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Appendix A

Expected Leachate Design Concentrations and Absorbed Radiation Dose

Table A-1. Predicted organic concentrations in leachate.

Constituent[a]	Maximum Leachate Concentration[b] (mg/L)	Average Leachate Concentration (mg/L)	Constituent[a]	Maximum Leachate Concentration[b] (mg/L)	Average Leachate Concentration (mg/L)
1,1,1-Trichloroethane	0.0609	0.0073	Acenaphthene	0.0399	0.0028
1,1,2,2-Tetrachloroethane	0.0002	0.0000	Acenaphthylene	0.3366	0.0230
1,1,2-Trichloroethane	0.0013	0.0002	Acetone	6.2674	0.3917
1,1-Dichloroethane	0.0105	0.0009	Acetonitrile	0.0002	0.0000
1,1-Dichloroethene	0.0004	0.0000	Acrolein	0.0001	0.0000
1,2,4-Trichlorobenzene	0.0113	0.0010	Acrylonitrile	0.0000	0.0000
1,2-Dichlorobenzene	0.0734	0.0046	Anthracene	0.0083	0.0013
1,2-Dichloroethane	0.0001	0.0000	Aramite	0.0000	0.0000
1,2-Dichloroethene (total)	0.0003	0.0000	Aroclor-1016	0.0000	0.0000
1,3-Dichlorobenzene	0.0071	0.0006	Aroclor-1254	0.0002	0.0000
1,4-Dichlorobenzene	5.1303	0.4578	Aroclor-1260	0.0087	0.0005
1,4-Dioxane	0.0000	0.0000	Aroclor-1268	0.2891	0.0181
2,4,5-Trichlorophenol	0.0441	0.0114	Benzene	1.3491	0.1685
2,4,6-Trichlorophenol	0.0427	0.0109	Benzidine	0.0000	0.0000
2,4-Dichlorophenol	0.0371	0.0023	Benzo(a)anthracene	0.0001	0.0000
2,4-Dimethylphenol	0.3041	0.0190	Benzo(a)pyrene	0.0000	0.0000
2,4-Dinitrophenol	0.1705	0.0173	Benzo(b)fluoranthene	0.0000	0.0000
2,4-Dinitrotoluene	0.0488	0.0041	Benzo(g,h,i)perylene	0.0000	0.0000
2,6-Dinitrotoluene	0.2903	0.0242	Benzo(k)fluoranthene	0.3024	0.1623
2-Butanone	0.0063	0.0004	Benzoic acid	0.1162	0.0073
2-Chloronaphthalene	0.0108	0.0007	Bis(2-Chloroethoxy)methane	0.0455	0.0444
2-Chlorophenol	0.1867	0.0208	bis(2-Chloroethyl)ether	0.0535	0.0048
2-Hexanone	0.0001	0.0001	bis(2-Chloroisopropyl)ether	0.0000	0.0000
2-Methylnaphthalene	1.7772	1.7403	bis(2-Ethylhexyl)phthalate	0.5714	0.0497
2-Methylphenol	0.2014	0.0126	Butane,1,1,3,4-Tetrachloro-	0.0001	0.0000
2-Nitroaniline	0.1728	0.1663	Butylbenzylphthalate	0.0080	0.0005
2-Nitrophenol	0.0098	0.0006	Carbazole	0.1856	0.1793
3,3'-Dichlorobenzidine	0.1896	0.0168	Carbon Disulfide	0.0734	0.0046
3-Methyl Butanal	0.0022	0.0021	Chlorobenzene	0.0679	0.0062
3-Nitroaniline	0.0165	0.0165	Chloroethane	0.0000	0.0000
4,6-Dinitro-2-methylphenol	0.0010	0.0001	Chloromethane	0.0000	0.0000
4-Bromophenyl-phenylether	0.0615	0.0595	Chrysene	4.4199	1.4812
4-Chloro-3-methylphenol	0.0810	0.0789	Decane, 3,4-Dimethyl	0.0004	0.0004

Table A-1. (continued).

Constituent[a]	Maximum Leachate Concentration[b] (mg/L)	Average Leachate Concentration (mg/L)	Constituent[a]	Maximum Leachate Concentration[b] (mg/L)	Average Leachate Concentration (mg/L)
4-Chloroaniline	0.0052	0.0052	Diacetone alcohol	0.0005	0.0000
4-Chlorophenyl-phenylether	0.0288	0.0284	Dibenz(a,h)anthracene	0.0006	0.0002
4-Methyl-2-Pentanone	0.1131	0.0071	Dibenzofuran	0.4156	0.0260
4-Methylphenol	0.3766	0.0235	Diethylphthalate	0.1897	0.0120
4-Nitroaniline	0.1728	0.1663	Dimethyl Disulfide	0.0127	0.0124
4-Nitrophenol	0.0029	0.0002	Dimethylphthalate	0.0001	0.0000
Di-n-butylphthalate	0.0000	0.0000	N-Nitroso-di-n-propylamine	0.0035	0.0003
Di-n-octylphthalate	0.4370	0.0370	N-Nitrosodiphenylamine	0.1896	0.0119
Eicosane	0.0472	0.0029	Octane,2,3,7-Trimethyl	0.0027	0.0024
Ethyl cyanide	0.0000	0.0000	o-Toluenesulfonamide	0.0033	0.0033
Ethylbenzene	0.0705	0.0050	Pentachlorophenol	0.0046	0.0010
Famphur	0.0000	0.0000	Phenanthrene	8.8500	0.8023
Fluoranthene	0.0221	0.0039	Phenol	0.1370	0.0086
Fluorene	3.0594	0.2043	Phenol,2,6-Bis(1,1-Dimethyl)	0.0674	0.0042
Heptadecane, 2,6,10,15-Tetra	0.0000	0.0000	p-Toluenesulfonamide	0.0000	0.0000
Hexachlorobenzene	0.0001	0.0000	Pyrene	3.2501	1.4592
Hexachlorobutadiene	0.0000	0.0000	RDX	0.0000	0.0000
Hexachlorocyclopentadiene	0.0025	0.0002	Styrene	0.0000	0.0000
Hexachloroethane	0.0000	0.0000	Tetrachloroethene	0.0235	0.0039
Indeno(1,2,3-cd)pyrene	0.1585	0.0524	Toluene	16.3666	1.0229
Isobutyl alcohol	0.0001	0.0000	Tributylphosphate	1.2292	0.1704
Isophorone	0.1829	0.0114	Trichloroethene	1.1526	0.3027
Isopropyl Alcohol/2-propanol	0.0000	0.0000	Trinitrotoluene	0.0000	0.0000
Kepone	0.2511	0.0704	Undecane,4,6-Dimethyl-	0.0003	0.0003
Mesityl oxide	1.2939	0.0809	Xylene (ortho)	0.0071	0.0006
Methyl Acetate	0.0057	0.0053	Xylene (total)	6.2805	0.5293
Methylene Chloride	0.0165	0.0010			
Naphthalene	1.9193	0.1398	Total Organics	69.5426	10.4515
Nitrobenzene	0.0948	0.0082			

a. Constituents based on the design Inventory (EDF-ER-264)
b. Peak and average concentrations during the 15 year active life of the landfill assuming the entire mass is placed in the landfill (EDF-ER-274)

Table A-2. Expected peak inorganic concentrations in leachate.

Constituent[a]	Maximum Leachate Concentration (mg/L)[b]	Average Leachate Concentration (mg/L)[b]
Aluminum	28.3029	28.3022
Antimony	0.1165	0.1164
Arsenic	1.8470	1.8434
Barium	3.5848	3.5843
Beryllium	0.0011	0.0011
Boron	36.4728	36.4292
Cadmium	0.5917	0.5911
Calcium	4035.0217	4030.1943
Chloride	31.1061	28.1653
Chromium	1.3691	1.3689
Cobalt	0.5999	0.5996
Copper	1.4906	1.4902
Cyanide	4.0932	3.8059
Dysprosium	0.2472	0.2472
Fluoride	64.4341	58.3424
Iron	46.5528	46.5516
Lead	0.5753	0.5753
Magnesium	883.9838	882.9262
Manganese	4.1300	4.1295
Mercury	49.7230	48.1710
Molybdenum	1.0117	1.0111
Nickel	0.1964	0.1964
Nitrate	65.4429	59.2558
Nitrate/Nitrite-N	3.6979	3.3483
Nitrite	0.1414	0.1281
Phosphorus	19.2492	19.2261
Potassium	74.8819	74.8518
Selenium	0.2084	0.2080
Silver	0.1092	0.1092
Sodium	2.7716	2.7714
Strontium	1.5094	1.5087
Sulfate	342.1180	309.7736
Sulfide	12641.8391	11446.6606
Terbium	2.3867	2.3866
Thallium	0.0037	0.0037
Vanadium	3.5063	3.5028
Ytterbium	0.8124	0.8123
Zinc	12.9486	12.9437
Zirconium	0.1151	0.1151
Total Inorganic Concentration	18367.1936	17116.2485

a. Constituents based on the design Inventory (2001 EDF-264)
b. Peak and average concentrations during the 15 year active life of the landfill assuming the entire mass is placed in the landfill (EDF-ER-274)

Table A-3. Expected peak rationuclides concentrations in leachate.

Constituent[a]	Maximum Leachate Concentration (pCi/L)[b]	Average Leachate Concentration (pCi/L)[b]	Constituent[a]	Maximum Leachate Concentration (pCi/L)[b]	Average Leachate Concentration (pCi/L)[b]
Ac225	1.1E-07	7.1E-09	Cm241	3.2E-81	2.0E-82
Ac227	4.5E-05	3.6E-05	Cm242	1.3E-17	1.1E-18
Ac228	3.4E-10	2.1E-11	Cm243	8.9E-07	7.4E-07
Ag106	0.0E+00	0.0E+00	Cm244	4.5E-04	3.4E-04
Ag108	4.1E-08	2.6E-09	Cm245	2.0E-08	2.0E-08
Ag108m	8.9E+00	8.5E+00	Cm246	4.5E-10	4.5E-10
Ag109m	5.5E-11	3.4E-12	Cm247	1.6E-16	1.6E-16
Ag110	5.7E-10	3.6E-11	Cm248	4.9E-17	4.9E-17
Ag110m	6.2E-08	6.0E-09	Cm250	1.4E-25	1.4E-25
Ag111	0.0E+00	0.0E+00	Co-57	3.7E-01	3.8E-02
Am241	7.0E+01	6.9E+01	Co-58	5.8E-15	3.8E-16
Am242	1.3E-04	8.3E-06	Co-60	1.9E+04	8.6E+03
Am242m	1.3E-04	1.3E-04	Cr-51	7.7E-53	4.8E-54
Am243	9.8E-04	9.8E-04	Cs132	0.0E+00	0.0E+00
Am245	0.0E+00	0.0E+00	Cs134	2.2E+01	4.9E+00
Am246	4.1E-25	2.5E-26	Cs135	7.2E-02	7.2E-02
At217	8.5E-04	5.3E-05	Cs136	0.0E+00	0.0E+00
Ba136m	0.0E+00	0.0E+00	Cs137	4.9E+04	4.1E+04
Ba137m	4.6E+05	2.9E+04	Er169	0.0E+00	0.0E+00
Ba140	0.0E+00	0.0E+00	Eu150	5.1E-08	3.2E-09
Be 10	4.6E-06	4.6E-06	Eu152	2.8E+03	2.0E+03
Bi210	1.1E-05	6.8E-07	Eu154	2.4E+03	1.4E+03
Bi211	1.8E-04	1.1E-05	Eu155	5.2E+02	2.2E+02
Bi212	5.5E-03	3.5E-04	Eu156	0.0E+00	0.0E+00
Bi213	0.0E+00	0.0E+00	Fe-59	2.0E-34	1.3E-35
Bi214	5.6E-05	3.5E-06	Fr221	1.0E-07	6.4E-09
Bk249	5.4E-22	6.2E-23	Fr223	5.6E-07	3.5E-08
Bk250	1.9E-26	1.2E-27	Gd152	1.1E-13	1.1E-13
C 14	9.1E-03	9.1E-03	Gd153	8.4E-11	8.1E-12
Cd109	8.1E-10	1.2E-10	H 3	8.3E+05	5.2E+05
Cd113m	2.7E+02	1.9E+02	Hf-181	1.7E-36	1.1E-37
Cd115m	7.0E-52	4.4E-53	Ho166m	1.1E-05	6.7E-07
Ce141	3.6E-71	2.3E-72	I129	2.2E+04	2.0E+04
Ce142	0.0E+00	0.0E+00	I131	0.0E+00	0.0E+00

Table A-3. (continued).

Constituent[a]	Maximum Leachate Concentration (pCi/L)[b]	Average Leachate Concentration (pCi/L)[b]
Ce144	3.6E-03	3.8E-04
Cf249	8.1E-16	8.0E-16
Cf250	4.1E-16	2.9E-16
Cf251	1.9E-18	1.9E-18
Cf252	4.4E-20	1.2E-20
Kr81[c]	0.0E+00	8.0E-05
Kr85[c]	0.0E+00	1.1E+07
La138	0.0E+00	0.0E+00
La140	2.2E-105	1.4E-106
Mn-54	3.9E-07	4.3E-08
Nb92	6.3E-18	6.3E-18
Nb93m	1.3E-01	9.5E-02
Nb94	8.8E-05	8.8E-05
Nb95	4.8E-32	3.0E-33
Nb95m	1.8E-34	1.1E-35
Nd144	1.4E-09	1.4E-09
Nd147	0.0E+00	0.0E+00
Np235	8.4E-09	1.1E-09
Np236	8.6E-06	8.6E-06
Np237	8.0E+01	8.0E+01
Np238	2.7E-05	1.7E-06
Np239	4.1E-02	2.6E-03
Np240	3.5E-12	2.2E-13
Np240m	3.1E-09	2.0E-10
Pa231	1.3E-04	1.3E-04
Pa233	7.9E-02	4.9E-03
Pa234	5.0E-06	3.1E-07
Pa234m	3.1E-03	1.9E-04
Pb209	4.8E-07	3.0E-08
Pb210	1.1E-05	8.7E-06
Pb211	1.8E-04	1.1E-05
Pb212	5.5E-03	3.5E-04
Pb214	5.6E-05	3.5E-06
In114	4.8E-54	3.0E-55
In114m	5.1E-54	3.2E-55
In115	1.5E-11	1.5E-11
In115m	0.0E+00	0.0E+00
K-40	1.3E+02	1.3E+02
Po216	3.7E-03	2.3E-04
Po218	3.7E-05	2.3E-06
Pr143	0.0E+00	0.0E+00
Pr144	7.4E-03	4.6E-04
Pr144m	1.1E-04	6.6E-06
Pu236	3.9E-05	1.1E-05
Pu237	8.6E-58	5.4E-59
Pu238	1.7E+03	1.6E+03
Pu239	4.8E+01	4.8E+01
Pu240	1.1E+01	1.1E+01
Pu241	4.6E+02	3.3E+02
Pu242	1.7E-03	1.7E-03
Pu243	4.6E-15	2.9E-16
Pu244	1.8E-10	1.8E-10
Pu246	9.9E-25	6.2E-26
Ra222	1.2E-115	7.3E-117
Ra223	2.0E-04	1.3E-05
Ra224	5.5E-03	3.5E-04
Ra225	5.1E-07	3.2E-08
Ra226	4.7E+00	4.7E+00
Ra228	1.5E-09	7.2E-10
Rb86	0.0E+00	0.0E+00
Rb87	2.0E-04	2.0E-04
Rh102	5.7E-04	1.6E-04
Rh103m	5.4E-57	3.4E-58
Rh106	2.2E-01	1.4E-02
Rn218	2.1E-112	1.3E-113
Rn219	3.4E-01	2.1E-02

Table A-3. (continued).

Constituent[a]	Maximum Leachate Concentration (pCi/L)[b]	Average Leachate Concentration (pCi/L)[b]	Constituent[a]	Maximum Leachate Concentration (pCi/L)[b]	Average Leachate Concentration (pCi/L)[b]
Pd107	1.1E-01	1.1E-01	Rn220	9.2E+00	5.8E-01
Pm146	2.4E-02	1.1E-02	Rn222	1.0E-01	6.5E-03
Pm147	1.6E+03	4.2E+02	Ru103	3.6E-28	2.3E-29
Pm148	1.7E-58	1.0E-59	Ru106	2.2E-01	2.8E-02
Pm148m	3.4E-57	2.1E-58	Sb124	4.1E-39	2.6E-40
Po210	6.8E-06	5.0E-07	Sb125	1.9E+02	5.1E+01
Po211	4.6E-09	2.9E-10	Sb126	4.1E-01	2.6E-02
Po212	2.2E-03	1.4E-04	Sb126m	2.9E+00	1.8E-01
Po213	2.9E-07	1.8E-08	Sc-46	9.2E-20	6.0E-21
Po214	3.7E-05	2.3E-06	Se 79	4.1E+01	4.1E+01
Po215	1.2E-04	7.6E-06	Sm146	1.8E-09	1.8E-09
Sm147	1.7E-05	1.7E-05	Th231	1.6E+00	1.0E-01
Sm148	4.2E-12	4.2E-12	Th232	1.6E+00	1.6E+00
Sm149	2.1E-11	2.1E-11	Th234	1.7E-02	1.1E-03
Sm151	1.4E+03	1.3E+03	Tl207	1.8E-04	1.1E-05
Sn117m	0.0E+00	0.0E+00	Tl208	2.0E-03	1.2E-04
Sn119m	1.1E-06	1.2E-07	Tl209	1.1E-08	6.6E-10
Sn121m	2.1E-01	1.9E-01	Tm170	2.7E-25	1.9E-26
Sn123	6.5E-16	4.7E-17	Tm171	6.6E-12	1.4E-12
Sn125	0.0E+00	0.0E+00	U230	0.0E+00	0.0E+00
Sn126	1.1E+00	1.1E+00	U232	8.8E-02	8.2E-02
Sr89	5.0E-42	3.1E-43	U233	4.2E-03	4.2E-03
Sr90	1.9E+06	1.6E+06	U234	9.9E+02	9.9E+02
Tb160	1.3E-33	8.5E-35	U235	1.8E+01	1.8E+01
Tb161	0.0E+00	0.0E+00	U236	3.3E+01	3.3E+01
Tc 98	6.8E-04	6.6E-04	U237	0.0E+00	0.0E+00
Tc99	2.2E+04	2.2E+04	U238	3.2E+02	3.2E+02
Te123	3.6E-14	3.6E-14	U240	4.2E-09	2.6E-10
Te123m	2.4E-22	1.7E-23	Xe127	2.6E-68	1.6E-69
Te125m	1.8E+01	1.1E+00	Xe129m	0.0E+00	0.0E+00
Te127	7.5E-19	4.7E-20	Xe131m	4.5E-108	2.8E-109
Te127m	7.6E-19	5.3E-20	Xe133	0.0E+00	0.0E+00
Te129	5.4E-70	3.4E-71	Y90	1.3E+05	8.4E+03

Table A-3. (continued).

Constituent[a]	Maximum Leachate Concentration (pCi/L)[b]	Average Leachate Concentration (pCi/L)[b]	Constituent[a]	Maximum Leachate Concentration (pCi/L)[b]	Average Leachate Concentration (pCi/L)[b]
Te129m	8.6E-70	5.4E-71	Y91	2.4E-36	1.5E-37
Th226	2.2E-116	1.4E-117	Zn65	1.7E-07	1.6E-08
Th227	1.8E-04	1.1E-05	Zr93	1.4E+00	1.4E+00
Th228	3.3E-01	6.7E-02	Zr95	4.9E-25	3.1E-26
Th229	5.1E-07	5.1E-07		2.3E+07	1.4E+07
Th230	1.7E+00	1.7E+00			

a. Constituents based on the design Inventory (2001 EDF-264)
b. Peak and average concentrations during the 15 year active life of the landfill assuming the entire mass is placed in the landfill (EDF-ER-274)
c. Constituents Kr-81 and Kr-85 are gaseous elements, so are not part of the leachate.

Table A-4. Radionuclide design absorption rate.

Constituent[a]	Landfill Design Absorption Rate Rads/Hour[b]	Evaporation Pond Design Absorption Rate Rads/Hour[b]	Constituent[a]	Landfill Design Absorption Rate Rads/Hour[b]	Evaporation Pond Design Absorption Rate Rads/Hour[b]
Ac225	3.95E-14	3.55E-13	Cm250	1.07E-32	9.61E-32
Ac227	2.15E-13	1.94E-12	Co-57	3.13E-09	2.82E-08
Ac228	2.73E-17	2.46E-16	Co-58	3.40E-22	3.06E-21
Ag106	1.53E-15	1.38E-14	Co-60	2.98E-03	2.68E-02
Ag108	8.63E-07	7.77E-06	Cr-51	1.65E-61	1.48E-60
Ag108m	0.00E+0	0.00E+0	Cs132	0.00E+0	0.00E+0
Ag109m	2.83E-19	2.54E-18	Cs134	2.29E-06	2.06E-05
Ag110	4.15E-17	3.73E-16	Cs135	2.40E-10	2.16E-09
Ag110m	1.03E-14	9.26E-14	Cs136	0.00E+0	0.00E+0
Ag111	0.00E+0	0.00E+0	Cs137	4.96E-04	4.47E-03
Am241	2.31E-05	2.08E-04	Er169	0.00E+0	0.00E+0
Am242	1.52E-12	1.37E-11	Eu150	8.84E-16	7.96E-15
Am242m	5.19E-13	4.67E-12	Eu152	2.16E-04	1.94E-03
Am243	3.13E-10	2.81E-09	Eu154	2.19E-04	1.97E-03
Am245	0.00E+0	0.00E+0	Eu155	3.78E-06	3.40E-05
Am246	3.07E-32	2.76E-31	Eu156	0.00E+0	0.00E+0
At217	3.59E-10	3.23E-09	Fe-59	1.59E-41	1.43E-40
Ba136m	0.00E+0	0.00E+0	Fr221	3.90E-14	3.51E-13
Ba137m	1.82E-02	1.64E-01	Fr223	1.46E-14	1.31E-13
Ba140	0.00E+0	0.00E+0	Gd152	1.45E-20	1.30E-19
Be 10	5.50E-14	4.95E-13	Gd153	7.60E-19	6.84E-18
Bi210	2.53E-13	2.27E-12	H 3	2.79E-04	2.52E-03
Bi211	7.19E-11	6.47E-10	Hf-181	7.62E-44	6.85E-43
Bi212	9.29E-10	8.36E-09	Ho166m	1.12E-12	1.01E-11
Bi213	0.00E+0	0.00E+0	I129	1.02E-04	9.15E-04
Bi214	7.20E-12	6.48E-11	I131	0.00E+0	0.00E+0
Bk249	1.06E-30	9.53E-30	In114	2.31E-61	2.08E-60
Bk250	1.36E-33	1.22E-32	In114m	7.21E-62	6.49E-61
C 14	2.68E-11	2.41E-10	In115	1.34E-19	1.21E-18
Cd109	9.48E-19	8.54E-18	In115m	0.00E+0	0.00E+0
Cd113m	2.95E-06	2.65E-05	K-40	4.62E-06	4.16E-05
Cd115m	2.62E-59	2.36E-58	Kr81	0.00E+0	0.00E+0
Ce141	5.30E-79	4.77E-78	Kr85	0.00E+0	0.00E+0
Ce142	0.00E+0	0.00E+0	La138	3.74E-112	3.37E-111

Table A-4. (continued).

