SAMPLE SPREADSHEET FOR CALCULATION OF BENZENE RBSLs BASED ON ASTM RBCA GUIDANCE

Leaking Underground Storage Tank Oversight Program

Santa Clara Valley Water District

	INPUT PARAMETERS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
Exposure	Target excess individual cancer risk [unitless]	TR	1.00E-06	1.00E-06	1.00E-06	1.00E-06
	Adult body weight [kg]	BW	70	70	70	70
	Averaging time for carcinogens [years]	AT_c	70	70	70	70
	Daily indoor inhalation rate [m3/day]	IR_air_ind	15	20	15	20
	Daily outdoor inhalation rate [m3/day]	IR_air_out	20	20	20	20
	Soil ingestion rate, mg/day	IR_soil	100	50	100	50
	Exposure frequency [days/year]	EF	350	250	350	250
	Exposure duration [years]	ED	30	25	30	25
	Oral relative absorption factor	RAF_o	1	1	1	1
	Skin surface area [cm2/day]	SA	3160	3160	3160	3160
	Soil to skin adherence factor [mg/cm2]	M	0.5	0.5	0.5	0.5
	Dermal relative absorption factor, volatiles/PAHs	RAF_d	0.5	0.5	0.5	0.5
	Averaging time for vapor flux [s]	tau	9.46E+08	7.88E+08	9.46E+08	7.88E+08
Building	Enclosed space air exchange rate [L/s]	ER	**0.000654**	0.00023	0.00014	0.00023
	Enclosed space volume/infiltration area ratio [cm]	L_b	**853.44**	300	200	300
	Enclosed space foundation or wall thickness [cm]	L_crack	15	15	15	15
	Aerial fraction of cracks in foundations/walls [cm2 cracks/cm2 total area]	nju	0.01	0.01	0.01	0.01
	Volumetric air content in in foundation/wall cracks [cm3 air/cm3 total volume]	Phi_acrack	0.26	0.26	0.26	0.26
	Volumetric water content in foundation/wall cracks [cm3 wate/cm3 total volume]	Phi_wcrack	0.12	0.12	0.12	0.12
Surface	Wind speed in ambient mixing zone [cm/s]	U_air	225	225	225	225
	Ambient air mixing zone height [cm]	delta_air	200	200	200	200
	Width of source area parallel to wind or groundwater flow direction [cm]	W	1500	1500	1500	1500
	Particulate emission rate [g/cm2-s]	P_o	6.9E-14	6.9E-14	6.90E-14	6.90E-14

	INPUT PARAMETERS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
Subsurface	Groundwater Darcy velocity [cm/year]	U_gw	**0.0011**	0.0011	2500	2500
	Infiltration rate of water through soil [cm/year]	I	**0.0029**	0.0029	30	30
	Groundwater mixing zone thickness [cm]	delta_gw	200	200	200	200
	Thickness of capillary fringe [cm]	h_cap	5	5	5	5
	Thickness of vadose zone [cm]	h_v	**193**	195	295	295
	Depth to subsurface soil sources [cm]	L_s	6.5' **198**	198	100	100
	Depth to groundwater [cm]	L_gw	**198**	198	300	300
	Lower depth of surficial soil zone [cm]	d	GW → 6.5' 10.5' **320**	320	100	100
						0
Soil	Total soil porosity [cm3/cm3 soil]	Phi_t	0.38	0.38	0.38	0.38
	Volumetric air content in vadose zone [cm3 air/cm3 soil]	Phi_as	***0.07***	0.07	*0.26*	0.26
	Volumetric water content in vadose zone [cm3 H2O/cm3 soil]	Phi_ws	**0.31**	0.31	0.12	0.12
	Volumetric air content in capillary fringe [cm3 air/cm3 soil]	Phi_acap	*0.038*	0.038	*0.038*	0.038
	Volumetric water content in capillary fringe [cm3 H2O/cm3 soil]	Phi_wcap	0.342	0.342	0.342	0.342
	Soil bulk density [g/cm3]	Ro_s	1.7	1.7	1.7	1.7
	Fraction of organic carbon in soil [unitless]	f_oc	0.01	0.01	0.01	0.01
Chemical	Inhalation slope factor [(mg/kg-day)-1]	SF_i	0.029	0.029	0.029	0.029
	Oral slope factor [(mg/kg-day)-1]	SF_o	0.029	0.029	0.029	0.029
	Henry's constant [cm3 H2O/cm3 air]	H	0.22	0.22	0.22	0.22
	Pure component solubility in water [mg/L]	S	1780	1780	1780	1780
	Carbon-water sorption coefficient [cm3 H2O/g C]	k_oc	38.02	38.02	38.02	38.02
	Soil-water sorption coefficient [cm3 H2O/g soil]	k_s	*0.380*	0.380	0.380	0.380
	Diffusion coeff. In air [cm2/s]	D_air	0.093	0.093	0.093	0.093
	Diffusion coeff. In water [cm2/s]	D_wat	0.000011	0.000011	0.000011	0.000011

