STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
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August 7, 2009

Dr. Douglas Morell
Golder Associates Inc
18300 NE Union Hill Road Suite 200
Redmond WA 98052-3333

Dear Dr. Morell:

Re: BIOSCREEN modeling of hypothetical contaminant travel times and recommended long term monitoring frequencies at Landsburg Mine site in Ravensdale, Washington

Please find attached the input parameters, simulation methodology, and model outputs decided upon by Ecology for this site.

Please implement the model simulations outlined in the accompanying document and present the results to Ecology to use for a final decision.

Please don't hesitate to contact me if you have any questions or comments.

Thank you,

Jerome B. Cruz, Ph.D., L.G., L.H.G.
Toxics Cleanup Program

JBC

Attachments

cc: William Kombol, Palmer Coking Coal Co.
Mike Mactutis, City of Kent Public Works
Robert F. Bakemeier, Bakemeier Law Firm (Bakemeier, P.C.)
Elliot Furst, Assistant Attorney General, Ecology Division
Robert Warren, WA State Department of Ecology
Ching-Pi Wang, WA State Department of Ecology
Ronald W. Timm, WA State Department of Ecology

BIOSCREEN MODELING OF HYPOTHETICAL CONTAMINANT TRAVEL TIMES AT THE LANDSBURG MINE SITE, RAVENSDALE, WASHINGTON

FLOW DISTANCE L

Two directions of flow simulations will be done: northward (from waste area at the northern subsidence trench area to the north portal) and southward (from waste area at the northern subsidence trench area to southern mine interior wells LMW-11 and LMW-9, and to the south portal wells).

The following table shows the recommended distances (in feet) by Golder Associates (representing the PLP Group), and Aspect Consulting (representing the City of Kent):

Table 1.

Flow Direction	Golder Associates	Aspect Consulting
Northward	700-800	600, 1200
Southward	1800, 2400	1700, 2300, 2900, 3500

In order to assume conservative (i.e., more protective) input values for the models, Ecology directs the PLP to use the following:

Northward flow: **600 feet (low range),**
800 feet (primary value)
1200 feet (high range)

Southward flow: **1400 feet (edge of trench area 7 to LMW-11)**
1700 feet (low range - edge of waste area to LMW-11 to LMW-9)
2300 feet (edge of waste area to LMW-11 to LMW-9 to portal wells LMW-3 and LMW-5). Primary distance is 2300 feet (waste edge to portal wells)
Option is left open to plug in longer distances of 2900 and 3500 feet for their own use.

The travel times between wells along these paths will also be a critical component of the modeling.

MODELED CONTAMINANTS

Golder Associates and Aspect Consulting recommended the following contaminants for the simulations:
1,4-dioxane (Kent)
Vinyl Chloride (Kent)
Methylene Chloride (PLPs)
Arsenic (PLPs and Kent)
Selenium (PLPs and Kent)
Cadmium (PLPs)

Ecology requests the modeling of all the recommended contaminants. Since biodegradation will not be considered in the simulations, the relevant major parameter that distinguishes the transport behavior in these choices of contaminants will be adsorption/retardation. However, including all the contaminants

may lead to calculating a wider range of travel times, source concentrations, dispersivities and transport behavior that aid in making conservative evaluations of long-term monitoring frequencies.

BIOSCREEN INPUT PARAMETERS

The following is a summary table (adapted from the original BIOSCREEN interface) showing the suggested input values and Ecology chosen values:

Table 2.

			Kent's values	PLP's values	Final Chosen Values	COMMENTS
1. HYDROGEOLOGY						
Seepage Velocity*	*Vs (ft/yr)*	**North** **South**	830.0 664	750.0 250	**830** **664**	**conservative**
or						Golder's Vs does not calculate from Vs=KI/n; Derives from assumed Q after remediation
Hydraulic Conductivity	*K (cm/sec)*		8.5E-01	8.0E-01		
Hydraulic Gradient	*I (ft/ft)*	**North** **South**	3.6E-04 2.9E-04	5.00E-03 1.0E-04		
Porosity	*n*		0.38	0.25		
2a. DISPERSION	**North**	**600 ft**				**Model a range of dispersivities**
*Longitudinal Dispersivity**	*alpha x (ft)*		6	22.0	**15.6 low** **19.5** **23.4 high**	**Use alpha x +/- 20%**
*Transverse Dispersivity**	*alpha y (ft)*		0.6	0.1	**1.6 low** **2.0** **2.4 high**	**Use alpha y +/- 20%**
*Vertical Dispersivity**	*alpha z (ft)*		0.06	0.0	**0.16 low** **0.2** **0.24 high**	**Use alpha z +/- 20%**
or						
Estimated Plume Length	*Lp (ft)*				**600 ft**	
2b. DISPERSION	**North**	**800 ft**				
*Longitudinal Dispersivity**	*alpha x (ft)*		8	22.0	**17.76 low** **22.2** **26.64 high**	**Use alpha x +/- 20%**
*Transverse Dispersivity**	*alpha y (ft)*		0.8	0.1	**1.76 low** **2.2** **2.64 high**	**Use alpha y +/- 20%**
*Vertical Dispersivity**	*alpha z (ft)*		0.08	0.0	**0.176 low** **0.22** **0.264 high**	**Use alpha z +/- 20%**
or						
Estimated Plume Length	*Lp (ft)*				**800 ft**	
2c. DISPERSION	**North**	**1200 ft**				

