Appendix B - Worksheets for Modeled EPC's

WORKSHEET 3.1
EXPOSURE POINT MODEL WORKSHEET
Westinghouse Electric Co. Hematite Site

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EPC Set: 1
Exposure Point: Shower Water/Bath Water to Indoor Air

Equation: H' x Concentration in water = Indoor Air Exposure Point Concentration

Parameters:	Value	Units	Definition
H'	Chemical-Specfic	L-water/L-air	Henry's Law Constant; describes the volatility of dilute species in water at 25°C.

Chemical Constituent of Potential Concern	Overburden Water Exposure Point Concentration ug/L-water	Henry's Law Constant H' L-water/L-air	Indoor Air Exposure Point Concentration ug/L-air	Indoor Air Exposure Point Concentration mg/m^3-air
1,1-Dichloroethene	1.64E+02	1.07E+00	1.76E+02	1.76E+02
cis-1,2-Dichloroethene	2.57E+03	1.67E-01	4.30E+02	4.30E+02
trans-1,2-Dichloroethene	1.24E+02	3.85E-01	4.78E+01	4.78E+01
Methylene chloride	1.93E+02	8.98E-02	1.73E+01	1.73E+01
Tetrachloroethene	2.93E+03	7.54E-01	2.21E+03	2.21E+03
Trichloroethene	3.32E+03	4.22E-01	1.40E+03	1.40E+03
Vinyl Chloride	2.29E+02	1.11E+00	2.54E+02	2.54E+02
Bis(2-ethylhexyl)phthalate	7.12E+00	4.18E-06	2.98E-05	2.98E-05

Note: Model assumes that the breathing zone is near or at the air/water interface where equilibrium exists.

WORKSHEET 3.2
EXPOSURE POINT MODEL WORKSHEET
Westinghouse Electric Co. Hematite Site

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EPC Set: 2
Exposure Point: Shower Water/Bath Water to Indoor Air

Equation: H' x Concentration in water = Indoor Air Exposure Point Concentration

Parameters:	Value	Units	Definition
H'	Chemical-Specfic	L-water/L-air	Henry's Law Constant; describes the volatility of dilute species in water at 25°C.

Chemical Constituent of Potential Concern	Bedrock Water Exposure Point Concentration ug/L-water	Henry's Law Constant H' L-water/L-air	Indoor Air Exposure Point Concentration ug/L-air	Indoor Air Exposure Point Concentration mg/m^3-air
1,1-Dichloroethene	1.05E+02	1.07E+00	1.12E+02	1.12E+02
cis-1,2-Dichloroethene	1.31E+03	1.67E-01	2.20E+02	2.20E+02
trans-1,2-Dichloroethene	7.40E+01	3.85E-01	2.85E+01	2.85E+01
Methylene chloride	7.34E+01	8.98E-02	6.59E+00	6.59E+00
Tetrachloroethene	1.15E+03	7.54E-01	8.64E+02	8.64E+02
Trichloroethene	2.72E+03	4.22E-01	1.15E+03	1.15E+03
Vinyl Chloride	1.32E+02	1.11E+00	1.46E+02	1.46E+02
Bis(2-ethylhexyl)phthalate	0.00E+00	4.18E-06	0.00E+00	0.00E+00

Note: Model assumes that the breathing zone is near or at the air/water interface where equilibrium exists.

WORKSHEET 3.3
EXPOSURE POINT MODEL WORKSHEET
Westinghouse Electric Co. Hematite Site

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EPC Set: 1
Exposure Point: Groundwater Vapor to Outdoor Air

Equations: VF x Concentration in water x CF2 = Outdoor Air Exposure Point Concentration
VF = H' x CF1 / (1 + (100 x Um x DELTAa x Lgw) / (DwsEFF x Wga))

Parameters:	Value	Units	Definition
VF	Calculated below	(mg/m^3-air)/(mg/L-water)	Volatization factor: models the outdoor air concentration of a contaminant from a groundwater source.
Um	4.69	m/s	Mean annual wind speed
DELTAa	200	cm	Ambient air mixing zone
Lgw	400	cm	Depth to groundwater
Wga	1500	cm	Dimension of soil source parallel to wind direction
CF1	1000	L/m^3	Conversion factor; liters to cubic meters
CF2	0.001	mg/ug	Coversion factor; micrograms to milligrams
DwsEFF	Calculated on Worksheet 3.7	cm^2/s	Effective diffusivity between groundwater and soil
H'	Chemical-Specfic	L-water/L-air	Henry's Law Constant, describes volatility of dilute species in water at 25°C.

