

US EPA ARCHIVE DOCUMENT

APPENDIX C
TIER 1 INPUT PARAMETERS

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Table C-1: IWEM Tier 1 Input Parameters for Landfill, No Liner Scenario

Input Type	Input No.	Parameter	Input Distribution Type	Units (output)	Percentiles ²						References	
					0	10	25	50	75	90		100
Source	SS1	Area	Regional Site-Based	m	40.5	486	2,430	12,100	52,600	142,000	3,120,000	USEPA, 1986 and 1997b
	SS2/3	Length/Width	Derived	m	6.36	22.0	49.3	110	229	376	1,770	Derived
	SS5	Recharge Rate	Regional Site-Based	m/yr	1.00E-05	0.0135	0.0686	0.122	0.308	0.438	1.15	ABB, 1995 and USEPA, 1997b
	SS6	Infiltration Rate	Regional Site-Based	m/yr	1.00E-05	0.0135	0.0658	0.109	0.274	0.411	1.08	ABB, 1995 and USEPA, 1997b
	SS10	Duration of Leaching	Derived	yr	9,340	48,200	94,500	199,000	521,000	1,810,000	1.20E+10	Derived
	SS11	Fraction of Landfill Occupied by Waste of Concern	Constant	unitless	1.00						Policy for Tier 1	
	SS12	Depth of Waste Disposal Facility	Regional Site-Based	m	0.510	0.880	1.32	2.57	4.09	6.13	10.1	USEPA, 1986 and 1997b
	SS13	Density of Hazardous Waste	Empirical	g/cm ³	0.700	0.737	0.794	0.889	1.33	1.45	2.10	Schanz and Salhotra, 1992
	FS1	Ratio of Waste Concentration to Leachate Concentration	Constant	L/kg	10000						Policy for Tier 1	
	SS15	Base Depth Below Grade	Constant	m	0.00						No data available	
Unsaturated Zone	US1	Saturated Hydraulic Conductivity	Lognormal ¹	m/yr	0.00377	0.594	2.04	7.80	35.0	169	2,450	Carsel and Parrish, 1988
	US2	Moisture Retention Parameter (alpha)	Johnson SB ¹	1/m	0.129	0.596	0.935	1.52	2.71	5.90	21.8	Carsel and Parrish, 1988
	US3	Moisture Retention Parameter (beta)	Johnson SB ¹	unitless	1.03	1.20	1.27	1.37	1.53	1.82	2.50	Carsel and Parrish, 1988
	US4	Residual Water Content	Johnson SB ¹	unitless	0.0106	0.0489	0.0609	0.0746	0.0857	0.0937	0.115	Carsel and Parrish, 1988
	US5	Saturated Water Content	Constant	unitless	0.410	0.410	0.430	0.450	0.450	0.450	0.450	Carsel and Parrish, 1988
	US6	Thickness of Unsaturated Zone	Regional Site-Based	m	0.305	1.68	3.96	6.10	15.2	42.7	610	API, 1989
	US7	Dispersivity	Derived	m	0.0267	0.0570	0.107	0.154	0.354	0.959	1.00	Gelhar, 1986; EPRI, 1985; USEPA, 1997a
	US8	Percent Organic Matter	Johnson SB ¹	unitless	0.00358	0.0341	0.0567	0.1020	0.177	0.289	1.69	Carsel and others, 1988
	US9	Bulk Density	Constant	g/cm ³	1.60	1.60	1.65	1.65	1.67	1.67	1.67	Carsel and others, 1988
	US10	Soil/Water Distribution Coefficient	Derived	cm ³ /g	chemical-specific value						Derived	
	US11	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption	
	US12	Chemical Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived	
	US13	Biodegradation Rate Coefficient	Constant	1/yr	0.00						Policy for Tier 1	
Saturated Zone	AS1	Average Particle Diameter	Empirical	cm	0.0004	0.0015	0.00557	0.0191	0.0409	0.0762	0.211	Sahe, 1974
	AS2	Aquifer Effective Porosity	Derived	unitless	0.0501	0.107	0.164	0.236	0.296	0.334	0.426	Davis, 1969; McWorter and Sunada 1977
	AS3	Aquifer Bulk Density	Derived	g/cm ³	1.16	1.30	1.43	1.56	1.63	1.70	1.80	Freeze and Cherry, 1979
	AS4	Aquifer Saturated Thickness	Regional Site-Based	m	0.305	4.27	7.62	14.3	32.4	91.4	914	API, 1989
	AS5	Longitudinal Hydraulic Conductivity	Regional Site-Based	m/yr	3.15	174	804	1,890	11,000	31,500	4,290,000	API, 1989
	AS6	Anisotropy Ratio	Constant	unitless	1.00						Assumption	
	AS7	Hydraulic Gradient	Regional Site-Based	unitless	0.000002	0.0009	0.002	0.0057	0.0151	0.0310	0.491	API, 1989
	AS8	Seepage Velocity	Derived	m/yr	0.100	3.15	16.3	55.0	321	1,320	11,000	Derived
	AS9	Retardation Factor	Derived	unitless	chemical-specific value						Derived	
	AS10	Longitudinal Dispersivity	Gelhar Empirical	m	0.109	0.928	2.72	6.18	9.76	14.5	40.0	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS11	Transverse Dispersivity	Gelhar Empirical	m	0.0136	0.116	0.340	0.773	1.22	1.81	4.99	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS12	Vertical Dispersivity	Gelhar Empirical	m	0.00500	0.00580	0.0170	0.0387	0.0610	0.0903	0.250	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS13	Temperature of Ambient Aquifer Water	Regional Site-Based	degrees C	7.50	7.50	12.5	12.5	17.5	22.5	22.5	Collins, 1925
	AS14	Ambient Groundwater pH	Empirical	standard units	3.21	5.17	6.05	6.81	7.41	7.92	9.70	USEPA STORET database
	AS15	Fraction of Organic Carbon	Johnson SB	unitless	0.0000164	0.000132	0.000234	0.000433	0.000810	0.00139	0.00984	USEPA STORET database
	AS16	Radial Distance of Observation Well from Downgradient Edge of Waste Unit	Constant	m	150						Policy for Tier 1	
AS17	Angle Off-Center of Observation Well	Constant	degrees	0.00						Policy for Tier 1		
AS20	Depth of Well Below Water Table	Uniform	m	0.00321	0.945	2.52	6.42	16.4	47.0	897	API, 1989	
AS21	Leading Coefficient of Freundlich Adsorption Isotherm	Derived	cm ³ /g	chemical-specific value						Derived		
AS22	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption		
AS23	Hydrolysis Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived		
AS24	Biodegradation Rate Coefficient	Derived	1/yr	0.00						Policy for Tier 1		

¹ The actual distribution type depends upon the soil type; the distribution types given here correspond to the silty loam soil (the most common type). In the Tier 1 modeling runs, soil type is automatically varied among the three soil types; each soil type has its own values/distributions of values for the soil parameters. The values presented in this table include all three soil types.

² Values were generated using a Monte Carlo simulation with 10,000 iterations.

Table C-2: IWEM Tier 1 Input Parameters for Surface Impoundment, No Liner Scenario