Constituent[a]	Landfill Design Absorption Rate Rads/Hour[b]	Evaporation Pond Design Absorption Rate Rads/Hour[b]
Ce144	2.40E-11	2.16E-10
Cf249	2.98E-22	2.69E-21
Cf250	1.48E-22	1.33E-21
Cf251	6.60E-25	5.94E-24
Cf252	2.70E-29	2.43E-28
Cm241	3.30E-89	2.97E-88
Cm242	4.91E-24	4.42E-23
Cm243	3.22E-13	2.90E-12
Cm244	1.56E-10	1.40E-09
Cm245	6.57E-15	5.92E-14
Cm246	1.43E-16	1.29E-15
Cm247	5.02E-23	4.52E-22
Cm248	1.35E-23	1.22E-22
Np239	1.02E-09	9.22E-09
Np240	3.29E-19	2.96E-18
Np240m	1.78E-16	1.60E-15
Pa231	4.12E-11	3.71E-10
Pa233	1.93E-09	1.74E-08
Pa234	7.31E-13	6.58E-12
Pa234m	1.55E-10	1.39E-09
Pb209	5.70E-15	5.13E-14
Pb210	2.53E-14	2.27E-13
Pb211	5.50E-12	4.95E-11
Pb212	1.06E-10	9.51E-10
Pb214	1.80E-12	1.62E-11
Pd107	2.19E-10	1.97E-09
Pm146	1.23E-09	1.10E-08
Pm147	5.86E-06	5.28E-05
Pm148	1.28E-65	1.15E-64
Pm148m	4.40E-64	3.96E-63
Po210	2.14E-12	1.92E-11
Po211	2.02E-15	1.82E-14
Po212	1.14E-09	1.03E-08
Po213	1.44E-13	1.30E-12

Constituent[a]	Landfill Design Absorption Rate Rads/Hour[b]	Evaporation Pond Design Absorption Rate Rads/Hour[b]
La140	0.00E+0	0.00E+0
Mn-54	1.93E-14	1.73E-13
Nb92	5.70E-25	5.13E-24
Nb93m	2.43E-10	2.19E-09
Nb94	9.04E-12	8.13E-11
Nb95	2.31E-39	2.08E-38
Nb95m	2.70E-42	2.43E-41
Nd144	1.54E-16	1.39E-15
Nd147	0.00E+0	0.00E+0
Np235	4.92E-18	4.43E-17
Np236	1.75E-13	1.57E-12
Np237	2.30E-05	2.07E-04
Np238	1.30E-12	1.17E-11
Rh103m	1.26E-65	1.13E-64
Rh106	2.10E-08	1.89E-07
Rn218	8.91E-119	8.02E-118
Rn219	1.37E-07	1.24E-06
Rn220	3.45E-06	3.10E-05
Rn222	3.38E-08	3.04E-07
Ru103	1.20E-35	1.08E-34
Ru106	5.17E-10	4.65E-09
Sb124	5.54E-46	4.99E-45
Sb125	5.84E-06	5.26E-05
Sb126	7.48E-08	6.73E-07
Sb126m	3.79E-07	3.41E-06
Sc-46	1.16E-26	1.04E-25
Se 79	1.27E-07	1.14E-06
Sm146	2.67E-16	2.40E-15
Sm147	2.29E-12	2.06E-11
Sm148	4.98E-19	4.48E-18
Sm149	0.00E+00	0.00E+00
Sm151	1.66E-06	1.49E-05
Sn117m	0.00E+0	0.00E+0
Sn119m	5.91E-15	5.32E-14

Table A-4. (continued).

Constituent[a]	Landfill Design Absorption Rate Rads/Hour[b]	Evaporation Pond Design Absorption Rate Rads/Hour[b]
Po214	1.71E-11	1.54E-10
Po215	5.36E-11	4.83E-10
Po216	1.49E-09	1.34E-08
Po218	1.34E-11	1.20E-10
Pr143	0.00E+0	0.00E+0
Pr144	5.64E-10	5.08E-09
Pr144m	7.44E-14	6.70E-13
Pu236	1.36E-11	1.22E-10
Pu237	3.20E-66	2.88E-65
Pu238	5.45E-04	4.91E-03
Pu239	1.46E-05	1.31E-04
Pu240	3.29E-06	2.96E-05
Pu241	1.42E-07	1.28E-06
Pu242	5.03E-10	4.53E-09
Pu243	5.30E-23	4.77E-22
Pu244	4.97E-17	4.47E-16
Pu246	9.07E-33	8.17E-32
Ra222	4.56E-122	4.10E-121
Ra223	7.11E-11	6.40E-10
Ra224	1.87E-09	1.68E-08
Ra225	3.63E-15	3.27E-14
Ra226	1.35E-06	1.21E-05
Ra228	1.05E-18	9.43E-18
Rb86	0.00E+0	0.00E+0
Rb87	9.50E-13	8.55E-12
Rh102	2.71E-12	2.44E-11
Tl208	4.66E-10	4.20E-09
Tl209	2.48E-15	2.24E-14
Tm170	5.29E-33	4.76E-32
Tm171	1.04E-20	9.33E-20
U230	0.00E+0	0.00E+0
U232	2.80E-08	2.52E-07
U233	1.21E-09	1.09E-08
U234	2.83E-04	2.54E-03

Constituent[a]	Landfill Design Absorption Rate Rads/Hour[b]	Evaporation Pond Design Absorption Rate Rads/Hour[b]
Sn121m	3.74E-11	3.36E-10
Sn123	2.03E-23	1.83E-22
Sn125	0.00E+0	0.00E+0
Sn126	2.42E-08	2.18E-07
Sr89	1.72E-49	1.55E-48
Sr90	6.16E-02	5.55E-01
Tb160	1.07E-40	9.59E-40
Tb161	6.13E-11	5.52E-10
Tc 98	1.11E-04	1.00E-03
Tc99	3.67E-23	3.31E-22
Te123	3.45E-30	3.10E-29
Te123m	1.72E-07	1.55E-06
Te125m	1.01E-26	9.13E-26
Te127	4.11E-27	3.69E-26
Te127m	1.94E-77	1.74E-76
Te129	1.57E-77	1.42E-76
Te129m	0.00E+0	0.00E+0
Th226	8.21E-123	7.39E-122
Th227	6.54E-11	5.89E-10
Th228	1.06E-07	9.54E-07
Th229	1.54E-13	1.39E-12
Th230	4.84E-07	4.36E-06
Th231	1.71E-08	1.54E-07
Th232	3.72E-07	3.35E-06
Th234	6.78E-11	6.10E-10
Tl207	5.38E-12	4.84E-11

Table A-4. (continued).

Constituent[a]	Landfill Design Absorption Rate Rads/Hour[b]	Evaporation Pond Design Absorption Rate Rads/Hour[b]	Constituent[a]	Landfill Design Absorption Rate Rads/Hour[b]	Evaporation Pond Design Absorption Rate Rads/Hour[b]
U235	4.95E-06	4.46E-05			
U236	8.94E-06	8.05E-05			
U237	0.00E+0	0.00E+0			
U238	8.06E-05	7.25E-04			
U240	3.99E-17	3.59E-16			
Xe127	4.85E-76	4.36E-75			
Xe129m	0.00E+0	0.00E+0			
Xe131m	4.33E-116	3.90E-115			
Xe133	0.00E+0	0.00E+0			
Y90	7.76E-03	6.99E-02			
Y91	8.79E-44	7.91E-43			
Zn65	5.88E-15	5.29E-14			
Zr93	1.66E-09	1.49E-08			
Zr95	2.47E-32	2.22E-31			
Total Design Absorption Rate	**9.30E-02 rads/hr**	**8.37E-01 rads/hr**			
Total Design Absorption	**1.22E+04 rads**	**1.10E+05 rads**			

a. Constituents based on the design Inventory (EDF-ER-264)

b. Based on average concentrations during the 15 year active life of the landfill assuming the entire mass is placed in the landfill (EDF-ER-274)

Appendix B

Geomembrane Dose Calculations

Appendix B-1

Geomembrane Dose in the Landfill

MONTGOMERY WATSON HARZA
Description: Radiation dosage to ICDF liner resulting from leachate exposure
Project #: 2470178
Prepared by: J. Thompson
Date: 10/6/01
Checked by: B. Adams/J. Pellicer
Date: 12/7/01

VARIABLES

Liner Thickness =	60 mils
Liner density =	0.94 g/cm^3
Depth of leachate =	4 cm

CONVERSIONS

pCi/Ci =	1.00E+12
cm^3/l =	1000
cm/mil =	2.54E-03
(dis/s)/Ci =	3.70E+10
sec/hr =	3600
g/kg =	1.00E+03
eV/Mev =	1.00E+06
J/eV =	1.60E-19
rad =	0.01 J/kg
rad/Gy =	100

Hand Calculation for Calculating Dose for Ac225

	1.14e-7pCi / liter	x	liter / 1000cm3	x	Ci / 1e12pCi	x	4cm3		= 4.56e-22 Ci		
	4.56e-22 Ci	x	3.7e10 dis / Ci sec	x	3600 sec / hour	x	5.832 MeV / dis	x	1e6 eV / MeV	= 0.3542 eV / hour	
Liner Mass:	60 mil	x	in / 1000 mil	x	2.54 cm / in	x	0.94 g / cm3	x	kg / 1000 g	= 1.432e-4 kg	
0.3542 eV / hour	x	1.6e-19 J / eV	x	1 / 1.432e-4 kg	x	rad kg / 0.01 J	= 3.95e-14 rad / hr				

Constituent	ICDF Average Activity Concentration (pCi/L)	ICDF Average Activity Concentration (Ci/cm^3)	Disintegration Energy from Alpha Radiation (MeV/dis)[a]	Disintegration Energy from Beta Radiation (MeV/dis)[a]	Disintegration Energy from Gamma Radiation (MeV/dis)[a]	Disintegration Energy from Electron Radiation (MeV/dis)[a]	Total Disintegration Energy (MeV/dis)[b]	ICDF Liner Radiation Dose (Rads/hr)
Ac225	1.14E-07	1.14E-22	5.794750712		0.015675725	0.021753375	5.832179811	3.95E-14
Ac227	4.54E-05	4.54E-20	0.067076762	0.009519	0.000269356	0.002766609	0.079631727	2.15E-13
Ac228	3.38E-10	3.38E-25		0.365039719	0.926920369	0.064207018	1.356167107	2.73E-17
Ag108	4.10E-08	4.10E-23		0.609441	0.017742571	0.000104798	0.627288369	1.53E-15
Ag108m	8.88E+00	8.88E-15			1.619571716	0.014175304	1.63374702	8.63E-07
Ag109m	5.46E-11	5.46E-26			0.011251468	0.075708836	0.086960304	2.83E-19
Ag110	5.75E-10	5.74855E-25		1.181485222	0.030569692	1.49286E-05	1.212069842	4.15E-17
Ag110m	6.16E-08	6.15802E-23		0.065497652	2.740392268	0.002891351	2.808781272	1.03E-14
Am241	7.01E+01	7.00857E-14	5.4776265		0.028100691	0.029402026	5.535129217	2.31E-05
Am242	1.33E-04	1.33277E-19		0.159206	0.01777726	0.014518168	0.191501428	1.52E-12
Am242m	1.33E-04	1.32877E-19	0.02491305		0.004697851	0.036045937	0.065656838	5.19E-13
Am243	9.82E-04	9.8225E-19	5.26454376		0.058325807	0.025255628	5.348125195	3.13E-10
Am246	4.06E-25	4.06494E-40		0.2600814	0.979943558	0.029091734	1.269116692	3.07E-32
At217	8.54E-04	8.53567E-19	7.065707158				7.065707158	3.59E-10
Ba137m	4.62E+05	4.61732E-10			0.597793455	0.063669106	0.661462561	1.82E-02
Be 10	4.57E-06	4.56737E-21		0.2025			0.2025	5.50E-14
Bi210	1.09E-05	1.09161E-20		0.389			0.389	2.53E-13
Bi211	1.83E-04	1.82992E-19	6.549152819	0.000476658	0.047468126	0.009283362	6.606380966	7.19E-11
Bi212	5.53E-03	5.52598E-18	2.173446631	0.459769426	0.184126961	0.008766847	2.826109865	9.29E-10
Bi214	5.62E-05	5.61657E-20		0.631854371	1.509899923	0.011891859	2.153646154	7.20E-12
Bk249	5.39E-22	5.39325E-37		0.03299967			0.03299967	1.06E-30
Bk250	1.94E-26	1.93749E-41		0.26636366	0.886746664	0.02698613	1.180096454	1.36E-33
C 14	9.11E-03	9.1119E-18		0.04947			0.04947	2.68E-11
Cd109	8.11E-10	8.11386E-25			0.014910997	0.004730612	0.019641609	9.48E-19
Cd113m	2.67E+02	2.67401E-13		0.185357358			0.185357358	2.95E-06
Cd115m	7.02E-52	7.01999E-67		0.606227346	0.021898515		0.62812586	2.62E-59
Ce141	3.61E-71	3.60929E-86		0.1446745	0.076850362	0.025152933	0.246677795	5.30E-79
Ce144	3.61E-03	3.61187E-18		0.0832751	0.019274755	0.009263998	0.111813852	2.40E-11
Cf249	8.09E-16	8.08594E-31	5.832326913		0.331949482	0.037464582	6.201740977	2.98E-22
Cf250	4.13E-16	4.13182E-31	6.019605686		0.001194765	0.004455842	6.025256294	1.48E-22
Cf251	1.87E-18	1.86599E-33	5.6630136		0.121953755	0.159025305	5.94399266	6.60E-25
Cf252	4.40E-20	4.39839E-35			0.006078129	0.004222783	0.010300912	2.70E-29
Cm241	3.24E-81	3.24048E-96	0.0592	0.112			0.1712	3.30E-89
Cm242	1.35E-17	1.34831E-32	6.104058752		0.00886198	0.007548684	6.120469416	4.91E-24

Constituent	ICDF Average Activity Concentration (pCi/L)	ICDF Average Activity Concentration (Ci/cm^3)	Disintegration Energy from Alpha Radiation (MeV/dis)[a]	Disintegration Energy from Beta Radiation (MeV/dis)[a]	Disintegration Energy from Gamma Radiation (MeV/dis)[a]	Disintegration Energy from Electron Radiation (MeV/dis)[a]	Total Disintegration Energy (MeV/dis)[b]	ICDF Liner Radiation Dose (Rads/hr)
Cm248	4.88E-17	4.88339E-32	4.652098978		0.001053916	0.004771581	4.657924475	1.35E-23
Cm250	1.38E-25	1.3823E-40	1.2975	0.00126			1.29876	1.07E-32
Co-57	3.67E-01	3.67011E-16			0.125116492	0.018266873	0.143383365	3.13E-09
Co-58	5.84E-15	5.84275E-30			0.97577339	0.003554852	0.979328243	3.40E-22
Co-60	1.92E+04	1.92228E-11		0.09579	2.505813093		2.601603093	2.98E-03
Cr-51	7.66E-53	7.66009E-68			0.032581687	0.003609603	0.036191289	1.65E-61
Cs-134	2.24E+01	2.24236E-14		0.156843574	1.555088123	0.005168308	1.717100005	2.29E-06
Cs135	7.16E-02	7.16176E-17		0.0563			0.0563	2.40E-10
Cs137	4.89E+04	4.88614E-11		0.1707536			0.1707536	4.96E-04
Eu150	5.09E-08	5.08758E-23		0.292			0.292	8.84E-16
Eu152	2.85E+03	2.84526E-12		0.083686791	1.152309414	0.040284747	1.276280952	2.16E-04
Eu154	2.41E+03	2.41379E-12		0.225199121	1.253240971	0.04847077	1.526910861	2.19E-04
Eu155	5.19E+02	5.18807E-13		0.04544052	0.060584231	0.016346264	0.122371015	3.78E-06
Fe-59	2.05E-34	2.0497E-49		0.117452592	1.188458138		1.30591073	1.59E-41
Fr221	1.02E-07	1.02416E-22	6.35419518		0.030918345	0.009345796	6.394459322	3.90E-14
Fr223	5.65E-07	5.64646E-22		0.341682282	0.054245778	0.038798691	0.434726751	1.46E-14
Gd152	1.13E-13	1.13275E-28	2.1496				2.1496	1.45E-20
Gd153	8.38E-11	8.38004E-26			0.110492119	0.041857881	0.15235	7.60E-19
H 3	8.26E+05	8.26041E-10		0.005685			0.005685	2.79E-04
Hf-181	1.73E-36	1.73311E-51		0.118616	0.544135316	0.075669588	0.738420904	7.62E-44
Ho166m	1.08E-05	1.07982E-20		0.040363706	1.59696433	0.103964407	1.741292443	1.12E-12
I129	2.16E+04	2.16334E-11		0.0409	0.024638767	0.013400713	0.078939479	1.02E-04
In114	4.83E-54	4.83478E-69		0.771593317	0.031986443	4.73967E-05	0.803627157	2.31E-61
In114m	5.06E-54	5.06252E-69			0.097219841	0.142167093	0.239386934	7.21E-62
In115	1.48E-11	1.48146E-26		0.152			0.152	1.34E-19
K-40	1.27E+02	1.27291E-13		0.454278782	0.155895094	0.00019193	0.610365806	4.62E-06
La140	2.21E-105	2.2065E-120		0.527461627	2.316273704	0.005168104	2.848903435	3.74E-112
Mn-54	3.86E-07	3.85666E-22			0.83600515	0.003819757	0.839824907	1.93E-14
Nb92	6.34E-18	6.34129E-33			1.503376922	0.006587855	1.509964777	5.70E-25
Nb93m	1.35E-01	1.34956E-16			0.001949851	0.02830264	0.030252491	2.43E-10
Nb94	8.83E-05	8.82572E-20		0.1458	1.573752035	0.001108272	1.720660307	9.04E-12
Nb95	4.80E-32	4.79764E-47		0.04343358	0.764449657	0.000960441	0.808843679	2.31E-39
Nb95m	1.84E-34	1.83993E-49		0.024094426	0.066299718	0.156400746	0.24679489	2.70E-42
Nd144	1.36E-09	1.3614E-24	1.9				1.9	1.54E-16
Np235	8.43E-09	8.43464E-24			0.006849299	0.00295462	0.009803919	4.92E-18
Np236	8.60E-06	8.60333E-21		0.007895	0.144249657	0.188908994	0.341053651	1.75E-13
Np237	7.98E+01	7.97825E-14	4.759362826		0.032973835	0.062385374	4.854722034	2.30E-05
Np238	2.70E-05	2.70471E-20		0.224714208	0.554083268	0.029658953	0.808456429	1.30E-12
Np239	4.14E-02	4.14422E-17		0.115125998	0.172110902	0.128163122	0.415400022	1.02E-09
Np240	3.46E-12	3.46382E-27		0.241	1.16312137	0.190279619	1.594400989	3.29E-19
Np240m	3.15E-09	3.14893E-24		0.590015065	0.333687187	0.025194589	0.948896841	1.78E-16
Pa231	1.27E-04	1.26888E-19	5.380806428		0.037179164	0.035516603	5.453502195	4.12E-11
Pa233	7.92E-02	7.91815E-17		0.0585556	0.217583236	0.133362528	0.409501364	1.93E-09
Pa234	4.98E-06	4.98489E-21		0.22297083	1.966021292	0.2744944	2.463486522	7.31E-13
Pa234m	3.11E-03	3.11453E-18		0.820374363	0.011413333	0.003045741	0.834833438	1.55E-10
Pb209	4.85E-07	4.84656E-22		0.1976			0.1976	5.70E-15
Pb210	1.09E-05	1.09161E-20		0.00651402	0.004510364	0.027874272	0.038898656	2.53E-14
Pb211	1.83E-04	1.82992E-19		0.452909635	0.050904428	0.001625278	0.505439341	5.50E-12
Pb212	5.53E-03	5.52598E-18		0.09961888	0.14811816	0.073508769	0.321245808	1.06E-10
Pb214	5.62E-05	5.61657E-20		0.2195445	0.249218235	0.069709256	0.538471991	1.80E-12
Pd107	1.11E-01	1.11124E-16		0.033101			0.033101	2.19E-10
Pm146	2.42E-02	2.42035E-17		0.0895829	0.753108251	0.008140193	0.850831344	1.23E-09
Pm147	1.59E+03	1.58971E-12		0.061957827	3.51654E-06		0.061961344	5.86E-06
Pm148	1.66E-58	1.65511E-73		0.72568641	0.574309603	0.000924896	1.30092091	1.28E-65
Pm148m	3.43E-57	3.42833E-72		0.1454396	1.991307208	0.01855489	2.155301698	4.40E-64
Po210	6.77E-06	6.7654E-21	5.304496719		8.8341E-06		5.304505553	2.14E-12
Po211	4.56E-09	4.5606E-24	7.442553252		0.007761102		7.450314354	2.02E-15
Po212	2.19E-03	2.18667E-18	8.7849				8.7849	1.14E-09
Po213	2.89E-07	2.89342E-22	8.3769694		0.000030381		8.376999781	1.44E-13
Po214	3.75E-05	3.74513E-20	7.686985013		8.29192E-05		7.687067933	1.71E-11
Po215	1.22E-04	1.22019E-19	7.386157912		0.000149158		7.38630707	5.36E-11
Po216	3.68E-03	3.68473E-18	6.77847216		1.44882E-05		6.778486648	1.49E-09
Po218	3.75E-05	3.74513E-20	6.001296466				6.001296466	1.34E-11
Pr144	7.38E-03	7.38075E-18		1.207181838	0.031914881	0.044921056	1.284017776	5.64E-10
Pr144m	1.06E-04	1.05542E-19			0.01184728		0.01184728	7.44E-14
Pu236	3.95E-05	3.94781E-20	5.759246369		0.001823624	0.010642416	5.771712409	1.36E-11
Pu237	8.64E-58	8.63987E-73			0.053631643	0.00860943	0.062241073	3.20E-66

