

**Appendix N**

**Johnson-Ettinger Air Vapor Model Runs  
Bioscreen Summary**

**River Terrace Remedial Investigation  
Former Dry Cleaner Building**



**Appendix N: Johnson-Ettinger Vapor Intrusion Model - Soil Data Input**

**DATA INPUT FOR VAPOR INTRUSION INTO BUILDINGS FROM PCE SUBSURFACE SOIL CONTAMINATION:**

<b>ENTER</b> Chemical CAS No. (numbers only, no dashes)	<b>ENTER</b> Initial soil conc., CR (ug/kg)	<b>Chemical</b>					
127184	1020	Tetrachloroethylene					
<b>ENTER</b> Average soil temperature, TS (oC)	<b>ENTER</b> Depth below grade to bottom of enclosed space floor, LF (cm)	<b>ENTER</b> Depth below grade to top of contamination, Lt (cm)	<b>ENTER</b> Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) Lb (cm)	<b>ENTER</b> Totals must add up to value of Ll (cell D28)			<b>ENTER</b> Soil stratum A SCS soil type (used to estimate soil vapor permeability)
	<b>ENTER</b> Thickness of soil stratum A, hA (cm)	<b>ENTER</b> Thickness of soil stratum B, (Enter value or 0) hB (cm)	<b>ENTER</b> Thickness of soil stratum C, (Enter value or 0) hC (cm)				
6	10	200	0	200	0	0	S
<b>ENTER</b> Stratum A soil dry bulk density, $\rho\beta A$ (g/cm3)	<b>ENTER</b> Stratum A soil total porosity, nA (unitless)	<b>ENTER</b> Stratum A soil water-filled porosity, $\theta\omega A$ (cm3/cm3)	<b>ENTER</b> Stratum A soil organic carbon fraction, focA (unitless)	<b>ENTER</b> Stratum B soil dry bulk density, $\rho\beta B$ (g/cm3)	<b>ENTER</b> Stratum B soil total porosity, nB (unitless)	<b>ENTER</b> Stratum B soil water-filled porosity, $\theta\omega B$ (cm3/cm3)	<b>ENTER</b> Stratum B soil organic carbon fraction, focB (unitless)
1.5	0.434	0.3	0.0033	0	0	0	0
<b>ENTER</b> Enclosed space floor thickness, Lcrack (cm)	<b>ENTER</b> Soil-bldg. pressure differential, $\Delta\Pi$ (g/cm-s2)	<b>ENTER</b> Enclosed space floor length, LB (cm)	<b>ENTER</b> Enclosed space floor width, WB (cm)	<b>ENTER</b> Enclosed space height, HB (cm)	<b>ENTER</b> Floor-wall seam crack width, w (cm)	<b>ENTER</b> Indoor air exchange rate, ER (1/h)	
15	40	1524	1220	305	0.1	0.45	
<b>ENTER</b> Averaging time for carcinogens, ATc (yrs)	<b>ENTER</b> Averaging time for noncarcinogens, ATnc (yrs)	<b>ENTER</b> Exposure duration, ED (yrs)	<b>ENTER</b> Exposure frequency, EF (days/yr)	<b>ENTER</b> Target risk for carcinogens, TR (unitless)	<b>ENTER</b> Target hazard quotient for noncarcinogens, THQ (unitless)		
70	30	30	350	1.0E-05	1		
				Used to calculate risk-based soil concentration.			

<b>INCREMENTAL RISK RESULTS:</b>	
Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
5.2E-06	NA