SAMPLE SPREADSHEET FOR CALCULATION OF BENZENE RBSLs BASED ON ASTM RBCA GUIDANCE
Leaking Underground Storage Tank Oversight Program
Santa Clara Valley Water District

	CALCULATED TRANSPORT COEFFICIENTS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
	Effective diffusion coeff in soil based on vapor conc [cm2/s]	Deff_s	9.8024E-05	9.80235E-05	0.00722511	0.007225113
	Effective diffusion coeff. Through capillary fringe [cm2/s]	Deff_cap	2.1732E-05	2.17324E-05	2.1732E-05	2.17324E-05
	Effective diffusion coeff. From groundwater to surface [cm2/s]	Deff_ws	9.0042E-05	9.00415E-05	0.00110742	0.001107410
	Effective diffusion coeff. Through foundation cracks [cm2/s]	Deff_crack	0.00725763	0.007257629	0.00725763	0.007257629
	Volatilization factor from subsurface soil to enclosed space [mg/m3 air/mg/kg soil]	VF_s_esp	0.0003097	0.00250516	0.07353951	0.02984499
	Volatilization factor from subsurface soil to ambient air [mg/m3 air/mg/kg soil]	VF_s_amb	6.3515E-06	6.3515E-06	0.00109375	0.00109375
	Volatilization factor from surficial soil to ambient air (vapor) [mg/m3 air/mg/kg soil]	VF_ss	9.7936E-06	1.0731E-05	9.1334E-05	0.0001000?
		VF_ss1	1.9168E-05	2.3012E-05	5.9901E-06	7.1912E-06
	Volatilization factor from surficial soil to ambient air (particulates) [mg/m3 air/mg/kg soil]	VF_p	2.3E-12	2.3E-12	2.3E-12	2.3E-12
	Volatilization factor from groundwater to enclosed space [mg/m3 air/mg/L H2O]	VF_w_esp	0.00016385	0.00132537	0.01645076	0.00667597
	Volatilization factor from groundwater to ambient air [mg/m3 air/mg/L H2O]	VF_w_amb	3.3349E-06	3.3349E-06	2.707E-05	2.707E-05
	Leaching factor from subsurface soils to groundwater [mg/L H2O/mg/kg soil]	LF_s_w	1.66525196	1.66525196	0.17044715	0.17044715

	CALCULATED TARGET LEVELS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
AIR	**RBSL for enclosed space air [ug/m3]**	**RBSL_air_esp**	**3.92E-01**	**4.93E-01**	**3.92E-01**	**4.93E-01**
	RBSL for ambient air [ug/m3]	**RBSL_air_amb**	**2.94E-01**	**4.93E-01**	**2.94E-01**	**4.93E-01**
SOIL	**Surficial soil - ingestion, inhalation of vapors and dust, dermal contact [mg/kg]**	**RBSL_s_surf**	**5.41E+00**	**9.36E+00**	**5.82E+00**	**1.00E+01**
	Subsurface soil RBSL - Enclosed space vapor inhalation from subsurface soil [mg/kg]	**RBSL_s_esp**	**1.26E+00**	**1.97E-01**	**5.32E-03**	**1.65E-02**
	Subsurface soil RBSL - Ambient air vapor inhalation from subsurface soil [mg/kg]	**RBSL_s_amb**	**4.62E+01**	**7.77E+01**	**2.69E-01**	**4.51E-01**
	Soil RBSL to protect groundwater MCL	RBSL_s_w_MCL	3.00E-03	3.00E-03	2.93E-02	2.93E-02
	Soil RBSL to protect groundwater RBSL enclosed space vapor inh. [mg/kg]	RBSL_s_w_esp	1.44E+00	2.24E-01	1.40E-01	4.34E-01
	Soil RBSL to protect groundwater RBSL ambient air vapor inh. [mg/kg]	RBSL_s_w_amb	5.29E+01	8.88E+01	6.36E+01	1.07E+02
	Concentration in soil at which pore-water and vapor become saturated [mg/kg]	C_s_sat	1.02E+03		8.62E+02	
GROUND-WATER	**Groundwater RBSL - Enclosed space vapor inhalation from groundwater [mg/L]**	RBSL_w_esp	**2.39E+00**	**3.72E-01**	**2.38E-02**	**7.39E-02**
	Groundwater RBSL - Ambient air vapor inhalation from groundwater [mg/L]	RBSL_w_amb	**8.81E+01**	**1.48E+02**	**1.08E+01**	**1.82E+01**
	MCL	MCL	**5.00E-03**	**5.00E-03**	**5.00E-03**	**5.00E-03**