Constituent	ICDF Average Activity Concentration (pCi/L)	ICDF Average Activity Concentration (Ci/cm^3)	Disintegration Energy from Alpha Radiation (MeV/dis)[a]	Disintegration Energy from Beta Radiation (MeV/dis)[a]	Disintegration Energy from Gamma Radiation (MeV/dis)[a]	Disintegration Energy from Electron Radiation (MeV/dis)[a]	Total Disintegration Energy (MeV/dis)[b]	ICDF Liner Radiation Dose (Rads/hr)
Pu238	1.67E+03	1.66644E-12	5.487135213		0.001600358	0.008259555	5.496995126	5.45E-04
Pu239	4.76E+01	4.75673E-14	5.147993305		0.000654063	0.004879569	5.153526936	1.46E-05
Pu240	1.07E+01	1.07109E-14	5.15442817		0.001526154	0.008332035	5.164286359	3.29E-06
Pu241	4.56E+02	4.56263E-13		0.005229895			0.005229895	1.42E-07
Pu242	1.72E-03	1.71827E-18	4.914950908		0.001267029	0.006838836	4.923056772	5.03E-10
Pu243	4.56E-15	4.56263E-30		0.160416257	0.024856596	0.009931485	0.195204338	5.30E-23
Pu244	1.82E-10	1.81534E-25	4.59129767		0.001091163	0.00576354	4.598152374	4.97E-17
Pu246	9.87E-25	9.86952E-40		0.054192	0.100325541		0.154517541	9.07E-33
Ra222	1.17E-115	1.1686E-130	6.543645859		0.009191111	0.000710852	6.553547823	4.56E-122
Ra223	2.02E-04	2.02468E-19	5.693111445		0.135359242	0.070979646	5.899450334	7.11E-11
Ra224	5.53E-03	5.52598E-18	5.674903074		0.010016186	0.002181394	5.687100654	1.87E-09
Ra225	5.12E-07	5.11833E-22		0.09364	0.014401901	0.011183962	0.119225863	3.63E-15
Ra226	4.73E+00	4.73487E-15	4.779486739		0.006748	0.003450946	4.789685685	1.35E-06
Ra228	1.52E-09	1.52191E-24		0.0099	6.67E-09	0.001668	0.011568007	1.05E-18
Rb87	2.02E-04	2.02493E-19		0.0788			0.0788	9.50E-13
Rh102	5.71E-04	5.71027E-19		0.0798			0.0798	2.71E-12
Rh103m	5.43E-57	5.42777E-72			0.001719179	0.03714169	0.038860869	1.26E-65
Rh106	2.18E-01	2.18418E-16		1.412048767	0.207318974		1.61936774	2.10E-08
Rn218	2.10E-112	2.0999E-127	7.13224054		0.000755544		7.132996084	8.91E-119
Rn219	3.38E-01	3.3765E-16	6.768687931		0.057349406	0.006215139	6.832252476	1.37E-07
Rn220	9.22E+00	9.2155E-15	6.287774939		0.000522244		6.288297183	3.45E-06
Rn222	1.03E-01	1.03486E-16	5.48922225		0.00038912		5.48961137	3.38E-08
Ru103	3.65E-28	3.64513E-43		0.06754106	0.483836014	0.00219364	0.553570714	1.20E-35
Ru106	2.21E-01	2.20509E-16		0.039401			0.039401	5.17E-10
Sb124	4.14E-39	4.14237E-54		0.377755372	1.868890831	0.002369455	2.249015659	5.54E-46
Sb125	1.85E+02	1.85236E-13		0.08644006	0.432562126	0.011201711	0.530203897	5.84E-06
Sb126	4.12E-01	4.11874E-16		0.2904498	2.753144672	0.008852224	3.052446696	7.48E-08
Sb126m	2.94E+00	2.94195E-15		0.5821	1.572598561	0.010281928	2.164980488	3.79E-07
Sc-46	9.18E-20	9.1778E-35		0.112016432	2.009462055		2.121478487	1.16E-26
Se 79	4.08E+01	4.08468E-14		0.0522			0.0522	1.27E-07
Sm146	1.77E-09	1.77335E-24	2.53				2.53	2.67E-16
Sm147	1.71E-05	1.7098E-20	2.2476				2.2476	2.29E-12
Sm148	4.20E-12	4.20258E-27	1.99				1.99	4.98E-19
Sm149	2.13E-11	2.13338E-26	0	0			0	0.00E+00
Sm151	1.41E+03	1.40601E-12		0.019629664	1.26002E-05	0.000142779	0.019785044	1.66E-06
Sn119m	1.14E-06	1.14041E-21			0.011398832	0.075702053	0.087100885	5.91E-15
Sn121m	2.07E-01	2.06532E-16		0.00304			0.00304	3.74E-11
Sn123	6.47E-16	6.4725E-31		0.520527904	0.006892023		0.527419926	2.03E-23
Sn126	1.13E+00	1.1334E-15		0.2501	0.056584693	0.051902929	0.358587622	2.42E-08
Sr89	4.96E-42	4.96364E-57		0.58294069	0.000136365		0.583077055	1.72E-49
Sr90	1.90E+06	1.8965E-09		0.546			0.546	6.16E-02
Tb160	1.32E-33	1.32325E-48		0.225914897	1.081655763	0.045293923	1.352864583	1.07E-40
Tc 98	6.80E-04	6.79832E-19		0.118	1.394806477	0.002533816	1.515340293	6.13E-11
Tc 99	2.21E+04	2.21364E-11		0.084600002	5.3616E-07		0.084600538	1.11E-04
Te123	3.62E-14	3.61635E-29			0.013085863	0.003979538	0.017065401	3.67E-23
Te123m	2.36E-22	2.35653E-37			0.147968536	0.097813431	0.245781966	3.45E-30
Te125m	1.81E+01	1.81252E-14			0.035029212	0.1243697	0.159398912	1.72E-07
Te127	7.48E-19	7.48362E-34		0.222944359	0.004837938		0.227782297	1.01E-26
Te127m	7.60E-19	7.59597E-34		0.004605048	0.01122391	0.074989512	0.090818471	4.11E-27
Te129	5.40E-70	5.39691E-85		0.524547312	0.057653871	0.021254015	0.603455198	1.94E-77
Te129m	8.57E-70	8.56757E-85		0.211896011	0.039439344	0.057284	0.308619356	1.57E-77
Th226	2.18E-116	2.1787E-131	6.30769684		0.008516701	0.019601821	6.335815362	8.21E-123
Th227	1.82E-04	1.81633E-19	5.90223546		0.109621209	0.038621827	6.050478496	6.54E-11
Th228	3.29E-01	3.2872E-16	5.39930015		0.003074111	0.019010262	5.421384523	1.06E-07
Th229	5.12E-07	5.11833E-22	4.862233245		0.094769364	0.099685142	5.056687752	1.54E-13
Th230	1.73E+00	1.73379E-15	4.67678788		0.001405096	0.012883269	4.691076245	4.84E-07
Th231	1.61E+00	1.60797E-15		0.080038999	0.023548831	0.074878474	0.178466304	1.71E-08
Th232	1.56E+00	1.55721E-15	4.00455		0.001196619	0.010883174	4.016629793	3.72E-07
Th234	1.71E-02	1.71215E-17		0.0433679	0.009067919	0.014136614	0.066572433	6.78E-11
Tl207	1.83E-04	1.82539E-19		0.4932555	0.002169023		0.495424523	5.38E-12
Tl208	1.98E-03	1.97939E-18		0.554863585	3.369590402	0.034133866	3.958587853	4.66E-10
Tl209	1.05E-08	1.05084E-23		1.8248	2.117940734	0.028724369	3.971465102	2.48E-15
Tm170	2.66E-25	2.65672E-40		0.315252	0.005426825	0.014066319	0.334745144	5.29E-33
Tm171	6.64E-12	6.64218E-27		0.0248128	0.000683304	0.000721114	0.026217219	1.04E-20
U232	8.83E-02	8.8251E-17	5.306496425		0.001781837	0.014381205	5.322659468	2.80E-08
U233	4.23E-03	4.22558E-18	4.813433579		0.000718117	0.003004358	4.817156054	1.21E-09
U234	9.95E+02	9.94693E-13	4.763028496		0.001476859	0.011293806	4.775799161	2.83E-04

Constituent	ICDF Average Activity Concentration (pCi/L)	ICDF Average Activity Concentration (Ci/cm^3)	Disintegration Energy from Alpha Radiation (MeV/dis)[a]	Disintegration Energy from Beta Radiation (MeV/dis)[a]	Disintegration Energy from Gamma Radiation (MeV/dis)[a]	Disintegration Energy from Electron Radiation (MeV/dis)[a]	Total Disintegration Energy (MeV/dis)[b]	ICDF Liner Radiation Dose (Rads/hr)
U235	1.82E+01	1.81903E-14	4.378449		0.153592927	0.041995511	4.574037438	4.95E-06
U236	3.34E+01	3.33559E-14	4.4925232		0.001373011	0.009564051	4.503460262	8.94E-06
U238	3.22E+02	3.22148E-13	4.1940197		0.001212454	0.008504387	4.203736541	8.06E-05
U240	4.19E-09	4.18818E-24		0.125	0.006717716	0.028465325	0.160183041	3.99E-17
Xe127	2.63E-68	2.63427E-83			0.278982226	0.030144757	0.309126983	4.85E-76
Xe131m	4.49E-108	4.4853E-123			0.02009925	0.142249615	0.162348865	4.33E-116
Y90	1.35E+05	1.34525E-10		0.93471862		0.035127416	0.969846036	7.76E-03
Y91	2.44E-36	2.43696E-51		0.6022883	0.0036147		0.605903	8.79E-44
Zn65	1.68E-07	1.67979E-22			0.583769699	0.004560562	0.588330261	5.88E-15
Zr93	1.43E+00	1.4275E-15		0.0195			0.0195	1.66E-09
Zr95	4.87E-25	4.87454E-40		0.116123	0.73494917		0.85107217	2.47E-32
Total Absorbed Dose Rate in Rads/Hour								**9.30E-02**
Total Absorbed Dose For 15 year Operational Life in Rads								**1.22E+04**

References:

a. Disintigration energy based on the total energy reported in the following sources:

Computer software: Radiation Decay Version 3.5 developed by Professor Charles Hacker, Griffith Univeristy, Gold Coast, ustraila

Handbook of Health Physics and Radiological Health, 3rd Edition, edited by Bernard Shlelen, Lester A. Slaback Jr., and Brian Kent Birky, Baltimore, Maryland, 1998

National Nuclear Data Center web site, Decay in the MIRD format, www:nndc.bnl.gov/nnbc/formmird.html

b. Total disintigration energy is the sum of alpha, beta, gamma, and electron energies.

Appendix B-2

Geomembrane Dose in the Evaporation Pond

MONTGOMERY WATSON HARZA
Description: Radiation dosage to ICDF evaporation ponds liner resulting from leachate exposure
Project #: 2470178
Prepared by: J. Thompson
Date: 10/6/01
Checked by: B. Adams/J. Pellicer
Date: 12-7-01

VARIABLES

Liner Thickness =	60 mils
Liner density =	0.94 g/cm^3
Depth of leachate =	36 cm

CONVERSIONS

pCi/Ci =	1.00E+12
cm^3/l =	1000
cm/mil =	2.54E-03
(dis/s)/Ci =	3.70E+10
sec/hr =	3600
g/kg =	1.00E+03
eV/Mev =	1.00E+06
J/eV =	1.60E-19
rad/Gy =	100

Constituent	ICDF Average Activity Concentration (pCi/L)	ICDF Average Activity Concentration (Ci/cm^3)	Disintegration Energy from Alpha Radiation (MeV/dis)[a]	Disintegration Energy from Beta Radiation (MeV/dis)[a]	Disintegration Energy from Gamma Radiation (MeV/dis)[a]	Disintegration Energy from Electron Radiation (MeV/dis)[a]	Total Disintegration Energy (MeV/dis)[b]	ICDF Liner Radiation Dose (Rads/hr)
Ac225	1.1E-07	1.14E-22	5.794750712		0.015675725	0.021753375	5.832179811	3.55E-13
Ac227	4.5E-05	4.54E-20	0.067076762	0.009519	0.000269356	0.002766609	0.079631727	1.94E-12
Ac228	3.4E-10	3.38E-25		0.365039719	0.926920369	0.064207018	1.356167107	2.46E-16
Ag108	4.1E-08	4.10E-23		0.609441	0.017742571	0.000104798	0.627288369	1.38E-14
Ag108m	8.9E+00	8.88E-15			1.619571716	0.014175304	1.63374702	7.77E-06
Ag109m	5.5E-11	5.46E-26			0.011251468	0.075708836	0.086960304	2.54E-18
Ag110	5.7E-10	5.74855E-25		1.181485222	0.030569692	1.49286E-05	1.212069842	3.73E-16
Ag110m	6.2E-08	6.15802E-23		0.065497652	2.740392268	0.002891351	2.808781272	9.26E-14
Am241	7.0E+01	7.00857E-14	5.4776265		0.028100691	0.029402026	5.535129217	2.08E-04
Am242	1.3E-04	1.33277E-19		0.159206	0.01777726	0.014518168	0.191501428	1.37E-11
Am242m	1.3E-04	1.32877E-19	0.02491305		0.004697851	0.036045937	0.065656838	4.67E-12
Am243	9.8E-04	9.8225E-19	5.26454376		0.058325807	0.025255628	5.348125195	2.81E-09
Am246	4.1E-25	4.06494E-40		0.2600814	0.979943558	0.029091734	1.269116692	2.76E-31
At217	8.5E-04	8.53567E-19	7.065707158				7.065707158	3.23E-09
Ba137m	4.6E+05	4.61732E-10			0.597793455	0.063669106	0.661462561	1.64E-01
Be 10	4.6E-06	4.56737E-21		0.2025			0.2025	4.95E-13
Bi210	1.1E-05	1.09161E-20		0.389			0.389	2.27E-12
Bi211	1.8E-04	1.82992E-19	6.549152819	0.000476658	0.047468126	0.009283362	6.606380966	6.47E-10
Bi214	5.6E-05	5.61657E-20		0.631854371	1.509899923	0.011891859	2.153646154	6.48E-11
Bk249	5.4E-22	5.39325E-37		0.03299967			0.03299967	9.53E-30
Bk250	1.9E-26	1.93749E-41		0.26636366	0.886746664	0.02698613	1.180096454	1.22E-32
Cd109	8.1E-10	8.11386E-25			0.014910997	0.004730612	0.019641609	8.54E-18
Cd113m	2.7E+02	2.67401E-13		0.185357358			0.185357358	2.65E-05
Ce141	3.6E-71	3.60929E-86		0.1446745	0.076850362	0.025152933	0.246677795	4.77E-78
Ce144	3.6E-03	3.61187E-18		0.0832751	0.019274755	0.009263998	0.111813852	2.16E-10
Cf249	8.1E-16	8.08594E-31	5.832326913		0.331949482	0.037464582	6.201740977	2.69E-21
Cf250	4.1E-16	4.13182E-31	6.019605686		0.001194765	0.004455842	6.025256294	1.33E-21
Cf251	1.9E-18	1.86599E-33	5.6630136		0.121953755	0.159025305	5.94399266	5.94E-24
Cm241	3.2E-81	3.24048E-96	0.0592	0.112			0.1712	2.97E-88
Cm242	1.3E-17	1.34831E-32	6.104058752		0.00886198	0.007548684	6.120469416	4.42E-23
Cm243	8.9E-07	8.883E-22	5.834234959		0.132613797	0.122747969	6.089596726	2.90E-12
Cm244	4.5E-04	4.50948E-19	5.796499747		0.001490051	0.006438553	5.804428351	1.40E-09
Cm245	2.0E-08	2.00547E-23	5.360616241		0.076920127	0.069851389	5.507387757	5.92E-14
Cm246	4.5E-10	4.47549E-25	5.37557179		0.001325463	0.006093795	5.382991049	1.29E-15
Cm247	1.6E-16	1.59758E-31	4.946722		0.317367237	0.014739412	5.278828648	4.52E-22
Cm248	4.9E-17	4.88339E-32	4.652098978		0.001053916	0.004771581	4.657924475	1.22E-22
Co-57	3.7E-01	3.67011E-16			0.125116492	0.018266873	0.143383365	2.82E-08
Co-58	5.8E-15	5.84275E-30			0.97577339	0.003554852	0.979328243	3.06E-21
Co-60	1.9E+04	1.92228E-11		0.09579	2.505813093		2.601603093	2.68E-02
Cr-51	7.7E-53	7.66009E-68			0.032581687	0.003609603	0.036191289	1.48E-60
Cs-134	2.2E+01	2.24236E-14		0.156843574	1.555088123	0.005168308	1.717100005	2.06E-05
Cs135	7.2E-02	7.16176E-17		0.0563			0.0563	2.16E-09
Cs137	4.9E+04	4.88614E-11		0.1707536			0.1707536	4.47E-03
Eu150	5.1E-08	5.08758E-23		0.292			0.292	7.96E-15
Eu152	2.8E+03	2.84526E-12		0.083686791	1.152309414	0.040284747	1.276280952	1.94E-03
Eu154	2.4E+03	2.41379E-12		0.225199121	1.253240971	0.04847077	1.526910861	1.97E-03
Eu155	5.2E+02	5.18807E-13		0.04544052	0.060584231	0.016346264	0.122371015	3.40E-05
Fe-59	2.0E-34	2.0497E-49		0.117452592	1.188458138		1.30591073	1.43E-40
Fr221	1.0E-07	1.02416E-22	6.35419518		0.030918345	0.009345796	6.394459322	3.51E-13

Constituent	ICDF Average Activity Concentration (pCi/L)	ICDF Average Activity Concentration (Ci/cm³)	Disintegration Energy from Alpha Radiation (MeV/dis)[a]	Disintegration Energy from Beta Radiation (MeV/dis)[a]	Disintegration Energy from Gamma Radiation (MeV/dis)[a]	Disintegration Energy from Electron Radiation (MeV/dis)[a]	Total Disintegration Energy (MeV/dis)[b]	ICDF Liner Radiation Dose (Rads/hr)
In114m	5.1E-54	5.06252E-69			0.097219841	0.142167093	0.239386934	6.49E-61
In115	1.5E-11	1.48146E-26		0.152			0.152	1.21E-18
K-40	1.3E+02	1.27291E-13		0.454278782	0.155895094	0.00019193	0.610365806	4.16E-05
La140	2.2E-105	2.2065E-120		0.527461627	2.316273704	0.005168104	2.848903435	3.37E-111
Mn-54	3.9E-07	3.85666E-22			0.83600515	0.003819757	0.839824907	1.73E-13
Nb92	6.3E-18	6.34129E-33			1.503376922	0.006587855	1.509964777	5.13E-24
Nb93m	1.3E-01	1.34956E-16			0.001949851	0.02830264	0.030252491	2.19E-09
Nb94	8.8E-05	8.82572E-20		0.1458	1.573752035	0.001108272	1.720660307	8.13E-11
Nb95m	1.8E-34	1.83993E-49		0.024094426	0.066299718	0.156400746	0.24679489	2.43E-41
Nd144	1.4E-09	1.3614E-24	1.9				1.9	1.39E-15
Np236	8.6E-06	8.60333E-21		0.007895	0.144249657	0.188908994	0.341053651	1.57E-12
Np239	4.1E-02	4.14422E-17		0.115125998	0.172110902	0.128163122	0.415400022	9.22E-09
Np240m	3.1E-09	3.14893E-24		0.590015065	0.333687187	0.025194589	0.948896841	1.60E-15
Pa231	1.3E-04	1.26888E-19	5.380806428		0.037179164	0.035516603	5.453502195	3.71E-10
Pa233	7.9E-02	7.91815E-17		0.0585556	0.217583236	0.133362528	0.409501364	1.74E-08
Pa234	5.0E-06	4.98489E-21		0.22297083	1.966021292	0.2744944	2.463486522	6.58E-12
Pa234m	3.1E-03	3.11453E-18		0.820374363	0.011413333	0.003045741	0.834833438	1.39E-09
Pb209	4.8E-07	4.84656E-22		0.1976			0.1976	5.13E-14
Pb210	1.1E-05	1.09161E-20		0.00651402	0.004510364	0.027874272	0.038898656	2.27E-13
Pb212	5.5E-03	5.52598E-18		0.09961888	0.14811816	0.073508769	0.321245808	9.51E-10
Pb214	5.6E-05	5.61657E-20		0.2195445	0.249218235	0.069709256	0.538471991	1.62E-11
Pd107	1.1E-01	1.11124E-16		0.033101			0.033101	1.97E-09
Pm146	2.4E-02	2.42035E-17		0.0895829	0.753108251	0.008140193	0.850831344	1.10E-08
Pm147	1.6E+03	1.58971E-12		0.061957827	3.51654E-06		0.061961344	5.28E-05
Pm148	1.7E-58	1.65511E-73		0.72568641	0.574309603	0.000924896	1.30092091	1.15E-64
Pm148m	3.4E-57	3.42833E-72		0.1454396	1.991307208	0.01855489	2.155301698	3.96E-63
Po210	6.8E-06	6.7654E-21	5.304496719		8.8341E-06		5.304505553	1.92E-11
Po211	4.6E-09	4.5606E-24	7.442553252		0.007761102		7.450314354	1.82E-14
Po212	2.2E-03	2.18667E-18	8.7849				8.7849	1.03E-08
Po213	2.9E-07	2.89342E-22	8.3769694		0.000030381		8.376999781	1.30E-12
Po214	3.7E-05	3.74513E-20	7.686985013		8.29192E-05		7.687067933	1.54E-10
Po215	1.2E-04	1.22019E-19	7.386157912		0.000149158		7.38630707	4.83E-10
Po216	3.7E-03	3.68473E-18	6.77847216		1.44882E-05		6.778486648	1.34E-08
Po218	3.7E-05	3.74513E-20	6.001296466				6.001296466	1.20E-10
Pr144	7.4E-03	7.38075E-18		1.207181838	0.031914881	0.044921056	1.284017776	5.08E-09
Pr144m	1.1E-04	1.05542E-19			0.01184728		0.01184728	6.70E-13
Pu236	3.9E-05	3.94781E-20	5.759246369		0.001823624	0.010642416	5.771712409	1.22E-10
Pu237	8.6E-58	8.63987E-73			0.053631643	0.00860943	0.062241073	2.88E-65
Pu238	1.7E+03	1.66644E-12	5.487135213		0.001600358	0.008259555	5.496995126	4.91E-03
Pu239	4.8E+01	4.75673E-14	5.147993305		0.000654063	0.004879569	5.153526936	1.31E-04
Pu240	1.1E+01	1.07109E-14	5.15442817		0.001526154	0.008332035	5.164286359	2.96E-05
Pu241	4.6E+02	4.56263E-13		0.005229895			0.005229895	1.28E-06
Pu242	1.7E-03	1.71827E-18	4.914950908		0.001267029	0.006838836	4.923056772	4.53E-09
Pu243	4.6E-15	4.56263E-30		0.160416257	0.024856596	0.009931485	0.195204338	4.77E-22
Pu244	1.8E-10	1.81534E-25	4.59129767		0.001091163	0.00576354	4.598152374	4.47E-16
Pu246	9.9E-25	9.86952E-40		0.054192	0.100325541		0.154517541	8.17E-32
Ra222	1.2E-115	1.1686E-130	6.543645859		0.009191111	0.000710852	6.553547823	4.10E-121
Ra224	5.5E-03	5.52598E-18	5.674903074		0.010016186	0.002181394	5.687100654	1.68E-08
Ra225	5.1E-07	5.11833E-22		0.09364	0.014401901	0.011183962	0.119225863	3.27E-14
Ra226	4.7E+00	4.73487E-15	4.779486739		0.006748	0.003450946	4.789685685	1.21E-05
Ra228	1.5E-09	1.52191E-24		0.0099	6.67E-09	0.001668	0.011568007	9.43E-18
Rb87	2.0E-04	2.02493E-19		0.0788			0.0788	8.55E-12
Rh102	5.7E-04	5.71027E-19		0.0798			0.0798	2.44E-11
Rh103m	5.4E-57	5.42777E-72			0.001719179	0.03714169	0.038860869	1.13E-64
Rh106	2.2E-01	2.18418E-16		1.412048767	0.207318974		1.61936774	1.89E-07
Rn218	2.1E-112	2.0999E-127	7.13224054		0.000755544		7.132996084	8.02E-118
Rn219	3.4E-01	3.3765E-16	6.768687931		0.057349406	0.006215139	6.832252476	1.24E-06
Rn220	9.2E+00	9.2155E-15	6.287774939		0.000522244		6.288297183	3.10E-05
Rn222	1.0E-01	1.03486E-16	5.48922225		0.00038912		5.48961137	3.04E-07
Ru103	3.6E-28	3.64513E-43		0.06754106	0.483836014	0.00219364	0.553570714	1.08E-34
Ru106	2.2E-01	2.20509E-16		0.039401			0.039401	4.65E-09
Sb124	4.1E-39	4.14237E-54		0.377755372	1.868890831	0.002369455	2.249015659	4.99E-45
Sb125	1.9E+02	1.85236E-13		0.08644006	0.432562126	0.011201711	0.530203897	5.26E-05
Sb126	4.1E-01	4.11874E-16		0.2904498	2.753144672	0.008852224	3.052446696	6.73E-07
Sc-46	9.2E-20	9.1778E-35		0.112016432	2.009462055		2.121478487	1.04E-25
Se 79	4.1E+01	4.08468E-14		0.0522			0.0522	1.14E-06
Sm146	1.8E-09	1.77335E-24	2.53				2.53	2.40E-15
Sm147	1.7E-05	1.7098E-20	2.2476				2.2476	2.06E-11
Sm148	4.2E-12	4.20258E-27	1.99				1.99	4.48E-18

