	0.036%	0.036%	NA	NA	NA
CuO	0.008%	0.008%	NA	NA	NA
Fe_2O_3	0.068%	0.068%	0.001%	0.015%	NA
MgO	0.015%	0.015%	NA	NA	NA
MnO	0.001%	0.001%	NA	NA	NA
Na_2O	0.005%	0.005%	NA	NA	NA
NiO	0.020%	0.020%	NA	NA	NA
PO_3	0.006%	0.006%	NA	NA	NA
PbO	0.006%	0.006%	NA	NA	NA
Pu	0.240%	0.240%	0.420%	0.234%	0.336%
Se	NA	NA	NA	NA	NA
SiO_2	2.46%	2.46%	6.75%	NA	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	0.000%	0.000%
Tl_2O_3	NA	NA	NA	NA	NA
UO	83.18%	83.18%	92.33%	87.82%	98.28%
ZnO	0.002%	0.002%	NA	NA	NA
ZrO_2	0.016%	0.016%	NA	NA	1.385%
PCB	0.000%	0.000%	NA	NA	NA

Note: The Am and Pu numbers use the ERPG-3 for uranium.

Table B-9. CWRG for the PEL-TWA Guideline -- KW Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Mass Fractions Divided by the PEL-TWA Guideline (m^3/g)					
Ag_2O	NA	NA	NA	NA	NA
Al_2O_3	6.202	6.20	5.760	57.68	NA
Am	0.871	0.871	0.461	0.011	0.144
B_2O_3	NA	NA	NA	NA	NA
BaO	0.596	0.596	NA	NA	NA
BeO	72.21	72.21	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.077	0.077	NA	NA	NA
CaO	NA	NA	NA	0.970	NA
CdO	NA	NA	NA	NA	NA
Cr_2O_3	0.986	0.986	NA	NA	NA
CuO	NA	NA	NA	NA	NA
Fe_2O_3	11.02	11.02	0.180	32.52	NA
MgO	NA	NA	NA	NA	NA
MnO	1.932	1.932	NA	NA	NA
Na_2O	NA	NA	NA	NA	NA
NiO	0.347	0.347	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	NA	NA	NA	NA	NA
Pu	59.54	59.54	61.27	1.55	65.59
Se	NA	NA	NA	NA	NA
SiO_2	NA	NA	866.4	305.6	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.002	0.002	0.001	0.000	0.001
Tl_2O_3	NA	NA	NA	NA	NA
UO	15,789	15,789	16,857	470.5	18,523
ZnO	0.081	0.081	NA	NA	NA
ZrO_2	0.125	0.125	NA	NA	13.05
PCB	7.907	7.907	NA	NA	NA
Total CWRG:	15,951	15,951	17,792	869	18,602
1/CWRG, mg/m^3:	0.063	0.063	0.056	1.151	0.054

Table B-9. CWRG for the PEL-TWA Guideline -- KW Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Percent Contributions to the CWRG for the PEL-TWA Guideline					
Ag_2O	NA	NA	NA	NA	NA
Al_2O_3	0.039%	0.039%	0.032%	6.638%	NA
Am	0.005%	0.005%	0.003%	0.001%	0.001%
B_2O_3	NA	NA	NA	NA	NA
BaO	0.004%	0.004%	NA	NA	NA
BeO	0.453%	0.453%	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.000%	0.000%	NA	NA	NA
CaO	NA	NA	NA	0.112%	NA
CdO	NA	NA	NA	NA	NA
Cr_2O_3	0.006%	0.006%	NA	NA	NA
CuO	NA	NA	NA	NA	NA
Fe_2O_3	0.069%	0.069%	0.001%	3.743%	NA
MgO	NA	NA	NA	NA	NA
MnO	0.012%	0.012%	NA	NA	NA
Na_2O	NA	NA	NA	NA	NA
NiO	0.002%	0.002%	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	NA	NA	NA	NA	NA
Pu	0.373%	0.373%	0.344%	0.178%	0.353%
Se	NA	NA	NA	NA	NA
SiO_2	NA	NA	4.87%	35.18%	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	0.000%	0.000%
Tl_2O_3	NA	NA	NA	NA	NA
UO	98.98%	98.98%	94.75%	54.15%	99.58%
ZnO	0.001%	0.001%	NA	NA	NA
ZrO_2	0.001%	0.001%	NA	NA	0.070%
PCB	0.050%	0.050%	NA	NA	NA

Note: The Am and Pu numbers use the PEL-TWA for uranium.