Input Type	Input No.	Parameter	Input Distribution Type	Units (output)	Percentiles ²						References	
					0	10	25	50	75	90		100
Source	SS1	Area	Regional Site-Based	m	9.30	174	401	1,770	6,970	28,300	4,860,000	USEPA, 2001
	SS2/3	Length/Width	Derived	m	3.05	13.2	20.0	42.1	83.5	168	2,200	Derived
	SS5	Recharge Rate	Regional Site-Based	m/yr	0.000100	0.00990	0.0465	0.144	0.269	0.377	1.84	ABB 1995 and USEPA, 1997b
	SS6	Infiltration Rate	Regional Site-Based	m/yr	3.78E-15	0.270	0.521	1.14	2.27	3.51	22.3	Derived
	SS10	Operational Life (Duration of Leaching)	Constant	yr	4.00	15.0	50.0	50.0	50.0	50.0	95.0	USEPA, 2001
	SS15	Base Depth Below Grade	DBGS	m	0.00	0.00	0.00	1.22	3.05	4.57	33.5	USEPA, 2001
	SS7	Waste Water Ponding Depth	HZERO	m	0.0100	0.460	0.993	1.81	2.95	4.24	18.2	USEPA, 2001
	SS16	Sediment Thickness (Thickness of Sludge)	DSLUDGE	m	0.20						Assumption	
SS22	Distance to Nearest Surface Water Body	DISSW	m	0.00	90.0	240	360	800	5,000	5,000	USEPA, 2001	
Unsaturated Zone	US1	Saturated Hydraulic Conductivity	Lognormal ¹	m/yr	0.00224	0.318	1.08	4.94	43.8	301	2,420	Carsel and Parrish, 1988
	US2	Moisture Retention Parameter (alpha)	Johnson SB ¹	l/m	0.104	0.516	0.801	1.36	3.19	7.88	22.3	Carsel and Parrish, 1988
	US3	Moisture Retention Parameter (beta)	Johnson SB ¹	unitless	1.03	1.18	1.23	1.31	1.61	1.91	2.43	Carsel and Parrish, 1988
	US4	Residual Water Content	Johnson SB ¹	unitless	0.00997	0.0525	0.0674	0.0812	0.0905	0.0976	0.115	Carsel and Parrish, 1988
	US5	Saturated Water Content	Constant	unitless	0.410	0.410	0.430	0.430	0.430	0.450	0.450	Carsel and Parrish, 1988
	US6	Thickness of Unsaturated Zone	Regional Site-Based	m	0.305	2.74	4.27	9.14	15.2	35.4	610	API, 1989
	US7	Dispersivity	Derived	m	0.0267	0.0803	0.114	0.22	0.354	0.799	1.00	Gelhar, 1986; EPRI, 1985;
	US8	Percent Organic Matter	Johnson SB ¹	unitless	0.00285	0.0316	0.0552	0.100	0.181	0.302	1.98	Carsel and others, 1988
	US9	Bulk Density	Constant	g/cm ³	1.60	1.60	1.65	1.6700	1.67	1.67	1.67	Carsel and others, 1988
	US10	Soil/Water Distribution Coefficient	Derived	cm ² /g	chemical-specific value						Derived	
	US11	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption	
	US12	Chemical Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived	
	US13	Biodegradation Rate Coefficient	Constant	1/yr	0.00						Policy for Tier 1	
Saturated Zone	AS1	Average Particle Diameter	Empirical	cm	0.000400	0.00145	0.00546	0.0196	0.0418	0.0777	0.211	Sahe, 1974
	AS2	Aquifer Effective Porosity	Derived	unitless	0.0500	0.108	0.162	0.233	0.294	0.333	0.430	Davis, 1969; McWorter and Sunada 1977
	AS3	Aquifer Bulk Density	Derived	g/cm ³	1.16	1.29	1.43	1.56	1.63	1.70	1.80	Freeze and Cherry, 1979
	AS4	Aquifer Saturated Thickness	Regional Site-Based	m	0.305	4.57	7.62	15.2	30.5	79.3	914	API, 1989
	AS5	Longitudinal Hydraulic Conductivity	Regional Site-Based	m/yr	3.15	126	315	2,210	9,780	24,800	7,660,000	API, 1989
	AS6	Anisotropy Ratio	Constant	unitless	1.00						Assumption	
	AS7	Hydraulic Gradient	Regional Site-Based	unitless	5.00E-07	0.000508	0.00200	0.00670	0.0141	0.0330	0.538	API, 1989
	AS8	Seepage Velocity	Derived	m/yr	0.100	2.48	11.1	43.4	227	814	10,800	Derived
	AS9	Retardation Factor	Derived	unitless	chemical-specific value						Derived	
	AS10	Longitudinal Dispersivity	Gelhar Empirical	m	0.104	0.802	2.44	5.71	9.01	15.6	40.0	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS11	Transverse Dispersivity	Gelhar Empirical	m	0.0130	0.100	0.305	0.714	1.13	1.95	5.00	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
Saturated Zone (cont'd)	AS12	Vertical Dispersivity	Gelhar Empirical	m	0.00500	0.00501	0.0152	0.0357	0.0563	0.0976	0.250	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS13	Temperature of Ambient Aquifer Water	Regional Site-Based	degrees C	7.5	7.5	12.5	17.5	17.5	17.5	27.5	Collins, 1925
	AS14	Ambient Groundwater pH	Empirical	standard units	3.20	5.21	6.06	6.81	7.42	7.91	9.69	USEPA/STORET database
	AS15	Fraction of Organic Carbon	Johnson SB	unitless	0.0000128	0.000135	0.000235	0.000430	0.000790	0.00137	0.0120	USEPA STORET database
	AS16	Radial Distance of Observation Well from Downgradient Edge of Waste Unit	Constant	m	150						Policy for Tier 1	
	AS17	Angle Off-Center of Observation Well	Constant	degrees	0.00						Policy for Tier 1	
	AS20	Depth of Well Below Water Table	Uniform	m	0.000126	0.953	2.49	6.04	15.2	39.4	904	API, 1989
	AS21	Leading Coefficient of Freundlich Adsorption Isotherm	Derived	cm ³ /g	chemical-specific value						Derived	
	AS22	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption	
	AS23	Hydrolysis Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived	
AS24	Biodegradation Rate Coefficient	Derived	1/yr	0.00						Policy for Tier 1		

¹ The actual distribution type depends upon the soil type; the distribution types given here correspond to the silty loam soil (the most common type). In the Tier 1 modeling runs, soil type is automatically varied among the three soil types; each soil type has its own values/distributions of values for the soil parameters. The values presented in this table include all three soil types.

² Values were generated using a Monte Carlo simulation with 10,000 iterations.

Table C-3: IWEM Tier 1 Input Parameters for Waste Pile, No Liner Scenario

Input Type	Input No.	Parameter	Input Distribution Type	Units (output)	Percentiles ²						References	
					0	10	25	50	75	90		100
Source	SS1	Area	Regional Site-Based	m	5.06	20.2	20.2	121	1,210	4,170	1,940,000	USEPA, 1986 and 1997b
	SS2/3	Length/Width	Derived	m	2.25	4.49	4.49	11.0	34.8	64.6	1,390	Derived
	SS5	Recharge Rate	Regional Site-Based	m/yr	0.00001	0.0508	0.0787	0.145	0.282	0.417	1.84	ABB, 1995 and USEPA, 1997b
	SS6	Infiltration Rate	Regional Site-Based	m/yr	0.0003	0.0602	0.128	0.255	0.391	0.538	1.82	ABB, 1995 and USEPA, 1997b
	SS10	Operational Life (Duration of Leaching)	Constant	yr	20.0						US EPA, 1996	
	SS15	Base Depth Below Land Surface		m	0.00						Assumption of waste pile design	
Unsatuated Zone	US1	Saturated Hydraulic Conductivity	Lognormal ¹	m/yr	0.00347	0.617	2.10	8.32	36.2	165	2,400	Carsel and Parrish, 1988
	US2	Moisture Retention Parameter (alpha)	Johnson SB ¹	1/m	0.120	0.624	0.946	1.55	2.71	5.76	20.2	Carsel and Parrish, 1988
	US3	Moisture Retention Parameter (beta)	Johnson SB ¹	unitless	1.02	1.20	1.26	1.38	1.53	1.82	2.52	Carsel and Parrish, 1988
	US4	Residual Water Content	Johnson SB ¹	unitless	0.0114	0.0487	0.0608	0.0742	0.0854	0.0934	0.114	Carsel and Parrish, 1988
	US5	Saturated Water Content	Constant	unitless	0.410	0.410	0.430	0.450	0.450	0.450	0.450	Carsel and Parrish, 1988
	US6	Thickness of Unsatuated Zone	Regional Site-Based	m	0.305	1.83	3.96	7.01	15.2	36.6	610	API, 1989
	US7	Dispersivity	Derived	m	0.0267	0.0603	0.107	0.174	0.354	0.825	1.00	Gelhar, 1986; EPRI, 1985; USEPA, 1997a
	US8	Percent Organic Matter	Johnson SB ¹	unitless	0.00421	0.0339	0.0569	0.100	0.175	0.294	3.56	Carsel and others, 1988
	US9	Bulk Density	Constant	g/cm ³	1.60	1.60	1.65	1.65	1.67	1.67	1.67	Carsel and others, 1988
	US10	Soil/Water Distribution Coefficient	Derived	cm ³ /g	chemical-specific value						Derived	
	US11	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption	
	US12	Chemical Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived	
	US13	Biodegradation Rate Coefficient	Constant	1/yr	0.00						Policy for Tier 1	
Saturated Zone	AS1	Average Particle Diameter	Empirical	cm	0.000401	0.00153	0.00549	0.0193	0.0408	0.0740	0.212	Sahe, 1974
	AS2	Aquifer Effective Porosity	Derived	unitless	0.0501	0.105	0.161	0.235	0.297	0.335	0.421	Davis, 1969; McWorter and Sunada 1977
	AS3	Aquifer Bulk Density	Derived	g/cm ³	1.16	1.30	1.43	1.56	1.63	1.69	1.80	Freeze and Cherry, 1979
	AS4	Aquifer Saturated Thickness	Regional Site-Based	m	0.305	3.60	7.38	15.2	33.5	91.4	914	API, 1989
	AS5	Longitudinal Hydraulic Conductivity	Regional Site-Based	m/yr	3.15	126	317	1,890	11,000	31,500	6,750,000	API, 1989
	AS6	Anisotropy Ratio	Constant	unitless	1.00						Assumption	
	AS7	Hydraulic Gradient	Regional Site-Based	unitless	0.000002	0.0009	0.00200	0.00570	0.0170	0.0330	0.301	API, 1989
	AS8	Seepage Velocity	Derived	m/yr	0.101	2.69	10.8	46.8	272	1,260	10,900	Derived
	AS9	Retardation Factor	Derived	unitless	chemical-specific value						Derived	
	AS10	Longitudinal Dispersivity	Gelhar Empirical	m	0.101	0.848	2.50	5.59	8.71	14.7	40.0	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS11	Transverse Dispersivity	Gelhar Empirical	m	0.0126	0.106	0.313	0.699	1.09	1.83	5.00	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS12	Vertical Dispersivity	Gelhar Empirical	m	0.00500	0.00530	0.0156	0.0350	0.0544	0.0916	0.250	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS13	Temperature of Ambient Aquifer Water	Regional Site-Based	degrees C	7.50	7.50	12.5	12.5	17.5	22.5	22.5	Collins, 1925
	AS14	Ambient Groundwater pH	Empirical	standard units	3.21	5.20	6.07	6.81	7.41	7.90	9.69	USEPA STORET database
	AS15	Fraction of Organic Carbon	Johnson SB	unitless	0.0000128	0.000132	0.000237	0.000437	0.000794	0.00137	0.00998	USEPA STORET database
	AS16	Radial Distance of Observation Well from Downgradient Edge of Waste Unit	Constant	m	150						Policy for Tier 1	
	AS17	Angle Off-Center of Observation Well	Constant	degrees	0.00						Policy for Tier 1	
	AS20	Depth of Well Below Water Table	Uniform	m	0.000308	0.868	2.44	6.27	16.9	47.7	892	API, 1989
	AS21	Leading Coefficient of Freundlich Adsorption Isotherm (soil/water distribution coeff)	Derived	cm ³ /g	chemical-specific value						Derived	
	AS22	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption	
AS23	Hydrolysis Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived		
AS24	Biodegradation Rate Coefficient	Derived	1/yr	0.00						Policy for Tier 1		