Appendix N: Johnson-Ettinger Vapor Intrusion Model - Groundwater Data Input

DATA INPUT FOR VAPOR INTRUSION INTO BUILDINGS FROM PCE GROUNDWATER CONTAMINATION:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., CW (ug/L)	ENTER Depth below grade to bottom of enclosed space floor, LF (cm)		ENTER Depth below grade to water table, LWT (cm)	ENTER Thickness of soil stratum A, hA (cm)		ENTER Thickness of soil stratum B, hB (cm)		ENTER Thickness of soil stratum C, hC (cm)		ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	ENTER User-defined stratum A soil vapor permeability, kv (cm2)	
127184	13000			200	0	0	0	0	0	0	A	S	S	
Chemical														
Tetrachloroethylene														
ENTER Average soil/ groundwater temperature, TS (oC)	ENTER Depth below grade to bottom of enclosed space floor, LF (cm)	ENTER Depth below grade to water table, LWT (cm)	ENTER Thickness of soil stratum A, hA (cm)	ENTER Thickness of soil stratum B, hB (cm)	ENTER Thickness of soil stratum C, hC (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	ENTER User-defined stratum A soil vapor permeability, kv (cm2)						
6	10	200	0	0	0	A	S	S						

ENTER Stratum A soil dry bulk density, ρβA (g/cm3)	ENTER Stratum A soil total porosity, nA (unitless)	ENTER Stratum A soil water-filled porosity, θwA (cm3/cm3)	ENTER Stratum B soil dry bulk density, ρβB (g/cm3)	ENTER Stratum B soil total porosity, nB (unitless)	ENTER Stratum B soil water-filled porosity, θwB (cm3/cm3)	ENTER Stratum C soil dry bulk density, ρβC (g/cm3)	ENTER Stratum C soil total porosity, nC (unitless)	ENTER Stratum C soil water-filled porosity, θwC (cm3/cm3)	ENTER Stratum C soil water-filled porosity, θwX (cm3/cm3)
1.5	0.43	0.3	1.5	0.3	0.3	1.5	0.3	0.3	0.3

ENTER Enclosed space floor thickness, Lcrack (cm)	ENTER Soil-bldg pressure differential, ΔPI (g/cm-s2)	ENTER Enclosed space floor length, LB (cm)	ENTER Enclosed space floor width, WB (cm)	ENTER Enclosed space height, HB (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	1524	1220	305	0.1	0.45

ENTER Averaging time for carcinogens, ATC (yrs)	ENTER Averaging time for noncarcinogens, ATNC (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-05	1

Used to calculate risk-based groundwater concentration.

**INCREMENTAL RISK RESULTS:**

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	4.6E-05
Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	NA

## Appendix N: Bioscreen Summary

The Bioscreen Natural Attenuation Decision Support System (AFCEE, 1996) was used to evaluate the likely natural attenuation of dissolved-phase PCE between the sentry wells and the bank of the Kenai River, a distance of approximately 15 feet. Due to the short travel time (approximately 10-20 days) and long half-life of PCE (nearly 3 years), appreciable biodegradation will not occur over this distance. Therefore, the only mechanisms for attenuation are adsorption to organic carbon, dispersion, and volatilization. The Bioscreen model does not consider volatilization; therefore, dispersion and adsorption are the two mechanisms modeled.

As stated in the Bioscreen manual, "dispersion refers to the process whereby a plume will spread out in a longitudinal direction, transversely, and vertically downwards due to mechanical mixing in the aquifer and chemical diffusion." A decrease in plume concentration will result from dispersion with cleaner water. At the River Terrace site, dispersion will reduce plume concentrations only near the plume boundaries, because those are the only areas where relatively clean water is available for mixing.

Due to the large size and heterogeneous nature of the present plume, the Bioscreen model could not be calibrated to site conditions. Instead, a range of input parameters was used to bracket reasonable results. Assumptions made in the Bioscreen simulations were conservative in nature (which result in overestimating the plume concentration). Assumptions are listed below:

- Steady-state plume with an infinite source (therefore, source degradation was not considered),
- The average site organic carbon fraction (0.22%) was used for calculating adsorption,
- The range in site hydrogeologic input parameters (provided in Table 6-4 of this report) based on slug testing and measured groundwater gradients was used.

"Reverse" modeling was performed to determine a reasonable input PCE concentration (i.e., sentry well PCE concentration) that would result in a PCE concentration of 0.005 mg/L after 15 feet of travel distance. The model was sensitive to the plume width and the longitudinal and transverse dispersivities. Varying groundwater flow velocities between the minimum and maximum calculated for this site did not impact the model results.