Constituent	ICDF Average Activity Concentration (pCi/L)	ICDF Average Activity Concentration (Ci/cm^3)	Disintegration Energy from Alpha Radiation (MeV/dis)[a]	Disintegration Energy from Beta Radiation (MeV/dis)[a]	Disintegration Energy from Gamma Radiation (MeV/dis)[a]	Disintegration Energy from Electron Radiation (MeV/dis)[a]	Total Disintegration Energy (MeV/dis)[b]	ICDF Liner Radiation Dose (Rads/hr)
Sm151	1.4E+03	1.40601E-12		0.019629664	1.26002E-05	0.000142779	0.019785044	1.49E-05
Sn119m	1.1E-06	1.14041E-21			0.011398832	0.075702053	0.087100885	5.32E-14
Sn121m	2.1E-01	2.06532E-16		0.00304			0.00304	3.36E-10
Sn123	6.5E-16	6.4725E-31		0.520527904	0.006892023		0.527419926	1.83E-22
Sn126	1.1E+00	1.1334E-15		0.2501	0.056584693	0.051902929	0.358587622	2.18E-07
Sr89	5.0E-42	4.96364E-57		0.58294069	0.000136365		0.583077055	1.55E-48
Sr90	1.9E+06	1.8965E-09		0.546			0.546	5.55E-01
Tb160	1.3E-33	1.32325E-48		0.225914897	1.081655763	0.045293923	1.352864583	9.59E-40
Tc 98	6.8E-04	6.79832E-19		0.118	1.394806477	0.002533816	1.515340293	5.52E-10
Tc 99	2.2E+04	2.21364E-11		0.084600002	5.3616E-07		0.084600538	1.00E-03
Te123	3.6E-14	3.61635E-29			0.013085863	0.003979538	0.017065401	3.31E-22
Te123m	2.4E-22	2.35653E-37			0.147968536	0.097813431	0.245781966	3.10E-29
Te125m	1.8E+01	1.81252E-14			0.035029212	0.1243697	0.159398912	1.55E-06
Te127m	7.6E-19	7.59597E-34		0.004605048	0.01122391	0.074989512	0.090818471	3.69E-26
Te129	5.4E-70	5.39691E-85		0.524547312	0.057653871	0.021254015	0.603455198	1.74E-76
Te129m	8.6E-70	8.56757E-85		0.211896011	0.039439344	0.057284	0.308619356	1.42E-76
Th226	2.2E-116	2.1787E-131	6.30769684		0.008516701	0.019601821	6.335815362	7.39E-122
Th227	1.8E-04	1.81633E-19	5.90223546		0.109621209	0.038621827	6.050478496	5.89E-10
Th228	3.3E-01	3.2872E-16	5.39930015		0.003074111	0.019010262	5.421384523	9.54E-07
Th229	5.1E-07	5.11833E-22	4.862233245		0.094769364	0.099685142	5.056687752	1.39E-12
Th230	1.7E+00	1.73379E-15	4.67678788		0.001405096	0.012883269	4.691076245	4.36E-06
Th231	1.6E+00	1.60797E-15		0.080038999	0.023548831	0.074878474	0.178466304	1.54E-07
Th232	1.6E+00	1.55721E-15	4.00455		0.001196619	0.010883174	4.016629793	3.35E-06
Th234	1.7E-02	1.71215E-17		0.0433679	0.009067919	0.014136614	0.066572433	6.10E-10
Tl207	1.8E-04	1.82539E-19		0.4932555	0.002169023		0.495424523	4.84E-11
Tl208	2.0E-03	1.97939E-18		0.554863585	3.369590402	0.034133866	3.958587853	4.20E-09
Tl209	1.1E-08	1.05084E-23		1.8248	2.117940734	0.028724369	3.971465102	2.24E-14
Tm170	2.7E-25	2.65672E-40		0.315252	0.005426825	0.014066319	0.334745144	4.76E-32
Tm171	6.6E-12	6.64218E-27		0.0248128	0.000683304	0.000721114	0.026217219	9.33E-20
U232	8.8E-02	8.8251E-17	5.306496425		0.001781837	0.014381205	5.322659468	2.52E-07
U233	4.2E-03	4.22558E-18	4.813433579		0.000718117	0.003004358	4.817156054	1.09E-08
U234	9.9E+02	9.94693E-13	4.763028496		0.001476859	0.011293806	4.775799161	2.54E-03
U235	1.8E+01	1.81903E-14	4.378449		0.153592927	0.041995511	4.574037438	4.46E-05
U236	3.3E+01	3.33559E-14	4.4925232		0.001373011	0.009564051	4.503460262	8.05E-05
U238	3.2E+02	3.22148E-13	4.1940197		0.001212454	0.008504387	4.203736541	7.25E-04
U240	4.2E-09	4.18818E-24		0.125	0.006717716	0.028465325	0.160183041	3.59E-16
Xe127	2.6E-68	2.63427E-83			0.278982226	0.030144757	0.309126983	4.36E-75
Xe131m	4.5E-108	4.4853E-123			0.02009925	0.142249615	0.162348865	3.90E-115
Y90	1.3E+05	1.34525E-10		0.93471862		0.035127416	0.969846036	6.99E-02
Zn65	1.7E-07	1.67979E-22			0.583769699	0.004560562	0.588330261	5.29E-14
Zr93	1.4E+00	1.4275E-15		0.0195			0.0195	1.49E-08
Zr95	4.9E-25	4.87454E-40		0.116123	0.73494917		0.85107217	2.22E-31
Total Absorbed Dose Rate in Rads/Hour								**8.36E-01**
Total Absorbed Dose For 15 year Operational Life in Rads								**1.10E+05**

References:

a. Disintigration energy based on the total energy reported in the following sources:

Computer software: Radiation Decay Version 3.5 developed by Professor Charles Hacker, Griffith Univeristy, Gold Coast, ustraila

Handbook of Health Physics and Radiological Health, 3rd Edition, edited by Bernard Shleien, Lester A. Slaback Jr., and Brian Kent Birky, Baltimore, Maryland, 1998

National Nuclear Data Center web site, Decay in the MIRD format, www:nndc.bnl.gov/nnbc/formmird.html

b. Total disintigration energy is the sum of alpha, beta, gamma, and electron energies.

Appendix B-3

Maximum Allowable Geomembrane Dose
Calculation for the Landfill

MONTGOMERY WATSON HARZA

Description: Back calculation of maximum allowable concentration for each distinct Parameter. for the landfill liner

Project #: 2470178

Prepared by: B.G. Adams

Date: 12/5/01

Checked by: J. Pellicer

Date: 12/7/01

VARIABLES

Liner Thickness =	60	mils
Liner density =	0.94	g/cm^3
Depth of leachate =	4	cm

15 yr Dose =	1.0E+06
Daily Dose =	1.8E+02
Dose Rad/hr =	7.6E+00

CONVERSIONS

pCi/Ci =	1.00E+12
cm^3/l =	1000
cm/mil =	2.54E-03
(dis/s)/Ci =	3.70E+10
sec/hr =	3600
g/kg =	1.00E+03
eV/Mev =	1.00E+06
J/eV =	1.60E-19
rad/Gy =	100

Constituent	ICDF Maximum Allowable Activity Concentration (pCi/L)	ICDF Maximum Allowable Activity Concentration (Ci/cm^3)	Disintegration Energy (MeV/dis)	ICDF Liner Absorbed Dose (Rads/hr)
Ac225	2.2E+07	2.19282E-08	5.832179811	7.61E+00
Ac227	1.6E+09	1.60601E-06	0.079631727	7.61E+00
Ac228	9.4E+07	9.43018E-08	1.356167107	7.61E+00
Ag108	2.0E+08	2.03876E-07	0.627288369	7.61E+00
Ag108m	7.8E+07	7.82796E-08	1.63374702	7.61E+00
Ag109m	1.5E+09	1.47066E-06	0.086960304	7.61E+00
Ag110	1.1E+08	1.05513E-07	1.212069842	7.61E+00
Ag110m	4.6E+07	4.55319E-08	2.808781272	7.61E+00
Am241	2.3E+07	2.3105E-08	5.535129217	7.61E+00
Am242	6.7E+08	6.67823E-07	0.191501428	7.61E+00
Am242m	1.9E+09	1.94784E-06	0.065656838	7.61E+00
Am243	2.4E+07	2.39129E-08	5.348125195	7.61E+00
Am246	1.0E+08	1.0077E-07	1.269116692	7.61E+00
At217	1.8E+07	1.81E-08	7.065707158	7.61E+00
Ba137m	1.9E+08	1.93343E-07	0.661462561	7.61E+00
Be 10	6.3E+08	6.31551E-07	0.2025	7.61E+00
Bi210	3.3E+08	3.28764E-07	0.389	7.61E+00
Bi211	1.9E+07	1.93584E-08	6.606380966	7.61E+00
Bi214	5.9E+07	5.93826E-08	2.153646154	7.61E+00
Bk249	3.9E+09	3.87546E-06	0.03299967	7.61E+00
Bk250	1.1E+08	1.08372E-07	1.180096454	7.61E+00
Cd109	6.5E+09	6.51113E-06	0.019641609	7.61E+00
Cd113m	6.9E+08	6.89959E-07	0.185357358	7.61E+00
Ce141	5.2E+08	5.18446E-07	0.246677795	7.61E+00
Ce144	1.1E+09	1.14377E-06	0.111813852	7.61E+00
Cf249	2.1E+07	2.06215E-08	6.201740977	7.61E+00

Constituent	ICDF Maximum Allowable Activity Concentration (pCi/L)	ICDF Maximum Allowable Activity Concentration (Ci/cm^3)	Disintegration Energy (MeV/dis)	ICDF Liner Absorbed Dose (Rads/hr)
Cf250	2.1E+07	2.12255E-08	6.025256294	7.61E+00
Cf251	2.2E+07	2.15157E-08	5.94399266	7.61E+00
Cm241	7.5E+08	7.47015E-07	0.1712	7.61E+00
Cm242	2.1E+07	2.08953E-08	6.120469416	7.61E+00
Cm243	2.1E+07	2.10012E-08	6.089596726	7.61E+00
Cm244	2.2E+07	2.2033E-08	5.804428351	7.61E+00
Cm245	2.3E+07	2.32214E-08	5.507387757	7.61E+00
Cm246	2.4E+07	2.3758E-08	5.382991049	7.61E+00
Cm247	2.4E+07	2.42268E-08	5.278828648	7.61E+00
Cm248	2.7E+07	2.74562E-08	4.657924475	7.61E+00
Co-57	8.9E+08	8.91938E-07	0.143383365	7.61E+00
Co-58	1.3E+08	1.30589E-07	0.979328243	7.61E+00
Co-60	4.9E+07	4.91578E-08	2.601603093	7.61E+00
Cr-51	3.5E+09	3.5337E-06	0.036191289	7.61E+00
Cs-134	7.4E+07	7.44797E-08	1.717100005	7.61E+00
Cs135	2.3E+09	2.27156E-06	0.0563	7.61E+00
Cs137	7.5E+08	7.48968E-07	0.1707536	7.61E+00
Eu150	4.4E+08	4.37976E-07	0.292	7.61E+00
Eu152	1.0E+08	1.00204E-07	1.276280952	7.61E+00
Eu154	8.4E+07	8.37567E-08	1.526910861	7.61E+00
Eu155	1.0E+09	1.04509E-06	0.122371015	7.61E+00
Fe-59	9.8E+07	9.79309E-08	1.30591073	7.61E+00
Fr221	2.0E+07	2E-08	6.394459322	7.61E+00
Fr223	2.9E+08	2.94183E-07	0.434726751	7.61E+00
Gd153	8.4E+08	8.39442E-07	0.15235	7.61E+00
H 3	2.2E+10	2.24959E-05	0.005685	7.61E+00
Ho166m	7.3E+07	7.34449E-08	1.741292443	7.61E+00
In114	1.6E+08	1.5914E-07	0.803627157	7.61E+00
In114m	5.3E+08	5.34236E-07	0.239386934	7.61E+00
In115	8.4E+08	8.41375E-07	0.152	7.61E+00
K-40	2.1E+08	2.09528E-07	0.610365806	7.61E+00
La140	4.5E+07	4.48906E-08	2.848903435	7.61E+00
Mn-54	1.5E+08	1.52281E-07	0.839824907	7.61E+00
Nb92	8.5E+07	8.46967E-08	1.509964777	7.61E+00
Nb93m	4.2E+09	4.22739E-06	0.030252491	7.61E+00
Nb94	7.4E+07	7.43255E-08	1.720660307	7.61E+00
Nb95m	5.2E+08	5.182E-07	0.24679489	7.61E+00
Nd144	6.7E+07	6.731E-08	1.9	7.61E+00
Np236	3.7E+08	3.74982E-07	0.341053651	7.61E+00
Np239	3.1E+08	3.0787E-07	0.415400022	7.61E+00
Np240m	1.3E+08	1.34777E-07	0.948896841	7.61E+00

Constituent	ICDF Maximum Allowable Activity Concentration (pCi/L)	ICDF Maximum Allowable Activity Concentration (Ci/cm^3)	Disintegration Energy (MeV/dis)	ICDF Liner Absorbed Dose (Rads/hr)
Pa231	2.3E+07	2.34508E-08	5.453502195	7.61E+00
Pa233	3.1E+08	3.12304E-07	0.409501364	7.61E+00
Pa234	5.2E+07	5.19138E-08	2.463486522	7.61E+00
Pa234m	1.5E+08	1.53191E-07	0.834833438	7.61E+00
Pb209	6.5E+08	6.47212E-07	0.1976	7.61E+00
Pb210	3.3E+09	3.28775E-06	0.038898656	7.61E+00
Pb212	4.0E+08	3.98103E-07	0.321245808	7.61E+00
Pb214	2.4E+08	2.37504E-07	0.538471991	7.61E+00
Pd107	3.9E+09	3.8636E-06	0.033101	7.61E+00
Pm146	1.5E+08	1.50311E-07	0.850831344	7.61E+00
Pm147	2.1E+09	2.06401E-06	0.061961344	7.61E+00
Pm148	9.8E+07	9.83065E-08	1.30092091	7.61E+00
Pm148m	5.9E+07	5.93369E-08	2.155301698	7.61E+00
Po210	2.4E+07	2.41095E-08	5.304505553	7.61E+00
Po211	1.7E+07	1.71656E-08	7.450314354	7.61E+00
Po212	1.5E+07	1.45578E-08	8.7849	7.61E+00
Po213	1.5E+07	1.52667E-08	8.376999781	7.61E+00
Po214	1.7E+07	1.66369E-08	7.687067933	7.61E+00
Po215	1.7E+07	1.73143E-08	7.38630707	7.61E+00
Po216	1.9E+07	1.88669E-08	6.778486648	7.61E+00
Po218	2.1E+07	2.13102E-08	6.001296466	7.61E+00
Pr144	1.0E+08	9.96007E-08	1.284017776	7.61E+00
Pr144m	1.1E+10	1.07948E-05	0.01184728	7.61E+00
Pu236	2.2E+07	2.21579E-08	5.771712409	7.61E+00
Pu237	2.1E+09	2.05474E-06	0.062241073	7.61E+00
Pu238	2.3E+07	2.32653E-08	5.496995126	7.61E+00
Pu239	2.5E+07	2.48158E-08	5.153526936	7.61E+00
Pu240	2.5E+07	2.47641E-08	5.164286359	7.61E+00
Pu241	2.4E+10	2.44535E-05	0.005229895	7.61E+00
Pu242	2.6E+07	2.59776E-08	4.923056772	7.61E+00
Pu243	6.6E+08	6.55155E-07	0.195204338	7.61E+00
Pu244	2.8E+07	2.78131E-08	4.598152374	7.61E+00
Pu246	8.3E+08	8.27667E-07	0.154517541	7.61E+00
Ra222	2.0E+07	1.95145E-08	6.553547823	7.61E+00
Ra224	2.2E+07	2.24876E-08	5.687100654	7.61E+00
Ra225	1.1E+09	1.07266E-06	0.119225863	7.61E+00
Ra226	2.7E+07	2.67009E-08	4.789685685	7.61E+00
Ra228	1.1E+10	1.10554E-05	0.011568007	7.61E+00
Rb87	1.6E+09	1.62296E-06	0.0788	7.61E+00
Rh102	1.6E+09	1.60262E-06	0.0798	7.61E+00
Rh103m	3.3E+09	3.29095E-06	0.038860869	7.61E+00

Constituent	ICDF Maximum Allowable Activity Concentration (pCi/L)	ICDF Maximum Allowable Activity Concentration (Ci/cm^3)	Disintegration Energy (MeV/dis)	ICDF Liner Absorbed Dose (Rads/hr)
Rh106	7.9E+07	7.89747E-08	1.61936774	7.61E+00
Rn218	1.8E+07	1.79292E-08	7.132996084	7.61E+00
Rn219	1.9E+07	1.87184E-08	6.832252476	7.61E+00
Rn220	2.0E+07	2.03376E-08	6.288297183	7.61E+00
Rn222	2.3E+07	2.32966E-08	5.48961137	7.61E+00
Ru103	2.3E+08	2.31026E-07	0.553570714	7.61E+00
Ru106	3.2E+09	3.24583E-06	0.039401	7.61E+00
Sb124	5.7E+07	5.68644E-08	2.249015659	7.61E+00
Sb125	2.4E+08	2.41207E-07	0.530203897	7.61E+00
Sb126	4.2E+07	4.18972E-08	3.052446696	7.61E+00
Sc-46	6.0E+07	6.0283E-08	2.121478487	7.61E+00
Se 79	2.4E+09	2.44998E-06	0.0522	7.61E+00
Sm146	5.1E+07	5.0549E-08	2.53	7.61E+00
Sm147	5.7E+07	5.69003E-08	2.2476	7.61E+00
Sm148	6.4E+07	6.42658E-08	1.99	7.61E+00
Sm151	6.5E+09	6.46392E-06	0.019785044	7.61E+00
Sn119m	6.5E+09	6.46392E-06	0.019785044	7.61E+00
Sn121m	1.5E+09	1.46829E-06	0.087100885	7.61E+00
Sn123	4.2E+10	4.20688E-05	0.00304	7.61E+00
Sn126	2.4E+08	2.4248E-07	0.527419926	7.61E+00
Sr89	3.6E+08	3.56646E-07	0.358587622	7.61E+00
Sr90	2.2E+08	2.19335E-07	0.583077055	7.61E+00
Tb160	2.3E+08	2.34229E-07	0.546	7.61E+00
Tc 98	9.5E+07	9.4532E-08	1.352864583	7.61E+00
Tc 99	8.4E+07	8.43962E-08	1.515340293	7.61E+00
Te123	1.5E+09	1.51168E-06	0.084600538	7.61E+00
Te123m	7.5E+09	7.49405E-06	0.017065401	7.61E+00
Te127	8.0E+08	8.02321E-07	0.159398912	7.61E+00
Te127m	1.4E+09	1.40818E-06	0.090818471	7.61E+00
Te129	1.4E+09	1.40818E-06	0.090818471	7.61E+00
Th226	4.1E+08	4.14391E-07	0.308619356	7.61E+00
Th227	2.0E+07	2.01851E-08	6.335815362	7.61E+00
Th228	2.1E+07	2.1137E-08	6.050478496	7.61E+00
Th229	2.4E+07	2.35897E-08	5.421384523	7.61E+00
Th230	2.5E+07	2.52911E-08	5.056687752	7.61E+00
Th231	2.7E+07	2.72622E-08	4.691076245	7.61E+00
Th232	7.2E+08	7.166E-07	0.178466304	7.61E+00
Th234	3.2E+07	3.18399E-08	4.016629793	7.61E+00
Tl207	1.9E+09	1.92105E-06	0.066572433	7.61E+00
Tl208	2.6E+08	2.5814E-07	0.495424523	7.61E+00
Tl209	3.2E+07	3.23067E-08	3.958587853	7.61E+00

Constituent	ICDF Maximum Allowable Activity Concentration (pCi/L)	ICDF Maximum Allowable Activity Concentration (Ci/cm^3)	Disintegration Energy (MeV/dis)	ICDF Liner Absorbed Dose (Rads/hr)
Tm170	3.2E+07	3.2202E-08	3.971465102	7.61E+00
Tm171	3.8E+08	3.82049E-07	0.334745144	7.61E+00
U232	4.9E+09	4.87805E-06	0.026217219	7.61E+00
U233	2.4E+07	2.40273E-08	5.322659468	7.61E+00
U234	2.7E+07	2.65487E-08	4.817156054	7.61E+00
U235	2.7E+07	2.67786E-08	4.775799161	7.61E+00
U236	2.8E+07	2.79598E-08	4.574037438	7.61E+00
U238	2.8E+07	2.83979E-08	4.503460262	7.61E+00
U240	3.0E+07	3.04227E-08	4.203736541	7.61E+00
Xe127	8.0E+08	7.98393E-07	0.160183041	7.61E+00
Xe131m	4.1E+08	4.1371E-07	0.309126983	7.61E+00
Y90	7.9E+08	7.87742E-07	0.162348865	7.61E+00
Zn65	1.3E+08	1.31865E-07	0.969846036	7.61E+00
Zr93	2.2E+08	2.17376E-07	0.588330261	7.61E+00
Zr95	6.6E+09	6.55841E-06	0.0195	7.61E+00

Appendix B-4

Geomembrane Maximum Allowable Dose in the Evaporation Pond

MONTGOMERY WATSON HARZA

Description: Back calculation of maximum allowable concentration for each distinct Parameter for the evaporation ponds

Project #: 2470178

Prepared by: B.G. Adams

Date: 12/5/01

Checked by: J. Pellicer

Date: 12/7/01

VARIABLES

Liner Thickness =	60	mils
Liner density =	0.94	g/cm^3
Depth of leachate =	36	cm

15 yr Dose =	1,000,000
Daily Dose =	182.6484018
Dose Rad/hr =	7.610350076

CONVERSIONS

pCi/Ci =	1.00E+12
cm^3/l =	1000
cm/mil =	2.54E-03
(dis/s)/Ci =	3.70E+10
sec/hr =	3600
g/kg =	1.00E+03
eV/Mev =	1.00E+06
J/eV =	1.60E-19
rad/Gy =	100

Constituent	ICDF Maximum Activity Concentration (pCi/l)	ICDF Maximum Activity Concentration (Ci/cm^3)	Dissintegration Energy (MeV/dis)	ICDF Liner Radiation Dose (Rads/hr)
Ac225	2.4E+06	2.43646E-09	5.832179811	7.61E+00
Ac227	1.8E+08	1.78445E-07	0.079631727	7.61E+00
Ac228	1.0E+07	1.0478E-08	1.356167107	7.61E+00
Ag108	2.3E+07	2.26529E-08	0.627288369	7.61E+00
Ag108m	8.7E+06	8.69773E-09	1.63374702	7.61E+00
Ag109m	1.6E+08	1.63407E-07	0.086960304	7.61E+00
Ag110	1.2E+07	1.17237E-08	1.212069842	7.61E+00
Ag110m	5.1E+06	5.05909E-09	2.808781272	7.61E+00
Am241	2.6E+06	2.56722E-09	5.535129217	7.61E+00
Am242	7.4E+07	7.42025E-08	0.191501428	7.61E+00
Am242m	2.2E+08	2.16427E-07	0.065656838	7.61E+00
Am243	2.7E+06	2.65699E-09	5.348125195	7.61E+00
Am246	1.1E+07	1.11967E-08	1.269116692	7.61E+00
At217	2.0E+06	2.01111E-09	7.065707158	7.61E+00
Ba137m	2.1E+07	2.14825E-08	0.661462561	7.61E+00
Be 10	7.0E+07	7.01723E-08	0.2025	7.61E+00
Bi210	3.7E+07	3.65293E-08	0.389	7.61E+00
Bi211	2.2E+06	2.15093E-09	6.606380966	7.61E+00
Bi214	6.6E+06	6.59806E-09	2.153646154	7.61E+00
Bk249	4.3E+08	4.30607E-07	0.03299967	7.61E+00
Bk250	1.2E+07	1.20413E-08	1.180096454	7.61E+00
Cd109	7.2E+08	7.23459E-07	0.019641609	7.61E+00
Cd113m	7.7E+07	7.66621E-08	0.185357358	7.61E+00
Ce141	5.8E+07	5.76051E-08	0.246677795	7.61E+00
Ce144	1.3E+08	1.27085E-07	0.111813852	7.61E+00
Cf249	2.3E+06	2.29127E-09	6.201740977	7.61E+00