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			Residential	Commercial	Residential	Commercial
Exposure	Target excess individual cancer risk [unitless]	TR	1.00E-06	1.00E-06	1.00E-06	1.00E-06
	Adult body weight [kg]	BW	70	70	70	70
	Averaging time for carcinogens [years]	AT_c	70	70	70	70
	Daily indoor inhalation rate [m3/day]	IR_air_ind	15	20	15	20
	Daily outdoor inhalation rate [m3/day]	IR_air_out	20	20	20	20
	Soil ingestion rate, mg/day	IR_soil	100	50	100	50
	Exposure frequency [days/year]	EF	350	250	350	250
	Exposure duration [years]	ED	30	25	30	25
	Oral relative absorption factor	RAF_o	1	1	1	1
	Skin surface area [cm2/day]	SA	3160	3160	3160	3160
	Soil to skin adherence factor [mg/cm2]	M	0.5	0.5	0.5	0.5
	Dermal relative absorption factor, volatiles/PAHs	RAF_d	0.5	0.5	0.5	0.5
	Averaging time for vapor flux [s]	tau	9.46E+08	7.88E+08	9.46E+08	7.88E+08
Building	Enclosed space air exchange rate [L/s]	ER	**0.000654**	0.00023	0.00014	0.00023
	Enclosed space volume/infiltration area ratio [cm]	L_b	**853.44**	300	200	300
	Enclosed space foundation or wall thickness [cm]	L_crack	15	15	15	15
	Aerial fraction of cracks in foundations/walls [cm2 cracks/cm2 total area]	nju	0.01	0.01	0.01	0.01
	Volumetric air content in in foundation/wall cracks [cm3 air/cm3 total volume]	Phi_acrack	0.26	0.26	0.26	0.26
	Volumetric water content in foundation/wall cracks [cm3 wate/cm3 total volume]	Phi_wcrack	0.12	0.12	0.12	0.12
Surface	Wind speed in ambient mixing zone [cm/s]	U_air	225	225	225	225
	Ambient air mixing zone height [cm]	delta_air	200	200	200	200
	Width of source area parallel to wind or groundwater flow direction [cm]	W	1500	1500	1500	1500
	Particulate emission rate [g/cm2-s]	P_o	6.9E-14	6.9E-14	6.90E-14	6.90E-14

	INPUT PARAMETERS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
Subsurface	Groundwater Darcy velocity [cm/year]	U_gw	**0.0011**	0.0011	2500	2500
	Infiltration rate of water through soil [cm/year]	I	**0.0029**	0.0029	30	30
	Groundwater mixing zone thickness [cm]	delta_gw	200	200	200	200
	Thickness of capillary fringe [cm]	h_cap	5	5	5	5
	Thickness of vadose zone [cm]	h_v	**315**	315	*295*	295
	Depth to subsurface soil sources [cm]	L_s	6.5' **198**	198	100	100
	Depth to groundwater [cm]	L_gw	10.5' **320**	320	300	300
	Lower depth of surficial soil zone [cm]	d	GW → 10.5' **320**	320	100	100
						0
Soil	Total soil porosity [cm3/cm3 soil]	Phi_t	0.38	0.38	0.38	0.38
	Volumetric air content in vadose zone [cm3 air/cm3 soil]	Phi_as	***0.07***	0.07	*0.26*	0.26
	Volumetric water content in vadose zone [cm3 H2O/cm3 soil]	Phi_ws	**0.31**	0.31	0.12	0.12
	Volumetric air content in capillary fringe [cm3 air/cm3 soil]	Phi_acap	*0.038*	0.038	*0.038*	0.038
	Volumetric water content in capillary fringe [cm3 H2O/cm3 soil]	Phi_wcap	0.342	0.342	0.342	0.342
	Soil bulk density [g/cm3]	Ro_s	1.7	1.7	1.7	1.7
	Fraction of organic carbon in soil [unitless]	f_oc	0.01	0.01	0.01	0.01
Chemical	Inhalation slope factor [(mg/kg-day)-1]	SF_i	0.029	0.029	0.029	0.029
	Oral slope factor [(mg/kg-day)-1]	SF_o	0.029	0.029	0.029	0.029
	Henry's constant [cm3 H2O/cm3 air]	H	0.22	0.22	0.22	0.22
	Pure component solubility in water [mg/L]	S	1780	1780	1780	1780
	Carbon-water sorption coefficient [cm3 H2O/g C]	k_oc	38.02	38.02	38.02	38.02
	Soil-water sorption coefficient [cm3 H2O/g soil]	k_s	*0.380*	0.380	0.380	0.380
	Diffusion coeff. In air [cm2/s]	D_air	0.093	0.093	0.093	0.093
	Diffusion coeff. In water [cm2/s]	D_wat	0.000011	0.000011	0.000011	0.000011