Since dispersion cannot practically be measured in the field, reasonable dispersivity values can be based on literature data and are often used as a calibration parameter. Dispersivity data from over 50 sites has been compiled by Gelhar et al. (1992) and reproduced in the Bioscreen manual. Key points are bulleted below:

- Transverse dispersivity can generally be estimated as  $0.1 \times \text{longitudinal dispersivity}$
- Vertical dispersivity is very low
- Longitudinal dispersivity is a function of scale. For a plume length between 200 feet (60 m) and 600 feet (200 m) in length, longitudinal dispersivity values range between approximately 33 ft (2 m) and 66 ft (20 m). The plume length at the River Terrace site cannot accurately be determined, since it is

truncated by the Kenai River. However, the distance from the upper part of the lower plume (i.e., MW-24 area) to the Kenai River is approximately 200 feet, which indicates the plume is a minimum of approximately 200 feet long.

The Bioscreen simulations concluded that an input concentration of 0.015 mg/L should result in a PCE concentration less than or equal to 0.005 mg/L at the river, given certain circumstances, as listed below:

- If the plume is less than or equal to 20 feet wide, with longitudinal/transverse dispersivities less than or equal to 90 ft/9 ft, or
- If the plume is less than or equal to 10 feet wide, with longitudinal/transverse dispersivities less than or equal to 40 ft/4 ft.

Based on the Bioscreen modeling, it is reasonable to conclude that a maximum PCE concentration of 0.015 mg/L, detected in only one monitoring well, should not result in PCE concentration exceeding 0.005 mg/L

**BIOSCREEN Input Screen. River Terrace Site**  
**20' PCE Plume, Average GW Velocity**

**BIOSCREEN Natural Attenuation Decision Support System**

Air Force Center for Environmental Excellence  
 Version 1.3

**1. HYDROGEOLOGY**

Seepage Velocity\* Vs

Hydraulic Conductivity K

Hydraulic Gradient i

Porosity n

**2. DISPERSION**

Longitudinal Dispersivity\* alpha x

Transverse Dispersivity\* alpha y

Vertical Dispersivity\* alpha z

Estimated Plume Length Lp

**3. ADSORPTION**

Retardation Factor\* R

Soil Bulk Density rho

Partition Coefficient Koc

Fraction Organic Carbon foc

**4. BIODEGRADATION**

1st Order Decay Coeff\* lambda

Solute Half-Life t-half

**or Instantaneous Reaction Model**

Delta Oxygen\* DO

Delta Nitrate\* NO3

Observed Ferrous Iron\* Fe2+

Delta Sulfate\* SO4

Observed Methane\* CH4

River Terrace  
 PCE-20' plume  
 Run Name

**Data Input Instructions:**

1. Enter value directly... or
  2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
- Variable\*  → Value calculated by model.  
 (Don't enter any data).

Modeled Area Length\*

Modeled Area Width\*

Simulation Time\*

**6. SOURCE DATA**

Source Thickness in Sat. Zone\*

Source Zones:

Width* (ft)	Conc. (mg/L)*
0	
20	0
20	0.015
20	0
0	0

**Source Decay (see Help):**

Source Half-life\*

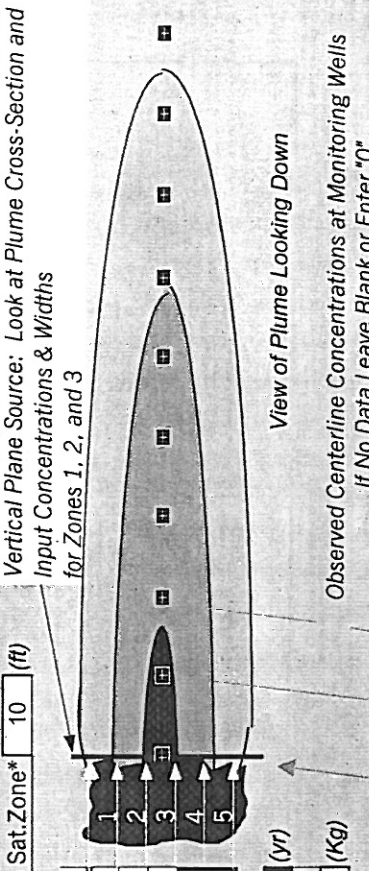
Soluble Mass In NAPL, Soil

**7. FIELD DATA FOR COMPARISON**

Concentration (mg/L)