Chemical Constituent of Potential Concern	Exposure Point Concentration ug/L-water	DwsEFF cm^2/s	Henry's Law Constant H' L-water/L-air	Volatization Factor VF (mg/m^3-air)/(mg/L-water)	Outdoor Air Exposure Point Concentration mg/m^3-air
1,1-Dichloroethene	1.64E+02	1.62E-02	1.07E+00	6.91E-04	1.14E-04
cis-1,2-Dichloroethene	2.57E+03	6.54E-02	1.67E-01	4.36E-04	1.12E-03
trans-1,2-Dichloroethene	1.24E+02	3.08E-02	3.85E-01	4.75E-04	5.90E-05
Methylene chloride	1.93E+02	1.17E-01	8.98E-02	4.19E-04	8.07E-05
Tetrachloroethene	2.93E+03	1.86E-02	7.54E-01	5.60E-04	1.64E-03
Trichloroethene	3.32E+03	2.93E-02	4.22E-01	4.94E-04	1.64E-03
Vinyl Chloride	2.29E+02	1.71E-02	1.11E+00	7.58E-04	1.74E-04
Bis(2-ethylhexyl)phthalate	7.12E+00	2.33E+03	4.18E-06	3.57E-04	2.54E-06

Note: Model Source is ASTM E1739-95 (as cited in MRBCA)

WORKSHEET 3.4
EXPOSURE POINT MODEL WORKSHEET
Westinghouse Electric Co. Hematite Site

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EPC Set: 4
Exposure Point: Surface soil vapors to outdoor air

Equations: VF x Concentration in surface soil = Outdoor Air Exposure Point Concentration
VF= [(Q/C x (3.14 x DA x T)^(.5) x CF1) / (2 x rb x Da)]^-1

Parameters:	Value	Units	Definition
VF	Calculated below	m^3/kg-soil	Volatization factor: models the outdoor air concentration of a contaminant from a surface soil source.
Q/C	68.81	(g/m^2-s)/(kg/m^3)	Inverse of the mean concentration at the center of square source
Foc	0.006	g/g	Fractional organic carbon in soil
rb	1.5	g/cm^3	Dry soil bulk density
rs	2.65	g/cm^3	Soil particle density
n	0.43	L-pore/L-soil	Total soil porosity (1-rb/rs)
THETAw	0.15	L-water/L-soil	Volumetric water content in soil
THETAa	0.28	L-air/L-soil	Volumetric air content in soil
T	9.50E+08	s	Exposure Interval
CF1	0.0001	m^2/cm^2	Conversion factor; square centimeters to square meters
DA	Calculated on Worksheet 3.8	cm^2/s	Apparent diffusivity

Chemical Constituent of Potential Concern	Exposure Point Concentration mg/kg-soil	Apparent Diffusivity DA cm^2/s	Volatization Factor VF kg-soil/m^3-air	Outdoor Air Exposure Point Concentration mg/m^3-air
Benzo(a)anthracene	8.53E-01	1.05E-10	8.19E-08	6.99E-08
Benzo(a)pyrene	9.15E-01	2.02E-11	3.59E-08	3.28E-08
Benzo(b)fluoranthene	1.26E+00	5.23E-10	1.83E-07	2.31E-07
Indeno(1,2,3-cd)pyrene	7.55E-01	3.87E-12	1.57E-08	1.19E-08
Aroclor-1254 (PCB-1254)	5.79E-02	3.79E-09	4.92E-07	2.85E-08
Aroclor-1260 (PCB-1260)	7.07E-02	4.23E-09	5.19E-07	3.67E-08

Note: Model Source is Soil Screening Guidance, EPA 1996.