¹ The actual distribution type depends upon the soil type; the distribution types given here correspond to the silty loam soil (the most common type). In the Tier 1 modeling runs, soil type is automatically varied among the three soil types; each soil type has its own values/distributions of values for the soil parameters. The values presented in this table include all three soil types.

² Values were generated using a Monte Carlo simulation with 10,000 iterations.

Table C-4: IWEM Tier 1 Input Parameters for Land Application Unit Scenario

Input Type	Input No.	Parameter	Input Distribution Type	Units (output)	Percentiles ²						References	
					0	10	25	50	75	90		100
Source	SS1	Area	Regional Site-Based	m	20.2	40.5	4,050	40,500	182,000	648,000	80,900,000	USEPA, 1986 and 1997b
	SS2/3	Length/Width	Derived	m	4.49	6.36	63.6	201	427	805	8,990	Derived
	SS5	Recharge Rate	Regional Site-Based	m/yr	0.00001	0.0104	0.0686	0.110	0.212	0.326	0.745	ABB, 1995 and USEPA, 1997b
	SS6	Infiltration Rate	Regional Site-Based	m/yr	0.00001	0.0130	0.0704	0.110	0.201	0.326	0.745	ABB, 1995 and USEPA, 1997b
	SS10	Operational Life (Duration of Leaching)	Constant	yr	40.0						US EPA, 1996	
	SS15	Base Depth Below Grade	Constant	m	0.00						Assumption of LAU Design	
Unsaturated Zone	US1	Saturated Hydraulic Conductivity	Lognormal ¹	m/yr	0.00224	0.586	2.01	7.80	33.8	147	2,510	Carsel and Parrish, 1988
	US2	Moisture Retention Parameter (alpha)	Johnson SB ¹	1/m	0.0926	0.605	0.929	1.51	2.59	5.41	20.8	Carsel and Parrish, 1988
	US3	Moisture Retention Parameter (beta)	Johnson SB ¹	unitless	1.04	1.20	1.26	1.37	1.51	1.78	2.55	Carsel and Parrish, 1988
	US4	Residual Water Content	Johnson SB ¹	unitless	0.0126	0.0498	0.0613	0.0749	0.0862	0.0942	0.115	Carsel and Parrish, 1988
	US5	Saturated Water Content	Constant	unitless	0.410	0.410	0.430	0.450	0.450	0.450	0.450	Carsel and Parrish, 1988
	US6	Thickness of Unsaturated Zone	Regional Site-Based	m	0.305	2.13	4.57	8.53	18.3	45.7	610	API, 1989
	US7	Dispersivity	Derived	m	0.0267	0.0669	0.121	0.208	0.423	1.00	1.00	Gelhar, 1986; EPRI, 1985; USEPA, 1997a
	US8	Percent Organic Matter	Johnson SB ¹	unitless	0.00418	0.0346	0.0578	0.102	0.175	0.291	1.96	Carsel and others, 1988
	US9	Bulk Density	Constant	g/cm ³	1.60	1.60	1.65	1.65	1.67	1.67	1.67	Carsel and others, 1988
	US10	Soil/Water Distribution Coefficient	Derived	cm ³ /g	chemical-specific value						Derived	
	US11	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption	
	US12	Chemical Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived	
	US13	Biodegradation Rate Coefficient	Constant	1/yr	0.00						Policy for Tier 1	
Saturated Zone	AS1	Average Particle Diameter	Empirical	cm	0.000402	0.00143	0.00545	0.0195	0.0408	0.0778	0.212	Sahe, 1974
	AS2	Aquifer Effective Porosity	Derived	unitless	0.0501	0.105	0.162	0.235	0.295	0.334	0.427	Davis, 1969; McWorter and Sunada, 1977
	AS3	Aquifer Bulk Density	Derived	g/cm ³	1.16	1.29	1.43	1.56	1.63	1.70	1.80	Freeze and Cherry, 1979
	AS4	Aquifer Saturated Thickness	Regional Site-Based	m	0.305	3.96	7.62	19.5	53.3	144	914	API, 1989
	AS5	Longitudinal Hydraulic Conductivity	Regional Site-Based	m/yr	3.15	94.6	315	2,190	11,000	31,500	6,310,000	API, 1989
	AS6	Anisotropy Ratio	Constant	unitless	1.00						Assumption	
	AS7	Hydraulic Gradient	Regional Site-Based	unitless	0.000002	0.000556	0.00200	0.00800	0.0223	0.0430	0.430	API, 1989
	AS8	Seepage Velocity	Derived	m/yr	0.100	2.34	9.93	50.2	316	1,210	10,900	Derived
	AS9	Retardation Factor	Derived	unitless	chemical-specific value						Derived	
	AS10	Longitudinal Dispersivity	Gelhar Empirical	m	0.108	1.02	2.99	6.70	10.7	16.1	40.0	EPRI 1985; Gelhar, 1986; Gelhar, 1992
	AS11	Transverse Dispersivity	Gelhar Empirical	m	0.0134	0.128	0.374	0.838	1.34	2.02	5.00	EPRI 1985; Gelhar, 1986; Gelhar, 1992
	AS12	Vertical Dispersivity	Gelhar Empirical	m	0.00500	0.00639	0.0187	0.0419	0.0669	0.101	0.250	EPRI 1985; Gelhar, 1986; Gelhar, 1992
	AS13	Temperature of Ambient Aquifer Water	Regional Site-Based	degrees C	7.50	7.50	12.5	12.5	17.5	17.5	22.5	Collins, 1925
	AS14	Ambient Groundwater pH	Empirical	standard units	3.21	5.20	6.07	6.82	7.42	7.89	9.69	USEPA's STORET database
	AS15	Fraction of Organic Carbon	Johnson SB	unitless	0.0000149	0.000130	0.000229	0.000421	0.000781	0.00133	0.0120	USEPA STORET database
	AS16	Radial Distance of Observation Well from Downgradient Edge of Waste Unit	Constant	m	150						Policy for Tier 1	
	AS17	Angle Off-Center of Observation Well	Constant	degrees	0.00						Policy for Tier 1	
	AS20	Depth of Well Below Water Table	Uniform	m	0.0000963	1.03	2.83	7.95	21.7	60.1	882	API, 1989
	AS21	Leading Coefficient of Freundlich Adsorption Isotherm	Derived	cm ³ /g	chemical-specific value						Derived	
	AS22	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption	
	AS23	Hydrolysis Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived	
	AS24	Biodegradation Rate Coefficient	Derived	1/yr	0.00						Policy for Tier 1	

¹ The actual distribution type depends upon the soil type; the distribution types given here correspond to the silty loam soil (the most common type). In the Tier 1 modeling runs, soil type is automatically varied among the three soil types; each soil type has its own values/distributions of values for the soil parameters. The values presented in this table include all three soil types.