Dist. from Source (ft)

**8. CHOOSE TYPE OF OUTPUT TO SEE:**

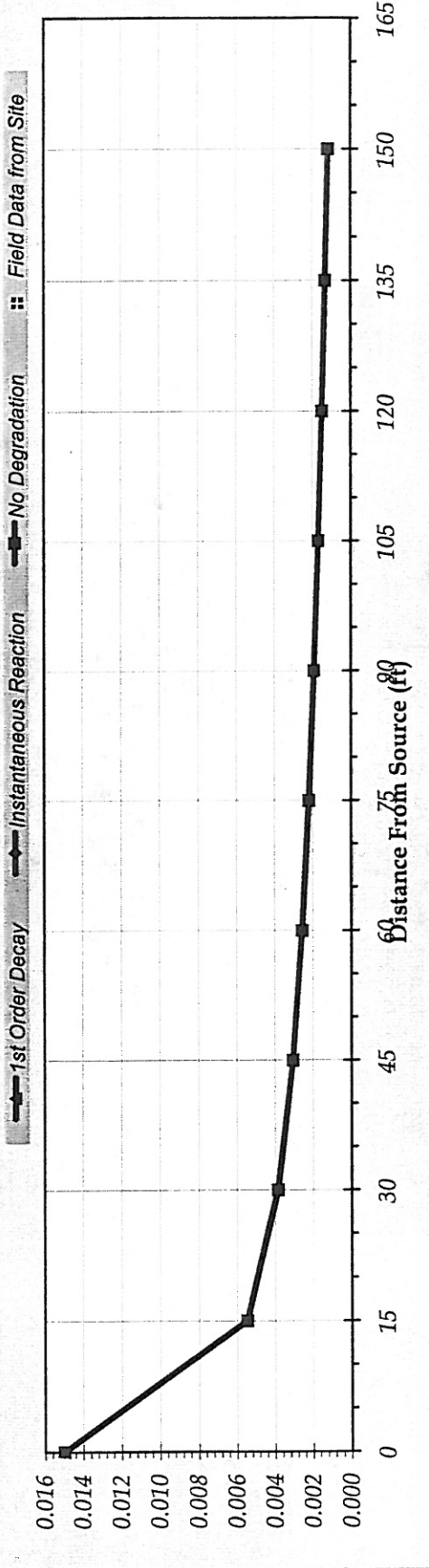


0	15	30	45	60	75	90	105	120	135	150
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River Terrace Site- Centerline Output  
 20' PCE Plume, Average GW Velocity

DISSOLVED BENZENE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)														
	0	15	30	45	60	75	90	105	120	135	150				
No Degradation	0.015	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001				
1st Order Decay	0.015	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001				
Inst. Reaction	0.015	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001				
Field Data from Site															



Calculate Animation

Time: 5 Years

Return to Input

Recalculate This Sheet



BIOSCREEN Input Screen. River Terrace Site.  
10' PCE Plume, High GW Velocity

**BIOSCREEN Natural Attenuation Decision Support System**

Air Force Center for Environmental Excellence

Version 1.3

**1. HYDROGEOLOGY**

Seepage Velocity*	Vs	4781.0 ↑ or	(ft/yr)
Hydraulic Conductivity	K		(cm/sec)
Hydraulic Gradient	i		(ft/ft)
Porosity	n	0.3	(-)