WORKSHEET 3.5
EXPOSURE POINT MODEL WORKSHEET
Westinghouse Electric Co. Hematite Site

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EPC Set: 4 & 5
Exposure Point: Surface soil or exposed subsurface soil to particulates in outdoor air

Equations: VF x Concentration in surface soil = Outdoor Air - Particulate Exposure Point Concentration
PEF = [Q/C x 3600/(.036 x (1-V) x (Um/Ut) x F(x))]^-1

Parameters:	Value	Units	Definition
PEF	Calculated below	m^3/kg soil	Particulate Emission Factor: models the outdoor air particulate concentration of a contaminant from a surface soil source.
Q/C:	(g/m^2-s)/(kg/m^3)	90.8	Inverse of mean concentration at center of 0.5-acre square source
V:	unitless	0.5	Fraction of vegetative cover
Um:	m/s	4.69	Mean annual wind speed
Ut:	m/s	11.32	Equivalent threshold value of windspeed
F(x):	unitless	0.194	Windspeed distribution function

Chemical Constituent of Potential Concern	Particulate Emission Factor PEF kg-soil/m^3-air
All Chemicals	7.60E-10

Note: Model Source is Soil Screening Guidance, EPA 1996.

WORKSHEET 3.6
EXPOSURE POINT MODEL WORKSHEET
Westinghouse Electric Co. Hematite Site

DRAFT

EPC Set: 5
Exposure Point: Exposed subsurface soil vapors to outdoor air

Equations: VF x Concentration in subsurface soil = Outdoor Air Exposure Point Concentration
VF= [(Q/C x (3.14 x DA x T)^(.5) x CF1) / (2 x rs x Da)]^-1

Parameters:	Value	Units	Definition
VF	Calculated below	m^3/kg-soil	Volatization factor: models the outdoor air concentration of a contaminant from a subsurface soil source.
Q/C	68.81	(g/m^2-s)/(kg/m^3)	Inverse of the mean concentration at the center of square source
Foc	0.006	g/g	Fractional organic carbon in soil
rb	1.5	g/cm^3	Dry soil bulk density
rs	2.65	g/cm^3	Soil particle density
n	0.43	L-pore/L-soil	Total soil porosity (1-rb/rs)
THETAw	0.15	L-water/L-soil	Volumetric water content in soil
THETAa	0.28	L-air/L-soil	Volumetric air content in soil
T	9.50E+08	s	Exposure Interval
CF1	0.0001	m^2/cm^2	Conversion factor; square centimeters to square meters
DA	Calculated on Worksheet 3.8	cm^2/s	Apparent diffusivity

Chemical Constituent of Potential Concern	Exposure Point Concentration mg/kg-soil	Apparent Diffusivity DA cm^2/s	Volatization Factor VF kg-soil/m^3-air	Outdoor Air Exposure Point Concentration mg/m^3-air
Tetrachloroethene	3.26E-01	4.25E-04	2.91E-04	9.47E-05
Trichloroethene	6.08E-02	1.38E-03	5.24E-04	3.19E-05

Note: Model Source is Soil Screening Guidance, EPA 1996.

WORKSHEET 3.7
EXPOSURE POINT MODEL WORKSHEET
Westinghouse Electric Co. Hematite Site

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Calculation of Effective Diffusivities
Intercalculation Worksheet

Parameters:	Value	Units	Definition
THETAw	0.15	cm^3-water/cm^3-total volume soil	Volumetric water content in soil
THETAa	0.28	cm^3-air/cm^3-total volume soil	Volumetric air content in soil
THETAt	0.43	cm^3/cm^3-total volume soil	Total porosity
hc	5	cm	Capillary fringe thickness
hv	400	cm	Thickness of vadose zone
Da	Chemical-Specfic	cm^2/s	Diffusivity in air
Dw	Chemical-Specfic	cm^2/s	Diffusivity in water
DwsEFF	Calculated below	cm^2/s	Effective diffusivity between groundwater and soil
DcrEFF	Calculated below	cm^2/s	Effective diffusivity through foundation cracks
DsEFF	Calculated below	cm^2/s	Effective diffusivity in soil
DcapEFF	Calculated below	cm^2/s	Effective diffusivity through capillary fringe
H'	Chemical-Specfic	L-water/L-air	Henry's Law Constant, describes volatility of dilute species in water at 25°C

DwsEFF Calculation

Equations: DwsEFF = (hc + hv) x ((hc/DcapEFF) + (hv/DsEFF))^-1

DcrEFF, DsEFF, DcapEff = Da x (THETAa^3.33)/(THETAt^2.0) + Dw x 1/H' x (THETAa^3.33)/(THETAt^2.0)

Chemical Constituent of Potential Concern	Diffusivity in Air Da cm^2/s	Diffusivity in Water Dw cm^2/s	Henry's Law Constant H' L-water/L-air	DcrEFF, DsEFF, DcapEFF cm^2/s	DwsEFF cm^2/s
1,1-Dichloroethene	9.00E-02	1.04E-05	1.07E+00	1.62E-02	1.62E-02
cis-1,2-Dichloroethene	8.84E-02	1.13E-05	1.67E-01	6.54E-02	6.54E-02
trans-1,2-Dichloroethene	7.03E-02	1.19E-05	3.85E-01	3.08E-02	3.08E-02
Methylene chloride	1.01E-01	1.17E-05	8.98E-02	1.17E-01	1.17E-01
Tetrachloroethene	7.20E-02	8.20E-06	7.54E-01	1.86E-02	1.86E-02
Trichloroethene	7.90E-02	9.10E-06	4.22E-01	2.93E-02	2.93E-02
Vinyl Chloride	1.06E-01	1.23E-05	1.11E+00	1.71E-02	1.71E-02
Bis(2-ethylhexyl)phthalate	3.51E-02	3.66E-06	4.18E-06	2.33E+03	2.33E+03
Benzo(a)anthracene	5.10E-02	9.00E-06	1.37E-04	7.12E+01	7.12E+01
Benzo(a)pyrene	4.30E-02	9.00E-06	4.63E-05	2.11E+02	2.11E+02
Benzo(b)fluoranthene	2.50E-02	6.41E-06	4.55E-03	2.15E+00	2.15E+00
Indeno(1,2,3-cd)pyrene	2.45E-02	6.31E-06	6.56E-05	1.49E+02	1.49E+02
Aroclor-1254 (PCB-1254)	2.37E-02	6.08E-06	8.20E-02	1.21E-01	1.21E-01
Aroclor-1260 (PCB-1260)	2.26E-02	5.78E-06	1.89E-01	5.35E-02	5.35E-02

Note: Model Source is ASTM E1739-95 (as cited in MRBCA). Calculation assumes soil in vadose zone, capillary fringe, and foundation cracks have equivalent geotechnical parameters.

WORKSHEET 3.8
EXPOSURE POINT MODEL WORKSHEET
Westinghouse Electric Co. Hematite Site

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Calculation of Apparent Diffusivity
Intercalculation Worksheet

Parameters:	Value	Units	Definition
rb	1.5	g/cm^3	Dry soil bulk density
rs	2.65	g/cm^3	Soil particle density
THETAt	0.43	L-pore/L-soil	Total soil porosity (1-rb/rs)
THETAw	0.15	L-water/L-soil	Volumetric water content in soil
THETAa	0.28	L-air/L-soil	Volumetric air content in soil
Da	Chemical-Specfic	cm^2/s	Diffusivity in air
Dw	Chemical-Specfic	cm^2/s	Diffusivity in water
Kd	Chemical-Specfic	cm^3/g	Soil-Water Partition Coefficient
H'	Chemical-Specfic	L-water/L-air	Henry's Law Constant, describes volatility of dilute species in water at 25°C

DA Calculation

Equation: DA = ((THETAa^3.33 x Da x H' + THETAw^3.33 x Dw)/ (THETAt)^2) / (rs x Kd + THETAw + THETAa x H')

Chemical Constituent of Potential Concern	Henry's Law Constant H' L-water/L-air	Diffusion Coefficient in Air Dair cm^2/s	Diffusion Coefficient in Water Dwater cm^2/s	Soil-Water Partition Coefficient Kd cm^3/g	Apparent Diffusivity DA cm^2/s
Benzo(a)anthracene	1.37E-04	5.10E-02	9.00E-06	2.22E+03	1.05E-10
Benzo(a)pyrene	4.63E-05	4.30E-02	9.00E-06	4.44E+03	2.02E-11
Benzo(b)fluoranthene	4.55E-03	2.50E-02	6.41E-06	6.29E+03	5.23E-10
Indeno(1,2,3-cd)pyrene	6.56E-05	2.45E-02	6.31E-06	1.78E+04	3.87E-12
Aroclor-1254 (PCB-1254)	8.20E-02	2.37E-02	6.08E-06	1.47E+04	3.79E-09
Aroclor-1260 (PCB-1260)	1.89E-01	2.26E-02	5.78E-06	2.90E+04	4.23E-09
Tetrachloroethene	7.54E-01	7.20E-02	8.20E-06	3.54E+00	4.25E-04
Trichloroethene	4.22E-01	7.90E-02	9.10E-06	5.93E-01	1.38E-03

Note: Model Source is Soil Screening Guidance, EPA 1996.