			Kent's values	PLP's values	Final Chosen Values	COMMENTS
*Longitudinal Dispersivity**	*alpha x (ft)*		12	22.0	31.12 low 26.4 31.68 high	Use alpha x +/- 20%
*Transverse Dispersivity**	*alpha y (ft)*		1.2	0.1	2.08 low 2.6 3.12 high	Use alpha y +/- 20%
*Vertical Dispersivity**	*alpha z (ft)*		0.12	0.0	0.208 low 0.26 0.312 high	Use alpha z +/- 20%
or						
Estimated Plume Length	*Lp (ft)*				**1200 ft**	
2d. DISPERSION	**South**	**1400 ft**				
*Longitudinal Dispersivity**	*alpha x (ft)*		14	34.5	22.48 low 28.1 33.72 high	Use alpha x +/- 20%
*Transverse Dispersivity**	*alpha y (ft)*		1.4	0.1	2.24 low 2.8 3.36 high	Use alpha y +/- 20%
*Vertical Dispersivity**	*alpha z (ft)*		0.14	0.0	0.16 low 0.2 0.24 high	Use alpha z +/- 20%
or						
Estimated Plume Length	*Lp (ft)*				**1400 ft**	
2e. DISPERSION	**South**	**1700 ft**				
*Longitudinal Dispersivity**	*alpha x (ft)*		17	34.5	24.24 low 30.3 36.36 high	Use alpha x +/- 20%
*Transverse Dispersivity**	*alpha y (ft)*		1.7	0.1	2.4 low 3.0 3.6 high	Use alpha y +/- 20%
*Vertical Dispersivity**	*alpha z (ft)*		0.17	0.0	0.16 low 0.2 0.24 high	Use alpha z +/- 20%
or						
Estimated Plume Length	*Lp (ft)*				**1700 ft**	
2f. DISPERSION	**South**	**2300 ft**				
*Longitudinal Dispersivity**	*alpha x (ft)*		23	34.5	27.2 low 34.0 40.8 high	Use alpha x +/- 20%
*Transverse Dispersivity**	*alpha y (ft)*		2.3	0.1	2.72 low 3.4 4.08 high	Use alpha y +/- 20%
*Vertical Dispersivity**	*alpha z (ft)*		0.23	0.0	0.16 low 0.2 0.24 high	Use alpha z +/- 20%
or						
Estimated Plume Length	*Lp (ft)*				**2300 ft**	

		Kent's values	PLP's values	Final Chosen Values	COMMENTS
3a. ADSORPTION	**1,4-DIOXANE**				
Retardation Factor*	*R*	32.0 north 17 south		**17**	
or		***or***	***or***		
Soil Bulk Density	*rho (kg/l)*	1.5			
Distribution Coefficient	*Kd*	8 north 4 south			**Estimate for north and south portions**
Partition Coefficient	*Koc (L/kg)*	17			
FractionOrganicCarbon	*foc*	0.46 north 0.24 south			**Estimate for north and south portions**
3b. ADSORPTION	**VINYL CHLORIDE**				
Retardation Factor*	*R*	55.5 north 29 south		**29**	
or		***or***	***or***		
Soil Bulk Density	*rho (kg/l)*	1.5	1.4		
Distribution Coefficient	*Kd*	14 north 7 south			**Estimate for north and south portions**
Partition Coefficient	*Koc (L/kg)*	30			
FractionOrganicCarbon	*foc*	0.46 north 0.24 south	2.3E-1		**Estimate for north and south portions**
3c. ADSORPTION	**METHYLENE CHLORIDE**				
Retardation Factor*	*R*		13.9	**14**	
or		***or***	***or***		
Soil Bulk Density	*rho (kg/l)*		1.4		
Distribution Coefficient	*Kd*		2.3		**Calculated**
Partition Coefficient	*Koc (L/kg)*		10		
FractionOrganicCarbon	*foc*		2.3E-1		
3d. ADSORPTION	**ARSENIC**				
Retardation Factor*	*R*	70.0	163.4	**70**	**Calculated**
or		***or***	***or***		
Soil Bulk Density	*rho (kg/l)*	1.5	1.4		
Distribution Coefficient	*Kd*	17	29		
Partition Coefficient	*Koc (L/kg)*				
FractionOrganicCarbon	*foc*		2.3E-1		
3e. ADSORPTION	**SELENIUM**				
Retardation Factor*	*R*	114.0	387.4	**114**	**Calculated**
or		***or***	***or***		
Soil Bulk Density	*rho (kg/l)*	1.5	1.4		