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	CALCULATED TRANSPORT COEFFICIENTS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
	Effective diffusion coeff in soil based on vapor conc [cm2/s]	Deff_s	9.8024E-05	9.80238E-05	0.00722511	0.007225113
	Effective diffusion coeff. Through capillary fringe [cm2/s]	Deff_cap	2.1732E-05	2.17324E-05	2.1732E-05	2.17324E-05
	Effective diffusion coeff. From groundwater to surface [cm2/s]	Deff_ws	9.2926E-05	9.29264E-05	0.00110742	0.001107416
	Effective diffusion coeff. Through foundation cracks [cm2/s]	Deff_crack	0.00725763	0.007257629	0.00725763	0.007257629
	Volatilization factor from subsurface soil to enclosed space [mg/m3 air/mg/kg soil]	VF_s_esp	0.0003097	0.00250516	0.07353951	0.02964195
	Volatilization factor from subsurface soil to ambient air [mg/m3 air/mg/kg soil]	VF_s_amb	6.3515E-06	6.3515E-06	0.00109375	0.00109375
	Volatilization factor from surficial soil to ambient air (vapor) [mg/m3 air/mg/kg soil]	VF_ss	9.7936E-06	1.0731E-05	9.1334E-05	0.00010007
		VF_ss1	1.9168E-05	2.3012E-05	5.9901E-06	7.1912E-06
	Volatilization factor from surficial soil to ambient air (particulates) [mg/m3 air/mg/kg soil]	VF_p	2.3E-12	2.3E-12	2.3E-12	2.3E-12
	Volatilization factor from groundwater to enclosed space [mg/m3 air/mg/L H2O]	VF_w_esp	0.00010798	0.00087347	0.01645076	0.00667507
	Volatilization factor from groundwater to ambient air [mg/m3 air/mg/L H2O]	VF_w_amb	2.1296E-06	2.1296E-06	2.707E-05	2.707E-05
	Leaching factor from subsurface soils to groundwater [mg/L H2O/mg/kg soil]	LF_s_w	1.66525196	1.66525196	0.17044715	0.17044715

	CALCULATED TARGET LEVELS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
AIR	**RBSL for enclosed space air [ug/m3]**	**RBSL_air_esp**	***3.92E-01***	***4.93E-01***	***3.92E-01***	***4.93E-01***
	RBSL for ambient air [ug/m3]	**RBSL_air_amb**	***2.94E-01***	***4.93E-01***	***2.94E-01***	***4.93E-01***
SOIL	**Surficial soil - ingestion, inhalation of vapors and dust, dermal contact [mg/kg]**	**RBSL_s_surf**	***5.41E+00***	***9.36E+00***	***5.82E+00***	***1.00E+01***
	Subsurface soil RBSL - Enclosed space vapor inhalation from subsurface soil [mg/kg]	**RBSL_s_esp**	***1.26E+00***	***1.97E-01***	***5.32E-03***	***1.65E-02***
	Subsurface soil RBSL - Ambient air vapor inhalation from subsurface soil [mg/kg]	**RBSL_s_amb**	***4.62E+01***	***7.77E+01***	***2.69E-01***	***4.51E-01***
	Soil RBSL to protect groundwater MCL	RBSL_s_w_MCL	*3.00E-03*	*3.00E-03*	*2.93E-02*	*2.93E-02*
	Soil RBSL to protect groundwater RBSL enclosed space vapor inh. [mg/kg]	RBSL_s_w_esp	*2.18E+00*	*3.39E-01*	*1.40E-01*	*4.34E-01*
	Soil RBSL to protect groundwater RBSL ambient air vapor inh. [mg/kg]	RBSL_s_w_amb	*8.28E+01*	*1.39E+02*	*6.36E+01*	*1.07E+02*
	Concentration in soil at which pore-water and vapor become saturated [mg/kg]	C_s_sat	*1.02E+03*		*8.62E+02*	
GROUND-WATER	**Groundwater RBSL - Enclosed space vapor inhalation from groundwater [mg/L]**	RBSL_w_esp	***3.63E+00***	***5.65E-01***	***2.38E-02***	***7.39E-02***
	Groundwater RBSL - Ambient air vapor inhalation from groundwater [mg/L]	RBSL_w_amb	***1.38E+02***	***2.32E+02***	***1.08E+01***	***1.82E+01***
	MCL	MCL	**5.00E-03**	**5.00E-03**	**5.00E-03**	**5.00E-03**

