PACIFIC
ENVIRONMENTAL
GROUP, INC.

FACSIMILE TRANSMITTAL

DATE: May 8, 1995 PROJECT #: 330-006.3C

TO: Amy Leech FAX: 510-337-9335

Alameda County Env. Health

FROM: Debra Moser

IF YOU HAVE ANY PROBLEMS RECEIVING THIS FACSIMILE, PLEASE CALL (408) 441-7500

SHEETS TO FOLLOW COVER PAGE

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COMMENTS: Here is the Risk Assessment information for indoor exposures.

2025 Gateway Place, Suite 440, San Jose, California 95110 (408) 441-7500 FAX (408) 441-7539

DRAFT

Table 1
Inhalation of Benzene Vapor in Enclosed Space
Adult Exposure

ARCO Service Station 0608
17601 Hesperian Boulevard
San Lorenzo, California

Determine benzene concentration in air at groundwater-air interface based on groundwater concentration. (Methodology from Modified Health Risk Assessment, October 5,1 993)

Using Henry's Law:

$$Csv = \frac{[\,Hb \times ((\,CWb / MWb\,) / (\,CWw / MWw\,)) / Pt\,] \times D \times MWb}{MWa} \times CF$$

Where:

Csv	=	Benzene Concentration in Air at the Groundwater-Air Interface [micrograms/milliliter]
Hb	=	Henry's Law Coefficient (Benzene) [atmospheres]
CWb	=	Benzene Concentration in Groundwater (Well MW-10, March 16, 1993) [grams/liter]
MWb	=	Molecular Weight of Benzene [grams/mole]
CWw	=	Water Concentration in Groundwater [grams/liter]
MWw	=	Molecular Weight of Water [grams/mole]
Pt	=	Total Pressure [atmospheres]
D	=	Density of Subsurface Air (50 degrees F) [grams/liter]
CF	=	Conversion Factor [1,000 micrograms-liter/gram-milliliter]
MWa	=	Molecular Weight of Air [grams/mole]

Values:

Hb	=	240	atm
CWb	=	3.40E-04	g/L
MWb	=	78.12	g/mole
CWw	=	1,000	g/L
MWw	=	18	g/mole
Pt	=	1	atm
D	=	1.2	g/L
CF	=	1,000	ug-L/g-mL
MWa	=	29	g/mole

Solution: **Csv = 6.08E-02 ug/mL**

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Table 1 (continued)
Inhalation of Benzene Vapor in Enclosed Space
Adult Exposure

ARCO Service Station 0608
17601 Hesperian Boulevard
San Lorenzo, California

Determine Benzene Flux Across Soil Surface

Using SEASOIL:

$$P = -\left(Da \times \left(\left(n - m\right)^{10/3} / n^2\right) \times \left(Catm - Csv\right) / L\right) \times CF$$

Where:
- P = Pollutant Flux Across the Soil Surface [milligrams per square centimeter-second]
- Da = Apparent Steady-State Benzene Diffusion Coefficient in Air [square centimeters/second]
- n = Soil Porosity [fraction]
- m = Soil Moisture [fraction]
- Catm = Benzene Concentration in Air at the Surface [micrograms/milliliter]
- Csv = Benzene Concentration in Air at the Groundwater-Air Interface [micrograms/milliliter]
- L = Depth of Soil Cover [centimeters]
- CF = Conversion Factor [milligrams-cubic centimeter/micrograms-milliliter]

Values:

Da	=	0.077 sq.cm/s
n	=	0.25
m	=	0.2
Catm	=	1.98E-03 ug/mL
Csv	=	6.08E-02 ug/mL
L	=	357.2 cm
CF	=	0.001 mg-cu.cm/ug-mL

Solution: P = **9.34E-12 mg/sq.cm-s**

Determine Volume of Air in Enclosed Space (Per Day Basis)

Using Box Model:

$$V = \left(A \times H \times ARR\right)$$

Where:
- V = Volume of Air in Enclosed Space [cubic meter]
- A = Area of Enclosed Space [square meter]
- H = Height of Enclosed Space [square meter]
- ARR = Air Recirculation Rate [volumes/day]

Values:

A	=	185.8 sq. m
H	=	2.4 m
ARR	=	12.0 volume/day

Solution: V = **5,438.2 cu. m/day**

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Table 1 (continued)
Inhalation of Benzene Vapor in Enclosed Space
Adult Exposure

ARCO Service Station 0608
17601 Hesperian Boulevard
San Lorenzo, California

Determine Benzene Concentration in Enclosed Space (with Crack Factor range of 0.1 to 0.001)

Using Box Model:

$$Cos = \frac{(P \times CF \times Cf \times A)}{V}$$

Where:

Ces	=	Benzene Concentration in Enclosed Space [milligrams/cubic meter]
P	=	Pollutant Flux Across the Soil Surface [milligrams per square centimeter-second]
CF	=	Conversion Factor [square centimeter-second/square meter-day]
Cf	=	Crack Factor [fraction]
A	=	Area of Enclosed Space [square meter]
V	=	Volume of Air in Enclosed Space [cubic meter/day]

Values:

P	=	9.34E-12	mg/sq.cm-s
CF	=	8.64E+08	sq.cm-s/sq.m-day
Cf	=	0.1 (or)	0.001
A	=	185.8	sq. m
V	=	5,438.2	cu. m/day

Solution:

Ces	=	**2.76E-05**	mg/cu.m (Cf = 0.1)
	=	**2.76E-07**	mg/cu.m (Cf = 0.001)

{ Conc. of benzene in house after considering crack factor

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May 2, 1995

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Table 1 (continued)
Inhalation of Benzene Vapor in Enclosed Space
Adult Exposure

ARCO Service Station 0608
17601 Hesperian Boulevard
San Lorenzo, California

Determine Carcinogenic Health Risk to Benzene Vapor in Enclosed Space

Equation:

$$RISK = \frac{(Ces \times IR \times ET \times EF \times ED \times SF)}{BW \times AT}$$

Where:

RISK	=	Carcinogenic Health Risk
Ces	=	Benzene Concentration in Enclosed Space [milligrams/cubic meter]
IR	=	Inhalation Rate [cubic meters/hour]
ET	=	Exposure Time [hours/day]
EF	=	Exposure Frequency [days/year]
ED	=	Exposure Duration [years]
SF	=	Slope Factor [kilograms-day/milligram]
BW	=	Body Weight [kilograms]
AT	=	Averaging Time [days]

Values:

Ces	=	2.76E-05	mg/cu.m	(Crack Factor = 0.1)
	=	2.76E-07	mg/cu.m	(Crack Factor = 0.001)
IR	=	0.83	cu.m/hour	
ET	=	15.36	hours/day	
EF	=	365	days/year	
ED	=	70	years	
SF	=	0.029	kg-day/mg	
BW	=	70	kilograms	
AT	=	25,550	days	

Solution:

RISK	=	**1.46E-07**	**(Crack Factor = 0.1)**
	=	**1.46E-09**	**(Crack Factor = 0.001)**

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Table 2
Inhalation of Benzene Vapor in Enclosed Space
Children Exposure

ARCO Service Station 0608
17601 Hesperian Boulevard
San Lorenzo, California

Determine benzene concentration in air at groundwater-air interface based on groundwater concentration. (Methodology from Modified Health Risk Assessment, October 5,1 993)

Using Henry's Law:

$$Csv = \frac{[\,Hb \times ((\,CWb / MWb\,) / (\,CWw / MWw\,)) / Pt\,] \times D \times MWb}{MWa} \times CF$$

Where:

Csv	=	Benzene Concentration in Air at the Groundwater-Air Interface [micrograms/milliliter]
Hb	=	Henry's Law Coefficient (Benzene) [atmospheres]
CWb	=	Benzene Concentration in Groundwater (Well MW-10, March 16, 1993) [grams/liter]
MWb	=	Molecular Weight of Benzene [grams/mole]
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Values:

Hb	=	240 atm
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CWw	=	1,000 g/L
MWw	=	18 g/mole
Pt	=	1 atm
D	=	1.2 g/L
CF	=	1,000 ug-mL/g-L
MWa	=	29 g/mole

Solution: Csv = **6.08E-02 ug/mL**

DRAFT

Table 2 (continued)
Inhalation of Benzene Vapor in Enclosed Space
Children Exposure