² Values were generated using a Monte Carlo simulation with 6,557 iterations.

Table C-5: IWEM Tier 1 Input Parameters for Landfill, Single Liner Scenario

Input Type	Input No.	Parameter	Input Distribution Type	Units (output)	Percentiles ²						References		
					0	10	25	50	75	90		100	
Source	SS1	Area	Regional Site-Based	m	40.5	567	2,480	12,100	54,600	149,000	3,120,000	USEPA, 1986 and 1997b	
	SS2/3	Length/Width	Derived	m	6.36	23.8	49.8	110	234	386	1,770	Derived	
	SS5	Recharge Rate	Regional Site-Based	m/yr	0.00001	0.0135	0.0686	0.130	0.312	0.446	1.15	ABB, 1995 and USEPA, 1997b	
	SS6	Infiltration Rate	Regional Site-Based	m/yr	0.00001	0.00944	0.0253	0.0432	0.0445	0.0486	0.0526	USEPA, 1999	
	SS10	Duration of Leaching	Derived	yr	81,100	228,000	376,000	728,000	1,370,000	2,930,000	1.63E+10	USEPA, 2001	
	SS11	Fraction of Landfill Occupied by Waste of Concern	Constant	unitless	1.00						Policy for Tier 1		
	SS12	Depth of Waste Disposal Facility	Regional Site-Based	m	0.510	0.883	1.32	2.58	4.09	6.14	10.1	USEPA, 1986 and 1997b	
	SS13	Density of Hazardous Waste	Empirical	g/cm ³	0.700	0.737	0.794	0.889	1.33	1.45	2.10	Schanz and Salhotra, 1992	
	FS1	Ratio of Waste Concentration to Leachate Concentration	Constant	L/kg	10000						Policy for Tier 1		
	SS15	Base Depth Below Grade	Constant	m	0.00						No data available		
	Unsaturated Zone	US1	Saturated Hydraulic Conductivity	Lognormal ¹	m/yr	0.00377	0.598	2.06	7.79	35.0	169	2,450	Carsel and Parrish, 1988
		US2	Moisture Retention Parameter (alpha)	Johnson SB ¹	1/m	0.129	0.595	0.935	1.52	2.72	5.92	21.8	Carsel and Parrish, 1988
		US3	Moisture Retention Parameter (beta)	Johnson SB ¹	unitless	1.04	1.20	1.27	1.37	1.53	1.82	2.50	Carsel and Parrish, 1988
		US4	Residual Water Content	Johnson SB ¹	unitless	0.0106	0.0489	0.0611	0.0746	0.0857	0.0937	0.115	Carsel and Parrish, 1988
		US5	Saturated Water Content	Constant	unitless	0.410	0.410	0.430	0.450	0.450	0.450	0.450	Carsel and Parrish, 1988
US6		Thickness of Unsaturated Zone	Regional Site-Based	m	0.305	1.68	3.96	6.10	15.2	36.6	610	API, 1989	
US7		Dispersivity	Derived	m	0.0267	0.0570	0.107	0.154	0.354	0.825	1.00	Gelhar, 1986; EPRI, 1985; USEPA, 1997a	
US8		Percent Organic Matter	Johnson SB ¹	unitless	0.00358	0.0340	0.0568	0.101	0.177	0.288	1.69	Carsel and others, 1988	
US9		Bulk Density	Constant	g/cm ³	1.60	1.60	1.65	1.65	1.67	1.67	1.67	Carsel and others, 1988	
US10		Soil/Water Distribution Coefficient	Derived	cm ³ /g	chemical-specific value						Derived		
US11		Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption		
US12		Chemical Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived		
US13		Biodegradation Rate Coefficient	Constant	1/yr	0.00						Policy for Tier 1		
Saturated Zone	AS1	Average Particle Diameter	Empirical	cm	0.000400	0.00151	0.00558	0.0192	0.0411	0.0765	0.211	Sahe, 1974	
	AS2	Aquifer Effective Porosity	Derived	unitless	0.0501	0.107	0.164	0.236	0.295	0.334	0.426	Davis, 1969; McWorter and Sunada 1977	
	AS3	Aquifer Bulk Density	Derived	g/cm ³	1.16	1.30	1.43	1.56	1.63	1.70	1.80	Freeze and Cherry, 1979	
	AS4	Aquifer Saturated Thickness	Regional Site-Based	m	0.305	4.03	7.62	12.2	32.0	91.4	914	API, 1989	
	AS5	Longitudinal Hydraulic Conductivity	Regional Site-Based	m/yr	3.15	141	631	1,890	11,000	31,500	4,290,000	API, 1989	
	AS6	Anisotropy Ratio	Constant	unitless	1.00						Assumption		
	AS7	Hydraulic Gradient	Regional Site-Based	unitless	0.000002	0.0009	0.002	0.00570	0.0153	0.0310	0.491	API, 1989	
	AS8	Seepage Velocity	Derived	m/yr	0.100	2.97	14.5	52.2	297	1,280	11,000	Derived	
	AS9	Retardation Factor	Derived	unitless	chemical-specific value						Derived		
	AS10	Longitudinal Dispersivity	Gelhar Empirical	m	0.109	0.916	2.71	6.15	9.72	14.4	40.0	EPRI, 1985; Gelhar, 1986; Gelhar, 1992	
	AS11	Transverse Dispersivity	Gelhar Empirical	m	0.0136	0.114	0.338	0.769	1.22	1.80	4.99	EPRI, 1985; Gelhar, 1986; Gelhar, 1992	
	AS12	Vertical Dispersivity	Gelhar Empirical	m	0.005	0.00572	0.0169	0.0385	0.0608	0.0899	0.250	EPRI, 1985; Gelhar, 1986; Gelhar, 1992	
	AS13	Temperature of Ambient Aquifer Water	Regional Site-Based	degrees C	7.50	7.50	12.5	12.5	17.5	22.5	22.5	Collins, 1925	
	AS14	Ambient Groundwater pH	Empirical	standard units	3.21	5.18	6.05	6.82	7.41	7.93	9.70	USEPA STORET database	
	AS15	Fraction of Organic Carbon	Johnson SB	unitless	0.0000164	0.000131	0.000234	0.000434	0.000810	0.00139	0.00984	USEPA STORET database	
	AS16	Radial Distance of Observation Well from Downgradient Edge of Waste Unit	Constant	m	150						Policy for Tier 1		
	AS17	Angle Off-Center of Observation Well	Constant	degrees	0.00						Policy for Tier 1		
	AS20	Depth of Well Below Water Table	Uniform	m	0.00321	0.944	2.49	6.27	16.1	46.3	897	API, 1989	
	AS21	Leading Coefficient of Freundlich Adsorption Isotherm	Derived	cm ³ /g	chemical-specific value						Derived		
	AS22	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption		
	AS23	Hydrolysis Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived		
	AS24	Biodegradation Rate Coefficient	Derived	1/yr	0.00						Policy for Tier 1		

¹ The actual distribution type depends upon the soil type; the distribution types given here correspond to the silty loam soil (the most common type). In the Tier 1 modeling runs, soil type is automatically varied among the three soil types; each soil type has its own values/distributions of values for the soil parameters. The values presented in this table include all three soil types.

² Values were generated using a Monte Carlo simulation with 10,000 iterations.

Table C-6: IWEM Tier 1 Input Parameters for Surface Impoundment, Single Liner Scenario

Input Type	Input No.	Parameter	Input Distribution Type	Units (output)	Percentiles ²							References
					0	10	25	50	75	90	100	
Source	SS1	Area	Regional Site-Based	m	9.30	192	581	1,860	7,810	29,800	4,860,000	USEPA, 2001
	SS2/3	Length/Width	Derived	m	3.05	13.8	24.1	43.1	88.4	173	2,200	Derived
	SS5	Recharge Rate	Regional Site-Based	m/yr	1.00E-05	0.00990	0.0465	0.147	0.269	0.377	1.84	ABB 1995 and USEPA, 1997b
	SS6	Infiltration Rate	Regional Site-Based	m/yr	3.78E-15	0.042	0.0629	0.108	0.163	0.217	0.798	Derived
	SS10	Operational Life (Duration of Leaching)	Constant	yr	4.00	15.0	50.0	50.0	50.0	50.0	95.0	USEPA, 2001
	SS15	Base Depth Below Grade	DBGS	m	0.00	0.00	0.00	1.52	3.05	4.57	33.5	USEPA, 2001
	SS7	Waste Water Ponding Depth	HZERO	m	0.0100	0.460	1.06	1.83	3.09	4.27	18.2	USEPA, 2001
		Total Impoundment Operating Depth	DEPTH	m	4.63							Derived
	SS16	Sediment Thickness (Thickness of Sludge)	DSLUDGE	m	0.20							Assumption
	SS22	Distance to Nearest Surface Water Body	DISSW	m	0.00	90.0	240	360	850	1,800	5,000	USEPA, 2001
Unsaturated Zone	US1	Saturated Hydraulic Conductivity	Lognormal ¹	m/yr	0.00224	0.347	1.20	5.56	49.6	308	2,420	Carsel and Parrish, 1988
	US2	Moisture Retention Parameter (alpha)	Johnson SB ¹	1/m	0.0983	0.524	0.815	1.39	3.31	7.97	22.3	Carsel and Parrish, 1988
	US3	Moisture Retention Parameter (beta)	Johnson SB ¹	unitless	1.02	1.18	1.23	1.31	1.63	1.92	2.43	Carsel and Parrish, 1988
	US4	Residual Water Content	Johnson SB ¹	unitless	0.00997	0.0522	0.0669	0.0809	0.0904	0.0976	0.115	Carsel and Parrish, 1988
	US5	Saturated Water Content	Constant	unitless	0.410	0.410	0.430	0.430	0.430	0.450	0.450	Carsel and Parrish, 1988
	US6	Thickness of Unsaturated Zone	Regional Site-Based	m	0.305	2.44	3.70	7.62	15.2	30.5	610	API, 1989
	US7	Dispersivity	Derived	m	0.0267	0.0737	0.101	0.188	0.354	0.691	1.00	Gelhar, 1986; EPRI, 1985; USEPA, 1997a
	US8	Percent Organic Matter	Johnson SB ¹	unitless	0.00254	0.0314	0.0550	0.0994	0.180	0.299	1.98	Carsel and others, 1988
	US9	Bulk Density	Constant	g/cm ³	1.60	1.60	1.65	1.67	1.67	1.67	1.67	Carsel and others, 1988
	US10	Soil/Water Distribution Coefficient	Derived	cm ³ /g	chemical-specific value							Derived
	US11	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00							Assumption
	US12	Chemical Degradation Rate Coefficient	Derived	1/yr	chemical-specific value							Derived
	US13	Biodegradation Rate Coefficient	Constant	1/yr	0.00							Policy for Tier 1
Saturated Zone	AS1	Average Particle Diameter	Empirical	cm	0.000400	0.00145	0.00540	0.0195	0.0415	0.0780	0.211	Sahe, 1974
	AS2	Aquifer Effective Porosity	Derived	unitless	0.0500	0.107	0.162	0.232	0.294	0.334	0.430	Davis, 1969; McWorter and Sunada 1977
	AS3	Aquifer Bulk Density	Derived	g/cm ³	1.16	1.29	1.43	1.56	1.63	1.70	1.80	Freeze and Cherry, 1979
	AS4	Aquifer Saturated Thickness	Regional Site-Based	m	0.305	3.66	7.32	13.7	30.0	76.2	914	API, 1989
	AS5	Longitudinal Hydraulic Conductivity	Regional Site-Based	m/yr	3.15	108	315	2,210	6,940	22,100	7,660,000	API, 1989
	AS6	Anisotropy Ratio	Constant	unitless	1.00							Assumption
	AS7	Hydraulic Gradient	Regional Site-Based	unitless	5.00E-07	0.000700	0.00200	0.00700	0.0150	0.0330	0.538	API, 1989
	AS8	Seepage Velocity	Derived	m/yr	0.100	2.11	9.36	34.1	193	723	10,800	Derived
	AS9	Retardation Factor	Derived	unitless	chemical-specific value							Derived
	AS10	Longitudinal Dispersivity	Gelhar Empirical	m	0.107	0.808	2.49	5.78	9.06	15.5	40.0	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS11	Transverse Dispersivity	Gelhar Empirical	m	0.0134	0.101	0.311	0.723	1.13	1.94	5.00	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS12	Vertical Dispersivity	Gelhar Empirical	m	0.00500	0.00505	0.0156	0.0361	0.0566	0.0969	0.250	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS13	Temperature of Ambient Aquifer Water	Regional Site-Based	degrees C	7.5	7.5	12.5	17.5	17.5	17.5	27.5	Collins, 1925
	AS14	Ambient Groundwater pH	Empirical	standard units	3.20	5.20	6.07	6.82	7.43	7.91	9.68	USEPA's STORET database
	AS15	Fraction of Organic Carbon	Johnson SB	unitless	0.0000128	0.000136	0.000236	0.000433	0.000794	0.00137	0.0103	USEPA STORET database
	AS16	Radial Distance of Observation Well from Downgradient Edge of Waste Unit	Constant	m	150							Policy for Tier 1
	AS17	Angle Off-Center of Observation Well	Constant	degrees	0.00							Policy for Tier 1
	AS20	Depth of Well Below Water Table	Uniform	m	0.000126	0.884	2.37	5.70	14.0	35.8	794	API, 1989
	AS21	Leading Coefficient of Freundlich Adsorption Isotherm	Derived	cm ³ /g	chemical-specific value							Derived
	AS22	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00							Assumption
	AS23	Hydrolysis Degradation Rate Coefficient	Derived	1/yr	chemical-specific value							Derived
	AS24	Biodegradation Rate Coefficient	Derived	1/yr	0.00							Policy for Tier 1

¹ The actual distribution type depends upon the soil type; the distribution types given here correspond to the silty loam soil (the most common type). In the Tier 1 modeling runs, soil type is automatically varied among the three soil types; each soil type has its own values/distributions of values for the soil parameters. The values presented in this table include all three soil types.

² Values were generated using a Monte Carlo simulation with 10,000 iterations.

Table C-7: IWEM Tier 1 Input Parameters for Waste Pile, Single Liner Scenario

Input Type	Input No.	Parameter	Input Distribution Type	Units (output)	Percentiles ²						References	
					0	10	25	50	75	90		100
Source	SS1	Area	Regional Site-Based	m	5.06	20.2	20.2	121	1,210	4,170	1,940,000	USEPA, 1986 and 1997b
	SS2/3	Length/Width	Derived	m	2.25	4.49	4.49	11.0	34.8	64.6	1,390	Derived
	SS5	Recharge Rate	Regional Site-Based	m/yr	0.00001	0.0508	0.0787	0.145	0.282	0.417	1.84	ABB, 1995 and USEPA, 1997b
	SS6	Infiltration Rate	Regional Site-Based	m/yr	0.00001	0.0264	0.0950	0.127	0.133	0.135	0.136	USEPA, 1999
	SS10	Duration of Leaching	Constant	yr	20.0						US EPA, 1996	
	SS15	Base Depth Below Grade	Constant	m	0.00						Assumption of waste pile design	
Unsaturated Zone	US1	Saturated Hydraulic Conductivity	Lognormal ¹	m/yr	0.00347	0.617	2.09	8.26	35.8	163	2,400	Carsel and Parrish, 1988
	US2	Moisture Retention Parameter (alpha)	Johnson SB ¹	1/m	0.120	0.620	0.942	1.54	2.70	5.76	20.2	Carsel and Parrish, 1988
	US3	Moisture Retention Parameter (beta)	Johnson SB ¹	unitless	1.02	1.20	1.26	1.38	1.53	1.82	2.52	Carsel and Parrish, 1988
	US4	Residual Water Content	Johnson SB ¹	unitless	0.0114	0.0487	0.0608	0.0743	0.0855	0.0935	0.114	Carsel and Parrish, 1988
	US5	Saturated Water Content	Constant	unitless	0.410	0.410	0.430	0.450	0.450	0.450	0.450	Carsel and Parrish, 1988
	US6	Thickness of Unsaturated Zone	Regional Site-Based	m	0.305	1.83	3.96	7.01	15.2	36.6	610	API, 1989
	US7	Dispersivity	Derived	m	0.0267	0.0603	0.107	0.174	0.354	0.825	1.00	Gelhar, 1986; EPRI, 1985; USEPA, 1997a
	US8	Percent Organic Matter	Johnson SB ¹	unitless	0.00421	0.0339	0.0566	0.100	0.175	0.294	3.56	Carsel and others, 1988
	US9	Bulk Density	Constant	g/cm ³	1.60	1.60	1.65	1.65	1.67	1.67	1.67	Carsel and others, 1988
	US10	Soil/Water Distribution Coefficient	Derived	cm ³ /g	chemical-specific value						Derived	
	US11	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption	
	US12	Chemical Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived	
	US13	Biodegradation Rate Coefficient	Constant	1/yr	0.00						Policy for Tier 1	
Saturated Zone	AS1	Average Particle Diameter	Empirical	cm	0.000401	0.00153	0.00547	0.0192	0.0408	0.0738	0.212	Sahe, 1974
	AS2	Aquifer Effective Porosity	Derived	unitless	0.0501	0.105	0.161	0.235	0.298	0.336	0.421	Davis, 1969; McWorter and Sunada 1977
	AS3	Aquifer Bulk Density	Derived	g/cm ³	1.16	1.30	1.43	1.56	1.63	1.69	1.80	Freeze and Cherry, 1979
	AS4	Aquifer Saturated Thickness	Regional Site-Based	m	0.305	3.60	7.32	15.2	33.2	91.4	914	API, 1989
	AS5	Longitudinal Hydraulic Conductivity	Regional Site-Based	m/yr	3.15	126	315	1,890	11,000	31,500	6,750,000	API, 1989
	AS6	Anisotropy Ratio	Constant	unitless	1.00						Assumption	
	AS7	Hydraulic Gradient	Regional Site-Based	unitless	0.000002	0.0009	0.002	0.00570	0.0170	0.0330	0.301	API, 1989
	AS8	Seepage Velocity	Derived	m/yr	0.101	2.64	10.5	45.7	263	1,240	10,900	Derived
	AS9	Retardation Factor	Derived	unitless	chemical-specific value						Derived	
	AS10	Longitudinal Dispersivity	Gelhar Empirical	m	0.101	0.845	2.50	5.60	8.73	14.8	40.0	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS11	Transverse Dispersivity	Gelhar Empirical	m	0.0126	0.106	0.312	0.700	1.09	1.85	5.00	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS12	Vertical Dispersivity	Gelhar Empirical	m	0.00500	0.00528	0.0156	0.0350	0.0546	0.0925	0.250	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS13	Temperature of Ambient Aquifer Water	Regional Site-Based	degrees C	7.50	7.50	12.5	12.5	17.5	22.5	22.5	Collins, 1925
	AS14	Ambient Groundwater pH	Empirical	standard units	3.21	5.19	6.06	6.80	7.41	7.90	9.69	USEPA STORET database
	AS15	Fraction of Organic Carbon	Johnson SB	unitless	0.0000128	0.000132	0.000237	0.000437	0.000793	0.00137	0.00998	USEPA STORET database
	AS16	Radial Distance of Observation Well from Downgradient Edge of Waste Unit	Constant	m	150						Policy for Tier 1	
	AS17	Angle Off-Center of Observation Well	Constant	degrees	0.00						Policy for Tier 1	
	AS20	Depth of Well Below Water Table	Uniform	m	0.000308	0.868	2.43	6.24	16.9	47.4	892	API, 1989
	AS21	Leading Coefficient of Freundlich Adsorption Isotherm	Derived	cm ³ /g	chemical-specific value						Derived	
	AS22	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption	
	AS23	Hydrolysis Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived	
	AS24	Biodegradation Rate Coefficient	Derived	1/yr	0.00						Policy for Tier 1	

¹ The actual distribution type depends upon the soil type; the distribution types given here correspond to the silty loam soil (the most common type). In the Tier 1 modeling runs, soil type is automatically varied among the three soil types; each soil type has its own values/distributions of values for the soil parameters. The values presented in this table include all three soil types.

² Values were generated using a Monte Carlo simulation with 10,000 iterations.

Table C-8: IWEM Tier 1 Input Parameters for Landfill, Composite Liner Scenario

Input Type	Input No.	Parameter	Input Distribution Type	Units (output)	Percentiles ²						References		
					0	10	25	50	75	90		100	
Source	SS1	Area	Regional Site-Based	m	40.5	445	2,480	12,100	54,600	134,000	3,120,000	USEPA, 1986 and 1997b	
	SS2/3	Length/Width	Derived	m	6.36	21.1	49.8	110	234	365	1,770	Derived	
	SS5	Recharge Rate	Regional Site-Based	m/yr	0.00001	0.0226	0.0780	0.143	0.326	0.450	1.15	ABB, 1995 and USEPA, 1997b	
	SS6	Infiltration Rate	Regional Site-Based	m/yr	0.00	0.00	0.00	0.00	0.0000730	0.000169	0.000401	TetraTech, 2001	
	SS10	Duration of Leaching	Derived	yr	0.00	0.00	0.00	0.00	301,000,000	1.09E+10	8.33E+12	USEPA, 2001	
	SS11	Fraction of Landfill Occupied by Waste of Concern	Constant	unitless	1.00						Policy for Tier 1		
	SS12	Depth of Waste Disposal Facility	Regional Site-Based	m	0.510	0.879	1.31	2.51	4.09	6.41	10.1	USEPA, 1986 and 1997b	
	SS13	Density of Hazardous Waste	Empirical	g/cm ³	0.700	0.738	0.794	0.888	1.33	1.46	2.10	Schanz and Salhotra, 1992	
	FS1	Ratio of Waste Concentration to Leachate Concentration	Constant	L/kg	10000						Policy for Tier 1		
	SS15	Base Depth Below Grade	Constant	m	0.00						No data available		
	Unsaturated Zone	US1	Saturated Hydraulic Conductivity	Lognormal ¹	m/yr	0.00463	0.608	2.06	8.35	36.7	180	2,390	Carsel and Parrish, 1988
		US2	Moisture Retention Parameter (alpha)	Johnson SB ¹	1/m	0.130	0.614	0.930	1.54	2.73	6.15	20.3	Carsel and Parrish, 1988
		US3	Moisture Retention Parameter (beta)	Johnson SB ¹	unitless	1.01	1.20	1.27	1.38	1.54	1.83	2.47	Carsel and Parrish, 1988
		US4	Residual Water Content	Johnson SB ¹	unitless	0.0118	0.0490	0.0613	0.0747	0.0857	0.0937	0.115	Carsel and Parrish, 1988
		US5	Saturated Water Content	Constant	unitless	0.410	0.410	0.430	0.450	0.450	0.450	0.450	Carsel and Parrish, 1988
US6		Thickness of Unsaturated Zone	Regional Site-Based	m	0.305	1.68	3.96	6.10	15.2	36.6	610	API, 1989	
US7		Dispersivity	Derived	m	0.0267	0.0570	0.107	0.154	0.354	0.825	1.00	Gelhar, 1986; EPRI, 1985; USEPA, 1997a	
US8		Percent Organic Matter	Johnson SB ¹	unitless	0.00347	0.0337	0.0566	0.102	0.179	0.294	1.60	Carsel and others, 1988	
US9		Bulk Density	Constant	g/cm ³	1.60	1.60	1.65	1.65	1.67	1.67	1.67	Carsel and others, 1988	
US10		Soil/Water Distribution Coefficient	Derived	cm ³ /g	chemical-specific value						Derived		
US11		Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption		
US12		Chemical Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived		
US13		Biodegradation Rate Coefficient	Constant	1/yr	0.00						Policy for Tier 1		
Saturated Zone	AS1	Average Particle Diameter	Empirical	cm	0.000401	0.00151	0.00538	0.0188	0.0413	0.0762	0.211	Sahe, 1974	
	AS2	Aquifer Effective Porosity	Derived	unitless	0.0502	0.105	0.163	0.236	0.296	0.335	0.424	Davis, 1969; McWorter and Sunada 1977	
	AS3	Aquifer Bulk Density	Derived	g/cm ³	1.16	1.30	1.43	1.55	1.63	1.70	1.80	Freeze and Cherry, 1979	
	AS4	Aquifer Saturated Thickness	Regional Site-Based	m	0.305	3.96	7.62	12.2	30.5	91.4	914	API, 1989	
	AS5	Longitudinal Hydraulic Conductivity	Regional Site-Based	m/yr	3.15	94.6	315	1,890	11,000	31,500	8,480,000	API, 1989	
	AS6	Anisotropy Ratio	Constant	unitless	1.00						Assumption		
	AS7	Hydraulic Gradient	Regional Site-Based	unitless	0.000002	0.001	0.002	0.00570	0.0180	0.0330	0.483	API, 1989	
	AS8	Seepage Velocity	Derived	m/yr	0.100	2.51	10.5	45.6	250	1,200	10,800	Derived	
	AS9	Retardation Factor	Derived	unitless	chemical-specific value						Derived		
	AS10	Longitudinal Dispersivity	Gelhar Empirical	m	0.111	0.958	2.91	6.38	9.87	14.7	40.0	EPRI, 1985; Gelhar, 1986; Gelhar, 1992	
	AS11	Transverse Dispersivity	Gelhar Empirical	m	0.0139	0.120	0.364	0.797	1.23	1.84	4.99	EPRI, 1985; Gelhar, 1986; Gelhar, 1992	
	AS12	Vertical Dispersivity	Gelhar Empirical	m	0.00500	0.00599	0.0182	0.0399	0.0617	0.0921	0.250	EPRI, 1985; Gelhar, 1986; Gelhar, 1992	
	AS13	Temperature of Ambient Aquifer Water	Regional Site-Based	degrees C	7.50	7.50	12.5	12.5	17.5	22.5	22.5	Collins, 1925	
	AS14	Ambient Groundwater pH	Empirical	standard un	3.20	5.20	6.06	6.79	7.39	7.89	9.70	USEPA STORET database	
	AS15	Fraction of Organic Carbon	Johnson SB	unitless	0.00000858	0.000135	0.000238	0.000443	0.000814	0.00140	0.0159	USEPA STORET database	
	AS16	Radial Distance of Observation Well from Downgradient Edge of Waste Unit	Constant	m	150						Policy for Tier 1		
	AS17	Angle Off-Center of Observation Well	Constant	degrees	0.00						Policy for Tier 1		
	AS20	Depth of Well Below Water Table	Uniform	m	0.000936	0.974	2.48	6.07	15.6	44.4	867	API, 1989	
	AS21	Leading Coefficient of Freundlich Adsorption Isotherm	Derived	cm ³ /g	chemical-specific value						Derived		
	AS22	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption		
	AS23	Hydrolysis Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived		
	AS24	Biodegradation Rate Coefficient	Derived	1/yr	0.00						Policy for Tier 1		

¹ The actual distribution type depends upon the soil type; the distribution types given here correspond to the silty loam soil (the most common type). In the Tier 1 modeling runs, soil type is automatically varied among the three soil types; each soil type has its own values/distributions of values for the soil parameters. The values presented in this table include all three soil types.

² Values were generated using a Monte Carlo simulation with 10,000 iterations.

Table C-9: IWEM Tier 1 Input Parameters for Surface Impoundment, Composite Liner Scenario

Input Type	Input No.	Parameter	Input Distribution Type	Units (output)	Percentiles ²						References	
					0	10	25	50	75	90		100
Source	SS1	Area	Regional Site-Based	m	9.30	206	609	2,020	8,760	35,200	4,860,000	USEPA, 2001
	SS2/3	Length/Width	Derived	m	3.05	14.4	24.7	45.0	93.6	188	2,200	Derived
	SS5	Recharge Rate	Regional Site-Based	m/yr	1.00E-05	0.00990	0.0465	0.168	0.271	0.450	1.84	ABB 1995 and USEPA, 1997b
	SS6	Infiltration Rate	Regional Site-Based	m/yr	0.00	0.00	0.00	0.0000488	0.000202	0.000498	0.00369	Derived
	SS10	Duration of Leaching	Constant	yr	4.00	15.0	50.0	50.0	50.0	50.0	95.0	USEPA, 2001
	SS15	Base Depth Below Grade	DBGS	m	0.00	0.00	0.00	1.52	3.38	4.57	33.5	USEPA, 2001
	SS7	Waste Water Ponding Depth	HZERO	m	0.0100	0.460	1.07	1.83	3.15	4.27	18.2	USEPA, 2001
		Total Impoundment Operating Depth	DEPTH	m				4.63				Derived
	SS16	Sediment Thickness	DSLUDGE	m				0.20				Assumption
	SS22	Distance to Nearest Surface Water Body	DSSW	m	0.00	105	240	360	1,000	2,000	5,000	USEPA, 2001
Unsaturated Zone	US1	Saturated Hydraulic Conductivity	Lognormal ¹	m/yr	0.00437	0.375	1.28	6.19	52.3	305	2,520	Carsel and Parrish, 1988
	US2	Moisture Retention Parameter (alpha)	Johnson SB ¹	1/m	0.109	0.534	0.817	1.42	3.31	8.06	19.8	Carsel and Parrish, 1988
	US3	Moisture Retention Parameter (beta)	Johnson SB ¹	unitless	1.02	1.18	1.23	1.31	1.64	1.93	2.49	Carsel and Parrish, 1988
	US4	Residual Water Content	Johnson SB ¹	unitless	0.00851	0.0521	0.0668	0.0809	0.0902	0.0973	0.115	Carsel and Parrish, 1988
	US5	Saturated Water Content	Constant	unitless	0.410	0.410	0.410	0.430	0.430	0.450	0.450	Carsel and Parrish, 1988
	US6	Thickness of Unsaturated Zone	Regional Site-Based	m	0.305	1.83	3.35	6.10	15.2	30.5	610	API, 1989
	US7	Dispersivity	Derived	m	0.0267	0.0603	0.0937	0.154	0.354	0.691	1.00	Gelhar, 1986; EPRI, 1985; USEPA, 1997a
	US8	Percent Organic Matter	Johnson SB ¹	unitless	0.00366	0.0319	0.0552	0.0993	0.180	0.304	2.75	Carsel and others, 1988
	US9	Bulk Density	Constant	g/cm ³	1.60	1.60	1.60	1.67	1.67	1.67	1.67	Carsel and others, 1988
	US10	Soil/Water Distribution Coefficient	Derived	cm ³ /g				chemical-specific value				Derived
	US11	Freundlich Adsorption Isotherm Exponent	Constant	unitless				1.00				Assumption
	US12	Chemical Degradation Rate Coefficient	Derived	1/yr				chemical-specific value				Derived
	US13	Biodegradation Rate Coefficient	Constant	1/yr				0.00				Policy for Tier 1
Saturated Zone	AS1	Average Particle Diameter	Empirical	cm	0.000401	0.00143	0.00538	0.0195	0.0407	0.0768	0.212	Sahe, 1974
	AS2	Aquifer Effective Porosity	Derived	unitless	0.0501	0.100	0.160	0.235	0.296	0.334	0.429	Davis, 1969; McWorter and Sunada 1977
	AS3	Aquifer Bulk Density	Derived	g/cm ³	1.16	1.29	1.43	1.56	1.63	1.70	1.80	Freeze and Cherry, 1979
	AS4	Aquifer Saturated Thickness	Regional Site-Based	m	0.305	3.53	6.10	12.2	24.4	61.0	914	API, 1989
	AS5	Longitudinal Hydraulic Conductivity	Regional Site-Based	m/yr	3.15	63.1	284	1,890	5,990	21,300	7,740,000	API, 1989
	AS6	Anisotropy Ratio	Constant	unitless				1.00				Assumption
	AS7	Hydraulic Gradient	Regional Site-Based	unitless	5.00E-07	0.000700	0.00200	0.00700	0.0151	0.0330	0.650	API, 1989
	AS8	Sepage Velocity	Derived	m/yr	0.100	1.53	7.44	28.2	183	680	11,000	Derived
	AS9	Retardation Factor	Derived	unitless				chemical-specific value				Derived
	AS10	Longitudinal Dispersivity	Gelhar Empirical	m	0.101	0.873	2.54	5.84	9.11	13.7	40.0	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS11	Transverse Dispersivity	Gelhar Empirical	m	0.0126	0.109	0.317	0.731	1.14	1.72	5.00	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS12	Vertical Dispersivity	Gelhar Empirical	m	0.00500	0.00546	0.0159	0.0365	0.0569	0.0859	0.250	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS13	Temperature of Ambient Aquifer Water	Regional Site-Based	degrees C	7.5	7.5	12.5	17.5	17.5	22.5	27.5	Collins, 1925
	AS14	Ambient Groundwater pH	Empirical	standard units	3.20	5.22	6.08	6.80	7.40	7.89	9.69	USEPA STORET database
	AS15	Fraction of Organic Carbon	Johnson SB	unitless	0.0000103	0.000136	0.000237	0.000429	0.000796	0.00135	0.00823	USEPA STORET database
	AS16	Radial Distance of Observation Well from Downgradient Edge of Waste Unit	Constant	m				150				Policy for Tier 1
	AS17	Angle Off-Center of Observation Well	Constant	degrees				0.00				Policy for Tier 1
	AS20	Depth of Well Below Water Table	Uniform	m	0.000118	0.803	2.18	5.38	13.1	31.9	908	API, 1989
	AS21	Leading Coefficient of Freundlich Adsorption Isotherm	Derived	cm ³ /g				chemical-specific value				Derived
	AS22	Freundlich Adsorption Isotherm Exponent	Constant	unitless				1.00				Assumption
AS23	Hydrolysis Degradation Rate Coefficient	Derived	1/yr				chemical-specific value				Derived	
AS24	Biodegradation Rate Coefficient	Derived	1/yr				0.00				Policy for Tier 1	

¹ The actual distribution type depends upon the soil type; the distribution types given here correspond to the silty loam soil (the most common type). In the Tier 1 modeling runs, soil type is automatically varied among the three soil types; each soil type has its own values/distributions of values for the soil parameters. The values presented in this table include all three soil types.

² Values were generated using a Monte Carlo simulation with 10,000 iterations.

Table C-10: IWEM Tier 1 Input Parameters for Waste Pile, Composite Liner Scenario

Input Type	Input No.	Parameter	Input Distribution Type	Units (output)	Percentiles ²						References	
					0	10	25	50	75	90		100
Source	SS1	Area	Regional Site-Based	m	5.06	20.2	20.2	121	1,210	4,170	2,020,000	USEPA, 1986 and 1997b
	SS2/3	Length/Width	Derived	m	2.25	4.49	4.49	11.0	34.8	64.6	1,420	Derived
	SS5	Recharge Rate	Regional Site-Based	m/yr	0.00001	0.0495	0.0787	0.147	0.286	0.419	1.68	ABB, 1995 and USEPA, 1997b
	SS6	Infiltration Rate	Regional Site-Based	m/yr	0.00	0.00	0.00	0.00	0.0000730	0.000167	0.000401	Tetra Tech, 2001
	SS10	Duration of Leaching	Constant	yr	20.0						US EPA, 1996	
	SS15	Base Depth Below Grade	Constant	m	0.00						Assumption of waste pile design	
Unsatuated Zone	US1	Saturated Hydraulic Conductivity	Lognormal ¹	m/yr	0.00684	0.611	2.04	8.26	35.5	159	2,520	Carsel and Parrish, 1988
	US2	Moisture Retention Parameter (alpha)	Johnson SB ¹	1/m	0.100	0.616	0.939	1.53	2.74	6.00	20.2	Carsel and Parrish, 1988
	US3	Moisture Retention Parameter (beta)	Johnson SB ¹	unitless	1.02	1.20	1.26	1.37	1.53	1.82	2.45	Carsel and Parrish, 1988
	US4	Residual Water Content	Johnson SB ¹	unitless	0.0156	0.0492	0.0610	0.0745	0.0857	0.0937	0.115	Carsel and Parrish, 1988
	US5	Saturated Water Content	Constant	unitless	0.410	0.410	0.430	0.450	0.450	0.450	0.450	Carsel and Parrish, 1988
	US6	Thickness of Unsatuated Zone	Regional Site-Based	m	0.305	1.68	3.96	6.10	15.2	34.1	610	API, 1989
	US7	Dispersivity	Derived	m	0.0267	0.0570	0.107	0.154	0.354	0.770	1.00	Gelhar, 1986; EPRI, 1985; USEPA, 1997a
	US8	Percent Organic Matter	Johnson SB ¹	unitless	0.00250	0.0336	0.0570	0.101	0.176	0.291	2.11	Carsel and others, 1988
	US9	Bulk Density	Constant	g/cm ³	1.60	1.60	1.65	1.65	1.67	1.67	1.67	Carsel and others, 1988
	US10	Soil/Water Distribution Coefficient	Derived	cm ³ /g	chemical-specific value						Derived	
	US11	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption	
	US12	Chemical Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived	
	US13	Biodegradation Rate Coefficient	Constant	1/yr	0.00						Policy for Tier 1	
Saturated Zone	AS1	Average Particle Diameter	Empirical	cm	0.000402	0.00149	0.00563	0.0200	0.0422	0.0781	0.211	Sahe, 1974
	AS2	Aquifer Effective Porosity	Derived	unitless	0.0501	0.106	0.168	0.238	0.298	0.335	0.423	Davis, 1969; McWorter and Sunada 1977
	AS3	Aquifer Bulk Density	Derived	g/cm ³	1.16	1.29	1.43	1.56	1.64	1.70	1.80	Freeze and Cherry, 1979
	AS4	Aquifer Saturated Thickness	Regional Site-Based	m	0.305	3.73	7.32	15.2	32.0	91.4	914	API, 1989
	AS5	Longitudinal Hydraulic Conductivity	Regional Site-Based	m/yr	3.15	94.6	315	1,890	11,000	31,500	4,440,000	API, 1989
	AS6	Anisotropy Ratio	Constant	unitless	1.00						Assumption	
	AS7	Hydraulic Gradient	Regional Site-Based	unitless	0.000002	0.000903	0.00200	0.00570	0.0180	0.0330	0.390	API, 1989
	AS8	Seepage Velocity	Derived	m/yr	0.100	2.08	8.68	42.2	245	1,210	10,900	Derived
	AS9	Retardation Factor	Derived	unitless	chemical-specific value						Derived	
	AS10	Longitudinal Dispersivity	Gelhar Empirical	m	0.101	0.864	2.58	5.60	8.72	15.2	40.0	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS11	Transverse Dispersivity	Gelhar Empirical	m	0.0126	0.108	0.322	0.701	1.09	1.90	5.00	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS12	Vertical Dispersivity	Gelhar Empirical	m	0.00500	0.00540	0.0161	0.0350	0.0545	0.0948	0.250	EPRI, 1985; Gelhar, 1986; Gelhar, 1992
	AS13	Temperature of Ambient Aquifer Water	Regional Site-Based	degrees C	7.50	7.50	12.5	12.5	17.5	22.5	22.5	Collins, 1925
	AS14	Ambient Groundwater pH	Empirical	standard units	3.21	5.23	6.08	6.82	7.42	7.93	9.68	USEPA STORET
	AS15	Fraction of Organic Carbon	Johnson SB	unitless	0.0000116	0.000133	0.000236	0.000435	0.000809	0.00142	0.0116	USEPA STORET
	AS16	Radial Distance of Observation Well from Downgradient Edge of Waste Unit	Constant	m	150						Policy for Tier 1	
	AS17	Angle Off-Center of Observation Well	Constant	degrees	0.00						Policy for Tier 1	
	AS20	Depth of Well Below Water Table	Uniform	m	0.00270	0.947	2.45	6.08	16.2	46.0	914	API, 1989
	AS21	Leading Coefficient of Freundlich Adsorption Isotherm	Derived	cm ³ /g	chemical-specific value						Derived	
	AS22	Freundlich Adsorption Isotherm Exponent	Constant	unitless	1.00						Assumption	
	AS23	Hydrolysis Degradation Rate Coefficient	Derived	1/yr	chemical-specific value						Derived	
	AS24	Biodegradation Rate Coefficient	Derived	1/yr	0.00						Policy for Tier 1	

¹ The actual distribution type depends upon the soil type; the distribution types given here correspond to the silty loam soil (the most common type). In the Tier 1 modeling runs, soil type is automatically varied among the three soil types; each soil type has its own values/distributions of values for the soil parameters. The values presented in this table include all three soil types.

² Values were generated using a Monte Carlo simulation with 10,000 iterations.

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