Table B-10. CWRG for the ERPG-1 Guideline -- KW Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Mass Fractions Divided by the ERPG-1 Guideline (m^3/g)					
Ag_2O	NA	NA	NA	NA	NA
Al_2O_3	4.13	4.13	3.840	38.45	NA
Am	0.073	0.073	0.038	0.001	0.012
B_2O_3	NA	NA	NA	NA	NA
BaO	0.199	0.199	NA	NA	NA
BeO	14.44	14.44	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.014	0.014	NA	NA	NA
CaO	NA	NA	NA	0.808	NA
CdO	NA	NA	NA	NA	NA
Cr_2O_3	0.329	0.329	NA	NA	NA
CuO	NA	NA	NA	NA	NA
Fe_2O_3	7.346	7.346	0.120	21.681	NA
MgO	NA	NA	NA	NA	NA
MnO	0.129	0.129	NA	NA	NA
Na_2O	NA	NA	NA	NA	NA
NiO	0.116	0.116	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	NA	NA	NA	NA	NA
Pu	4.962	4.962	5.106	0.129	5.466
Se	NA	NA	NA	NA	NA
SiO_2	NA	NA	288.8	102	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.001	0.001	0.000	0.000	0.000
Tl_2O_3	NA	NA	NA	NA	NA
UO	1,316	1,316	1,405	39	1,544
ZnO	0.054	0.054	NA	NA	NA
ZrO_2	0.063	0.063	NA	NA	6.527
PCB	2.636	2.636	NA	NA	NA
Total CWRG:	1,350	1,350	1,703	202	1,556
1/CWRG, mg/m^3:	0.741	0.741	0.587	4.947	0.643

Table B-10. CWRG for the ERPG-1 Guideline -- KW Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Percent Contributions to the CWRG for the ERPG-1 Guideline					
Ag_2O	NA	NA	NA	NA	NA
Al_2O_3	0.306%	0.306%	0.226%	19.021%	NA
Am	0.005%	0.005%	0.002%	0.000%	0.001%
B_2O_3	NA	NA	NA	NA	NA
BaO	0.015%	0.015%	NA	NA	NA
BeO	1.070%	1.070%	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.001%	0.001%	NA	NA	NA
CaO	NA	NA	NA	0.400%	NA
CdO	NA	NA	NA	NA	NA
Cr_2O_3	0.024%	0.024%	NA	NA	NA
CuO	NA	NA	NA	NA	NA
Fe_2O_3	0.544%	0.544%	0.007%	10.725%	NA
MgO	NA	NA	NA	NA	NA
MnO	0.010%	0.010%	NA	NA	NA
Na_2O	NA	NA	NA	NA	NA
NiO	0.009%	0.009%	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	NA	NA	NA	NA	NA
Pu	0.367%	0.367%	0.300%	0.064%	0.351%
Se	NA	NA	NA	NA	NA
SiO_2	NA	NA	16.96%	50.40%	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	0.000%	0.000%
Tl_2O_3	NA	NA	NA	NA	NA
UO	97.45%	97.45%	82.50%	19.39%	99.23%
ZnO	0.004%	0.004%	NA	NA	NA
ZrO_2	0.005%	0.005%	NA	NA	0.420%
PCB	0.195%	0.195%	NA	NA	NA

Note: The Am and Pu numbers use the ERPG-1 for uranium.

Table B-11. CWRG for the ERPG-2 Guideline -- KW Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Mass Fractions Divided by the ERPG-2 Guideline (m^3/g)					
Ag_2O	NA	NA	NA	NA	NA
Al_2O_3	4.13	4.13	3.840	38.45	NA
Am	0.073	0.073	0.038	0.001	0.012
B_2O_3	NA	NA	NA	NA	NA
BaO	0.119	0.119	NA	NA	NA
BeO	5.777	5.777	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.008	0.008	NA	NA	NA
CaO	NA	NA	NA	0.485	NA
CdO	NA	NA	NA	NA	NA
Cr_2O_3	0.197	0.197	NA	NA	NA
CuO	NA	NA	NA	NA	NA
Fe_2O_3	4.408	4.408	0.072	13.009	NA
MgO	NA	NA	NA	NA	NA
MnO	0.077	0.077	NA	NA	NA
Na_2O	NA	NA	NA	NA	NA
NiO	0.069	0.069	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	NA	NA	NA	NA	NA
Pu	4.962	4.962	5.106	0.129	5.466
Se	NA	NA	NA	NA	NA
SiO_2	NA	NA	173.3	61	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000	0.000	0.000	0.000	0.000
Tl_2O_3	NA	NA	NA	NA	NA
UO	1,316	1,316	1,405	39	1,544
ZnO	0.054	0.054	NA	NA	NA
ZrO_2	0.025	0.025	NA	NA	2.611
PCB	1.581	1.581	NA	NA	NA
Total CWRG:	1,337	1,337	1,587	152	1,552
1/CWRG, mg/m^3:	0.748	0.748	0.630	6.561	0.644

Table B-11. CWRG for the ERPG-2 Guideline -- KW Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Percent Contributions to the CWRG for the ERPG-2 Guideline					
Ag_2O	NA	NA	NA	NA	NA
Al_2O_3	0.309%	0.309%	0.242%	25.229%	NA
Am	0.005%	0.005%	0.002%	0.001%	0.001%
B_2O_3	NA	NA	NA	NA	NA
BaO	0.009%	0.009%	NA	NA	NA
BeO	0.432%	0.432%	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.001%	0.001%	NA	NA	NA
CaO	NA	NA	NA	0.318%	NA
CdO	NA	NA	NA	NA	NA
Cr_2O_3	0.015%	0.015%	NA	NA	NA
CuO	NA	NA	NA	NA	NA
Fe_2O_3	0.330%	0.330%	0.005%	8.536%	NA
MgO	NA	NA	NA	NA	NA
MnO	0.006%	0.006%	NA	NA	NA
Na_2O	NA	NA	NA	NA	NA
NiO	0.005%	0.005%	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	NA	NA	NA	NA	NA
Pu	0.371%	0.371%	0.322%	0.085%	0.352%
Se	NA	NA	NA	NA	NA
SiO_2	NA	NA	10.92%	40.11%	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	0.000%	0.000%
Tl_2O_3	NA	NA	NA	NA	NA
UO	98.39%	98.39%	88.51%	25.725%	99.48%
ZnO	0.004%	0.004%	NA	NA	NA
ZrO_2	0.002%	0.002%	NA	NA	0.168%
PCB	0.118%	0.118%	NA	NA	NA

Note: The Am and Pu numbers use the ERPG-2 for uranium.

Table B-12. CWRG for the ERPG-3 Guideline -- KW Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Mass Fractions Divided by the ERPG-3 Guideline (m^3/g)					
Ag_2O	NA	NA	NA	NA	NA
Al_2O_3	2.481	2.481	2.304	23.070	NA
Am	0.004	0.004	0.0023	0.0001	0.0007
B_2O_3	NA	NA	NA	NA	NA
BaO	0.024	0.024	NA	NA	NA
BeO	1.444	1.444	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.005	0.005	NA	NA	NA
CaO	NA	NA	NA	0.194	NA
CdO	NA	NA	NA	NA	NA
Cr_2O_3	0.020	0.020	NA	NA	NA
CuO	NA	NA	NA	NA	NA
Fe_2O_3	0.044	0.044	0.0007	0.130	NA
MgO	NA	NA	NA	NA	NA
MnO	0.001	0.001	NA	NA	NA
Na_2O	NA	NA	NA	NA	NA
NiO	0.017	0.017	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	NA	NA	NA	NA	NA
Pu	0.298	0.298	0.306	0.008	0.328
Se	NA	NA	NA	NA	NA
SiO_2	NA	NA	3.466	1.223	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.0000	0.0000	0.0000	0.0000	0.0000
Tl_2O_3	NA	NA	NA	NA	NA
UO	78.94	78.94	84.29	2.35	92.61
ZnO	0.0016	0.0016	NA	NA	NA
ZrO_2	0.013	0.013	NA	NA	1.305
PCB	0.0000	0.0000	NA	NA	NA
Total CWRG:	83.3	83.3	90.4	27.0	94.2
1/CWRG, mg/m^3:	12.0	12.0	11.1	37.1	10.6

Table B-12. CWRG for the ERPG-3 Guideline -- KW Basin Canister and Fuel Wash Sludge

Analyte	Canister Sludge		Fuel Washing Sludge		
	Full	Empty	Internal	Coating	Pieces
Percent Contributions to the CWRG for the ERPG-3 Guideline					
Ag_2O	NA	NA	NA	NA	NA
Al_2O_3	2.98%	2.98%	2.550%	85.52%	NA
Am	0.005%	0.005%	0.003%	0.000%	0.001%
B_2O_3	NA	NA	NA	NA	NA
BaO	0.029%	0.029%	NA	NA	NA
BeO	1.734%	1.734%	NA	NA	NA
BiO	NA	NA	NA	NA	NA
CO	0.006%	0.006%	NA	NA	NA
CaO	NA	NA	NA	0.719%	NA
CdO	NA	NA	NA	NA	NA
Cr_2O_3	0.024%	0.024%	NA	NA	NA
CuO	NA	NA	NA	NA	NA
Fe_2O_3	0.053%	0.053%	0.001%	0.482%	NA
MgO	NA	NA	NA	NA	NA
MnO	0.001%	0.001%	NA	NA	NA
Na_2O	NA	NA	NA	NA	NA
NiO	0.021%	0.021%	NA	NA	NA
PO_3	NA	NA	NA	NA	NA
PbO	NA	NA	NA	NA	NA
Pu	0.357%	0.357%	0.339%	0.029%	0.348%
Se	NA	NA	NA	NA	NA
SiO_2	NA	NA	3.84%	4.53%	NA
Sm_2O_3	NA	NA	NA	NA	NA
Sr	0.000%	0.000%	0.000%	0.000%	0.000%
Tl_2O_3	NA	NA	NA	NA	NA
UO	94.77%	94.77%	93.27%	8.72%	98.27%
ZnO	0.002%	0.002%	NA	NA	NA
ZrO_2	0.015%	0.015%	NA	NA	1.385%
PCB	0.000%	0.000%	NA	NA	NA

Note: The Am and Pu numbers use the ERPG-3 for uranium.

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Nuclear Safety	Date 9-29-99
Project Title/Work Order		EDT No. 626895
SNF-5066, Rev. 0 Comparison of Toxicological and Radiological Aspects of K Basins Sludge		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
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