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	INPUT PARAMETERS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
Exposure	Target excess individual cancer risk [unitless]	TR	1.00E-06	1.00E-06	1.00E-06	1.00E-06
	Adult body weight [kg]	BW	70	70	70	70
	Averaging time for carcinogens [years]	AT_c	70	70	70	70
	Daily indoor inhalation rate [m3/day]	IR_air_ind	15	20	15	20
	Daily outdoor inhalation rate [m3/day]	IR_air_out	20	20	20	20
	Soil ingestion rate, mg/day	IR_soil	100	50	100	50
	Exposure frequency [days/year]	EF	350	250	350	250
	Exposure duration [years]	ED	30	25	30	25
	Oral relative absorption factor	RAF_o	1	1	1	1
	Skin surface area [cm2/day]	SA	3160	3160	3160	3160
	Soil to skin adherence factor [mg/cm2]	M	0.5	0.5	0.5	0.5
	Dermal relative absorption factor, volatiles/PAHs	RAF_d	0.5	0.5	0.5	0.5
	Averaging time for vapor flux [s]	tau	9.46E+08	7.88E+08	9.46E+08	7.88E+08
Building	Enclosed space air exchange rate [L/s]	ER	**0.000654**	0.00023	0.00014	0.00023
	Enclosed space volume/infiltration area ratio [cm]	L_b	**853.44**	300	200	300
	Enclosed space foundation or wall thickness [cm]	L_crack	15	15	15	15
	Aerial fraction of cracks in foundations/walls [cm2 cracks/cm2 total area]	nju	0.01	0.01	0.01	0.01
	Volumetric air content in in foundation/wall cracks [cm3 air/cm3 total volume]	Phi_acrack	0.26	0.26	0.26	0.26
	Volumetric water content in foundation/wall cracks [cm3 wate/cm3 total volume]	Phi_wcrack	0.12	0.12	0.12	0.12
Surface	Wind speed in ambient mixing zone [cm/s]	U_air	225	225	225	225
	Ambient air mixing zone height [cm]	delta_air	200	200	200	200
	Width of source area parallel to wind or groundwater flow direction [cm]	W	1500	1500	1500	1500
	Particulate emission rate [g/cm2-s]	P_o	6.9E-14	6.9E-14	6.90E-14	6.90E-14

	INPUT PARAMETERS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
Subsurface	Groundwater Darcy velocity [cm/year]	U_gw	2500	2500	2500	2500
	Infiltration rate of water through soil [cm/year]	I	30	30	30	30
	Groundwater mixing zone thickness [cm]	delta_gw	200	200	200	200
	Thickness of capillary fringe [cm]	h_cap	5	5	5	5
	Thickness of vadose zone [cm]	h_v	**193**	193	295	295
	Depth to subsurface soil sources [cm]	L_s	6.5 **198**	198	100	100
	Depth to groundwater [cm]	L_gw	6.5 **198**	198	300	300
	Lower depth of surficial soil zone [cm]	d	10.5 **320**	320	100	100
						0
Soil	Total soil porosity [cm3/cm3 soil]	Phi_t	0.38	0.38	0.38	0.38
	Volumetric air content in vadose zone [cm3 air/cm3 soil]	Phi_as	***0.07***	0.07	*0.26*	0.26
	Volumetric water content in vadose zone [cm3 H2O/cm3 soil]	Phi_ws	**0.31**	0.31	0.12	0.12
	Volumetric air content in capillary fringe [cm3 air/cm3 soil]	Phi_acap	*0.038*	0.038	*0.038*	0.038
	Volumetric water content in capillary fringe [cm3 H2O/cm3 soil]	Phi_wcap	0.342	0.342	0.342	0.342
	Soil bulk density [g/cm3]	Ro_s	1.7	1.7	1.7	1.7
	Fraction of organic carbon in soil [unitless]	f_oc	0.01	0.01	0.01	0.01
Chemical	Inhalation slope factor [(mg/kg-day)-1]	SF_i	0.029	0.029	0.029	0.029
	Oral slope factor [(mg/kg-day)-1]	SF_o	0.029	0.029	0.029	0.029
	Henry's constant [cm3 H2O/cm3 air]	H	0.22	0.22	0.22	0.22
	Pure component solubility in water [mg/L]	S	1780	1780	1780	1780
	Carbon-water sorption coefficient [cm3 H2O/g C]	k_oc	38.02	38.02	38.02	38.02
	Soil-water sorption coefficient [cm3 H2O/g soil]	k_s	*0.380*	0.380	0.380	0.380
	Diffusion coeff. In air [cm2/s]	D_air	0.093	0.093	0.093	0.093
	Diffusion coeff. In water [cm2/s]	D_wat	0.000011	0.000011	0.000011	0.000011

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CALCULATED TRANSPORT COEFFICIENTS		SITE SPECIFIC		DEFAULT	
		Residential	Commercial	Residential	Commercial
Effective diffusion coeff in soil based on vapor conc [cm2/s]	Deff_s	9.8024E-05	9.80235E-05	0.00722511	0.007225113
Effective diffusion coeff. Through capillary fringe [cm2/s]	Deff_cap	2.1732E-05	2.17324E-05	2.1732E-05	2.17324E-05
Effective diffusion coeff. From groundwater to surface [cm2/s]	Deff_ws	9.0042E-05	9.00415E-05	0.00110742	0.001107416
Effective diffusion coeff. Through foundation cracks [cm2/s]	Deff_crack	0.00725763	0.007257629	0.00725763	0.007257629
Volatilization factor from subsurface soil to enclosed space [mg/m3 air/mg/kg soil]	VF_s_esp	0.0003097	0.00250516	0.07353951	0.02964499
Volatilization factor from subsurface soil to ambient air [mg/m3 air/mg/kg soil]	VF_s_amb	6.3515E-06	6.3515E-06	0.00109375	0.001093753
Volatilization factor from surficial soil to ambient air (vapor) [mg/m3 air/mg/kg soil]	VF_ss	9.7936E-06	1.0731E-05	9.1334E-05	0.00010007
	VF_ss1	1.9168E-05	2.3012E-05	5.9901E-06	7.1912E-06
Volatilization factor from surficial soil to ambient air (particulates) [mg/m3 air/mg/kg soil]	VF_p	2.3E-12	2.3E-12	2.3E-12	2.3E-12
Volatilization factor from groundwater to enclosed space [mg/m3 air/mg/L H2O]	VF_w_esp	0.00016385	0.00132537	0.01645076	0.00667597
Volatilization factor from groundwater to ambient air [mg/m3 air/mg/L H2O]	VF_w_amb	3.3349E-06	3.3349E-06	2.707E-05	2.707E-05
Leaching factor from subsurface soils to groundwater [mg/L H2O/mg/kg soil]	LF_s_w	0.14445178	0.14445178	0.17044715	0.17044715

	CALCULATED TARGET LEVELS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
AIR	**RBSL for enclosed space air [ug/m3]**	**RBSL_air_esp**	**3.92E-01**	**4.93E-01**	**3.92E-01**	**4.93E-01**
	RBSL for ambient air [ug/m3]	**RBSL_air_amb**	**2.94E-01**	**4.93E-01**	**2.94E-01**	**4.93E-01**
SOIL	**Surficial soil - ingestion, inhalation of vapors and dust, dermal contact [mg/kg]**	**RBSL_s_surf**	**5.41E+00**	**9.36E+00**	**5.82E+00**	**1.00E+01**
	Subsurface soil RBSL - Enclosed space vapor inhalation from subsurface soil [mg/kg]	**RBSL_s_esp**	**1.26E+00**	**1.97E-01**	**5.32E-03**	**1.65E-02**
	Subsurface soil RBSL - Ambient air vapor inhalation from subsurface soil [mg/kg]	**RBSL_s_amb**	**4.62E+01**	**7.77E+01**	**2.69E-01**	**4.51E-01**
	Soil RBSL to protect groundwater MCL	RBSL_s_w_MCL	3.46E-02	3.46E-02	2.93E-02	2.93E-02
	Soil RBSL to protect groundwater RBSL enclosed space vapor inh. [mg/kg]	RBSL_s_w_esp	1.65E+01	2.58E+00	1.40E-01	4.34E-01
	Soil RBSL to protect groundwater RBSL ambient air vapor inh. [mg/kg]	RBSL_s_w_amb	6.10E+02	1.02E+03	6.36E+01	1.07E+02
	Concentration in soil at which pore-water and vapor become saturated [mg/kg]	C_s_sat	1.02E+03		8.62E+02	
GROUND-WATER	**Groundwater RBSL - Enclosed space vapor inhalation from groundwater [mg/L]**	RBSL_w_esp	**2.39E+00**	**3.72E-01**	**2.38E-02**	**7.39E-02**
	Groundwater RBSL - Ambient air vapor inhalation from groundwater [mg/L]	RBSL_w_amb	**8.81E+01**	**1.48E+02**	**1.08E+01**	**1.82E+01**
	MCL	MCL	**5.00E-03**	**5.00E-03**	**5.00E-03**	**5.00E-03**

SAMPLE SPREADSHEET FOR CALCULATION OF BENZENE RBSLs BASED ON ASTM RBCA GUIDANCE
Leaking Underground Storage Tank Oversight Program
Santa Clara Valley Water District