ARCO Service Station 0608
17601 Hesperian Boulevard
San Lorenzo, California

Determine Benzene Flux Across Soil Surface

Using SEASOIL:

$$P = -(Da \times ((n - m)^{10/3} / n^2) \times (Catm - Csv) / L) \times CF$$

Where:

P	=	Pollutant Flux Across the Soil Surface [milligrams per square centimeter]
Da	=	Apparent Steady-State Benzene Diffusion Coefficient in Air [square centimeters/second]
n	=	Soil Porosity [fraction]
m	=	Soil Moisture [fraction]
Catm	=	Benzene Concentration in Air at the Surface [micrograms/milliliter]
Csv	=	Benzene Concentration in Air at the Groundwater-Air Interface [micrograms/milliliter]
L	=	Depth of Soil Cover [centimeters]
CF	=	Conversion Factor [milligrams-cubic centimeter/micrograms-milliliter]

Values:

Da	=	0.077 sq.cm/s
n	=	0.25
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Solution: P = **9.34E-12 mg/sq.cm-s**

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Using Box Model:

$$V = (A \times H \times ARR)$$

Where:

V	=	Volume of Air In Enclosed Space [cubic meter]
A	=	Area of Enclosed Space [square meter]
H	=	Height of Enclosed Space [square meter]
ARR	=	Air Recirculation Rate [volumes/day]

Values:

A	=	185.8 sq. m
H	=	2.4 m
ARR	=	12.0 volume/day

Solution: V = **5,438.2 cu. m/day**

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Table 2 (continued)
Inhalation of Benzene Vapor in Enclosed Space
Children Exposure

ARCO Service Station 0608
17601 Hesperian Boulevard
San Lorenzo, California

Determine Benzene Concentration in Enclosed Space (with Crack Factor range of 0.1 to 0.001)

Using Box Model:

$$Ces = \frac{(P \times CF \times Cf \times A)}{V}$$

Where:
- Ces = Benzene Concentration in Enclosed Space [milligrams/cubic meter]
- P = Pollutant Flux Across the Soil Surface [milligrams per square centimeter-second]
- CF = Conversion Factor [square centimeter-second/square meter-day]
- Cf = Crack Factor [fraction]
- A = Area of Enclosed Space [square meter]
- V = Volume of Air in Enclosed Space [cubic meter/day]

Values:
- P = 9.34E-12 mg/sq.cm-s
- CF = 8.64E+08 sq.cm-s/sq.m-day
- Cf = 0.1 (or) 0.001
- A = 185.8 sq. m
- V = 5,438.2 cu. m

Solution:
- Ces = **2.76E-05 mg/cu.m** (Cf = 0.1)
- = **2.76E-07 mg/cu.m** (Cf = 0.001)

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Table 2 (continued)
Inhalation of Benzene Vapor in Enclosed Space
Children Exposure

ARCO Service Station 0608
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San Lorenzo, California

Determine Carcinogenic Health Risk to Benzene Vapor in Enclosed Space

Equation:

$$RISK = \frac{(Ces \times IR \times ET \times EF \times ED \times SF)}{BW \times AT}$$

Where:

RISK = Carcinogenic Health Risk
Ces = Benzene Concentration in Enclosed Space [milligrams/cubic meter]
IR = Inhalation Rate [cubic meters/hour]
ET = Exposure Time [hours/day]
EF = Exposure Frequency [days/year]
ED = Exposure Duration [years]
SF = Slope Factor [kilograms-day/milligram]
BW = Body Weight [kilograms]
AT = Averaging Time [days]

Values:

Ces	=	2.76E-05 mg/cu.m	(Crack Factor = 0.1)
	=	2.76E-07 mg/cu.m	(Crack Factor = 0.001)
IR	=	0.83 cu.m/hour	
ET	=	15.36 hours/day	
EF	=	365 days/year	
ED	=	9 years	
SF	=	0.029 kg-day/mg	
BW	=	25 kilograms	
AT	=	25,550 days	

Solution:

RISK	=	5.24E-08	(Crack Factor = 0.1)
	=	5.24E-10	(Crack Factor = 0.001)