Constituent	ICDF Maximum Activity Concentration (pCi/l)	ICDF Maximum Activity Concentration (Ci/cm^3)	Dissintegration Energy (MeV/dis)	ICDF Liner Radiation Dose (Rads/hr)
Cf250	2.4E+06	2.35839E-09	6.025256294	7.61E+00
Cf251	2.4E+06	2.39063E-09	5.94399266	7.61E+00
Cm241	8.3E+07	8.30017E-08	0.1712	7.61E+00
Cm242	2.3E+06	2.3217E-09	6.120469416	7.61E+00
Cm243	2.3E+06	2.33347E-09	6.089596726	7.61E+00
Cm244	2.4E+06	2.44811E-09	5.804428351	7.61E+00
Cm245	2.6E+06	2.58015E-09	5.507387757	7.61E+00
Cm246	2.6E+06	2.63978E-09	5.382991049	7.61E+00
Cm247	2.7E+06	2.69186E-09	5.278828648	7.61E+00
Cm248	3.1E+06	3.05069E-09	4.657924475	7.61E+00
Co-57	9.9E+07	9.91042E-08	0.143383365	7.61E+00
Co-58	1.5E+07	1.45098E-08	0.979328243	7.61E+00
Co-60	5.5E+06	5.46197E-09	2.601603093	7.61E+00
Cr-51	3.9E+08	3.92633E-07	0.036191289	7.61E+00
Cs-134	8.3E+06	8.27552E-09	1.717100005	7.61E+00
Cs135	2.5E+08	2.52396E-07	0.0563	7.61E+00
Cs137	8.3E+07	8.32187E-08	0.1707536	7.61E+00
Eu150	4.9E+07	4.8664E-08	0.292	7.61E+00
Eu152	1.1E+07	1.11338E-08	1.276280952	7.61E+00
Eu154	9.3E+06	9.3063E-09	1.526910861	7.61E+00
Eu155	1.2E+08	1.16121E-07	0.122371015	7.61E+00
Fe-59	1.1E+07	1.08812E-08	1.30591073	7.61E+00
Fr221	2.2E+06	2.22222E-09	6.394459322	7.61E+00
Fr223	3.3E+07	3.26869E-08	0.434726751	7.61E+00
Gd153	9.3E+07	9.32714E-08	0.15235	7.61E+00
H 3	2.5E+09	2.49954E-06	0.005685	7.61E+00
Ho166m	8.2E+06	8.16054E-09	1.741292443	7.61E+00
In114	1.8E+07	1.76822E-08	0.803627157	7.61E+00
In114m	5.9E+07	5.93595E-08	0.239386934	7.61E+00
In115	9.3E+07	9.34861E-08	0.152	7.61E+00
K-40	2.3E+07	2.32809E-08	0.610365806	7.61E+00
La140	5.0E+06	4.98785E-09	2.848903435	7.61E+00
Mn-54	1.7E+07	1.69201E-08	0.839824907	7.61E+00
Nb92	9.4E+06	9.41074E-09	1.509964777	7.61E+00
Nb93m	4.7E+08	4.6971E-07	0.030252491	7.61E+00
Nb94	8.3E+06	8.25839E-09	1.720660307	7.61E+00
Nb95m	5.8E+07	5.75777E-08	0.24679489	7.61E+00
Nd144	7.5E+06	7.47889E-09	1.9	7.61E+00
Np236	4.2E+07	4.16647E-08	0.341053651	7.61E+00
Np239	3.4E+07	3.42077E-08	0.415400022	7.61E+00
Np240m	1.5E+07	1.49752E-08	0.948896841	7.61E+00

Constituent	ICDF Maximum Activity Concentration (pCi/l)	ICDF Maximum Activity Concentration (Ci/cm^3)	Dissintegration Energy (MeV/dis)	ICDF Liner Radiation Dose (Rads/hr)
Pa231	2.6E+06	2.60565E-09	5.453502195	7.61E+00
Pa233	3.5E+07	3.47005E-08	0.409501364	7.61E+00
Pa234	5.8E+06	5.7682E-09	2.463486522	7.61E+00
Pa234m	1.7E+07	1.70212E-08	0.834833438	7.61E+00
Pb209	7.2E+07	7.19124E-08	0.1976	7.61E+00
Pb210	3.7E+08	3.65305E-07	0.038898656	7.61E+00
Pb212	4.4E+07	4.42337E-08	0.321245808	7.61E+00
Pb214	2.6E+07	2.63893E-08	0.538471991	7.61E+00
Pd107	4.3E+08	4.29289E-07	0.033101	7.61E+00
Pm146	1.7E+07	1.67012E-08	0.850831344	7.61E+00
Pm147	2.3E+08	2.29335E-07	0.061961344	7.61E+00
Pm148	1.1E+07	1.09229E-08	1.30092091	7.61E+00
Pm148m	6.6E+06	6.59299E-09	2.155301698	7.61E+00
Po210	2.7E+06	2.67883E-09	5.304505553	7.61E+00
Po211	1.9E+06	1.90729E-09	7.450314354	7.61E+00
Po212	1.6E+06	1.61754E-09	8.7849	7.61E+00
Po213	1.7E+06	1.6963E-09	8.376999781	7.61E+00
Po214	1.8E+06	1.84855E-09	7.687067933	7.61E+00
Po215	1.9E+06	1.92382E-09	7.38630707	7.61E+00
Po216	2.1E+06	2.09632E-09	6.778486648	7.61E+00
Po218	2.4E+06	2.3678E-09	6.001296466	7.61E+00
Pr144	1.1E+07	1.10667E-08	1.284017776	7.61E+00
Pr144m	1.2E+09	1.19942E-06	0.01184728	7.61E+00
Pu236	2.5E+06	2.46199E-09	5.771712409	7.61E+00
Pu237	2.3E+08	2.28304E-07	0.062241073	7.61E+00
Pu238	2.6E+06	2.58503E-09	5.496995126	7.61E+00
Pu239	2.8E+06	2.75731E-09	5.153526936	7.61E+00
Pu240	2.8E+06	2.75157E-09	5.164286359	7.61E+00
Pu241	2.7E+09	2.71705E-06	0.005229895	7.61E+00
Pu242	2.9E+06	2.8864E-09	4.923056772	7.61E+00
Pu243	7.3E+07	7.2795E-08	0.195204338	7.61E+00
Pu244	3.1E+06	3.09035E-09	4.598152374	7.61E+00
Pu246	9.2E+07	9.1963E-08	0.154517541	7.61E+00
Ra222	2.2E+06	2.16827E-09	6.553547823	7.61E+00
Ra224	2.5E+06	2.49862E-09	5.687100654	7.61E+00
Ra225	1.2E+08	1.19185E-07	0.119225863	7.61E+00
Ra226	3.0E+06	2.96677E-09	4.789685685	7.61E+00
Ra228	1.2E+09	1.22838E-06	0.011568007	7.61E+00
Rb87	1.8E+08	1.80329E-07	0.0788	7.61E+00
Rh102	1.8E+08	1.78069E-07	0.0798	7.61E+00
Rh103m	3.7E+08	3.65661E-07	0.038860869	7.61E+00

Constituent	ICDF Maximum Activity Concentration (pCi/l)	ICDF Maximum Activity Concentration (Ci/cm^3)	Dissintegration Energy (MeV/dis)	ICDF Liner Radiation Dose (Rads/hr)
Rh106	8.8E+06	8.77496E-09	1.61936774	7.61E+00
Rn218	2.0E+06	1.99213E-09	7.132996084	7.61E+00
Rn219	2.1E+06	2.07983E-09	6.832252476	7.61E+00
Rn220	2.3E+06	2.25974E-09	6.288297183	7.61E+00
Rn222	2.6E+06	2.58851E-09	5.48961137	7.61E+00
Ru103	2.6E+07	2.56695E-08	0.553570714	7.61E+00
Ru106	3.6E+08	3.60648E-07	0.039401	7.61E+00
Sb124	6.3E+06	6.31827E-09	2.249015659	7.61E+00
Sb125	2.7E+07	2.68008E-08	0.530203897	7.61E+00
Sb126	4.7E+06	4.65525E-09	3.052446696	7.61E+00
Sc-46	6.7E+06	6.69811E-09	2.121478487	7.61E+00
Se 79	2.7E+08	2.7222E-07	0.0522	7.61E+00
Sm146	5.6E+06	5.61656E-09	2.53	7.61E+00
Sm147	6.3E+06	6.32225E-09	2.2476	7.61E+00
Sm148	7.1E+06	7.14065E-09	1.99	7.61E+00
Sm151	7.2E+08	7.18214E-07	0.019785044	7.61E+00
Sn119m	7.2E+08	7.18214E-07	0.019785044	7.61E+00
Sn121m	1.6E+08	1.63143E-07	0.087100885	7.61E+00
Sn123	4.7E+09	4.67431E-06	0.00304	7.61E+00
Sn126	2.7E+07	2.69423E-08	0.527419926	7.61E+00
Sr89	4.0E+07	3.96274E-08	0.358587622	7.61E+00
Sr90	2.4E+07	2.43705E-08	0.583077055	7.61E+00
Tb160	2.6E+07	2.60254E-08	0.546	7.61E+00
Tc 98	1.1E+07	1.05036E-08	1.352864583	7.61E+00
Tc 99	9.4E+06	9.37736E-09	1.515340293	7.61E+00
Te123	1.7E+08	1.67965E-07	0.084600538	7.61E+00
Te123m	8.3E+08	8.32673E-07	0.017065401	7.61E+00
Te127	8.9E+07	8.91467E-08	0.159398912	7.61E+00
Te127m	6.2E+07	6.23836E-08	0.227782297	7.61E+00
Te129	1.6E+08	1.56465E-07	0.090818471	7.61E+00
Th226	4.6E+07	4.60434E-08	0.308619356	7.61E+00
Th227	2.2E+06	2.24279E-09	6.335815362	7.61E+00
Th228	2.3E+06	2.34856E-09	6.050478496	7.61E+00
Th229	2.6E+06	2.62108E-09	5.421384523	7.61E+00
Th230	2.8E+06	2.81012E-09	5.056687752	7.61E+00
Th231	3.0E+06	3.02913E-09	4.691076245	7.61E+00
Th232	8.0E+07	7.96223E-08	0.178466304	7.61E+00
Th234	3.5E+06	3.53776E-09	4.016629793	7.61E+00
Tl207	2.1E+08	2.1345E-07	0.066572433	7.61E+00
Tl208	2.9E+07	2.86823E-08	0.495424523	7.61E+00
Tl209	3.6E+06	3.58964E-09	3.958587853	7.61E+00

Constituent	ICDF Maximum Activity Concentration (pCi/l)	ICDF Maximum Activity Concentration (Ci/cm^3)	Dissintegration Energy (MeV/dis)	ICDF Liner Radiation Dose (Rads/hr)
Tm170	3.6E+06	3.578E-09	3.971465102	7.61E+00
Tm171	4.2E+07	4.24499E-08	0.334745144	7.61E+00
U232	5.4E+08	5.42006E-07	0.026217219	7.61E+00
U233	2.7E+06	2.6697E-09	5.322659468	7.61E+00
U234	2.9E+06	2.94985E-09	4.817156054	7.61E+00
U235	3.0E+06	2.9754E-09	4.775799161	7.61E+00
U236	3.1E+06	3.10664E-09	4.574037438	7.61E+00
U238	3.2E+06	3.15533E-09	4.503460262	7.61E+00
U240	3.4E+06	3.3803E-09	4.203736541	7.61E+00
Xe127	8.9E+07	8.87103E-08	0.160183041	7.61E+00
Xe131m	4.6E+07	4.59678E-08	0.309126983	7.61E+00
Y90	8.8E+07	8.75269E-08	0.162348865	7.61E+00
Zn65	2.3E+07	2.34524E-08	0.605903	7.61E+00
Zr93	2.4E+07	2.41529E-08	0.588330261	7.61E+00
Zr95	7.3E+08	7.28712E-07	0.0195	7.61E+00

Appendix C

Manufacturers' Maximum Constituent Concentration Data for HDPE Geomembrane

HDPE Liner Manufacturer's Compatibility Data

LINER COMPATIBILITY

1. **Identify the manufacturer and the type of liner that will be used in the landfill which will contain the form R wastes.**

   MANUFACTURER: **GSE Lining Technology, Inc.**
   LINER TYPE: **60 mil HDPE**

2. **Describe how the following types of chemicals will affect the liner to be used to contain the form R waste:**

   aromatic halogenated hydrocarbons - SEE ATTACHED SHEET

   aliphatic halogenated hydrocarbons - SEE ATTACHED SHEET

   aromatic hydrocarbons - SEE ATTACHED SHEET

   aliphatic hydrocarbons - SEE ATTACHED SHEET

   volatile and semi-volatile organics - SEE ATTACHED SHEET

   oil and grease - SEE ATTACHED SHEET

   strong oxidizers - GENERALLY NO SIGNIFICANT EFFECT

   acids - GENERALLY NO SIGNIFICANT EFFECT

   bases - GENERALLY NO SIGNIFICANT EFFECT

   dissolved metals, salts and nutrients - GENERALLY NO EFFECT

3. **Give an acceptable compatibility limit for each of the compounds on the following pages and certificate liner manufacturer:**

Signature of Liner Manufacturer:

_____

Matthew W. Adams
Technical Support Chemist

_____

Date

FORM-R/PAGE 1

Aromatic Halogenated Hydrocarbons

Aromatic Halogenated Hydrocarbons tend to be absorbed into polyethylene over long periods of time where they may function as a plasticizer. As a result, the polyethylene may swell and become softer and more elastic. These effects are generally reversible if the exposure is terminated.

Since polyethylene consists of a range of molecular weight molecules and somewhat different branching arrangements, some lower density polyethylenes may contain fractions that are extractable. Some types of chemical stabilizers and processing aids may also be extractable.

These above noted effects increase with increasing temperature. Softening, swelling and increased elasticity may rapidly reduce the usefulness of polyethylene as a structural component such as for use as a pressure pipe. Generally, these effects do not seriously affect the performance of polyethylene as a containment membrane.

GSE HyperFlex® polyethylene geomembranes are manufactured from a narrow molecular weight range resin designed to minimize the possibility of extractable fractions and maximize the resistance to stress cracking.

Aliphatic Halogenated Hydrocarbons

Similar effects as for Aromatic Halogenated Hydrocarbons but generally less severe. Some materials have little or no effect.

Aromatic Hydrocarbons

Again similar to Aromatic Halogenated Hydrocarbons but generally less severe. Many materials have no significant effect.

Aliphatic Hydrocarbons

Again similar, but with further reductions of general severity. Most materials have no significant effect.

Volatile and Semivolatile Organics

These are mostly covered by the previously noted comments about hydrocarbons.

Oil and Grease

Mineral, vegetable and animal oils, fats or grease generally have no significant effect.

Strong Oxidizers - Generally no significant effect.

Acids - Generally no significant effect.

Dissolved Metals, Salts and Nutrients - Generally no effect.

FORM R
LINER COMPATABILITY

PARAMETER CLASSIFICATION	PARAMETER	MANUFACTURER'S LINER/LEACHATE LIMIT mg/l
Aromatic Halogenated Hydrocarbons	polychlorinated biphenyl	(2000)
	aldrin	(2000)
	dichlorobenzene	(2000)
	hexachlorobenzene	(2000)
	pentachlorobenzene	(2000)
	trichlorobenzene	(2000)
	tetrachlorobenzene	(2000)
	2-chloronaphthalene	(2000)
	chloronaphthalene	(2000)
	chlorobenzene	(2000)
	4,4-DDT	(2000)
	4,4-DDE	(2000)
	4,4-DDD	(2000)
Aliphatic Halogenated Hydrocarbons	bromoform	(2000)
	carbon tetrachloride	(2000)
	chlorodibromomethane	(2000)
	chloroethane	(2000)
	chloroform	(2000)
	dichlorobromomethane	(2000)
	dichlorodifluoromethane	(2000)
	dichloroethane	(2000)
	dichloropropane	(2000)
	dichloroethene	(2000)
	ethylene chloride	(2000)
	ethylene dichloride	(2000)
	hexachloroethane	(2000)
	methyl bromide	(2000)
	methyl chloride	(2000)
	methylene chloride	(2000)
	tetrachloroethane	(2000)
	tetrachloroethene	(2000)
	trichloroethane	(2000)
	trichloroethene	(2000)
	trichlorofluoromethane	(2000)
	vinyl chloride	(2000)

TEMPERATURE 70 °F

FORM R
LINER COMPATABILITY

PARAMETER CLASSIFICATION	PARAMETER	MANUFACTURER'S LINER/LEACHATE LIMIT mg/1
Aromatic Hydrocarbons	acenapthene	(2000)
	acenaphthylene	(2000)
	anthracene	(2000)
	benzene	(2000)
	benzo(a)anthracene	(2000)
	benzo(a)pyrene	(2000)
	benzo(g,h,i)perylene	(2000)
	benzo(k)fluoranthene	(2000)
	3,4-benzoflouranthene	(2000)
	chrysene	(2000)
	dibenzo(a,h)anthracene	(2000)
	ethyl benzene	(2000)
	flouranthene	(2000)
	flourene	(2000)
	ideno(1,2,3,c,d)pyrene	(2000)
	naphthalene	(2000)
	phenanthrene	(2000)
	pyrene	(2000)
	styrene	(5000)
	toluene	(5000)
	xylene	(5000)
Aliphatic Hydrocarbons	heptane	(500,000)
	hexane	(500,000)
	octane	(500,000)

TEMPERATURE 70 °F

FORM R
LINER COMPATABILITY

PARAMETER CLASSIFICATION	PARAMETER	MANUFACTURER'S LINER/LEACHATE LIMIT mg/l
Volatile & Semivolatile Organics	acrolein	(200,000)
	acrylonitrile	(200,000)
	acetone	(200,000)
	amyl acetate	(200,000)
	benzidine	(200,000)
	butyl alcohol	(500,000)
	bis(2-chloroethoxy)methane	(2,000)
	bis(2-chloroethosy)ether	(2,000)
	bis(2-chloroisopropy)ether	(2,000)
	bis(2-etylhexyl)ptththalate	(2,000)
	4-bromophenyl phenyl ether	(2,000)
	butyl benzyl phthalate	(200,000)
	cresol	(100,000)
	chlordane	(2,000)
	alpha-BHC	(2,000)
	beta-BHC	(2,000)
	gamma-BHC	(2,000)
	delta-BHC	(2,000)
	dieldrin	(2,000)
	dichlorobenzidine	(2,000)
	diethyl phthalate	(100,000)
	dibutyl phthalate	(100,000)
	dimethyl phthalate	(100,000)
	isobutyl alchohol	(500,000)
	isopropyl alcohol	(500,000)
	methyl alcohol	(500,000)
	2-chloroethyl vinyl ether	(2,000)
	2-chlorophenol	(2,000)
	dichlorophenol	(2,000)
	dimethyl phenol	(2,000)
	dinitro-o-cresol	(2,000)
	dinitrophenol	(2,000)
	dinitrotoluene	(2,000)
	diphenylhydrazine	(2,000)
	ethyl acetate	(100,000)
	ethyl ether	(2,000)
	ethyl glycol	(500,000)
	endosulfan	(2,000)
	endrin	(2,000)
	formaldehyde	(200,000)
	heptachlor	(2,000)
	hexachlorocyclopentadiene	(2,000)
	hexachlorobutadiene	(2,000)
	isophorone	(2,000)
	methyl ethyl ketone	(200,000)
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FORM R

LINER COMPATABILITY

PARAMETER CLASSIFICATION	PARAMETER	MANUFACTURER'S LINER/LEACHATE LIMIT mg/l
Volatile & Semivolotile Organics (cont.)	methyl isobutyl ketone	(500,000)
	nitrophenol	(100,000)
	N-nitrosodimethylamine	(100,000)
	N-nitrosodi-n-propylamine	(100,000)
	nitrobenzene	(100,000)
	pentachlorophenol	(100,000)
	phenol	(100,000)
	pyridine	(100,000)
	toxaphene	(100,000)
	trichlorophenol	(100,000)
	2,4,5-TP(silvex)	(?)

TEMPERATURE 70 °F

FORM R
LINER COMPATABILITY

PARAMETER CLASSIFICATION	PARAMETER	MANUFACTURER'S LINER/LEACHATE LIMIT mg/l
Acids & Bases	acetic acid	(500,000)
	chromic acid	(100,000)
	citric acid	(500,000)
	hydrobromic acid	(100,000)
	hydrochloric acid	(350,000)
	hydrocyanic acid	(100,000)
	hydrofluoric acid	(750,000)
	nitric acid	(500,000)
	picric acid	(500,000)
	phosphoric acid	(500,000)
	perchloric acid	(500,000)
	sulfuric acid	(500,000)
	potassium hydroxide	(500,000)
	sodium hydroxide	(500,000)
Products & Various Substances	antifreeze	(500,000)
	asphalt	(500,000)
	cresols	(100,000)
	crude oil	(500,000)
	diesel fuel	(500,000)
	fatty acids	(500,000)
	freon	(500,000)
	fuel oil	(500,000)
	gasoline	(500,000)
	hydraulic oil	(500,000)
	kerosene	(500,000)
	lacquers	(500,000)
	lubricating oil	(500,000)
	mineral spirits	(500,000)
	naphtha	(500,000)
	paraffin	(500,000)
	transformer oil	(500,000)
Miscellaneous	pH	(0.5-13.0 pH unit)
	strong oxidizers*	(1000-500,000)
	metals, salts, nutrients	(500,000)

*potassium permaganate, potassium dichromate, chlorine, peroxides

TEMPERATURE 70 °F

Chemical Resistance

For environmental lining solutions...the world comes to GSE.®

GSE is the world's leading supplier of high quality, polyethylene geomembranes. GSE polyethylene geomembranes are resistant to a great number and combinations of chemicals. Note that the effect of chemicals on any material is influenced by a number of variable factors such as temperature, concentration, exposed area and duration. Many tests have been performed that use geomembranes and certain specific chemical mixtures. Naturally, however, every mixture of chemicals cannot be tested for, and various criteria may be used to judge performance. Reported performance ratings may not apply to all applications of a given material in the same chemical. Therefore, these ratings are offered as a guide only.