		Kent's values	PLP's values	Final Chosen Values	COMMENTS
Distribution Coefficient	*Kd*	29	69		
Partition Coefficient	*Koc (L/kg)*				
FractionOrganicCarbon	*foc*		2.3E-1		
3f. ADSORPTION	**CADMIUM**				
Retardation Factor*	*R*		314.6	**315**	
or		*or*	*or*		
Soil Bulk Density	*rho (kg/l)*		1.4		
Distribution Coefficient	*Kd*		56		
Partition Coefficient	*Koc (L/kg)*				
FractionOrganicCarbon	*foc*				
5. GENERAL					
Modeled Area Length*		Variable	Variable	**see Table 1**	
Modeled Area Width*		16	15	**15**	
Simulation Time*		80		**Variable**	Adjust time to get CUL at POC (breakthrough)
6a. SOURCE DATA	**1,4-DIOXANE**				NOTE: No source half life
	Source Thickness in Sat.Zone*	16	15	**15**	
Source Zones:					
Width* (ft)	Conc. (mg/L)*			**Use 3 values:**	
3		24.81		10 low 24.48 148.9 high	Aspect uses 3% TCA and 1% TCE from sludge characterization
3		24.81		10 low 24.48 148.9 high	High value is estimated effective solubility
3		24.81		10 low 24.48 148.9 high	Low value is adopted from Golder Associates
6b. SOURCE DATA	**VINYL CHLORIDE**				
	Source Thickness in Sat.Zone*	16	15	**15**	
Source Zones:					

			Kent's values	PLP's values	Final Chosen Values	COMMENTS
Width* (ft)	Conc. (mg/L)*				**Use 3 values:**	
3			1530		28 low 620.3 1530 high	Middle value is predicted from sludge data
3			1530		28 low 620.3 1530 high	High value is maximum TCE in sludge
3			1530		28 low 620.3 1530 high	Low value is 1% of solubility

6c. SOURCE DATA **METHYLENE CHLORIDE**

Source Thickness in Sat.Zone*	16	15	**15**

Source Zones:

Width* (ft)	Conc. (mg/L)*				**Use 3 values:**	
3				10	10 low 685.1 13000 high	Middle value is predicted from sludge data
3				10	10 low 685.1 13000 high	High value is maximum TCE in sludge
3				10	10 low 685.1 13000 high	Low value is 1% of solubility

6d. SOURCE DATA **ARSENIC**

Source Thickness in Sat.Zone*	16	15	**15**

Source Zones:

Width* (ft)	Conc. (mg/L)*				**Use 3 values:**	
3			1000	10	0.8914 low 10 1000 high	Middle value is from Golder Associates
3			1000	10	0.8914 low 10 1000 high	High value is from Kent & originally Golder
3			1000	10	0.8914 low 10 1000 high	Low value is predicted from portal soils (Table 5-12)

		Kent's values	PLP's values	Final Chosen Values	COMMENTS
[redacted]					

6e. SOURCE DATA **SELENIUM**

Source Thickness in Sat.Zone*	16	15	**15**	

Source Zones:

Width* (ft)	Conc. (mg/L)*			**Use 3 values:**	
3		1000	10	0.3871 low 10 1000 high	Middle value is from Golder Associates
3		1000	10	0.3871 low 10 1000 high	Low value is predicted from Table 5-9 Trench soils
3		1000	10	0.3871 low 10 1000 high	High value is from Kent & originally Golder
[redacted]					

6f. SOURCE DATA **CADMIUM**

Source Thickness in Sat.Zone*	16	15	**15**	

Source Zones:

Width* (ft)	Conc. (mg/L)*			**Use 3 values:**	
3			10	3.2 low 10 1000 high	Middle value is from Golder Associates
3			10	3.2 low 10 1000 high	Low value is predicted from Table 5-9 Trench soils
3			10	3.2 low 10 1000 high	High value is from Kent & originally Golder
[redacted]					

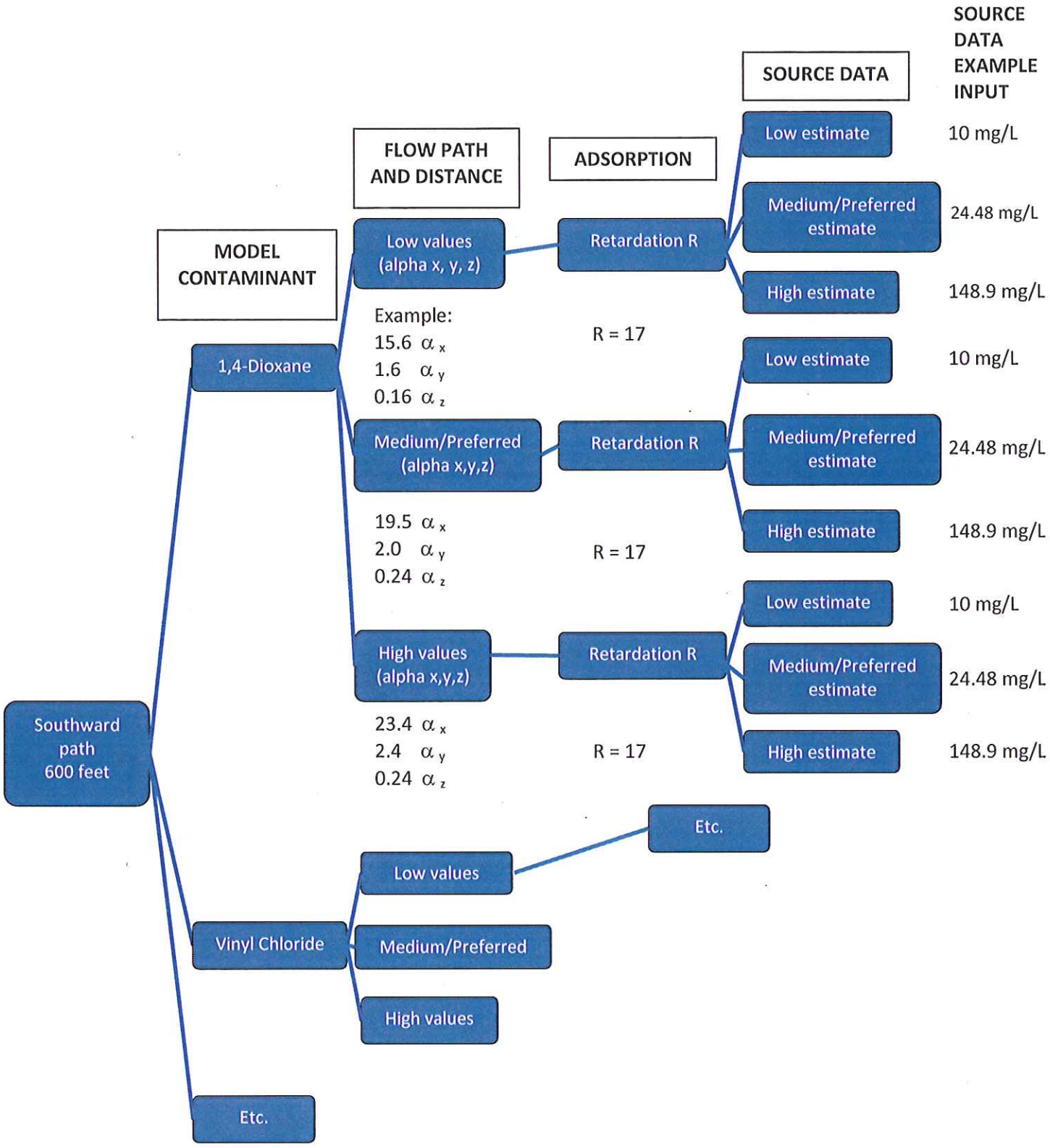


Figure 1. Example process chart for travel time simulation using BIOSCREEN Input Parameters.

The following are the recommended outputs for the simulation results:

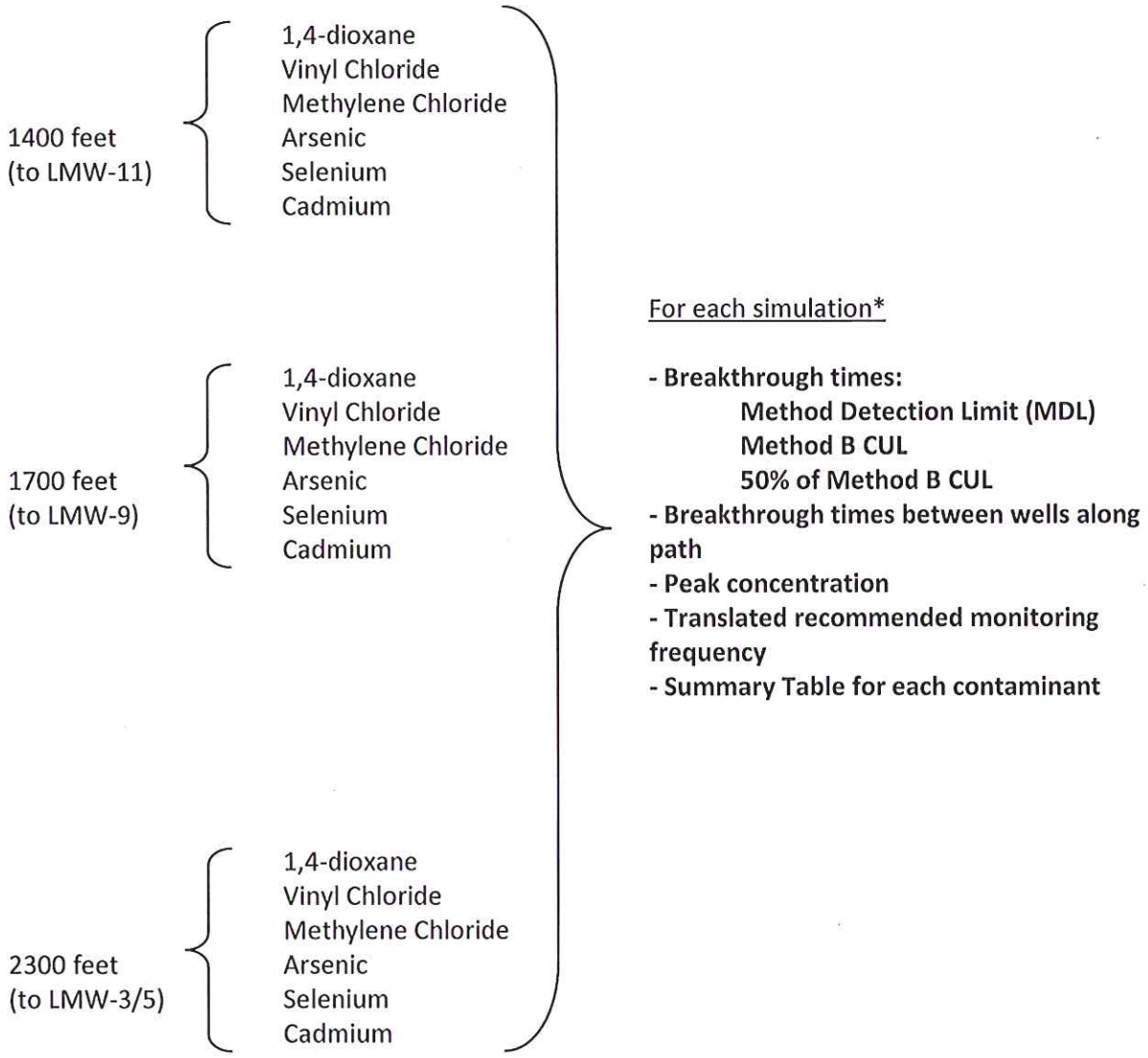
NORTHWARD FLOW

600 feet (to LMW-2/4)	1,4-dioxane Vinyl Chloride Methylene Chloride Arsenic Selenium Cadmium
800 feet (to LMW-2/4)	1,4-dioxane Vinyl Chloride Methylene Chloride Arsenic Selenium Cadmium
1200 feet (to LMW-2/4)	1,4-dioxane Vinyl Chloride Methylene Chloride Arsenic Selenium Cadmium

For each simulation*

- **Breakthrough times:**
  - **Method Detection Limit (MDL)**
  - **Method B CUL**
  - **50% of Method B CUL**
- **Breakthrough times including between portal and wells along path**
- **Peak concentration**
- **Translated recommended monitoring frequency**
- **Summary Table for each contaminant**

SOUTHWARD FLOW



* See Figure 1 for simulation methodology.