	INPUT PARAMETERS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
Exposure	Target excess individual cancer risk [unitless]	TR	1.00E-06	1.00E-06	1.00E-06	1.00E-06
	Adult body weight [kg]	BW	70	70	70	70
	Averaging time for carcinogens [years]	AT_c	70	70	70	70
	Daily indoor inhalation rate [m3/day]	IR_air_ind	15	20	15	20
	Daily outdoor inhalation rate [m3/day]	IR_air_out	20	20	20	20
	Soil ingestion rate, mg/day	IR_soil	100	50	100	50
	Exposure frequency [days/year]	EF	350	250	350	250
	Exposure duration [years]	ED	30	25	30	25
	Oral relative absorption factor	RAF_o	1	1	1	1
	Skin surface area [cm2/day]	SA	3160	3160	3160	3160
	Soil to skin adherence factor [mg/cm2]	M	0.5	0.5	0.5	0.5
	Dermal relative absorption factor, volatiles/PAHs	RAF_d	0.5	0.5	0.5	0.5
	Averaging time for vapor flux [s]	tau	9.46E+08	7.88E+08	9.46E+08	7.88E+08
Building	Enclosed space air exchange rate [L/s]	ER	**0.000654**	0.00023	0.00014	0.00023
	Enclosed space volume/infiltration area ratio [cm]	L_b	**853.44**	300	200	300
	Enclosed space foundation or wall thickness [cm]	L_crack	15	15	15	15
	Aerial fraction of cracks in foundations/walls [cm2 cracks/cm2 total area]	nju	0.01	0.01	0.01	0.01
	Volumetric air content in in foundation/wall cracks [cm3 air/cm3 total volume]	Phi_acrack	0.26	0.26	0.26	0.26
	Volumetric water content in foundation/wall cracks [cm3 wate/cm3 total volume]	Phi_wcrack	0.12	0.12	0.12	0.12
Surface	Wind speed in ambient mixing zone [cm/s]	U_air	225	225	225	225
	Ambient air mixing zone height [cm]	delta_air	200	200	200	200
	Width of source area parallel to wind or groundwater flow direction [cm]	W	1500	1500	1500	1500
	Particulate emission rate [g/cm2-s]	P_o	6.9E-14	6.9E-14	6.90E-14	6.90E-14

	INPUT PARAMETERS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
Subsurface	Groundwater Darcy velocity [cm/year]	U_gw	2500	2500	2500	2500
	Infiltration rate of water through soil [cm/year]	I	30	30	30	30
	Groundwater mixing zone thickness [cm]	delta_gw	200	200	200	200
	Thickness of capillary fringe [cm]	h_cap	5	5	5	5
	Thickness of vadose zone [cm]	h_v	**315**	315	*295*	295
	Depth to subsurface soil sources [cm]	L_s	**198** (6.5')	198	100	100
	Depth to groundwater [cm]	L_gw	**320** (10.5')	320	300	300
	Lower depth of surficial soil zone [cm]	d (GW → 10.5')	**320**	320	100	100
						0
Soil	Total soil porosity [cm3/cm3 soil]	Phi_t	0.38	0.38	0.38	0.38
	Volumetric air content in vadose zone [cm3 air/cm3 soil]	Phi_as	***0.07***	0.07	*0.26*	0.26
	Volumetric water content in vadose zone [cm3 H2O/cm3 soil]	Phi_ws	**0.31**	0.31	0.12	0.12
	Volumetric air content in capillary fringe [cm3 air/cm3 soil]	Phi_acap	*0.038*	0.038	*0.038*	0.038
	Volumetric water content in capillary fringe [cm3 H2O/cm3 soil]	Phi_wcap	0.342	0.342	0.342	0.342
	Soil bulk density [g/cm3]	Ro_s	1.7	1.7	1.7	1.7
	Fraction of organic carbon in soil [unitless]	f_oc	0.01	0.01	0.01	0.01
Chemical	Inhalation slope factor [(mg/kg-day)-1]	SF_i	0.029	0.029	0.029	0.029
	Oral slope factor [(mg/kg-day)-1]	SF_o	0.029	0.029	0.029	0.029
	Henry's constant [cm3 H2O/cm3 air]	H	0.22	0.22	0.22	0.22
	Pure component solubility in water [mg/L]	S	1780	1780	1780	1780
	Carbon-water sorption coefficient [cm3 H2O/g C]	k_oc	38.02	38.02	38.02	38.02
	Soil-water sorption coefficient [cm3 H2O/g soil]	k_s	*0.380*	0.380	0.380	0.380
	Diffusion coeff. In air [cm2/s]	D_air	0.093	0.093	0.093	0.093
	Diffusion coeff. In water [cm2/s]	D_wat	0.000011	0.000011	0.000011	0.000011