Abbreviations

S = Satisfactory
L = Limited application possible
U = Unsatisfactory
— = Not tested

Concentration

sat. sol. = Saturated aqueous solution, prepared at 20°C (68°F)
sat. = aqueous solution with concentration above 10% but below saturation level
dil. sol. = diluted aqueous solution with concentration below 10%
cust. conc. = customary service concentration

Medium	Concentration	Resistance at: 20 °C (68 °F)	Resistance at: 60 °C (140 °F)
A			
Acetic acid	100%	S	L
Acetic acid	10%	S	S
Acetic acid anhydride	100%	S	L
Acetone	100%	L	L
Adipic acid	sat. sol.	S	S
Allyl alcohol	96%	S	S
Aluminum chloride	sat. sol.	S	S
Aluminum fluoride	sat. sol.	S	S
Aluminum sulfate	sat. sol.	S	S
Alum	sol.		S
Ammonia, aqueous	dil. sol	S	S
Ammonia, gaseous dry	100%	S	
Ammonia, liquid	100%	S	S
Ammonium chloride	sat. sol.	S	S
Ammonium fluoride	sol.	S	S
Ammonium nitrate	sat. sol.		S
Ammonium sulfate	sat. sol.	S	S
Ammonium sulfide	sol.	S	S
Amyl acetate	100%	S	L
Amyl alcohol	100%	S	L
Aniline	100%	S	L
Antimony trichloride	90%	S	S
Arsenic acid	sat. sol.	S	S
Aqua regia	HCl-HNO33/1	U	U
B			
Barium carbonate	sat. sol.	S	S
Barium chloride	sat. sol.	S	S
Barium hydroxide	sat. sol.	S	S
Barium sulfate	sat. sol.	S	S
Barium sulfide	sol.	S	S
Benzaldehyde	100%	S	L
Benzene	—	L	L
Benzoic acid	sat. sol.	S	S
Beer	—	S	S
Borax (sodium tetraborate)	sat. sol.	S	S
Boric acid	sat. sol.	S	S
Bromine, gaseous dry	100%	U	U
Bromine, liquid	100%	U	U
Butane, gaseous	100%	S	S
1-Butanol	100%	S	S
Butyric acid	100%	S	L
C			
Calcium carbonate	sat. sol.	S	S
Calcium chlorate	sat. sol.	S	S
Calcium chloride	sat. sol.	S	S
Calcium nitrate	sat. sol.	S	S
Calcium sulfate	sat. sol.	S	S
Calcium sulfide	dil. sol.	L	L
Carbon dioxide, gaseous dry	100%	S	S
Carbon disulfide	100%	L	U
Carbon monoxide	100%	S	S
Chloracetic acid	sol.	S	S
Carbon tetrachloride	100%	L	U
Chlorine, aqueous solution	sat. sol.	L	U
Chlorine, gaseous dry	100%	L	U
Chloroform	100%	U	U
Chromic acid	20%	S	L
Chromic acid	50%	S	
Citric acid	sat. sol.	S	S
Copper chloride	sat. sol.	S	S
Copper nitrate	sat. sol.	S	S
Copper sulfate	sat. sol	S	S
Cresylic acid	sat. sol.	L	—
Cyclohexanol	100%	S	S
Cyclohexanone	100%	S	L
D			
Decahydronaphthalene	100%	S	L
Dextrine	sol.	S	S
Diethyl ether	100%	L	—
Dioctylphthalate	100%	S	L
Dioxane	100%	S	S
E			
Ethanediol	100%	S	S
Ethanol	40%	S	L
Ethyl acetate	100%	S	U
Ethylene trichloride	100%	U	U
F			
Ferric chloride	sat. sol.	S	S
Ferric nitrate	sol.	S	S
Ferric sulfate	sat. sol.	S	S
Ferrous chloride	sat. sol.	S	S
Ferrous sulfate	sat. sol.	S	S
Fluorine, gaseous	100%	U	U
Fluorosilicic acid	40%	S	
Formaldehyde	40%	S	S
Formic acid	50%	S	S
Formic acid	98-100%	S	S
Furfuryl alcohol	100%	S	L
G			
Gasoline	—	S	L
Glacial acetic acid	96%	S	L
Glucose	sat. sol.	S	S
Glycerine	100%	S	S
Glycol	sol.	S	S
H			
Heptane	100%	S	U
Hydrobromic acid	50%	S	S

(CONTINUED ON OTHER SIDE)

(S) Satisfactory: *Liner material is resistant to the given reagent at the given concentration and temperature. No mechanical or chemical degradation is observed.*
(L) Limited Application Possible: *Liner material may reflect some attack. Factors such as concentration, pressure and temperature directly affect liner performance against the given media. Application, however, is possible under less severe conditions, e.g. lower concentration, secondary containment, additional liner protections, etc.*
(U) Unsatisfactory: *Liner material is not resistant to the given reagent at the given concentration and temperature. Mechanical and/or chemical degradation is observed.*
(–) Not tested
This information is provided for reference purposes only and is not intended as a warranty or guarantee. GSE assumes no liability in connection with the use of this information.

Medium	Concentration	Resistance at: 20 °C (68 °F)	60 °C (140 °F)
Hydrobromic acid	100%	S	S
Hydrochloric acid	10%	S	S
Hydrochloric acid	35%	S	S
Hydrocyanic acid	10%	S	S
Hydrofluoric acid	4%	S	S
Hydrofluoric acid	60%	S	L
Hydrogen	100%	S	S
Hydrogen peroxide	30%	S	L
Hydrogen peroxide	90%	S	U
Hydrogen sulfide, gaseous	100%	S	S
L			
Lactic acid	100%	S	S
Lead acetate	sat. sol.	S	—
M			
Magnesium carbonate	sat. sol.	S	S
Magnesium chloride	sat. sol.	S	S
Magnesium hydroxide	sat. sol.	S	S
Magnesium nitrate	sat. sol.	S	S
Maleic acid	sat. sol.	S	S
Mercuric chloride	sat. sol.	S	S
Mercuric cyanide	sat. sol.	S	S
Mercuric nitrate	sol.	S	S
Mercury	100%	S	S
Methanol	100%	S	S
Methylene chloride	100%	L	—
Milk	—	S	S
Molasses	—	S	S
N			
Nickel chloride	sat. sol.	S	S
Nickel nitrate	sat. sol.	S	S
Nickel sulfate	sat. sol.	S	S
Nicotinic acid	dil. sol.	S	—
Nitric acid	25%	S	S
Nitric acid	50%	S	U
Nitric acid	75%	U	U
Nitric acid	100%	U	U
O			
Oils and Grease	—	S	L
Oleic acid	100%	S	L
Orthophosphoric acid	50%	S	S
Orthophosphoric acid	95%	S	L
Oxalic acid	sat. sol.	S	S
Oxygen	100%	S	L
Ozone	100%	L	U
P			
Petroleum (kerosene)	—	S	L
Phenol	sol.	S	S
Phosphorus trichloride	100%	S	L
Photographic developer	cust. conc.	S	S
Picric acid	sat. sol.	S	—
Potassium bicarbonate	sat. sol.	S	S
Potassium bisulfide	sol.	S	S
Potassium bromate	sat. sol.	S	S
Potassium bromide	sat. sol.	S	S
Potassium carbonate	sat. sol.	S	S
Potassium chlorate	sat. sol.	S	S
Potassium chloride	sat. sol.	S	S
Potassium chromate	sat. sol.	S	S
Potassium cyanide	sol.	S	S
Potassium dichromate	sat. sol.	S	S
Potassium ferricyanide	sat. sol.	S	S
Potassium ferrocyanide	sat. sol.	S	S
Potassium fluoride	sat. sol.	S	S
Potassium hydroxide	10%	S	S
Potassium hydroxide	sol.	S	S
Potassium hypochlorite	sol.	S	L
Potassium nitrate	sat. sol.	S	S
Potassium orthophosphate	sat. sol.	S	S
Potassium perchlorate	sat. sol.	S	S

Medium	Concentration	Resistance at: 20 °C (68 °F)	60 °C (140 °F)
Potassium permanganate	20%	S	S
Potassium persulfate	sat. sol.	S	S
Potassium sulfate	sat. sol.	S	S
Potassium sulfite	sol.	S	S
Propionic acid	50%	S	S
Propionic acid	100%	S	L
Pyridine	100%	S	L
Q			
Quinol (Hydroquinone)	sat. sol.	S	S
S			
Salicylic acid	sat. sol.	S	S
Silver acetate	sat. sol.	S	S
Silver cyanide	sat. sol.	S	S
Silver nitrate	sat. sol.	S	S
Sodium benzoate	sat. sol.	S	S
Sodium bicarbonate	sat. sol.	S	S
Sodium biphosphate	sat. sol.	S	S
Sodium bisulfite	sol.	S	S
Sodium bromide	sat. sol.	S	S
Sodium carbonate	sat. sol.	S	S
Sodium chlorate	sat. sol.	S	S
Sodium chloride	sat. sol.	S	S
Sodium cyanide	sat. sol.	S	S
Sodium ferricyanide	sat. sol.	S	S
Sodium ferrocyanide	sat. sol.	S	S
Sodium fluoride	sat. sol.	S	S
Sodium hydroxide	40%	S	S
Sodium hydroxide	sat. sol.	S	S
Sodium hypochlorite	15% active chlorine	S	S
Sodium nitrate	sat. sol.	S	S
Sodium nitrite	sat. sol.	S	S
Sodium orthophosphate	sat. sol.	S	S
Sodium sulfate	sat. sol.	S	S
Sodium sulfide	sat. sol.	S	S
Sulfur dioxide, dry	100%	S	S
Sulfur trioxide	100%	U	U
Sulfuric acid	10%	S	S
Sulfuric acid	50%	S	S
Sulfuric acid	98%	S	U
Sulfuric acid	fuming	U	U
Sulfurous acid	30%	S	S
T			
Tannic acid	sol.	S	S
Tartaric acid	sol.	S	S
Thionyl chloride	100%	L	U
Toluene	100%	L	U
Triethylamine	sol.	S	L
U			
Urea	sol.	S	S
Urine	—	S	S
W			
Water	—	S	S
Wine vinegar	—	S	S
Wines and liquors	—	S	S
X			
Xylenes	100%	L	U
Y			
Yeast	sol.	S	S
Z			
Zinc carbonate	sat. sol.	S	S
Zinc chloride	sat. sol.	S	S
Zinc (II) chloride	sat. sol.	S	S
Zinc (IV) chloride	sat. sol.	S	S
Zinc oxide	sat. sol.	S	S
Zinc sulfate	sat. sol.	S	S

Specific immersion testing should be undertaken to ascertain the suitability of chemicals not listed above with reference to special requirements.

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Marlex®

POLYETHYLENE

TECHNICAL SERVICE MEMORANDUM

TSM-243
September, 1994

Engineering Properties of Marlex Resins

INTRODUCTION

It is sometimes necessary to have information about high density polyethylene (HDPE) that does not normally appear on the typical resin data sheet. This Technical Service Memorandum supplies data on many of the infrequently published physical, chemical and electrical properties of our Marlex resins. In this Memorandum, we will briefly discuss many of these test procedures and provide available information concerning particular resin properties as well as comparing Marlex HDPE to other resin types.

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Deformation of Plastics Under Load (ASTM D621)

Method A: Rigid Plastics – A ½ in *(12.7 mm)* cubical specimen is maintained under a constant compressive force of 500 pounds *(227 kg)* between the parallel plates of a device manufactured by the Luster Jordan Company. The whole assembly is enclosed in a constant temperature oven at 122°F *(50°C)*. The change in thickness is observed over a period of 24 hours and reported as follows:

POLYETHYLENE MATERIAL	ORIGINAL HEIGHT, in *(cm)*	DEFORMED HEIGHT, in *(cm)*	DEFORMATION, PERCENT	TIME ELAPSED, HOURS	PRESSURE, psi *(MPa)*	TEMPERATURE, °F *(°C)*
High Density	0.506 *(1.27)*	0.465 *(1.18)*	8.1	22	2000 *(13.8)*	122 *(50)*
Low Density	0.509 *(1.30)*	0.425 *(1.08)*	16.5	24	2000 *(13.8)*	122 *(50)*

Method B: Non-Rigid Plastics – Method B is essentially the same as Method A except that (1) the test specimen is in the shape of a cylinder 1.129 in *(28.7 mm)* in diameter and 0.250 in *(6.4 mm)* thick having the two flat surfaces parallel; (2) the pressure is 100 psi *(0.69 MPa)*; and (3) the test period is 3 hours. The results of testing by Method B are as follows:

POLYETHYLENE MATERIAL	ORIGINAL HEIGHT, in *(cm)*	DEFORMED HEIGHT, in *(cm)*	DEFORMATION, PERCENT	TIME ELAPSED, HOURS	PRESSURE, psi *(MPa)*	TEMPERATURE, °F *(°C)*
High Density	0.483 *(1.23)*	0.483 *(1.23)*	0	3	100 *(0.69)*	122 *(50)*
Low Density	0.498 *(1.26)*	0.496 *(1.25)*	5	3	100 *(0.69)*	122 *(50)*

Irradiation – Effects on Properties of HDPE of Gamma and Beta Irradiation

Data indicate that polymer crosslinking occurs with beta or gamma irradiation accompanied by an increase in density, tensile strength and hardness and by a decrease in solubility. Irradiation of Marlex high density polyethylene also increases resistance to environmental stress cracking.

TYPICAL PROPERTIES	TEMPERATURE, °F *(°C)*	BETA IRRADIATION DOSAGE (MEGARADS) 0	5	10	15	50
Tensile Strength, psi *(MPa)*	82 *(28)*	4110 *(28.3)*	4217 *(29.1)*	4293 *(30)*	4400 *(30.3)*	4560 *(31.4)*
	200 *(93)*	1303 *(8.98)*	1567 *(10.8)*	1640 *(11.3)*	1120 *(7.7)*	1477 *(10.8)*
	270 *(132)*	–	180 *(1.2)*	212 *(1.46)*	455 *(3.13)*	745 *(5.13)*
Elongation, %	82 *(28)*	20	18	22	20	20
	200 *(93)*	167	375	520	505	133
	270 *(132)*	–	510	445	385	110
Hardness, Shore D		64	67	67	68	70
Density, g/cm³		0.96	0.96	0.96	0.96	0.96
Solubility, Tetralin, 266°F *(130°C)*		Soluble	Insoluble	Insoluble	Insoluble	Insoluble
Color		White	White	Ivory	Ivory	Tan

TYPICAL PROPERTIES	TEMPERATURE, °F *(°C)*	GAMMA IRRADIATION DOSAGE (MEGARADS) 0	1	10	100
Tensile Strength, psi *(MPa)*	82 *(28)*	5840 *(40.2)**	7007 *(51.7)*	7120 *(49.1)*	8360 *(57.6)*
Elongation, %	82 *(28)*	13	15	15	1
Hardness, Shore D		64	68	70	70
Density, g/cm³		0.952	0.955	0.955	0.967
Solubility, Tetralin 266°F *(130°C)*		Soluble	Insoluble	Insoluble	Insoluble

*Measured by different laboratories.

TABLE 9

Effect of Gamma and Beta Irradiation of Marlex HDPE on Environmental Stress Cracking in IGEPAL CO-630 at 122°F (50°C)

TYPE OF IRRADIATION DOSAGE, RADS	F_{50} VALUES, h	
	GAMMA	BETA
None	20	20
1×10^4	20	–
3×10^4	24	–
6×10^5	110	40
1×10^7	700	350
3×10^7	350	350
1×10^8	1	–

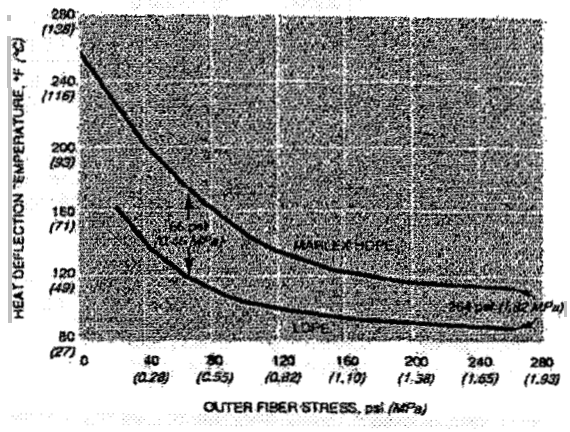
Heat Deflection Temperature (ASTM D648)

This test is primarily intended to determine the temperature at which an arbitrary deformation occurs when specimens are subjected to a specific fiber stress. It is used to indicate the behavior of plastic material at elevated temperatures in applications which are similar to the test procedure. Although this test is designed for more rigid materials such as polystyrene, unplasticized vinyl polymers and nylon, it is especially useful in comparing Marlex HDPE with other polyethylenes.

Injection molded bars 5 in. *(127 mm)* long, 0.5 in. *(12.7 mm)* wide and 0.25 in. *(6.4 mm)* thick are supported along the 0.25 in. edge between two points 4 in. *(100 mm)* apart. Weight is applied at the center of the span to impose a fiber stress of 66 psi *(0.46 MPa)*. The bars are immersed in silicone oil and the bath temperature increased at a rate of 3.6°F *(2°C)* per minute. The bath temperature at the instant the specimen deflects (bends) 0.010 in. *(0.254 mm)* is the heat deflection temperature. In a more stringent test which was originally designed for thermosetting resins, a heavier weight is used to impose a 264 psi *(1.8 MPa)* fiber stress. Therefore, care should be taken to designate the load involved when interpreting heat deflection data. Figure 6 compares the heat deflection temperature of a typical Marlex high density polyethylene with low density polyethylene at various loadings.

FIGURE 6

Effect of Loading on Heat Deflection Temperature

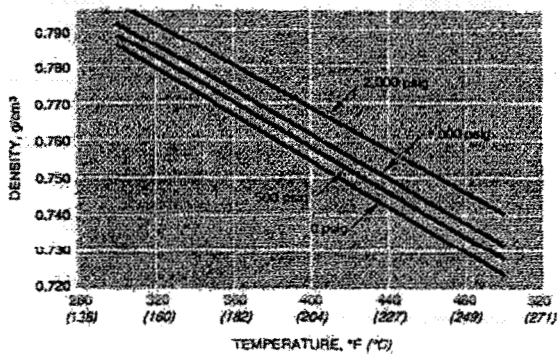


Melt Density

The density of molten Marlex HDPE differs from its density in the solid form. Unlike the solid density, which covers a broad range depending upon resin morphology, the density of all Marlex HDPEs in the melted state is about the same at a given temperature and pressure. The melt density may be useful in the design of extruders and other molding equipment.

FIGURE 7

Melt Density vs. Temperature at Indicated Pressures for Marlex HDPE



Appendix D

Suggested Maximum Leachate Concentrations for Individual Constituents

Table D-1. Suggested maximum leachate concentrations for organic constituents for liner compatibility.

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
1,1,1-Trichloroethane	0.0609	-[d]	-[d]	20[e]	20
1,1,2,2-Tetrachloroethane	0.0002	-	-	-	-
1,1,2-Trichloroethane	0.0013	-	-	-	-
1,1-Dichloroethane	0.0105	-	-	-	-
1,1-Dichloroethene	0.0004	-	-	-	-
1,2,4-Trichlorobenzene	0.0113	-	-	-	-
1,2-Dichlorobenzene	0.0734	-	-	-	-
1,2-Dichloroethane	0.0001	-	-	-	-
1,2-Dichloroethene (total)	0.0003	-	-	-	-
1,3-Dichlorobenzene	0.0071	2,000[f]	-	-	2,000
1,4-Dichlorobenzene	5.1303	-	-	-	-
1,4-Dioxane	0.0000	-	-	-	-
2,4,5-Trichlorophenol	0.0441	-	-	-	-
2,4,6-Trichlorophenol	0.0427	-	-	-	-
2,4-Dichlorophenol	0.0371	-	-	-	-
2,4-Dimethylphenol	0.3041	-	-	-	-
2,4-Dinitrophenol	0.1705	-	-	-	-
2,4-Dinitrotoluene	0.0488	-	-	-	-
2,6-Dinitrotoluene	0.2903	-	-	-	-
2-Butanone	0.0063	200,000[f]	-	-	200,000
2-Chloro-phthalene	0.0108	2,000[g]	-	-	2,000
2-Chlorophenol	0.1867	2,000[g]	-	-	2,000
2-Hexanone	0.0001	-	-	-	-
2-Methyl-phthalene	1.7772	-	-	-	-

Table D-1. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
2-Methylphenol	0.2014	-	-	-	-
2-Nitroaniline	0.1728	-	-	-	-
2-Nitrophenol	0.0098	-	-	-	-
3,3'-Dichlorobenzidine	0.1896	-	-	-	-
3-Methyl Buta-l	0.0022	-	-	-	-
3-Nitroaniline	0.0165	-	-	-	-
4,6-Dinitro-2-methylphenol	0.0010	-	-	-	-
4-Bromophenyl-phenylether	0.0615	2,000[g]	-	-	2,000
4-Chloro-3-methylphenol	0.0810	-	-	-	-
4-Chloroaniline	0.0052	-	-	-	-
4-Chlorophenyl-phenylether	0.0288	-	-	-	-
4-Methyl-2-Pentanone	0.1131	-	-	-	-
4-Methylphenol	0.3766	-	-	-	-
4-Nitroaniline	0.1728	-	-	-	-
4-Nitrophenol	0.0029	-	-	-	-
Ace-phthene	0.0399	2,000[g]	-	-	2,000
Ace-phthylene	0.3366	2,000[g]	-	-	2,000
Acetone	6.2674	200,000[g]	-	-	100,000
Acetonitrile	0.0002	-	-	-	-
Acrolein	0.0001	200,000[g]	-	-	200,000
Acrylonitrile	0.0000	200,000[g]	-	-	200,000
Anthracene	0.0083	2,000[g]	-	-	2,000
Aramite	0.0000	-	-	-	-
Aroclor-1016	0.0000	-	-	-	-

Table D-1. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
Aroclor-1254	0.0002	-	-	-	-
Aroclor-1260	0.0087	-	-	-	-
Aroclor-1268	0.2891	-	-	-	-
Benzene	1.3491	2,000[g]	-	-	1,000
Benzidine	0.0000	200,000[g]	-	-	200,000
Benzo(a)anthracene	0.0001	2,000[g]	-	-	2,000
Benzo(a)pyrene	0.0000	2,000[g]	-	-	2,000
Benzo(b)fluoranthene	0.0000	2,000[g]	-	-	2,000
Benzo(g,h,i)perylene	0.0000	-	-	-	-
Benzo(k)fluoranthene	0.3024	-	-	-	-
Benzoic acid	0.1162	-	-	-	-
bis(2-Chloroethoxy)methane	0.0455	2,000[g]	-	-	2,000
bis(2-Chloroethyl)ether	0.0535	2,000[g]	-	-	2,000
bis(2-Chloroisopropyl)ether	0.0000	2,000[g]	-	-	2,000
bis(2-Ethylhexyl)phthalate	0.5714	2,000[g]	-	-	2,000
Butane,1,1,3,4-Tetrachloro-	0.0001	-	-	-	-
Butylbenzylphthalate	0.0080	200,000[g]	-	-	200,000
Carbazole	0.1856	-	-	-	-
Carbon Disulfide	0.0734	-	-	-	-
Chlorobenzene	0.0679	2,000[g]	-	-	2,000
Chloroethane	0.0000	-	-	-	-
Chloromethane	0.0000	2,000[g]	-	-	2,000
Chrysene	4.4199	2,000[g]	-	-	2,000

Table D-1. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
Decane, 3,4-Dimethyl	0.0004	-	-	-	-
Diacetone alcohol	0.0005	-	-	-	-
Dibenz(a,h)anthracene	0.0006	2,000[g]	-	-	2,000
Dibenzofuran	0.4156	-	-	-	-
Diethylphthalate	0.1897	100,000[g]	-	-	100,000
Dimethyl Disulfide	0.0127	-	-	-	-
Dimethylphthalate	0.0001	100,000[g]	-	-	100,000
Di-n-butylphthalate	0.0000	100,000[f]	-	-	100,000
Di-n-octylphthalate	0.4370	-	-	-	-
Eicosane	0.0472	-	-	-	-
Ethyl cyanide	0.0000	-	-	-	-
Ethylbenzene	0.0705	2,000[g]	-	-	2,000
Famphur	0.0000	-	-	-	-
Fluoranthene	0.0221	2,000[g]	-	-	2,000
Fluorene	3.0594	2,000[g]	-	-	2,000
Heptadecane, 2,6,10,15-Tetra	0.0000	-	-	-	-
Hexachlorobenzene	0.0001	2,000[g]	-	-	2,000
Hexachlorobutadiene	0.0000	2,000[g]	-	-	2,000
Hexachlorocyclopentadiene	0.0025	2,000[g]	-	-	2,000
Hexachloroethane	0.0000	2,000[g]	-	-	2,000
Indeno(1,2,3-cd)pyrene	0.1585	2,000[g]	-	-	2,000
Isobutyl alcohol	0.0001	500,000[g]	-	-	500,000
Isophorone	0.1829	2,000[g]	-	-	2,000

Table D-1. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
Isopropyl Alcohol/2-propanol	0.0000	500,000[g]	-	-	500,000
Kepone	0.2511	-	-	-	-
Mesityl oxide	1.2939	-	-	-	-
Methyl Acetate	0.0057	-	-	-	-
Methylene Chloride	0.0165	2,000[g]	-	20[e]	20
-phthalene	1.9193	2,000[g]	-	-	2,000
Nitrobenzene	0.0948	100,000[g]	-	-	100,000
N-Nitroso-di-n-propylamine	0.0035	100,000[g]	-	-	100,000
N-Nitrosodiphenylamine	0.1896	100,000[g]	-	-	100,000
Octane,2,3,7-Trimethyl	0.0027	-	-	-	-
o-Toluenesulfo-mide	0.0033	-	-	-	-
Pentachlorophenol	0.0046	100,000[g]	-	-	100,000
Phe-nthrene	8.8500	2,000[g]	-	-	2,000
Phenol	0.1370	100,000[g]	-	-	100,000
Phenol,2,6-Bis(1,1-Dimethyl)	0.0674	-	-	-	-
p-Toluenesulfo-mide	0.0000	-	-	-	-
Pyrene	3.2501	2,000[g]	-	-	2,000
RDX	0.0000	5,000[g]	-	-	5,000
Styrene	0.0000	2,000[g]	-	-	2,000
Tetrachloroethene	0.0235	5,000[g]	-	20[h]	20
Toluene	16.3666	-	-	-	-
Tributylphosphate	1.2292	2,000[g]	-	1,100[e]	1,100

Table D-1. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
Trichloroethene	1.1526	-	-	-	-
Trinitrotoluene	0.0000	-	-	-	-
Undecane,4,6-Dimethyl-	0.0003	5,000[g]	-	-	5,000
Xylene (ortho)	0.0071	-	-	-	-
Xylene (total)	6.2805	-	-	-	-

Notes

a. Constituent reported in the "INEEL CERCLA Disposal Facility Design Inventory (EDF-ER-264).
b. Predicted leachate concentration in the first year of the ICDF landfill operation (EDF-ER-274).
c. The suggested maximum concentration selected for the ICDF liner system is based on the lowest of the concentrations listed for HDPE, GCL, and clay materials and are applicable for the leachate in the landfill and the waste liquids in the evaporation ponds.
d. "–" indicates that a specific test value was not available, compatibility issues are not anticipated.
e. The TCE solubility limit in water is 1,100 mg/l. A minimum of 2 pore volumes of permeant liquid was passed through the clay sample or until the concentration of total organic carbon in the influent and effluent were the same (Bowders and Daniel 1988). No significant change in permeability was observed.
f. From "Evaluation of Liner/Leachate Chemical Compatibility for the Environmental Restoration Disposal Facility," BHI-00359.
g. From manufacturer specifications.
h. 20 mg/l is the typical concentration of leachate found in muncipal landfills. No change in clay permeability was observed at this concentration (Kim, Tuncer, and Park 1999).

Table D-2. Suggested maximum leachate concentrations for inorganic constituent for liner compatibility.

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/l)	Compatible Concentration For GCL (mg/l)	Compatible Concentration For Clay (mg/l)	Suggested Maximum Leachate Concentration[c] (mg/l)
Aluminum	28.3029				
Antimony	0.1165				
Arsenic	1.8470	500,000[d]	-	-[e]	500,000
Barium	3.5848				
Beryllium	0.0011				
Boron	36.4728	500,000[d]	-	-[e]	500,000
Cadmium	0.5917	500,000[d]	-	-[e]	500,000
Calcium	4035.0217	500,000[d]	-	-[e]	500,000
Chloride	31.1061				
Chromium	1.3691				
Cobalt	0.5999	500,000[d]	-	-[e]	500,000
Copper	1.4906	500,000[d]	-	-[e]	500,000
Cyanide	4.0932	500,000[d]	-	-[e]	500,000
Dysprosium	0.2472				
Fluoride	64.4341				
Iron	46.5528				
Lead	0.5753				
Magnesium	883.9838	500,000[d]	-	-[e]	500,000
Manganese	4.1300				
Mercury	49.6286				
Molybdenum	1.0117	500,000[d]	-	-[e]	500,000
Nickel	0.1964				
Nitrate	65.4429				
Nitrate/Nitrite-N	3.6979				
Nitrite	0.1414				
Phosphorus	19.2492	500,000[d]	-	-[e]	500,000
Potassium	74.8819	500,000[d]	-	-[e]	500,000
Selenium	0.2084	500,000[d]	-	-[e]	500,000
Silver	0.1092				
Sodium	2.7716				
Strontium	1.5094	500,000[d]	-	-[e]	500,000

Table D-2. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/l)	Compatible Concentration For GCL (mg/l)	Compatible Concentration For Clay (mg/l)	Suggested Maximum Leachate Concentration[c] (mg/l)
Sulfate	342.1180				
Sulfide	12641.8391				
Terbium	2.3867				
Thallium	0.0037				
Va-dium	3.5063	500,000[d]	-	-[e]	500,000
Ytterbium	0.8124				
Zinc	12.9486	500,000[4]	-	-[e]	500,000
Zirconium	0.1151				
Total Inorganic	18367.1936				

a. Constituent reported in the "INEEL CERCLA Disposal Facility Design Inventory (EDF-ER-264).
b. Predicted leachate concentration in the first year of the ICDF landfill operation (EDF-ER-274).
c. The suggested maximum concentration selected for the ICDF liner system is based on the lowest of the concentrations listed for HDPE, GCL, and clay materials and are applicable for the leachate in the landfill and the waste liquids in the evaporation ponds.
d. From manufacturer specifications
e. From manufacturer specifications

Table D-3. Suggested maximum leachate concentrations for radionuclide constituents for liner compatibility in the ICDF Landfill.

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Ac225	1.1E-07	2.2E+07
Ac227	4.5E-05	1.6E+09
Ac228	3.4E-10	9.4E+07
Ag106	0.0E+00	2.0E+08
Ag108	4.1E-08	-
Ag108m	8.9E+00	7.8E+07
Ag109m	5.5E-11	1.5E+09
Ag110	5.7E-10	1.1E+08
Ag110m	6.2E-08	4.6E+07
Ag111	0.0E+00	-
Am241	7.0E+01	2.3E+07
Am242	1.3E-04	6.7E+08
Am242m	1.3E-04	1.9E+09
Am243	9.8E-04	2.4E+07
Am245	0.0E+00	-
Am246	4.1E-25	1.0E+08
At217	8.5E-04	1.8E+07
Ba136m	0.0E+00	-
Ba137m	4.6E+05	1.9E+08
Ba140	0.0E+00	-
Be 10	4.6E-06	6.3E+08
Bi210	1.1E-05	3.3E+08
Bi211	1.8E-04	1.9E+07
Bi212	5.5E-03	4.5E+07
Bi213	0.0E+00	-
Bi214	5.6E-05	5.9E+07
Bk249	5.4E-22	3.9E+09
Bk250	1.9E-26	1.1E+08
C 14	9.1E-03	2.6E+09
Cd109	8.1E-10	6.5E+09
Cd113m	2.7E+02	6.9E+08
Cd115m	7.0E-52	2.0E+08
Ce141	3.6E-71	5.2E+08
Ce142	0.0E+00	-
Ce144	3.6E-03	1.1E+09
Cf249	8.1E-16	2.1E+07
Cf250	4.1E-16	2.1E+07
Cf251	1.9E-18	2.2E+07
Cf252	4.4E-20	1.2E+10
Cm241	3.2E-81	7.5E+08
Cm242	1.3E-17	2.1E+07
Cm243	8.9E-07	2.1E+07
Cm244	4.5E-04	2.2E+07
Cm245	2.0E-08	2.3E+07
Cm246	4.5E-10	2.4E+07
Cm247	1.6E-16	2.4E+07
Cm248	4.9E-17	2.7E+07
Cm250	1.4E-25	9.8E+07
Co-57	3.7E-01	8.9E+08
Co-58	5.8E-15	1.3E+08

Table D-3. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Co-60	1.9E+04	4.9E+07
Cr-51	7.7E-53	3.5E+09
Cs132	0.0E+00	-
Cs134	2.2E+01	7.4E+07
Cs135	7.2E-02	2.3E+09
Cs136	0.0E+00	-
Cs137	4.9E+04	7.5E+08
Er169	0.0E+00	-
Eu150	5.1E-08	4.4E+08
Eu152	2.8E+03	1.0E+08
Eu154	2.4E+03	8.4E+07
Eu155	5.2E+02	1.0E+09
Eu156	0.0E+00	-
Fe-59	2.0E-34	9.8E+07
Fr221	1.0E-07	2.0E+07
Fr223	5.6E-07	2.9E+08
Gd152	1.1E-13	5.9E+07
Gd153	8.4E-11	8.4E+08
H 3	8.3E+05	2.2E+10
Hf-181	1.7E-36	1.7E+08
Ho166m	1.1E-05	7.3E+07
I129	2.2E+04	1.6E+09
I131	0.0E+00	-
In114	4.8E-54	1.6E+08
In114m	5.1E-54	5.3E+08
In115	1.5E-11	8.4E+08
In115m	0.0E+00	-
K-40	1.3E+02	2.1E+08
Kr81[d]	8.8E-05	-
Kr85[d]	1.9E+07	-
La138	0.0E+00	-
La140	2.2E-105	4.5E+07
Mn-54	3.9E-07	1.5E+08
Nb92	6.3E-18	8.5E+07
Nb93m	1.3E-01	4.2E+09
Nb94	8.8E-05	7.4E+07
Nb95	4.8E-32	1.6E+08
Nb95m	1.8E-34	5.2E+08
Nd144	1.4E-09	6.7E+07
Nd147	0.0E+00	-
Np235	8.4E-09	1.3E+10
Np236	8.6E-06	3.7E+08
Np237	8.0E+01	2.6E+07
Np238	2.7E-05	1.6E+08
Np239	4.1E-02	3.1E+08
Np240	3.5E-12	8.0E+07
Np240m	3.1E-09	1.3E+08
Pa231	1.3E-04	2.3E+07
Pa233	7.9E-02	3.1E+08
Pa234	5.0E-06	5.2E+07

Table D-3. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Pa234m	3.1E-03	1.5E+08
Pb209	4.8E-07	6.5E+08
Pb210	1.1E-05	3.3E+09
Pb211	1.8E-04	2.5E+08
Pb212	5.5E-03	4.0E+08
Pb214	5.6E-05	2.4E+08
Pd107	1.1E-01	3.9E+09
Pm146	2.4E-02	1.5E+08
Pm147	1.6E+03	2.1E+09
Pm148	1.7E-58	9.8E+07
Pm148m	3.4E-57	5.9E+07
Po210	6.8E-06	2.4E+07
Po211	4.6E-09	1.7E+07
Po212	2.2E-03	1.5E+07
Po213	2.9E-07	1.5E+07
Po214	3.7E-05	1.7E+07
Po215	1.2E-04	1.7E+07
Po216	3.7E-03	1.9E+07
Po218	3.7E-05	2.1E+07
Pr143	0.0E+00	-
Pr144	7.4E-03	1.0E+08
Pr144m	1.1E-04	1.1E+10
Pu236	3.9E-05	2.2E+07
Pu237	8.6E-58	2.1E+09
Pu238	1.7E+03	2.3E+07
Pu239	4.8E+01	2.5E+07
Pu240	1.1E+01	2.5E+07
Pu241	4.6E+02	2.4E+10
Pu242	1.7E-03	2.6E+07
Pu243	4.6E-15	6.6E+08
Pu244	1.8E-10	2.8E+07
Pu246	9.9E-25	8.3E+08
Ra222	1.2E-115	2.0E+07
Ra223	2.0E-04	2.2E+07
Ra224	5.5E-03	2.2E+07
Ra225	5.1E-07	1.1E+09
Ra226	4.7E+00	2.7E+07
Ra228	1.5E-09	1.1E+10
Rb86	0.0E+00	-
Rb87	2.0E-04	1.6E+09
Rh102	5.7E-04	1.6E+09
Rh103m	5.4E-57	3.3E+09
Rh106	2.2E-01	7.9E+07
Rn218	2.1E-112	1.8E+07
Rn219	3.4E-01	1.9E+07
Rn220	9.2E+00	2.0E+07
Rn222	1.0E-01	2.3E+07
Ru103	3.6E-28	2.3E+08
Ru106	2.2E-01	3.2E+09
Sb124	4.1E-39	5.7E+07

Table D-3. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Sb125	1.9E+02	2.4E+08
Sb126	4.1E-01	4.2E+07
Sb126m	2.9E+00	5.9E+07
Sc-46	9.2E-20	6.0E+07
Se 79	4.1E+01	2.4E+09
Sm146	1.8E-09	5.1E+07
Sm147	1.7E-05	5.7E+07
Sm148	4.2E-12	6.4E+07
Sm149[e]	2.1E-11	-
Sm151	1.4E+03	6.5E+09
Sn117m	0.0E+00	-
Sn119m	1.1E-06	6.5E+09
Sn121m	2.1E-01	1.5E+09
Sn123	6.5E-16	4.2E+10
Sn125	0.0E+00	-
Sn126	1.1E+00	2.4E+08
Sr89	5.0E-42	3.6E+08
Sr90	1.9E+06	2.2E+08
Tb160	1.3E-33	2.3E+08
Tb161	0.0E+00	-
Tc 98	6.8E-04	9.5E+07
Tc 99	2.2E+04	8.4E+07
Te123	3.6E-14	1.5E+09
Te123m	2.4E-22	7.5E+09
Te125m	1.8E+01	5.2E+08
Te127	7.5E-19	8.0E+08
Te127m	7.6E-19	5.6E+08
Te129	5.4E-70	1.4E+09
Te129m	8.6E-70	2.1E+08
Th226	2.2E-116	4.1E+08
Th227	1.8E-04	2.0E+07
Th228	3.3E-01	2.1E+07
Th229	5.1E-07	2.4E+07
Th230	1.7E+00	2.5E+07
Th231	1.6E+00	2.7E+07
Th232	1.6E+00	7.2E+08
Th234	1.7E-02	3.2E+07
Tl207	1.8E-04	1.9E+09
Tl208	2.0E-03	2.6E+08
Tl209	1.1E-08	3.2E+07
Tm170	2.7E-25	3.2E+07
Tm171	6.6E-12	3.8E+08
U230	0.0E+00	-
U232	8.8E-02	4.9E+09
U233	4.2E-03	2.4E+07
U234	9.9E+02	2.7E+07
U235	1.8E+01	2.7E+07
U236	3.3E+01	2.8E+07
U237	0.0E+00	-
U238	3.2E+02	2.8E+07

Table D-3. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
U240	4.2E-09	3.0E+07
Xe127	2.6E-68	8.0E+08
Xe129m	0.0E+00	-
Xe131m	4.5E-108	4.1E+08
Xe133	0.0E+00	-
Y90	1.3E+05	7.9E+08
Y91	2.4E-36	1.3E+08
Zn65	1.7E-07	2.1E+08
Zr93	1.4E+00	2.2E+08
Zr95	4.9E-25	6.6E+09

Notes:

a. Constituent reported in the "INEEL CERCLA Disposal Facility Design Inventory" (EDF-ER-264).

b. Predicted average leachate activity concentration during the 15 year operational period.

c. The suggested maximum activity concentration selected for the ICDF liner system is based on a total absorbed dose of 1,000,000 rads for the individual constituent and a 4 cm leachate depth.

d. The constituents are gaseous elements so not part of the leachate.

e. No energy emitted since stable isotope.

Table D-4. Suggested maximum leachate concentrations for radionuclide constituents for liner compatibility in the ICDF Evaporation Pond

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Ac225	1.1E-07	2.4E+06
Ac227	4.5E-05	1.8E+08
Ac228	3.4E-10	1.0E+07
Ag106	0.0E+00	2.3E+07
Ag108	4.1E-08	-
Ag108m	8.9E+00	8.7E+06
Ag109m	5.5E-11	1.6E+08
Ag110	5.7E-10	1.2E+07
Ag110m	6.2E-08	5.1E+06
Ag111	0.0E+00	-
Am241	7.0E+01	2.6E+06
Am242	1.3E-04	7.4E+07
Am242m	1.3E-04	2.2E+08
Am243	9.8E-04	2.7E+06
Am245	0.0E+00	-
Am246	4.1E-25	1.1E+07
At217	8.5E-04	2.0E+06
Ba136m	0.0E+00	-
Ba137m	4.6E+05	2.1E+07
Ba140	0.0E+00	-
Be 10	4.6E-06	7.0E+07
Bi210	1.1E-05	3.7E+07
Bi211	1.8E-04	2.2E+06
Bi212	5.5E-03	5.0E+06
Bi213	0.0E+00	-
Bi214	5.6E-05	6.6E+06
Bk249	5.4E-22	4.3E+08
Bk250	1.9E-26	1.2E+07
C 14	9.1E-03	2.9E+08
Cd109	8.1E-10	7.2E+08
Cd113m	2.7E+02	7.7E+07
Cd115m	7.0E-52	2.3E+07
Ce141	3.6E-71	5.8E+07
Ce142	0.0E+00	-
Ce144	3.6E-03	1.3E+08
Cf249	8.1E-16	2.3E+06
Cf250	4.1E-16	2.4E+06
Cf251	1.9E-18	2.4E+06
Cf252	4.4E-20	1.4E+09
Cm241	3.2E-81	8.3E+07
Cm242	1.3E-17	2.3E+06
Cm243	8.9E-07	2.3E+06
Cm244	4.5E-04	2.4E+06
Cm245	2.0E-08	2.6E+06
Cm246	4.5E-10	2.6E+06
Cm247	1.6E-16	2.7E+06
Cm248	4.9E-17	3.1E+06
Cm250	1.4E-25	1.1E+07

Table D-4. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Co-57	3.7E-01	9.9E+07
Co-58	5.8E-15	1.5E+07
Co-60	1.9E+04	5.5E+06
Cr-51	7.7E-53	3.9E+08
Cs132	0.0E+00	-
Cs134	2.2E+01	8.3E+06
Cs135	7.2E-02	2.5E+08
Cs136	0.0E+00	-
Cs137	4.9E+04	8.3E+07
Er169	0.0E+00	-
Eu150	5.1E-08	4.9E+07
Eu152	2.8E+03	1.1E+07
Eu154	2.4E+03	9.3E+06
Eu155	5.2E+02	1.2E+08
Eu156	0.0E+00	-
Fe-59	2.0E-34	1.1E+07
Fr221	1.0E-07	2.2E+06
Fr223	5.6E-07	3.3E+07
Gd152	1.1E-13	6.6E+06
Gd153	8.4E-11	9.3E+07
H 3	8.3E+05	2.5E+09
Hf-181	1.7E-36	1.9E+07
Ho166m	1.1E-05	8.2E+06
I129	2.2E+04	1.8E+08
I131	0.0E+00	-
In114	4.8E-54	1.8E+07
In114m	5.1E-54	5.9E+07
In115	1.5E-11	9.3E+07
In115m	0.0E+00	-
K-40	1.3E+02	2.3E+07
Kr81[d]	8.8E-05	-
Kr85[d]	1.9E+07	-
La138	0.0E+00	-
La140	2.2E-105	5.0E+06
Mn-54	3.9E-07	1.7E+07
Nb92	6.3E-18	9.4E+06
Nb93m	1.3E-01	4.7E+08
Nb94	8.8E-05	8.3E+06
Nb95	4.8E-32	1.8E+07
Nb95m	1.8E-34	5.8E+07
Nd144	1.4E-09	7.5E+06
Nd147	0.0E+00	-
Np235	8.4E-09	1.4E+09
Np236	8.6E-06	4.2E+07
Np237	8.0E+01	2.9E+06
Np238	2.7E-05	1.8E+07
Np239	4.1E-02	3.4E+07
Np240	3.5E-12	8.9E+06
Np240m	3.1E-09	1.5E+07
Pa231	1.3E-04	2.6E+06

Table D-4. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Pa233	7.9E-02	3.5E+07
Pa234	5.0E-06	5.8E+06
Pa234m	3.1E-03	1.7E+07
Pb209	4.8E-07	7.2E+07
Pb210	1.1E-05	3.7E+08
Pb211	1.8E-04	2.8E+07
Pb212	5.5E-03	4.4E+07
Pb214	5.6E-05	2.6E+07
Pd107	1.1E-01	4.3E+08
Pm146	2.4E-02	1.7E+07
Pm147	1.6E+03	2.3E+08
Pm148	1.7E-58	1.1E+07
Pm148m	3.4E-57	6.6E+06
Po210	6.8E-06	2.7E+06
Po211	4.6E-09	1.9E+06
Po212	2.2E-03	1.6E+06
Po213	2.9E-07	1.7E+06
Po214	3.7E-05	1.8E+06
Po215	1.2E-04	1.9E+06
Po216	3.7E-03	2.1E+06
Po218	3.7E-05	2.4E+06
Pr143	0.0E+00	-
Pr144	7.4E-03	1.1E+07
Pr144m	1.1E-04	1.2E+09
Pu236	3.9E-05	2.5E+06
Pu237	8.6E-58	2.3E+08
Pu238	1.7E+03	2.6E+06
Pu239	4.8E+01	2.8E+06
Pu240	1.1E+01	2.8E+06
Pu241	4.6E+02	2.7E+09
Pu242	1.7E-03	2.9E+06
Pu243	4.6E-15	7.3E+07
Pu244	1.8E-10	3.1E+06
Pu246	9.9E-25	9.2E+07
Ra222	1.2E-115	2.2E+06
Ra223	2.0E-04	2.4E+06
Ra224	5.5E-03	2.5E+06
Ra225	5.1E-07	1.2E+08
Ra226	4.7E+00	3.0E+06
Ra228	1.5E-09	1.2E+09
Rb86	0.0E+00	-
Rb87	2.0E-04	1.8E+08
Rh102	5.7E-04	1.8E+08
Rh103m	5.4E-57	3.7E+08
Rh106	2.2E-01	8.8E+06
Rn218	2.1E-112	2.0E+06
Rn219	3.4E-01	2.1E+06
Rn220	9.2E+00	2.3E+06
Rn222	1.0E-01	2.6E+06
Ru103	3.6E-28	2.6E+07

Table D-4. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Ru106	2.2E-01	3.6E+08
Sb124	4.1E-39	6.3E+06
Sb125	1.9E+02	2.7E+07
Sb126	4.1E-01	4.7E+06
Sb126m	2.9E+00	6.6E+06
Sc-46	9.2E-20	6.7E+06
Se 79	4.1E+01	2.7E+08
Sm146	1.8E-09	5.6E+06
Sm147	1.7E-05	6.3E+06
Sm148	4.2E-12	7.1E+06
Sm149[e]	2.1E-11	-
Sm151	1.4E+03	7.2E+08
Sn117m	0.0E+00	-
Sn119m	1.1E-06	7.2E+08
Sn121m	2.1E-01	1.6E+08
Sn123	6.5E-16	4.7E+09
Sn125	0.0E+00	-
Sn126	1.1E+00	2.7E+07
Sr89	5.0E-42	4.0E+07
Sr90	1.9E+06	2.4E+07
Tb160	1.3E-33	2.6E+07
Tb161	0.0E+00	-
Tc 98	6.8E-04	1.1E+07
Tc 99	2.2E+04	9.4E+06
Te123	3.6E-14	1.7E+08
Te123m	2.4E-22	8.3E+08
Te125m	1.8E+01	5.8E+07
Te127	7.5E-19	8.9E+07
Te127m	7.6E-19	6.2E+07
Te129	5.4E-70	1.6E+08
Te129m	8.6E-70	2.4E+07
Th226	2.2E-116	4.6E+07
Th227	1.8E-04	2.2E+06
Th228	3.3E-01	2.3E+06
Th229	5.1E-07	2.6E+06
Th230	1.7E+00	2.8E+06
Th231	1.6E+00	3.0E+06
Th232	1.6E+00	8.0E+07
Th234	1.7E-02	3.5E+06
Tl207	1.8E-04	2.1E+08
Tl208	2.0E-03	2.9E+07
Tl209	1.1E-08	3.6E+06
Tm170	2.7E-25	3.6E+06
Tm171	6.6E-12	4.2E+07
U230	0.0E+00	-
U232	8.8E-02	5.4E+08
U233	4.2E-03	2.7E+06
U234	9.9E+02	2.9E+06
U235	1.8E+01	3.0E+06
U236	3.3E+01	3.1E+06

Table D-4. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
U237	0.0E+00	-
U238	3.2E+02	3.2E+06
U240	4.2E-09	3.4E+06
Xe127	2.6E-68	8.9E+07
Xe129m	0.0E+00	-
Xe131m	4.5E-108	4.6E+07
Xe133	0.0E+00	-
Y90	1.3E+05	8.8E+07
Y91	2.4E-36	1.5E+07
Zn65	1.7E-07	2.3E+07
Zr93	1.4E+00	2.4E+07
Zr95	4.9E-25	7.3E+08

Notes:

a. Constituent reported in the "INEEL CERCLA Disposal Facility Design Inventory (EDF-ER-264).
b. Predicted average leachate activity concentration during the 15 year operational period.
c. The suggested maximum activity concentration selected for the ICDF liner system is based on a total absorbed dose of 1,000,000 rads for the individual constituent and a 36 cm liquid waste depth.
d. The constituents are gaseous elements so not part of the leachate.
e. Stable isotope

Appendix E

Suggested Maximum Leachate Concentrations for Individual Constituents in Evaporation Pond Liquid

Table E-1. Suggested maximum leachate concentrations for organic constituents for liner compatibility in evaporation pond.