**2. DISPERSION**

Longitudinal Dispersivity*	alpha x	40.0	(ft)
Transverse Dispersivity*	alpha y	4.0	(ft)
Vertical Dispersivity*	alpha z		(ft)
Estimated Plume Length	Lp	↑ or 75	(ft)

**3. ADSORPTION**

Retardation Factor*	R	5.1 ↑ or	(-)
Soil Bulk Density	rho	2.1	(kg/l)
Partition Coefficient	Koc	265	(L/kg)
Fraction Organic Carbon	foc	2.20E-03	(-)

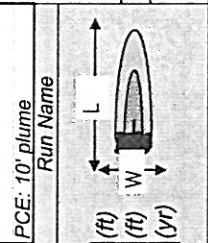
**4. BIODEGRADATION**

1st Order Decay Coeff*	lambda	7.3E-4 ↑ or 948.00	(per yr)
Solute Half-Life or Instantaneous Reaction Model	t-half		(year)
Delta Oxygen*	DO		(mg/L)
Delta Nitrate*	NO3		(mg/L)
Observed Ferrous Iron*	Fe2+		(mg/L)
Delta Sulfate*	SO4		(mg/L)
Observed Methane*	CH4		(mg/L)

**Data Input Instructions:**

1. Enter value directly... or  
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).  
Variable\* → Data used directly in model.  
20 → Value calculated by model. (Don't enter any data).

River Terrace  
PCE: 10' plume  
Run Name



Modeled Area Length*	150	(ft)
Modeled Area Width*	90	(ft)
Simulation Time*	5	(yr)

**6. SOURCE DATA**

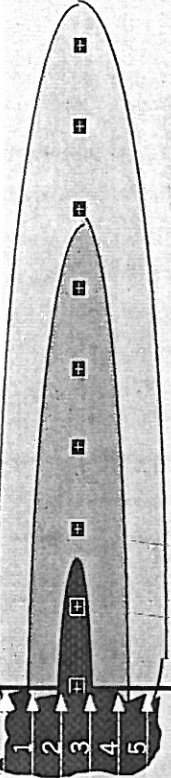
Source Thickness in Sat. Zone\* 10 (ft)

Source Zones:	Width* (ft)	Conc. (mg/L)*
0	20	0
1	10	0.015
2	20	0
3	0	0

Source Decay (see Help):

Source Half-life*	>1000	(yr)
Soluble Mass In NAPL, Soil	500.00	(Kg)

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells  
If No Data Leave Blank or Enter "0"

**7. FIELD DATA FOR COMPARISON**

Concentration (mg/L)	
Dist. from Source (ft)	

0	15	30	45	60	75	90	105	120	135	150
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**8. CHOOSE TYPE OF OUTPUT TO SEE:**

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

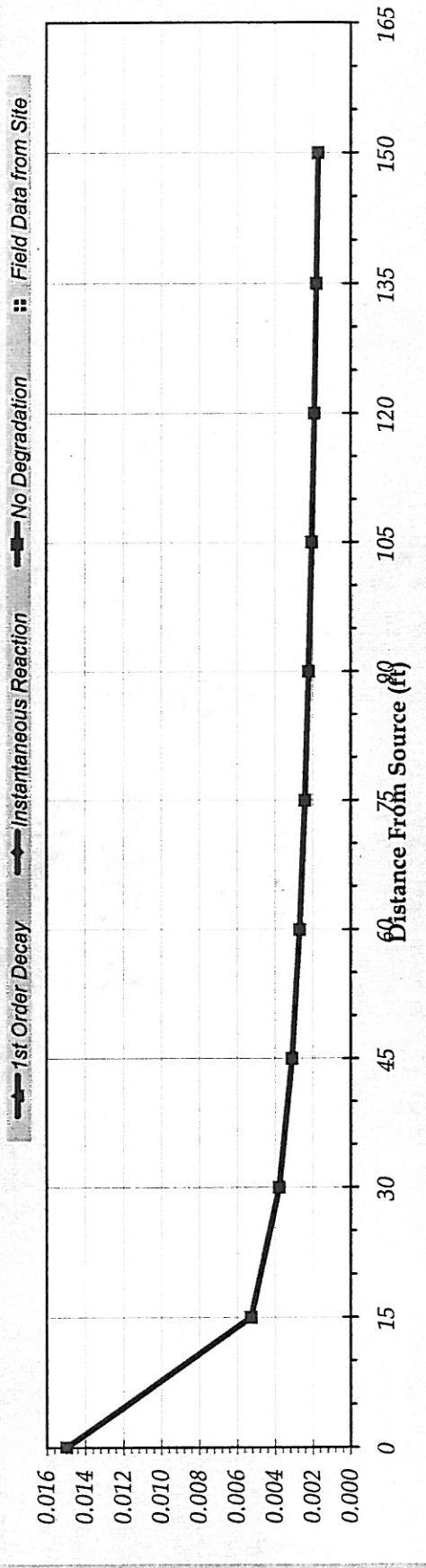
Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