SAMPLE SPREADSHEET FOR CALCULATION OF BENZENE RBSLs BASED ON ASTM RBCA GUIDANCE
Leaking Underground Storage Tank Oversight Program
Santa Clara Valley Water District

	CALCULATED TRANSPORT COEFFICIENTS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
	Effective diffusion coeff in soil based on vapor conc [cm2/s]	Deff_s	9.8024E-05	9.80235E-05	0.00722511	0.007225113
	Effective diffusion coeff. Through capillary fringe [cm2/s]	Deff_cap	2.1732E-05	2.17324E-05	2.1732E-05	2.17324E-05
	Effective diffusion coeff. From groundwater to surface [cm2/s]	Deff_ws	9.2926E-05	9.29264E-05	0.001107442	0.001107443
	Effective diffusion coeff. Through foundation cracks [cm2/s]	Deff_crack	0.00725763	0.007257629	0.00725763	0.007257629
	Volatilization factor from subsurface soil to enclosed space [mg/m3 air/mg/kg soil]	VF_s_esp	0.0003097	0.00250516	0.07353951	0.02984199
	Volatilization factor from subsurface soil to ambient air [mg/m3 air/mg/kg soil]	VF_s_amb	6.3515E-06	6.3515E-06	0.00109375	0.001093753
	Volatilization factor from surficial soil to ambient air (vapor) [mg/m3 air/mg/kg soil]	VF_ss	9.7936E-06	1.0731E-05	9.1334E-05	0.00010007
		VF_ss1	1.9168E-05	2.3012E-05	5.9901E-06	7.1912E-06
	Volatilization factor from surficial soil to ambient air (particulates) [mg/m3 air/mg/kg soil]	VF_p	2.3E-12	2.3E-12	2.3E-12	2.3E-12
	Volatilization factor from groundwater to enclosed space [mg/m3 air/mg/L H2O]	VF_w_esp	0.00010798	0.00087347	0.01645076	0.00567597
	Volatilization factor from groundwater to ambient air [mg/m3 air/mg/L H2O]	VF_w_amb	2.1296E-06	2.1296E-06	2.707E-05	2.707E-05
	Leaching factor from subsurface soils to groundwater [mg/L H2O/mg/kg soil]	LF_s_w	0.14445178	0.14445178	0.17044715	0.17044715

	CALCULATED TARGET LEVELS		SITE SPECIFIC		DEFAULT	
			Residential	Commercial	Residential	Commercial
AIR	**RBSL for enclosed space air [ug/m3]**	**RBSL_air_esp**	**3.92E-01**	**4.93E-01**	**3.92E-01**	**4.93E-01**
	RBSL for ambient air [ug/m3]	**RBSL_air_amb**	**2.94E-01**	**4.93E-01**	**2.94E-01**	**4.93E-01**
SOIL	**Surficial soil - ingestion, inhalation of vapors and dust, dermal contact [mg/kg]**	**RBSL_s_surf**	**5.41E+00**	**9.36E+00**	**5.82E+00**	**1.00E+01**
	Subsurface soil RBSL - Enclosed space vapor inhalation from subsurface soil [mg/kg]	**RBSL_s_esp**	**1.26E+00**	**1.97E-01**	**5.32E-03**	**1.65E-02**
	Subsurface soil RBSL - Ambient air vapor inhalation from subsurface soil [mg/kg]	**RBSL_s_amb**	**4.62E+01**	**7.77E+01**	**2.69E-01**	**4.51E-01**
	Soil RBSL to protect groundwater MCL	RBSL_s_w_MCL	3.46E-02	3.46E-02	2.93E-02	2.93E-02
	Soil RBSL to protect groundwater RBSL enclosed space vapor inh. [mg/kg]	RBSL_s_w_esp	2.51E+01	3.91E+00	1.40E-01	4.34E-01
	Soil RBSL to protect groundwater RBSL ambient air vapor inh. [mg/kg]	RBSL_s_w_amb	9.55E+02	1.60E+03	6.36E+01	1.07E+02
	Concentration in soil at which pore-water and vapor become saturated [mg/kg]	C_s_sat	1.02E+03		8.62E+02	
GROUND-WATER	**Groundwater RBSL - Enclosed space vapor inhalation from groundwater [mg/L]**	RBSL_w_esp	**3.63E+00**	**5.65E-01**	**2.38E-02**	**7.39E-02**
	Groundwater RBSL - Ambient air vapor inhalation from groundwater [mg/L]	RBSL_w_amb	**1.38E+02**	**2.32E+02**	**1.08E+01**	**1.82E+01**
	MCL	MCL	**5.00E-03**	**5.00E-03**	**5.00E-03**	**5.00E-03**