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
1,1,1-Trichloroethane	0.0609	-[d]	-[d]	20[e]	20
1,1,2,2-Tetrachloroethane	0.0002	-	-	-	-
1,1,2-Trichloroethane	0.0013	-	-	-	-
1,1-Dichloroethane	0.0105	-	-	-	-
1,1-Dichloroethene	0.0004	-	-	-	-
1,2,4-Trichlorobenzene	0.0113	-	-	-	-
1,2-Dichlorobenzene	0.0734	-	-	-	-
1,2-Dichloroethane	0.0001	-	-	-	-
1,2-Dichloroethene (total)	0.0003	-	-	-	-
1,3-Dichlorobenzene	0.0071	2,000[f]	-	-	2,000
1,4-Dichlorobenzene	5.1303	-	-	-	-
1,4-Dioxane	0.0000	-	-	-	-
2,4,5-Trichlorophenol	0.0441	-	-	-	-
2,4,6-Trichlorophenol	0.0427	-	-	-	-
2,4-Dichlorophenol	0.0371	-	-	-	-
2,4-Dimethylphenol	0.3041	-	-	-	-
2,4-Dinitrophenol	0.1705	-	-	-	-
2,4-Dinitrotoluene	0.0488	-	-	-	-
2,6-Dinitrotoluene	0.2903	-	-	-	-
2-Butanone	0.0063	200,000[f]	-	-	200,000
2-Chloro-phthalene	0.0108	2,000[g]	-	-	2,000
2-Chlorophenol	0.1867	2,000[g]	-	-	2,000
2-Hexanone	0.0001	-	-	-	-
2-Methyl-phthalene	1.7772	-	-	-	-

Table E-1. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
2-Methylphenol	0.2014	-	-	-	-
2-Nitroaniline	0.1728	-	-	-	-
2-Nitrophenol	0.0098	-	-	-	-
3,3'-Dichlorobenzidine	0.1896	-	-	-	-
3-Methyl Buta-l	0.0022	-	-	-	-
3-Nitroaniline	0.0165	-	-	-	-
4,6-Dinitro-2-methylphenol	0.0010	-	-	-	-
4-Bromophenyl-phenylether	0.0615	2,000[g]	-	-	2,000
4-Chloro-3-methylphenol	0.0810	-	-	-	-
4-Chloroaniline	0.0052	-	-	-	-
4-Chlorophenyl-phenylether	0.0288	-	-	-	-
4-Methyl-2-Pentanone	0.1131	-	-	-	-
4-Methylphenol	0.3766	-	-	-	-
4-Nitroaniline	0.1728	-	-	-	-
4-Nitrophenol	0.0029	-	-	-	-
Ace-phthene	0.0399	2,000[g]	-	-	2,000
Ace-phthylene	0.3366	2,000[g]	-	-	2,000
Acetone	6.2674	200,000[g]	-	-	100,000
Acetonitrile	0.0002	-	-	-	-
Acrolein	0.0001	200,000[g]	-	-	200,000
Acrylonitrile	0.0000	200,000[g]	-	-	200,000
Anthracene	0.0083	2,000[g]	-	-	2,000
Aramite	0.0000	-	-	-	-
Aroclor-1016	0.0000	-	-	-	-

Table E-1. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
Aroclor-1254	0.0002	-	-	-	-
Aroclor-1260	0.0087	-	-	-	-
Aroclor-1268	0.2891	-	-	-	-
Benzene	1.3491	2,000[g]	-	-	1,000
Benzidine	0.0000	200,000[g]	-	-	200,000
Benzo(a)anthracene	0.0001	2,000[g]	-	-	2,000
Benzo(a)pyrene	0.0000	2,000[g]	-	-	2,000
Benzo(b)fluoranthene	0.0000	2,000[g]	-	-	2,000
Benzo(g,h,i)perylene	0.0000	-	-	-	-
Benzo(k)fluoranthene	0.3024	-	-	-	-
Benzoic acid	0.1162	-	-	-	-
bis(2-Chloroethoxy)methane	0.0455	2,000[g]	-	-	2,000
bis(2-Chloroethyl)ether	0.0535	2,000[g]	-	-	2,000
bis(2-Chloroisopropyl)ether	0.0000	2,000[g]	-	-	2,000
bis(2-Ethylhexyl)phthalate	0.5714	2,000[g]	-	-	2,000
Butane,1,1,3,4-Tetrachloro-	0.0001	-	-	-	-
Butylbenzylphthalate	0.0080	200,000[g]	-	-	200,000
Carbazole	0.1856	-	-	-	-
Carbon Disulfide	0.0734	-	-	-	-
Chlorobenzene	0.0679	2,000[g]	-	-	2,000
Chloroethane	0.0000	-	-	-	-
Chloromethane	0.0000	2,000[g]	-	-	2,000
Chrysene	4.4199	2,000[g]	-	-	2,000

Table E-1. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
Decane, 3,4-Dimethyl	0.0004	-	-	-	-
Diacetone alcohol	0.0005	-	-	-	-
Dibenz(a,h)anthracene	0.0006	2,000[g]	-	-	2,000
Dibenzofuran	0.4156	-	-	-	-
Diethylphthalate	0.1897	100,000[g]	-	-	100,000
Dimethyl Disulfide	0.0127	-	-	-	-
Dimethylphthalate	0.0001	100,000[g]	-	-	100,000
Di-n-butylphthalate	0.0000	100,000[f]	-	-	100,000
Di-n-octylphthalate	0.4370	-	-	-	-
Eicosane	0.0472	-	-	-	-
Ethyl cyanide	0.0000	-	-	-	-
Ethylbenzene	0.0705	2,000[g]	-	-	2,000
Famphur	0.0000	-	-	-	-
Fluoranthene	0.0221	2,000[g]	-	-	2,000
Fluorene	3.0594	2,000[g]	-	-	2,000
Heptadecane, 2,6,10,15-Tetra	0.0000	-	-	-	-
Hexachlorobenzene	0.0001	2,000[g]	-	-	2,000
Hexachlorobutadiene	0.0000	2,000[g]	-	-	2,000
Hexachlorocyclopentadiene	0.0025	2,000[g]	-	-	2,000
Hexachloroethane	0.0000	2,000[g]	-	-	2,000
Indeno(1,2,3-cd)pyrene	0.1585	2,000[g]	-	-	2,000
Isobutyl alcohol	0.0001	500,000[g]	-	-	500,000
Isophorone	0.1829	2,000[g]	-	-	2,000

Table E-1. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
Isopropyl Alcohol/2-propanol	0.0000	500,000[g]	-	-	500,000
Kepone	0.2511	-	-	-	-
Mesityl oxide	1.2939	-	-	-	-
Methyl Acetate	0.0057	-	-	-	-
Methylene Chloride	0.0165	2,000[g]	-	20[e]	20
-phthalene	1.9193	2,000[g]	-	-	2,000
Nitrobenzene	0.0948	100,000[g]	-	-	100,000
N-Nitroso-di-n-propylamine	0.0035	100,000[g]	-	-	100,000
N-Nitrosodiphenylamine	0.1896	100,000[g]	-	-	100,000
Octane,2,3,7-Trimethyl	0.0027	-	-	-	-
o-Toluenesulfo-mide	0.0033	-	-	-	-
Pentachlorophenol	0.0046	100,000[g]	-	-	100,000
Phe-nthrene	8.8500	2,000[g]	-	-	2,000
Phenol	0.1370	100,000[g]	-	-	100,000
Phenol,2,6-Bis(1,1-Dimethyl)	0.0674	-	-	-	-
p-Toluenesulfo-mide	0.0000	-	-	-	-
Pyrene	3.2501	2,000[g]	-	-	2,000
RDX	0.0000	5,000[g]	-	-	5,000
Styrene	0.0000	2,000[g]	-	-	2,000
Tetrachloroethene	0.0235	5,000[g]	-	20[h]	20
Toluene	16.3666	-	-	-	-
Tributylphosphate	1.2292	2,000[g]	-	1,100[e]	1,100

Table E-1. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/L)	Compatible Concentration For GCL (mg/L)	Compatible Concentration For Clay (mg/L)	Suggested Maximum Leachate Concentration[c] (mg/L)
Trichloroethene	1.1526	-	-	-	-
Trinitrotoluene	0.0000	-	-	-	-
Undecane,4,6-Dimethyl-	0.0003	5,000[g]	-	-	5,000
Xylene (ortho)	0.0071	-	-	-	-
Xylene (total)	6.2805	-	-	-	-

Notes

a. Constituent reported in the "INEEL CERCLA Disposal Facility Design Inventory (EDF-ER-264)
b. Predicted leachate concentration in the first year of the ICDF landfill operation (EDF-ER-274).
c. The suggested maximum concentration selected for the ICDF liner system is based on the lowest of the concentrations listed for HDPE, GCL, and clay materials and are applicable for the leachate in the landfill and the waste liquids in the evaporation ponds.
d. "–" indicates that a specific test value was not available, compatibility issues are not anticipated.
e. The TCE solubility limit in water is 1,100 mg/l. A minimum of 2 pore volumes of permeant liquid was passed through the clay sample or until the concentration of total organic carbon in the influent and effluent were the same (Bowders and Daniel 1988). No significant change in permeability was observed.
f. From "Evaluation of Liner/Leachate Chemical Compatibility for the Environmental Restoration Disposal Facility" (USACE, 1995, *Evaluation of Liner/Leachate Chemical Compatibility For the Environmental Restoration Disposal Facility*, U.S. Army Corps of Engineers, Walla Walla, Washington.).
g. From manufacturer specifications.
h. 20 mg/l is the typical concentration of leachate found in muncipal landfills. No change in clay permeability was observed at this concentration (Kim, Tuncer, and Park 1999).
i. Maximum allowable concentration reduced by 50 percent since liner may reflect some attack at a pure concentration based on manufactures maximum concentration data (see Appendix B).

Table E-2. Suggested maximum leachate concentrations for inorganic constituent for liner compatibility.

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/l)	Compatible Concentration For GCL (mg/l)	Compatible Concentration For Clay (mg/l)	Suggested Maximum Leachate Concentration[c] (mg/l)
Aluminum	28.3029				
Antimony	0.1165				
Arsenic	1.8470	500,000[d]	-	-[e]	500,000
Barium	3.5848				
Beryllium	0.0011				
Boron	36.4728	500,000[d]	-	-[e]	500,000
Cadmium	0.5917	500,000[d]	-	-[e]	500,000
Calcium	4035.0217	500,000[d]	-	-[e]	500,000
Chloride	31.1061				
Chromium	1.3691				
Cobalt	0.5999	500,000[d]	-	-[e]	500,000
Copper	1.4906	500,000[d]	-	-[e]	500,000
Cyanide	4.0932	500,000[d]	-	-[e]	500,000
Dysprosium	0.2472				
Fluoride	64.4341				
Iron	46.5528				
Lead	0.5753				
Magnesium	883.9838	500,000[d]	-	-[e]	500,000
Manganese	4.1300				
Mercury	0.0944				
Molybdenum	1.0117	500,000[d]	-	-[e]	500,000
Nickel	0.1964				
Nitrate	65.4429				
Nitrate/Nitrite-N	3.6979				
Nitrite	0.1414				
Phosphorus	19.2492	500,000[d]	-	-[e]	500,000
Potassium	74.8819	500,000[d]	-	-[e]	500,000
Selenium	0.2084	500,000[d]	-	-[e]	500,000
Silver	0.1092				
Sodium	2.7716				
Strontium	1.5094	500,000[d]	-	-[e]	500,000

Table E-2. (continued).

Constituent[a]	Predicted Concentration in Leachate[b] (mg/L)	Compatible Concentration For HDPE (mg/l)	Compatible Concentration For GCL (mg/l)	Compatible Concentration For Clay (mg/l)	Suggested Maximum Leachate Concentration[c] (mg/l)
Sulfate	342.1180				
Sulfide	12641.8391				
Terbium	2.3867				
Thallium	0.0037				
Va-dium	3.5063	500,000[d]	-	-[e]	500,000
Ytterbium	0.8124				
Zinc	12.9486	500,000[4]	-	-[e]	500,000
Zirconium	0.1151				
Total Inorganic	18317.5650				

a. Constituent reported in the "INEEL CERCLA Disposal Facility Design Inventory (EDF-ER-264).
b. Predicted leachate concentration in the first year of the ICDF landfill operation (EDF-ER-274).
c. The suggested maximum concentration selected for the ICDF liner system is based on the lowest of the concentrations listed for HDPE, GCL, and clay materials and are applicable for the leachate in the landfill and the waste liquids in the evaporation ponds.
d. From manufacturer specifications
e. From manufacturer specifications

Table E-3. Suggested maximum leachate concentrations for radionuclide constituents for liner compatibility in the ICDF Evaporation Pond

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Ac225	1.1E-07	2.4E+06
Ac227	4.5E-05	1.8E+08
Ac228	3.4E-10	1.0E+07
Ag106	0.0E+00	2.3E+07
Ag108	4.1E-08	-
Ag108m	8.9E+00	8.7E+06
Ag109m	5.5E-11	1.6E+08
Ag110	5.7E-10	1.2E+07
Ag110m	6.2E-08	5.1E+06
Ag111	0.0E+00	-
Am241	7.0E+01	2.6E+06
Am242	1.3E-04	7.4E+07
Am242m	1.3E-04	2.2E+08
Am243	9.8E-04	2.7E+06
Am245	0.0E+00	-
Am246	4.1E-25	1.1E+07
At217	8.5E-04	2.0E+06
Ba136m	0.0E+00	-
Ba137m	4.6E+05	2.1E+07
Ba140	0.0E+00	-
Be 10	4.6E-06	7.0E+07
Bi210	1.1E-05	3.7E+07
Bi211	1.8E-04	2.2E+06
Bi212	5.5E-03	5.0E+06
Bi213	0.0E+00	-
Bi214	5.6E-05	6.6E+06
Bk249	5.4E-22	4.3E+08
Bk250	1.9E-26	1.2E+07
C 14	9.1E-03	2.9E+08
Cd109	8.1E-10	7.2E+08
Cd113m	2.7E+02	7.7E+07
Cd115m	7.0E-52	2.3E+07
Ce141	3.6E-71	5.8E+07
Ce142	0.0E+00	-
Ce144	3.6E-03	1.3E+08
Cf249	8.1E-16	2.3E+06
Cf250	4.1E-16	2.4E+06
Cf251	1.9E-18	2.4E+06
Cf252	4.4E-20	1.4E+09
Cm241	3.2E-81	8.3E+07
Cm242	1.3E-17	2.3E+06
Cm243	8.9E-07	2.3E+06
Cm244	4.5E-04	2.4E+06
Cm245	2.0E-08	2.6E+06
Cm246	4.5E-10	2.6E+06
Cm247	1.6E-16	2.7E+06
Cm248	4.9E-17	3.1E+06
Cm250	1.4E-25	1.1E+07
Co-57	3.7E-01	9.9E+07
Co-58	5.8E-15	1.5E+07

Table E-3. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Co-60	1.9E+04	5.5E+06
Cr-51	7.7E-53	3.9E+08
Cs132	0.0E+00	-
Cs134	2.2E+01	8.3E+06
Cs135	7.2E-02	2.5E+08
Cs136	0.0E+00	-
Cs137	4.9E+04	8.3E+07
Er169	0.0E+00	-
Eu150	5.1E-08	4.9E+07
Eu152	2.8E+03	1.1E+07
Eu154	2.4E+03	9.3E+06
Eu155	5.2E+02	1.2E+08
Eu156	0.0E+00	-
Fe-59	2.0E-34	1.1E+07
Fr221	1.0E-07	2.2E+06
Fr223	5.6E-07	3.3E+07
Gd152	1.1E-13	6.6E+06
Gd153	8.4E-11	9.3E+07
H 3	8.3E+05	2.5E+09
Hf-181	1.7E-36	1.9E+07
Ho166m	1.1E-05	8.2E+06
I129	2.2E+04	1.8E+08
I131	0.0E+00	-
In114	4.8E-54	1.8E+07
In114m	5.1E-54	5.9E+07
In115	1.5E-11	9.3E+07
In115m	0.0E+00	-
K-40	1.3E+02	2.3E+07
Kr81[d]	8.8E-05	-
Kr85[d]	1.9E+07	-
La138	0.0E+00	-
La140	2.2E-105	5.0E+06
Mn-54	3.9E-07	1.7E+07
Nb92	6.3E-18	9.4E+06
Nb93m	1.3E-01	4.7E+08
Nb94	8.8E-05	8.3E+06
Nb95	4.8E-32	1.8E+07
Nb95m	1.8E-34	5.8E+07
Nd144	1.4E-09	7.5E+06
Nd147	0.0E+00	-
Np235	8.4E-09	1.4E+09
Np236	8.6E-06	4.2E+07
Np237	8.0E+01	2.9E+06
Np238	2.7E-05	1.8E+07
Np239	4.1E-02	3.4E+07
Np240	3.5E-12	8.9E+06
Np240m	3.1E-09	1.5E+07
Pa231	1.3E-04	2.6E+06
Pa233	7.9E-02	3.5E+07
Pa234	5.0E-06	5.8E+06

Table E-3. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Pa234m	3.1E-03	1.7E+07
Pb209	4.8E-07	7.2E+07
Pb210	1.1E-05	3.7E+08
Pb211	1.8E-04	2.8E+07
Pb212	5.5E-03	4.4E+07
Pb214	5.6E-05	2.6E+07
Pd107	1.1E-01	4.3E+08
Pm146	2.4E-02	1.7E+07
Pm147	1.6E+03	2.3E+08
Pm148	1.7E-58	1.1E+07
Pm148m	3.4E-57	6.6E+06
Po210	6.8E-06	2.7E+06
Po211	4.6E-09	1.9E+06
Po212	2.2E-03	1.6E+06
Po213	2.9E-07	1.7E+06
Po214	3.7E-05	1.8E+06
Po215	1.2E-04	1.9E+06
Po216	3.7E-03	2.1E+06
Po218	3.7E-05	2.4E+06
Pr143	0.0E+00	-
Pr144	7.4E-03	1.1E+07
Pr144m	1.1E-04	1.2E+09
Pu236	3.9E-05	2.5E+06
Pu237	8.6E-58	2.3E+08
Pu238	1.7E+03	2.6E+06
Pu239	4.8E+01	2.8E+06
Pu240	1.1E+01	2.8E+06
Pu241	4.6E+02	2.7E+09
Pu242	1.7E-03	2.9E+06
Pu243	4.6E-15	7.3E+07
Pu244	1.8E-10	3.1E+06
Pu246	9.9E-25	9.2E+07
Ra222	1.2E-115	2.2E+06
Ra223	2.0E-04	2.4E+06
Ra224	5.5E-03	2.5E+06
Ra225	5.1E-07	1.2E+08
Ra226	4.7E+00	3.0E+06
Ra228	1.5E-09	1.2E+09
Rb86	0.0E+00	-
Rb87	2.0E-04	1.8E+08
Rh102	5.7E-04	1.8E+08
Rh103m	5.4E-57	3.7E+08
Rh106	2.2E-01	8.8E+06
Rn218	2.1E-112	2.0E+06
Rn219	3.4E-01	2.1E+06
Rn220	9.2E+00	2.3E+06
Rn222	1.0E-01	2.6E+06
Ru103	3.6E-28	2.6E+07
Ru106	2.2E-01	3.6E+08
Sb124	4.1E-39	6.3E+06

Table E-3. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
Sb125	1.9E+02	2.7E+07
Sb126	4.1E-01	4.7E+06
Sb126m	2.9E+00	6.6E+06
Sc-46	9.2E-20	6.7E+06
Se 79	4.1E+01	2.7E+08
Sm146	1.8E-09	5.6E+06
Sm147	1.7E-05	6.3E+06
Sm148	4.2E-12	7.1E+06
Sm149[e]	2.1E-11	-
Sm151	1.4E+03	7.2E+08
Sn117m	0.0E+00	-
Sn119m	1.1E-06	7.2E+08
Sn121m	2.1E-01	1.6E+08
Sn123	6.5E-16	4.7E+09
Sn125	0.0E+00	-
Sn126	1.1E+00	2.7E+07
Sr89	5.0E-42	4.0E+07
Sr90	1.9E+06	2.4E+07
Tb160	1.3E-33	2.6E+07
Tb161	0.0E+00	-
Tc 98	6.8E-04	1.1E+07
Tc 99	2.2E+04	9.4E+06
Te123	3.6E-14	1.7E+08
Te123m	2.4E-22	8.3E+08
Te125m	1.8E+01	5.8E+07
Te127	7.5E-19	8.9E+07
Te127m	7.6E-19	6.2E+07
Te129	5.4E-70	1.6E+08
Te129m	8.6E-70	2.4E+07
Th226	2.2E-116	4.6E+07
Th227	1.8E-04	2.2E+06
Th228	3.3E-01	2.3E+06
Th229	5.1E-07	2.6E+06
Th230	1.7E+00	2.8E+06
Th231	1.6E+00	3.0E+06
Th232	1.6E+00	8.0E+07
Th234	1.7E-02	3.5E+06
Tl207	1.8E-04	2.1E+08
Tl208	2.0E-03	2.9E+07
Tl209	1.1E-08	3.6E+06
Tm170	2.7E-25	3.6E+06
Tm171	6.6E-12	4.2E+07
U230	0.0E+00	-
U232	8.8E-02	5.4E+08
U233	4.2E-03	2.7E+06
U234	9.9E+02	2.9E+06
U235	1.8E+01	3.0E+06
U236	3.3E+01	3.1E+06
U237	0.0E+00	-
U238	3.2E+02	3.2E+06

Table E-3. (continued).

Constituent[a]	Predicted Activity Concentration in Leachate[b] (pCi/L)	Suggested Maximum Activity Concentration[c] (pCi/L)
U240	4.2E-09	3.4E+06
Xe127	2.6E-68	8.9E+07
Xe129m	0.0E+00	-
Xe131m	4.5E-108	4.6E+07
Xe133	0.0E+00	-
Y90	1.3E+05	8.8E+07
Y91	2.4E-36	1.5E+07
Zn65	1.7E-07	2.3E+07
Zr93	1.4E+00	2.4E+07
Zr95	4.9E-25	7.3E+08

Notes:

a. Constituent reported in the "INEEL CERCLA Disposal Facility Design Inventory" (EDF-ER-264).
b. Predicted average leachate activity concentration during the 15 year operational period.
c. The suggested maximum activity concentration selected for the ICDF liner system is based on a total absorbed dose of 1,000,000 rads for the individual constituent and a 36 cm liquid waste depth.
d. The constituents are gaseous elements so not part of the leachate.
e. Stable isotope