River Terrace Site - Centerline Output.  
 10' PCE Plume, High GW Velocity

DISSOLVED BENZENE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)														
	0	15	30	45	60	75	90	105	120	135	150	165			
No Degradation	0.015	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002		
1st Order Decay	0.015	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002		
Inst. Reaction	0.015	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002		
Field Data from Site															



Time:

Calculate Animation

Return to Input

Recalculate This Sheet

**BIOSCREEN Input Screen. River Terrace Site**  
**10' PCE Plume, Average GW Velocity**

**BIOSCREEN Natural Attenuation Decision Support System**

Air Force Center for Environmental Excellence  
 Version 1.3

**1. HYDROGEOLOGY**

Seepage Velocity* or Hydraulic Conductivity	Vs	157.0 ↑ or	(ft/yr)
Hydraulic Gradient	K		(cm/sec)
Porosity	i		(ft/ft)
	n	0.3	(-)

**2. DISPERSION**

Longitudinal Dispersion*	alpha x	40.0	(ft)
Transverse Dispersion*	alpha y	4.0	(ft)
Vertical Dispersion*	alpha z	↑ or	(ft)
Estimated Plume Length	Lp	75	(ft)

**3. ADSORPTION**

Retardation Factor*	R	5.1	(-)
or Soil Bulk Density	rho	2.1	(kg/l)
Partition Coefficient	Koc	265	(L/kg)
Fraction Organic Carbon	foc	2.20E-03	(-)

**4. BIODEGRADATION**

1st Order Decay Coeff* or Solute Half-Life or Instantaneous Reaction Model	lambda	7.3E-4 ↑ or 948.00	(per yr) (year)
Delta Oxygen*	DO		(mg/L)
Delta Nitrate*	NO3		(mg/L)
Observed Ferrrous Iron*	Fe2+		(mg/L)
Delta Sulfate*	SO4		(mg/L)
Observed Methane*	CH4		(mg/L)

**5. GENERAL**

Modeled Area Length*	150	(ft)
Modeled Area Width*	90	(ft)
Simulation Time*	5	(yr)

River Terrace  
 PCE: 10' plume  
 Run Name

**6. SOURCE DATA**

Source Thickness in Sat. Zone\* 10 (ft)

Source Zones:	
Width* (ft)	Conc. (mg/L)*
0	
20	0
10	0.015
20	0
0	0

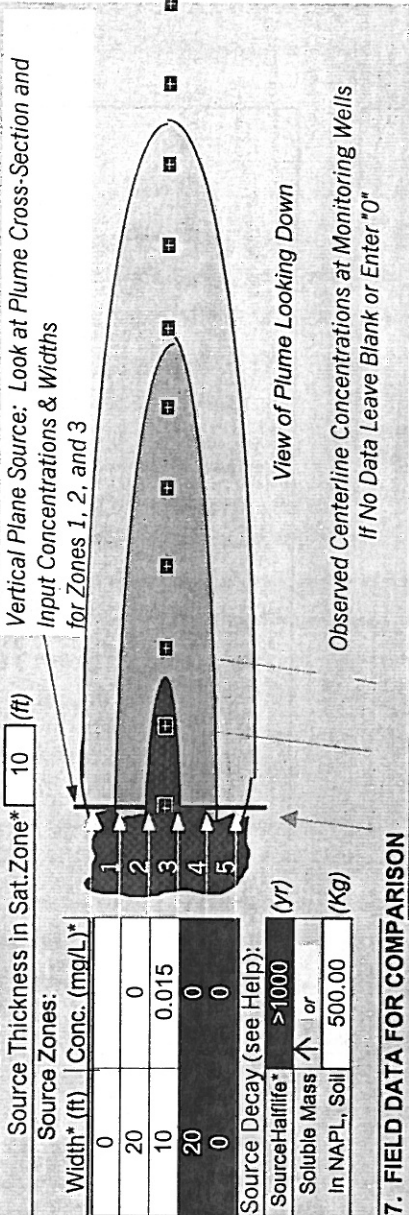
**Data Input Instructions:**

1. Enter value directly... or  
 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable\* → Data used directly in model.  
 → Value calculated by model.  
 (Don't enter any data).

115  
 ↑ or  
 0.02

20



**8. CHOOSE TYPE OF OUTPUT TO SEE:**

<b>RUN CENTERLINE</b>	<b>RUN ARRAY</b>
<b>View Output</b>	<b>View Output</b>

**Help**

Recalculate This Sheet

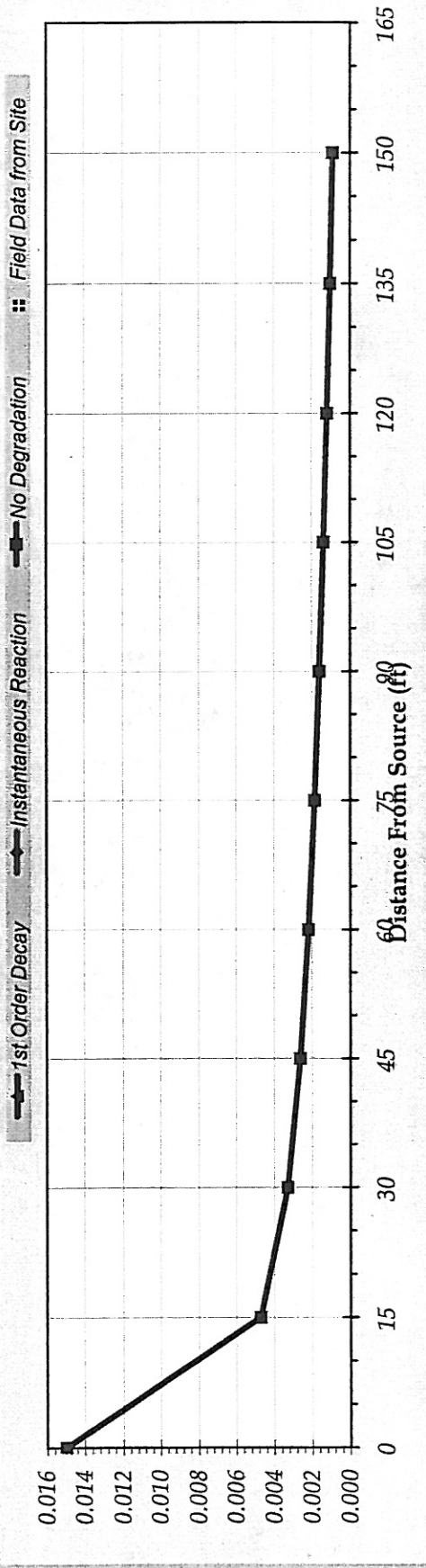
Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

River Terrace Site - Centerline Output  
 10' PCE Plume, Average GW Velocity

DISSOLVED BENZENE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)														
	0	15	30	45	60	75	90	105	120	135	150	165			
No Degradation	0.015	0.005	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001			
1st Order Decay	0.015	0.005	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001			
Inst. Reaction	0.015	0.005	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001			
Field Data from Site															



Time: