Click Here to Return to Main Document

Appendix F.8

Sample Calculations

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 1 OF 3

CLIENT Raymark - Ferry Creek		JOB NUMBER 7491	
SUBJECT Residental Ingestion of Soil - Commercial Worker			
BASED ON Rags 1989		DRAWING NUMBER	
BY JMM	CHECKED BY RJF	APPROVED BY	DATE 4/10/00

Purpose: To calculate noncarcinogenic and carcinogenic risk for the Current/Future Commercial/Industrial Worker via incidental ingestion of soil.

Relevant equation:

$$\text{Intake (mg/Kg-day)} = \frac{Cs \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

where

Cs = Concentration in soil (mg/kg)
IR = Soil ingestion Rate (mg/day)
CF = Conversion Factor (Kg/mg)
FI = Fraction of soil from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (Kg)
ATn = Averaging time for noncarcinogenic exposures (days)
ATc = Averaging time for carcinogenic exposures (days)
and

Reasonable Maximum Exposure (RME)		Central Tendency Exposure (CTE)	
Cs	chemical specific	Cs	chemical specific
IR	100 (mg/day)	IR	50 mg/day
CF	1.0E+6 (Kg/mg)	CF	1.0E-6 (Kg/mg)
FI	1 (unitless)	FI	1 (unitless)
EF	250 (days/year)	EF	250 days/year
ED	25 (years)	ED	9 (years)
BW	70 (Kg)	BW	70 Kg
ATc	25,550 days	ATc	25,550 days
ATn	9,125 days	ATn	3,285 days

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT	
Incidental Ingestion of Soil - Commercial Worker	
BASED ON	DRAWING NUMBER
RAGs 1989	
BY / CHECKED BY / APPROVED BY / DATE	
gmm / KJ / / 4/10/00	

Intake of arsenic at a concentration of 9.3 mg/kg in Area D, surface soil under RME assumption:

RME Noncarcinogenic Intake (mg/kg-day) of arsenic $= \frac{9.3\ \frac{mg}{Kg} \times 100\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 1 \times 250\ \frac{days}{yr} \times 25\ years}{70\ Kg \times 9,125\ days}$

$= \boxed{9.10\ E^{-6}\ mg/kg\text{-}day}$ ✓

RME Carcinogenic Intake (mg/kg-day) of arsenic $= \frac{9.3\ \frac{mg}{Kg} \times 100\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 1 \times 250\ \frac{days}{yr} \times 25\ years}{70\ Kg \times 25,550\ days}$

$= \boxed{3.25\ E^{-6}\ mg/kg\text{-}day}$ ✓

Then Incremental Cancer Risk (ICR) and Hazard Quotient (HQ) are calculated using the following equations:

ICR (unitless) = Carcinogenic Intake (mg/kg-day) × Cancer Slope Factor (CSF) (kg/mg-day)

HQ (unitless) = $\frac{\text{Noncarcinogenic intake}}{\text{Reference Dose}}$ $\frac{mg/kg\text{-}day}{mg/kg\text{-}day}$

where the CSF for arsenic = $1.5E^{+0}$ and RFD for arsenic = $3.0E^{-4}$ ✓

ICR arsenic (unitless) $= 3.25\ E^{-6}\ mg/kg\text{-}day \times 1.5\ kg/mg\text{-}day = \boxed{4.9\ E^{-6}\ RME}$

HQ arsenic (unitless) $= \frac{9.10\ E^{-6}\ mg/kg\text{-}day}{3.0\ E^{-4}\ mg/kg\text{-}day} = \boxed{3.0\ E^{-2}\ RME}$ ✓

CLIENT	Raymark - Ferry creek	JOB NUMBER	
SUBJECT	Dermal Exposition of soil - Commercial Worker		
BASED ON	RAGs 1989	DRAWING NUMBER	
BY	CHECKED BY	APPROVED BY	DATE
gmm	MV		4/10/00

Intake of Arsenic at a concentration of 4.4 mg/kg in Area D Surface Soil under CTE assumption:

$$\text{CTE Noncarcinogenic Intake (mg/Kg-day)} = \frac{4.4\ \frac{mg}{Kg} \times 50\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 1 \times 250\ \frac{days}{year} \times 9\ years}{70\ Kg \times 3,285\ days} = \boxed{2.15\ E^{-6}\ mg/Kg\text{-}day} \checkmark$$

$$\text{CTE Carcinogenic Intake (mg/Kg-day)} = \frac{4.4\ \frac{mg}{Kg} \times 50\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 1 \times 250\ \frac{days}{year} \times 9\ years}{70\ Kg \times 25,550\ days} = \boxed{2.77\ E^{-7}\ mg/Kg/day} \checkmark$$

Then ICR and HQ are calculated for arsenic where the

$$\text{ICR arsenic (unitless)} = 2.77E^{-7}\ mg/Kg\text{-}day \times 1.5\ Kg/mg\text{-}day = \boxed{4.2\ E^{-7}\ CTE} \checkmark$$

$$\text{HQ arsenic (unitless)} = \frac{2.15E^{-6}\ mg/Kg\text{-}day}{3.0\ E^{-4}\ mg/Kg\text{-}day} = \boxed{7.2\ E^{-3}\ CTE} \checkmark$$

References

USEPA Dec. 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final. OSWER EPA/540/1-89/002.

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 1 OF 3

CLIENT Raymark - Ferry Creek		JOB NUMBER 7491	
SUBJECT Direct Dermal Contact With Soil - Commercial Worker			
BASED ON RAGs 1989		DRAWING NUMBER	
BY GMM	CHECKED BY RJF	APPROVED BY	DATE 4/10/00

Purpose: To calculate carcinogenic and noncarcinogenic risk for the Current/Future Commercial/Industrial Worker in surface soil.

Relevant equation:

$$\text{Absorbed dose } \left(\frac{mg}{kg\text{-}day}\right) = \frac{Cs \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

where:

Cs = Chemical concentration in soil (mg/Kg)
CF = Conversion Factor (Kg/mg)
SA = Skin surface available for contact (cm^2/event)
AF = Soil to Skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure Frequency (events/year)
ED = Exposure Duration (years)
BW = Bodyweight (Kg)
ATN = Averaging Time for noncarcinogenic exposures (days)
ATc = Averaging Time for carcinogenic exposures (days)

and

Reasonable Maximum Exposure (RME)		Central Tendency Exposure CTE	
Cs	chemical specific (mg/Kg)	Cs	chemical specific (mg/kg)
CF	$1.0E^{-6}$ (Kg/mg)	CF	$1.0E^{-6}$ (Kg/mg)
SA	2,500 cm^2/event	SA	2,500 cm^2/event
AF	0.20 mg/cm^2	AF	0.02 mg/cm^2
ABS	chemical specific (unitless)	ABS	chemical specific (unitless)
EF	250 events/year	EF	250 events/year
ED	25 years	ED	9 years
BW	70 Kg	BW	70 Kg
ATN	9,125 days	ATN	3,285 days
ATc	25,550 days	ATc	25,550 days

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT	
Direct Dermal Contact with Soil - Commercial Worker	
BASED ON RAGS 1989	DRAWING NUMBER
BY JMM / CHECKED BY RF / APPROVED BY / DATE 4/10/00	

Absorbed dose of arsenic at a concentration of 9.3 mg/Kg in Area D, surface soil under RME assumptions:

RME Noncarcinogenic Absorbed Dose (mg/Kg-day) $= \dfrac{9.3\ \frac{mg}{Kg} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 2,500\ \frac{cm^2}{event} \times 0.20\ \frac{mg}{cm^2} \times 0.03 \times 250\ \frac{events}{year} \times 25\ yrs}{70\ Kg \times 9,125\ days}$

$= \boxed{1.37\ E^{-6}\ mg/Kg\text{-}day}$ ✓

RME Carcinogenic Absorbed Dose (mg/Kg-day) $= \dfrac{9.3\ \frac{mg}{Kg} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 2,500\ \frac{cm^2}{event} \times 0.20\ \frac{mg}{cm^2} \times 0.03 \times 250\ \frac{events}{year} \times 25\ years}{70\ Kg \times 25,550\ days}$

$= \boxed{4.87\ E^{-7}\ mg/Kg\text{-}day}$ ✓

Then Incremental Cancer Risk (ICR) and Hazard Quotient (HQ) are calculated via the following equations:

ICR (unitless) = Carcinogenic Absorbed Dose (mg/Kg-day) × Cancer Slope Factor (CSF) (Kg/mg-day)

HQ (unitless) = $\dfrac{\text{noncarcinogenic Absorbed Dose (mg/Kg-day)}}{\text{Reference Dose (RfD) (mg/Kg-day)}}$

Where the CSF of Arsenic = $1.5\ E^{+0}$ and the RfD of arsenic = $3.0E^{-4}$

ICR Arsenic (unitless) = $4.87E^{-7}$ mg/Kg-day × 1.5 Kg/mg-day = $\boxed{7.3\ E^{-7}\ RME}$ ✓

HQ arsenic (unitless) = $\dfrac{1.37\ E^{-6}\ mg/Kg\text{-}day}{3.0\ E^{-4}\ mg/Kg\text{-}day} = \boxed{4.5\ E^{-3}\ RME}$ ✓

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 3 OF 3

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT: Direct Dermal Contact w/ Soil - Commercial Worker	
BASED ON: RAGS 1989	DRAWING NUMBER:
BY: JMM / CHECKED BY: MH	APPROVED BY: / DATE: 4/10/00

Absorbed dose of arsenic at a concentration of 4.4 mg/kg in Area D surface soil under CTE assumptions:

$$\text{CTE Noncarcinogenic Absorbed Dose (mg/kg-day)} = \frac{4.4\ \frac{mg}{kg} \times 1.0E^{-6}\ \frac{kg}{mg} \times 2500\ \frac{cm^2}{event} \times 0.02\ \frac{mg}{cm^2} \times 0.03 \times 250\ \frac{events}{yr} \times 9\ yrs}{70\ kg \times 3,285\ days} = 6.46\ E^{-8}\ mg/kg\text{-day}$$ ✓

$$\text{CTE Carcinogenic Absorbed Dose (mg/kg-day)} = \frac{4.4\ \frac{mg}{kg} \times 1.0E^{-6}\ \frac{kg}{mg} \times 2500\ \frac{cm^2}{event} \times 0.02\ \frac{mg}{cm^2} \times 0.03 \times 250\ \frac{events}{yr} \times 9\ yrs}{70\ kg \times 25,550\ days} = 8.30\ E^{-9}\ mg/kg\text{-day}$$ ✓

ICR arsenic (unitless) = $8.30E^{-9}$ mg/kg-day × 1.5 kg/mg-day = $1.2E^{-8}$ CTE ✓

HQ arsenic (unitless) = $\frac{6.46E^{-8}\ mg/kg\text{-day}}{3.0E^{-4}\ mg/kg\text{-day}} = 2.2E^{-4}$ CTE ✓

References

USEPA 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (PART A) Interim Final OSWER EPA/540/1-89/002.

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 1 OF 3

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT	
Incidental Ingestion of Soil - Frequent Recreational User (Adult)	
BASED ON	DRAWING NUMBER
Rags 1989	Adult
BY / CHECKED BY	APPROVED BY / DATE
GMM / MK	4/10/00

Purpose: To calculate noncarcinogenic and carcinogenic risk for the frequent recreational user (Adult) via incidental ingestion of surface soil.

Relevant equation:

$$\text{Intake (mg/Kg day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

where

Cs = Concentration in soil (mg/kg)
IR = Soil ingestion Rate (mg/day)
CF = Conversion Factor (Kg/mg)
FI = Fraction of soil from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (Kg)
ATn = Averaging time for noncarcinogenic exposures (days)
ATc = Averaging time for carcinogenic exposures (days)
and

Reasonable Maximum Exposure (RME)		Central Tendency Exposure (CTE)	
Cs	chemical specific	Cs	chemical specific
IR	100 mg/day	IR	50 mg/day
CF	1.0E-6 (Kg/mg)	CF	1.0E-6 (Kg/mg)
FI	1 unitless	FI	1 unitless
EF	150 days/year	EF	150 days/year
ED	24 years	ED	7 years
BW	70 Kg	BW	70 Kg
ATc	25,550 days	ATc	25,550 days
ATn	9,125 days	ATn	3285 days

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT	
Incidental Ingestion of soil - Frequent Recreational User (Adult)	
BASED ON RAGs 1989	DRAWING NUMBER
BY gmm / CHECKED BY RJ / APPROVED BY / DATE 4/10/00	

Intake of arsenic at a concentration of 8.2 $\frac{mg}{Kg}$ in area D, surface soil under RME assumptions

RME Noncarcinogenic Intake (mg/kg-day) of arsenic $= \frac{8.2 \frac{mg}{Kg} \times 100 \frac{mg}{day} \times 1.0E^{-6} \frac{Kg}{mg} \times 1 \times 150 \frac{days}{yr} \times 24 yrs}{70 Kg \times 9,125 days}$

$= \boxed{4.62E^{-6} mg/kg\text{-}day}$ ✓

RME Carcinogenic Intake (mg/kg-day) of arsenic $= \frac{8.2 \frac{mg}{Kg} \times 100 \frac{mg}{Kg} \times 1.0E^{-6} \frac{Kg}{mg} \times 1 \times 150 \frac{days}{yr} \times 24 yrs}{70 Kg \times 25,550 days}$

$= \boxed{1.65E^{-6} mg/kg\text{-}day}$ ✓

When Incremental Cancer Risk (ICR) and Hazard Quotient (HQ) are calculated with the following equations:

ICR (unitless) = Carcinogenic Intake (mg/kg-day) x Cancer Slope Factor (CSF) (kg/mg-day)

HQ (unitless) = $\frac{\text{Noncarcinogenic intake}}{\text{Reference Dose}}$ $\frac{mg/kg\text{-}day}{mg/kg\text{-}day}$

where the CSF for arsenic = $1.5E^{+0}$ and RFD for arsenic = $3.0E^{-4}$

ICR arsenic (unitless) = $1.65E^{-6} mg/kg\text{-}day \times 1.5 kg/mg\text{-}day = \boxed{2.5E^{-6} RME}$ ✓

HQ arsenic (unitless) = $\frac{4.62E^{-6} mg/kg\text{-}day}{3.0E^{-4} mg/kg\text{-}day} = \boxed{1.5E^{-2} RME}$ ✓

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 3 OF 3

CLIENT Raymark - Ferry creek		JOB NUMBER 7491	
SUBJECT Incidental Ingestion of soil - Frequent Recreational User			
BASED ON RAGs 1989		DRAWING NUMBER (Attach)	
BY JMM	CHECKED BY RJV	APPROVED BY	DATE 4/10/00

Intake of arsenic at a concentration of 4.8 mg/kg in Area D, surface

$$\text{CTE Non-carcinogenic Intake (mg/kg-day)} = \frac{4.8\ \frac{mg}{kg} \times 50\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{kg}{mg} \times 1 \times 150\ \frac{days}{yr} \times 7\ yrs}{70\ kg \times 3,285\ days}$$

$$= \boxed{1.10E^{-6}\ mg/kg\text{-}day} \checkmark$$

$$\text{CTE Carcinogenic Intake (mg/kg-day)} = \frac{4.8\ \frac{mg}{kg} \times 50\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{kg}{mg} \times 1 \times 150\ \frac{days}{yr} \times 7\ yrs}{70\ kg \times 25,550\ days}$$

$$= \boxed{1.41E^{-7}\ mg/kg\text{-}day} \checkmark$$

Then ICR and HQ are calculated for arsenic where the

$$\text{ICR arsenic (unitless)} = 1.41E^{-7}\ mg/kg\text{-}day \times 1.5\ kg/mg\text{-}day = \boxed{2.1E^{-7}\ CTE} \checkmark$$

$$\text{HQ arsenic (unitless)} = \frac{1.10E^{-6}\ mg/kg\text{-}day}{3.0E^{-4}\ mg/kg\text{-}day} = \boxed{3.7E^{-3}\ CTE} \checkmark$$

References

USEPA Dec. 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final. OSWER EPA/540/1-89/002.

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 1 OF 3

CLIENT Raymark - Ferry Creek		JOB NUMBER 7491	
SUBJECT Direct Dermal Contact With Soil - Frequent Recreational User (adult)			
BASED ON RAGs 1989		DRAWING NUMBER	
BY JMM	CHECKED BY RJF	APPROVED BY	DATE 4/10/00

Purpose: To calculate carcinogenic and noncarcinogenic risk for the frequent recreational user (adult) via direct dermal contact with soil

Relevant equation:

$$\text{Absorbed dose} \left(\frac{mg}{kg\text{-}day}\right) = \frac{Cs \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

where:

Cs = Chemical concentration in soil (mg/Kg)
CF = Conversion Factor (Kg/mg)
SA = Skin surface available for contact (cm^2/event)
AF = Soil to Skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure Frequency (events/year)
ED = Exposure Duration (years)
BW = Bodyweight (Kg)
ATN = Averaging Time for noncarcinogenic exposures (days)
ATc = Averaging Time for carcinogenic exposures (days)

and

Reasonable Maximum Exposure (RME)		Central Tendency Exposure CTE	
Cs	chemical specific (mg/Kg)	Cs	chemical specific (mg/kg)
CF	1.0E-6 (Kg/mg)	CF	1.0E-6 (Kg/mg)
SA	5,700 cm^2/event	SA	5,700 cm^2/event
AF	0.07 mg/cm^2	AF	0.01 mg/cm^2
ABS	chemical specific (unitless)	ABS	chemical specific (unitless)
EF	150 events/year	EF	150 events/year
ED	24 years	ED	7 years
BW	70 Kg	BW	70 Kg
ATN	9,125 days	ATN	3,285 days
ATc	25,550 days	ATc	25,550 days

CLIENT Raymark - Ferry Creek		JOB NUMBER 7491	
SUBJECT Direct Dermal Contact with Soil - Frequent Recreational User (Adult)			
BASED ON RAGS 1989		DRAWING NUMBER	
BY JMM	CHECKED BY MV	APPROVED BY	DATE 4/10/00

Absorbed dose of arsenic at a concentration of 8.2 mg/Kg in Area D, surface soil - via RME assumptions:

$$\text{RME Noncarcinogenic Absorbed Dose (mg/Kg-day)} = \frac{8.2\ \frac{mg}{Kg} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 5{,}700\ \frac{cm^2}{event} \times 0.07\ mg/cm^2 \times .03 \times 150\ \frac{events}{year} \times 24\ yr}{70\ Kg \times 9{,}125\ days}$$

$$= \boxed{5.53E^{-7}\ mg/Kg\text{-}day} \checkmark$$

$$\text{RME Carcinogenic Absorbed Dose (mg/Kg-day)} = \frac{8.2\ \frac{mg}{Kg} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 5700\ \frac{cm^2}{event} \times 0.07\ mg/cm^2 \times 0.03 \times 50\ \frac{events}{yr} \times 24\ year}{70\ Kg \times 25{,}550\ days}$$

$$= \boxed{1.98E^{-7}\ mg/Kg\text{-}day} \checkmark$$

Then incremental Cancer Risk (ICR) and Hazard Quotient (HQ) are calculated via the following equations:

$$\text{ICR (unitless)} = \text{Carcinogenic Absorbed Dose (mg/Kg-day)} \times \text{Cancer Slope Factor (CSF) (Kg/mg-day)}$$

$$\text{HQ (unitless)} = \frac{\text{noncarcinogenic Absorbed Dose (mg/Kg-day)}}{\text{Reference Dose (RfD) (mg/Kg-day)}}$$

Where the CSF of Arsenic = $1.5E^{+0}$ and the RfD of arsenic = $3.0E^{-4}$ ✓

$$\text{ICR Arsenic (unitless)} = 1.98E^{-7}\ mg/Kg\text{-}day \times 1.5\ Kg/mg\text{-}day = \boxed{3.0E^{-7}\ RME}$$

$$\text{HQ arsenic (unitless)} = \frac{5.53E^{-7}\ mg/Kg\text{-}day}{3.0E^{-4}\ mg/Kg\text{-}day} = \boxed{1.8E^{-3}\ RME} \checkmark$$

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT: Direct Dermal Contact w/ Soil - Frequent Recreational User (Adult)	
BASED ON	DRAWING NUMBER
BY: JMM	CHECKED BY: [illegible]
APPROVED BY	DATE: 4/10/00

Absorbed dose of arsenic at a concentration of 4.8 mg/kg in Area D, surface soils under CTE assumptions:

$$\text{CTE Noncarcinogenic Absorbed Dose (mg/kg-day)} = \frac{4.8\ \frac{mg}{kg} \times 1.0E^{-6}\ \frac{kg}{mg} \times 5{,}700\ \frac{cm^2}{event} \times 0.01\ \frac{mg}{cm^2} \times 0.03 \times 150\ \frac{events}{yr} \times 7\ yrs}{70\ kg \times 3{,}285\ days} = \boxed{3.75\ E^{-8}\ mg/kg\text{-}day}\ \checkmark$$

$$\text{CTE Carcinogenic Absorbed Dose (mg/kg-day)} = \frac{4.8\ \frac{mg}{kg} \times 1.0E^{-6}\ \frac{kg}{mg} \times 5700\ \frac{cm^2}{event} \times 0.01\ \frac{mg}{cm^2} \times 0.03 \times 150\ \frac{events}{yr} \times 7\ yrs}{70\ kg \times 25{,}550\ days} = \boxed{4.82\ E^{-9}\ mg/kg\text{-}day}\ \checkmark$$

$$\text{ICR arsenic (unitless)} = 4.82E^{-9}\ mg/kg\text{-}day \times 1.5\ kg/mg\text{-}day = \boxed{7.2\ E^{-9}\ CTE}\ \checkmark$$

$$\text{HQ arsenic (unitless)} = \frac{3.75\ E^{-8}\ mg/kg\text{-}day}{3.0\ E^{-4}\ mg/kg\text{-}day} = \boxed{1.2\ E^{-4}\ CTE}\ \checkmark$$

Reference

USEPA 1989 Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (PART A) Interim Final OSWER EPA/540/1-89/002.

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 1 OF 3

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT	
Residential Ingestion of Soil - Frequent Recreational User (Child)	
BASED ON Rags 1989	DRAWING NUMBER
BY GMM / CHECKED BY MF / APPROVED BY / DATE 4/10/00	

Purpose: To calculate noncarcinogenic and carcinogenic risk for the frequent recreational user (child) via the incidental ingestion of soil.

Relevant equation:

$$\text{Intake (mg/Kg-day)} = \frac{Cs \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

where

Cs = Concentration in soil (mg/Kg)
IR = Soil ingestion Rate (mg/day)
CF = Conversion Factor (Kg/mg)
FI = Fraction of soil from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (Kg)
ATn = Averaging time for noncarcinogenic exposures (days)
ATc = Averaging time for carcinogenic exposures (days)

and

Reasonable Maximum Exposure (RME)		Central Tendency Exposure (CTE)	
Cs	chemical specific	Cs	chemical specific
IR	200 mg/day	IR	100 mg/day
CF	$1.0E^{-6}$ (Kg/mg)	CF	$1.0E^{-6}$ (Kg/mg)
FI	1 unitless	FI	1 unitless
EF	150 days/year	EF	150 days/year
ED	6 years	ED	2 years
BW	15 Kg	BW	15 Kg
ATc	25,550 days	ATc	25,550 days
ATn	9,125 days	ATn	3,285 days

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT: Incidental Ingestion of soil - Frequent Recreational user	
BASED ON: RAGs 1989	DRAWING NUMBER: Child
BY: gmm / CHECKED BY: RM	APPROVED BY: / DATE: 4/10/00

Intake of arsenic at a concentration of 8.2 mg/kg in Area D Surface soil under RME assumptions

RME Noncarcinogenic Intake (mg/kg-day) of arsenic $= \frac{8.2\ mg/kg \times 200\ mg/day \times 1.0E^{-6}\ kg/mg \times 1 \times 150\ days/yr \times 6\ years}{15\ kg \times 9,125\ days} =$ **1.08 E-5 mg/kg-day** ✓

RME Carcinogenic Intake (mg/kg-day) of arsenic $= \frac{8.2\ mg/kg \times 200\ mg/day \times 1.0E^{-6}\ kg/mg \times 1 \times 150\ days/yr \times 6\ years}{15\ kg \times 25,550\ days} =$ **3.85 E-4 mg/kg-day** ✓

When Incremental Cancer Risk (ICR) and Hazard Quotient (HQ) are calculated with the following equations:

ICR (unitless) = Carcinogenic Intake (mg/kg-day) × Cancer Slope Factor (CSF) (kg/mg-day)

HQ (unitless) = Noncarcinogenic intake (mg/kg-day) / Reference Dose (mg/kg-day)

where the CSF for arsenic = 1.5E+0 and RFD for arsenic = 3.0E-4 ✓

ICR arsenic (unitless) 3.85 E-6 mg/kg-day × 1.5 kg/mg-day = **5.8 E-6 RME** ✓

HQ arsenic (unitless) $\frac{1.08\ E^{-5}\ mg/kg\text{-}day}{3.0\ E^{-4}\ mg/kg\text{-}day} =$ **3.6 E-2 RME** ✓

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 3 OF 3

CLIENT: Raymark - Ferry creek		JOB NUMBER: 749/	
SUBJECT: Dermal Dosage of soil - Frequent Recreational User (Child)			
BASED ON: RAGs 1989		DRAWING NUMBER:	
BY: JMM	CHECKED BY: MH	APPROVED BY:	DATE: 4/10/00

Dermal Uptake of arsenic at a concentration of 4.8 mg/kg in Area D surface soil under CTE assumptions

$$\text{CTE Noncarcinogenic Dermal Uptake (mg/kg-day)} = \frac{4.8\ \text{mg/kg} \times 100\ \text{mg/day} \times 1.0E\text{-}6\ \text{kg/mg} \times 1 \times 150\ \text{days/yr} \times 2\ \text{yrs}}{15\ \text{kg} \times 3,285\ \text{days}}$$

$$= \boxed{2.92E^{-6}\ \text{mg/kg-day}} \checkmark$$

$$\text{CTE Carcinogenic Dermal Uptake (mg/kg-day)} = \frac{4.8\ \text{mg/kg} \times 100\ \text{mg/day} \times 1.0E^{-6}\ \text{kg/mg} \times 1 \times 150\ \text{days/yr} \times 2\ \text{yrs}}{15\ \text{kg} \times 25,550\ \text{days}}$$

$$= \boxed{3.76E^{-7}\ \text{mg/kg-day}} \checkmark$$

Then ICR and HQ are calculated for arsenic where the

$$\text{ICR arsenic (unitless)} = 3.76E^{-7}\ \text{mg/kg-day} \times 1.5\ \text{kg/mg-day} = \boxed{5.6E^{-7}\ \text{CTE}} \checkmark$$

$$\text{HQ arsenic (unitless)} = \frac{2.92E^{-6}\ \text{mg/kg-day}}{3.0E^{-4}\ \text{mg/kg-day}} = \boxed{9.7E^{-3}\ \text{CTE}} \checkmark$$

References

USEPA Dec. 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final. OSWER EPA/540/1-89/002.

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 1 OF 3

CLIENT Raymark - Ferry Creek		JOB NUMBER 7491	
SUBJECT Direct Dermal Contact with Soil - Frequent Recreational User (Child)			
BASED ON RAGs 1989		DRAWING NUMBER	
BY JMM	CHECKED BY RJK	APPROVED BY	DATE 4/10/00

Purpose: To calculate carcinogenic and noncarcinogenic risk for the frequent recreational user (Child) via direct dermal contact with soil.

Relevant equation:

$$\text{Absorbed dose (mg/kg-day)} = \frac{Cs \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

where:

Cs = Chemical concentration in soil (mg/kg)
CF = Conversion Factor (kg/mg)
SA = Skin surface available for contact (cm^2/event)
AF = Soil to Skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure Frequency (events/year)
ED = Exposure Duration (years)
BW = Bodyweight (kg)
AT_N = Averaging Time for noncarcinogenic exposures (days)
AT_C = Averaging Time for carcinogenic exposures (days)

and

Reasonable Maximum Exposure (RME)		Central Tendency Exposure CTE	
Cs	chemical specific (mg/kg)	Cs	chemical specific (mg/kg)
CF	$1.0E^{-6}$ (kg/mg)	CF	$1.0E^{-6}$ (kg/mg)
SA	2900 cm^2/event	SA	2,900 cm^2/event
AF	0.20 mg/cm^2	AF	0.06 mg/cm^2
ABS	chemical specific (unitless)	ABS	chemical specific (unitless)
EF	150 events/year	EF	150 events/year
ED	6 years	ED	2 years
BW	15 Kg	BW	15 Kg
AT_N	9,125 days	AT_N	3,285 days
AT_C	25,550 days	AT_C	25,550 days

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT: Direct Dermal Contact with Soil - Frequent Recreational User	
BASED ON: RAGs 1989	DRAWING NUMBER: Child
BY: JMM / CHECKED BY: MJ	APPROVED BY: / DATE: 4/10/00

Absorbed dose of arsenic at a concentration of 8.2 mg/Kg in Area D surface Soil under RME assumptions:

RME Noncarcinogenic Absorbed Dose (mg/Kg-day) $= \frac{8.2\ \frac{mg}{Kg} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 2900\ \frac{cm^2}{event} \times .20\ \frac{mg}{cm^2} \times .03 \times 150\ \frac{events}{yr} \times 6\ years}{15\ Kg \times 9,125\ days}$

$= \boxed{9.38\ E^{-7}\ mg/Kg\text{-}day}$ ✓

RME Carcinogenic Absorbed Dose (mg/Kg-day) $= \frac{8.2\ \frac{mg}{Kg} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 2900\ \frac{cm^2}{event} \times .20\ \frac{mg}{cm^2} \times .03 \times 150\ \frac{events}{yr} \times 6\ years}{15\ Kg \times 25,550\ days}$

$= \boxed{3.35E^{-7}\ mg/Kg\text{-}day}$ ✓

The incremental Cancer Risk (ICR) and Hazard Quotient (HQ) are calculated via the following equations:

ICR (unitless) = Carcinogenic Absorbed Dose (mg/Kg-day) × Cancer Slope Factor (CSF) (Kg/mg-day)

HQ (unitless) = $\frac{\text{Noncarcinogenic Absorbed Dose (mg/Kg-day)}}{\text{Reference Dose (RfD) (mg/Kg-day)}}$

Where the CSF of Arsenic = 1.5 E^{+0} and the RfD of arsenic = 3.0E-4

ICR Arsenic (unitless) = $3.35\ E^{-7}\ mg/Kg\text{-}day \times 1.5\ Kg/mg\text{-}day = \boxed{5.0E^{-7}\ RME}$ ✓

HQ Arsenic (unitless) = $\frac{9.38E^{-7}\ mg/Kg\text{-}day}{90\ E^{-4}\ mg/Kg\text{-}day} = \boxed{3.1\ E^{-3}\ RME}$ ✓

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT: Direct Dermal Contact w/ Soil - Frequent Recreational User Child	
BASED ON	DRAWING NUMBER
BY: JMM / CHECKED BY: RH	APPROVED BY / DATE: 4/10/00

Absorbed dose of arsenic at a concentration of 4.8 mg/kg in Area D, surface soils via direct dermal contact with soil

CTE Noncarcinogenic Absorbed Dose (mg/kg-day) $= \frac{4.8\ \frac{mg}{kg} \times 1.0E^{-6}\ \frac{kg}{mg} \times 2900\ \frac{cm^2}{event} \times 0.06\ \frac{mg}{cm^2} \times .03 \times 150\ \frac{events}{yr} \times 2\ yrs}{15\ kg \times 3,285\ days}$

$= \boxed{1.53E^{-7}\ mg/kg\text{-}day}$ ✓

CTE Carcinogenic Absorbed Dose (mg/kg-day) $= \frac{4.8\ \frac{mg}{kg} \times 1.0E^{-6}\ \frac{kg}{mg} \times 2900\ \frac{cm^2}{event} \times 0.06\ \frac{mg}{cm^2} \times .03 \times 150\ \frac{events}{yr} \times 2\ yrs}{15\ kg \times 25,550\ days}$

$= \boxed{1.96E^{-8}\ mg/kg\text{-}day}$ ✓

ICR arsenic (unitless) $= 1.96E^{-8}\ mg/kg\text{-}day \times 1.5\ kg/mg\text{-}day = \boxed{2.9E^{-8}\ CTE}$ ✓

HQ arsenic (unitless) $= \frac{1.53E^{-7}\ mg/kg\text{-}day}{3.0E^{-4}\ mg/kg\text{-}day} = \boxed{5.1E^{-4}\ CTE}$ ✓

Reference

USEPA 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (PART A) Interim Final OSWER EPA/540/1-89/002.

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 1 OF 3

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT: Incidental Ingestion of Soil - Wetland/Marsh Receptor - Adult	
BASED ON: Rags 1989	DRAWING NUMBER
BY: JMM / CHECKED BY: RJY	APPROVED BY / DATE: 4/10/00

Purpose: To calculate noncarcinogenic and carcinogenic risk for the Adult Wetland/Marsh Receptor via incidental ingestion of soil.

Relevant equation:

$$\text{Intake (mg/Kg-day)} = \frac{Cs \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

where

Cs = Concentration in soil (mg/kg)
IR = Soil ingestion Rate (mg/day)
CF = Conversion Factor (Kg/mg)
FI = Fraction of soil from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (Kg)
ATn = Averaging time for noncarcinogenic exposures (days)
ATc = Averaging time for carcinogenic exposures (days)
and

Reasonable Maximum Exposure (RME)		Central Tendency Exposure (CTE)	
Cs	chemical specific	Cs	Chemical specific
IR	100 mg/day	IR	50 mg/day
CF	$1.0E^{-6}$ (Kg/mg)	CF	$1.0E^{-6}$ (Kg/mg)
FI	1 unitless	FI	1 unitless
EF	20 days/year	EF	20 days/year
ED	24 years	ED	7 years
BW	70 Kg	BW	70 Kg
ATc	25,550 days	ATc	25,550 days
ATn	8,760 days	ATn	2,555 days

CLIENT	JOB NUMBER
Raymark - Fessy Creek	7491
SUBJECT: Incidental Ingestion of soil - Woodland Mouse Receptor Adult	
BASED ON: RAGs 1989	DRAWING NUMBER
BY: gmm / CHECKED BY: MH	APPROVED BY / DATE: 4/10/00

Intake of arsenic at a concentration of 22.1 mg/kg in Area E Surface Soil under RME assumptions:

$$\text{RME Non-carcinogenic Intake (mg/kg-day) of arsenic} = \frac{22.1\ \frac{mg}{kg} \times 100\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{kg}{mg} \times 1 \times 20\ \frac{days}{yrs} \times 24\ yrs}{70\ kg \times 8,760\ days}$$

$$= \boxed{1.73\ E^{-6}\ mg/kg\text{-}day} \checkmark$$

$$\text{RME Carcinogenic Intake (mg/kg-day) of arsenic} = \frac{22.1\ \frac{mg}{kg} \times 100\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{kg}{mg} \times 1 \times 20\ \frac{days}{yrs} \times 24\ yrs}{70\ kg \times 25,550\ days}$$

$$= \boxed{593E^{-7}\ mg/kg\text{-}day} \checkmark$$

When Incremental Cancer Risk (ICR) and Hazard Quotient (HQ) are calculated with the following equations:

ICR (unitless) = Carcinogenic Intake (mg/kg-day) × Cancer Slope Factor (CSF) (kg/mg-day)

HQ (unitless) = Non-carcinogenic intake (mg/kg-day) / Reference Dose (mg/kg-day)

where the CSF for arsenic = $1.5E^{+0}$ and RFD for arsenic = $3.0E^{-4}$

ICR arsenic (unitless): $5.93\ E^{-7}$ (mg/kg-day) × 1.5 kg/mg-day = $\boxed{8.9E^{-7}\ RME}$ ✓

HQ arsenic (unitless): $\frac{1.73\ E^{-6}\ mg/kg\text{-}day}{3.0\ E^{-4}\ mg/kg\text{-}day} = \boxed{5.8\ E^{-3}\ RME}$ ✓

CLIENT	JOB NUMBER		
Raymark - Ferry creek	7491		
SUBJECT	Dermal Ingestion of soil - Wetland/Marsh Receptor - Adult		
BASED ON RAGs 1989	DRAWING NUMBER		
BY JMM	CHECKED BY RH	APPROVED BY	DATE 4/10/00

Intake of arsenic at a concentration of 11.8 mg/kg in Area E surface soil under CTE assumptions:

$$\text{CTE Noncarcinogenic Intake (mg/kg-day)} = \frac{11.8\ \frac{mg}{kg} \times 50\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{kg}{mg} \times 1 \times 20\ \frac{days}{yr} \times 7\ years}{70\ kg \times 2,555\ days}$$

$$= \boxed{4.61\ E^{-7}\ mg/kg\text{-}day} \checkmark$$

$$\text{CTE Carcinogenic Intake (mg/kg-day)} = \frac{11.8\ \frac{mg}{kg} \times 50\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{kg}{mg} \times 1 \times 20\ \frac{days}{yr} \times 7\ years}{70\ kg \times 25,550\ days}$$

$$= \boxed{4.60\ E^{-8}\ mg/kg\text{-}day} \checkmark$$

Then ICR and HQ are calculated for arsenic where the

$$\text{ICR arsenic (unitless)} = 4.60E^{-8}\ mg/kg\text{-}day \times 1.5\ kg/mg\text{-}day = \boxed{6.9E^{-8}\ CTE} \checkmark$$

$$\text{HQ arsenic (unitless)} = \frac{4.61\ E^{-7}\ mg/kg\text{-}day}{3.0E^{-4}\ mg/kg\text{-}day} = \boxed{1.5E^{-3}\ CTE} \checkmark$$

References

USEPA. Dec. 1989. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. OSWER EPA/540/1-89/002.

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 1 OF 3

CLIENT Raymark - Ferry Creek		JOB NUMBER 7491	
SUBJECT Direct Dermal Contact with Soil - Wetland Marsh Receptor			
BASED ON RAGs 1989		DRAWING NUMBER Adult	
BY JMM	CHECKED BY RH	APPROVED BY	DATE 4/10/00

Purpose: To calculate carcinogenic and noncarcinogenic risk for the Wetland Marsh Receptor - Adult via direct dermal contact with site soil.

Relevant equation:

$$\text{Absorbed dose } (\text{mg/kg-day}) = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

where:

CS = Chemical concentration in soil (mg/kg)
CF = Conversion Factor (kg/mg)
SA = Skin surface available for contact (cm^2/event)
AF = Soil to Skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure Frequency (events/year)
ED = Exposure Duration (years)
BW = Bodyweight (kg)
ATN = Averaging Time for noncarcinogenic exposures (days)
ATC = Averaging Time for carcinogenic exposures (days)

and

Reasonable Maximum Exposure (RME)		Central Tendency Exposure CTE	
CS	Chemical specific (mg/kg)	CS	Chemical specific (mg/kg)
CF	$1.0E^{-6}$ (kg/mg)	CF	$1.0E^{-6}$ (kg/mg)
SA	5,700 cm^2/event	SA	5,700 cm^2/event
AF	0.3 mg/cm^2	AF	0.04 mg/cm^2
ABS	Chemical specific (unitless)	ABS	Chemical specific (unitless)
EF	20 events/year	EF	20 events/year
ED	24 years	ED	7 years
BW	70 kg	BW	70 kg
ATN	8,760 days	ATN	2,555 days
ATC	25,550 days	ATC	25,550 days

CLIENT	JOB NUMBER
Raymark - Ferry Creek	
SUBJECT	
Direct Dermal Contact with Soil - Wetland Marsh Receptor	
BASED ON	DRAWING NUMBER
RAGS 1989	Adult
BY / CHECKED BY	APPROVED BY / DATE
JMM / KH	4/10/00.

Absorbed dose of arsenic at a concentration of 22.1 mg/Kg in Area E, surface soil under RME assumptions:

$$\text{RME Noncarcinogenic Absorbed Dose (mg/Kg-day)} = \frac{22.1\ \frac{mg}{Kg} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 5700\ \frac{cm^2}{event} \times 0.3\ mg/cm^2 \times .03 \times 20\ \frac{events}{year} \times 24\ years}{70\ Kg \times 8760\ days} = \boxed{8.87\ E^{-7}\ mg/Kg\text{-}day}\ \checkmark$$

$$\text{RME Carcinogenic Absorbed Dose (mg/Kg-day)} = \frac{22.1\ \frac{mg}{Kg} \times 1.0E^{-6}\ \frac{Kg}{mg} \times 5700\ \frac{cm^2}{event} \times 0.3\ \frac{mg}{cm^2} \times .03 \times 20\ \frac{events}{year} \times 24\ years}{70\ Kg \times 25{,}550\ days} = \boxed{3.04\ E^{-7}\ mg/Kg\text{-}day}\ \checkmark$$

Then Incremental Cancer Risk (ICR) and Hazard Quotient (HQ) are calculated via the following equations:

ICR (unitless) = Carcinogenic Absorbed Dose (mg/Kg-day) x Cancer Slope Factor (CSF) (Kg/mg-day)

HQ (unitless) = Noncarcinogenic Absorbed Dose (mg/Kg-day) / Reference Dose (RfD) (mg/Kg-day)

Where the CSF of Arsenic = 1.5 E^{+0} and the RfD of arsenic = 3.0E-4

ICR Arsenic (unitless) 3.04 E^{-7} mg/Kg-day x 1.5 Kg/mg-day = $\boxed{4.6\ E^{-7}\ RME}$ ✓

HQ Arsenic (unitless) $\frac{8.87\ E^{-7}\ mg/Kg\text{-}day}{3.0\ E^{-4}\ mg/Kg\text{-}day} = \boxed{3.0\ E^{-3}\ RME}$ ✓

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 3 OF 3

CLIENT	JOB NUMBER
Raymark - Ferry Creek	
SUBJECT: Direct Dermal Contact w/ Ka Soil - Wetland Marsh Receptor	
BASED ON	DRAWING NUMBER: Adult
BY: JMM / CHECKED BY: MH / APPROVED BY:	DATE: 4/10/00

Absorbed dose of arsenic at a concentration of 11.8 mg/kg in Area E, surface soil under CTE assumptions.

$$\text{CTE Noncarcinogenic Absorbed Dose (mg/kg-day)} = \frac{11.8\ \frac{mg}{kg} \times 1.0E^{-6}\ \frac{kg}{mg} \times 5,700\ \frac{cm^2}{event} \times 0.04\ \frac{mg}{cm^2} \times .03 \times 20\ \frac{events}{yr} \times 7\ years}{70\ kg \times 2,555\ days} = 6.32\ E^{-8}\ mg/kg\text{-}day \quad \checkmark$$

$$\text{CTE Carcinogenic Absorbed Dose (mg/kg-day)} = \frac{11.8\ \frac{mg}{kg} \times 1.0E^{-6}\ \frac{kg}{mg} \times 5,700\ \frac{cm^2}{event} \times 0.04\ \frac{mg}{cm^2} \times .03 \times 20\ \frac{events}{yr} \times 7\ years}{70\ kg \times 25,550\ days} = 6.32\ E^{-9}\ mg/kg\text{-}day \quad \checkmark$$

ICR arsenic (unitless) = $6.32E^{-9}$ mg/kg-day $\times$ 1.5 kg/mg-day = $9.5\ E^{-9}$ CTE ✓

HQ arsenic (unitless) $\frac{6.32E^{-8}\ mg/kg\text{-}day}{3.0E^{-4}\ mg/kg\text{-}day} = 2.1\ E^{-4}$ CTE ✓

Reference

USEPA 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (PART A) Interim Final OSWER EPA/540/1-89/002.

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 1 OF 3

CLIENT Raymark - Ferry Creek		JOB NUMBER 7491	
SUBJECT Residental Ingestion of Soil - Wetland Marsh Receptor			
BASED ON Rags 1989		DRAWING NUMBER Pre-Adolescent Child	
BY JMM	CHECKED BY RH	APPROVED BY	DATE 9/10/00

Purpose: To calculate noncarcinogenic and carcinogenic risk for the Wetland Marsh Receptor - Pre Adolescent Child via incidental ingestion of soil.

Relevant equation:

$$\text{Intake (mg/Kg-day)} = \frac{Cs \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

where

Cs = Concentration in soil (mg/kg)
IR = Soil ingestion Rate (mg/day)
CF = Conversion Factor (Kg/mg)
FI = Fraction of soil from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (Kg)
ATn = Averaging time for noncarcinogenic exposures (days)
ATc = Averaging time for carcinogenic exposures (days)
and

Reasonable Maximum Exposure (RME)		Central Tendency Exposure (CTE)	
Cs	chemical specific	Cs	chemical specific
IR	100 mg/day	IR	50 mg/day
CF	$1.0E^{-6}$ (Kg/mg)	CF	$1.0E^{-6}$ (Kg/mg)
FI	1 unitless	FI	1 unitless
EF	90 days/year	EF	90 days/year
ED	6 years	ED	2 years
BW	31 Kg	BW	31 Kg
ATc	25,550 days	ATc	25,550 days
ATn	2,190 days	ATn	730 days

CLIENT	JOB NUMBER	
Raymark - Ferry Creek	7491	
SUBJECT		
Incidental Ingestion of soil - Wetland Marsh Receptor		
BASED ON	DRAWING NUMBER	
RAGs 1989	Pre-Adolescent Child	
BY / CHECKED BY	APPROVED BY	DATE
gmm / RH		9/10/00

Onfake of arsenic at a concentration of 22.1 mg/kg in Area E surface soils under RME assumptions:

$$\text{RME Noncarcinogenic Onfake (mg/kg-day) of arsenic} = \frac{22.1\ \frac{mg}{kg} \times 100\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{kg}{mg} \times 1 \times 20\ \frac{days}{year} \times 6\ years}{31\ kg \times 2,190\ days}$$

= 3.9 E-6 mg/kg-day ✓

$$\text{RME Carcinogenic Onfake (mg/kg-day) of arsenic} = \frac{22.1\ \frac{mg}{kg} \times 100\ \frac{mg}{day} \times 1.0E^{-6}\ \frac{kg}{mg} \times 1 \times 20\ \frac{days}{year} \times 6\ years}{31\ kg \times 25,550\ days}$$

= 3.3 E-7 mg/kg-day ✓

When incremental Cancer Risk (ICR) and Hazard Quotient (HQ) are calculated with the following equations:

ICR (unitless) = Carcinogenic Onfake (mg/kg-day) x Cancer Slope Factor (CSF) (kg/mg-day)

HQ (unitless) = Noncarcinogenic intake (mg/kg-day) / Reference Dose (mg/kg-day)

where the CSF for arsenic = 1.5E+0 and RFD for arsenic = 3.0E-4

ICR arsenic (unitless) = 3.3 E-7 mg/kg-day x 1.5 kg/mg-day = 5.0E-7 RME ✓

HQ arsenic (unitless) = 3.9 E-6 mg/kg-day / 3.0E-4 mg/kg-day = 1.3 E-2 RME ✓

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 3 OF 3

CLIENT	JOB NUMBER
Raymark - Ferry creek	
SUBJECT	
Dermal Ingestion of soil - wetland Marsh Receptor	
BASED ON	DRAWING NUMBER
RAGs 1989	Pre-Adolescent Child
BY / CHECKED BY / APPROVED BY / DATE	
JMM / RH / / 9/10/00	

Intake of arsenic at a concentration of 11.8 mg/kg in Area E Surface soil under CTE assumptions

$$\text{CTE Noncarcinogenic Intake (mg/kg-day)} = \frac{11.8\ \frac{mg}{kg} \times 50\ \frac{mg}{day} \times 1.0E\text{-}6\ \frac{kg}{mg} \times 1 \times 20\ days/year \times 2\ years}{31\ kg \times 730\ days} = \boxed{1.0\ E\text{-}6\ mg/kg\text{-}day}\ \checkmark$$

$$\text{CTE Carcinogenic Intake (mg/kg-day)} = \frac{11.8\ mg/kg \times 50\ \frac{mg}{day} \times 1.0E\text{-}6\ \frac{kg}{mg} \times 1 \times 20\ days/year \times 2\ years}{31\ kg \times 25{,}550\ days} = \boxed{3.0\ E\text{-}8\ mg/kg\text{-}day}\ \checkmark$$

Then ICR and HQ are calculated for arsenic where the

$$\text{ICR arsenic (unitless)} = 3.0\ E\text{-}8\ mg/kg\text{-}day \times 1.5\ E = \boxed{4.5\ E\text{-}8\ CTE}\ \checkmark$$

$$\text{HQ arsenic (unitless)} = \frac{1.0E\text{-}6\ mg/kg\text{-}day}{3.0E\text{-}4\ mg/kg\ day} = \boxed{3.5\ E\text{-}3\ CTE}\ \checkmark$$

References

USEPA Dec. 1989 Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final. OSWER EPA/540/1-89/002

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 1 OF 3

CLIENT	JOB NUMBER		
Raymark - Ferry Creek	7491		
SUBJECT	Direct Dermal Contact with Soil - Wetland Marsh Receptor		
BASED ON RAGs 1989	DRAWING NUMBER	Pre-Adolescent-Child	
BY	CHECKED BY	APPROVED BY	DATE
GMM	KH		4/10/00

Purpose: To calculate carcinogenic and noncarcinogenic risk for the wetland/Marsh Receptor (Pre-Adolescent-Child) via direct dermal contact with soil.

Relevant equation:

$$\text{Absorbed dose} \left(\frac{\text{mg}}{\text{kg-day}}\right) = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

where:

CS = Chemical concentration in soil (mg/kg)
CF = Conversion Factor (kg/mg)
SA = Skin surface available for contact (cm^2/event)
AF = Soil to Skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure Frequency (events/year)
ED = Exposure Duration (years)
BW = Bodyweight (kg)
AT_N = Averaging Time for noncarcinogenic exposures (days)
AT_C = Averaging Time for carcinogenic exposures (days)

and

Reasonable Maximum Exposure (RME)		Central Tendency Exposure CTE	
CS	chemical specific (mg/kg)	CS	chemical specific (mg/kg)
CF	$1.0E^{-6}$ (kg/mg)	CF	$1.0E^{-6}$ (kg/mg)
SA	3,200 cm^2/event	SA	3,200 cm^2/event
AF	1.0 mg/cm^2	AF	0.20 mg/cm^2
ABS	chemical specific (unitless)	ABS	chemical specific (unitless)
EF	20 events/year	EF	20 events/year
ED	6 years	ED	2 years
BW	31 Kg	BW	31 Kg
AT_N	2,190 days	AT_N	730 days
AT_C	25,550 days	AT_C	25,550 days

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 2 OF 3

CLIENT Raymark - Ferry Creek		JOB NUMBER 7491	
SUBJECT Direct Dermal Contact with Soil - Wetland Marsh Receptor			
BASED ON RAGS 1989		DRAWING NUMBER The Adolescent Child	
BY JMM	CHECKED BY KH	APPROVED BY	DATE 4/10/00

Absorbed dose of arsenic at a concentration of 22.1 mg/Kg in Area E, surface soil under RME assumptions.

RME Noncarcinogenic Absorbed Dose (mg/Kg-day) = $\frac{22.1 \frac{mg}{Kg} \times 1.0E^{-6} \frac{Kg}{mg} \times 3,200 \frac{cm^2}{event} \times 1.0 mg/cm^2 \times 0.03 \times 20 \frac{events}{yr} \times 6 yrs}{31 Kg \times 2,190 days}$

= 3.75 E-6 mg/Kg-day ✓

RME Carcinogenic Absorbed Dose (mg/Kg-day) = $\frac{22.1 \frac{mg}{Kg} \times 1.0E^{-6} \frac{Kg}{mg} \times 3,200 \frac{cm^2}{event} \times 1.0 mg/cm^2 \times 0.03 \times 20 \frac{events}{yr} \times 6 yrs}{31 Kg \times 25,550 days}$

= 3.01 E-7 mg/Kg-day ✓

The Incremental Cancer Risk (ICR) and Hazard Quotient (HQ) are calculated via the following equations:

ICR (unitless) = Carcinogenic Absorbed Dose (mg/Kg-day) x Cancer Slope Factor (CSF) (Kg/mg-day)

HQ (unitless) = $\frac{\text{noncarcinogenic Absorbed Dose (mg/Kg-day)}}{\text{Reference Dose (RfD) (mg/Kg-day)}}$

Where the CSF of Arsenic = 1.5 E+0 and the RfD of arsenic = 3.0E-4 ✓

ICR Arsenic (unitless) = 3.21 E-7 mg/Kg-day x 1.5 Kg/mg-day = 4.8 E-7 RME ✓

HQ Arsenic (unitless) = $\frac{3.75 E^{-6} mg/Kg-day}{3.0 E^{-4} mg/Kg-day}$ = 1.3 E-2 RME ✓

TETRA TECH NUS, INC. **CALCULATION WORKSHEET**

CLIENT Raymark - Ferry Creek	JOB NUMBER 7491
SUBJECT Direct Dermal Contact with Soil - Wetland Marsh Receptor	
BASED ON	DRAWING NUMBER Pre-Adolescent Child
BY JMM / CHECKED BY HH	APPROVED BY / DATE 4/10/00

Absorbed dose of arsenic at a concentration of 11.8 mg/kg in Area E surface soil under CTE assumptions.

CTE Noncarcinogenic Absorbed Dose (mg/kg-day)

$$= \frac{11.8\,\frac{mg}{kg} \times 1.0E^{-6}\,\frac{kg}{mg} \times 3{,}200\,cm^2/event \times 0.20\,\frac{mg}{cm^2} \times 0.03 \times 20\,\frac{events}{year} \times 2\,years}{31\,kg \times 730\,days}$$

$$= \boxed{4.00\,E^{-7}\,mg/kg\text{-}day}$$ ✓

CTE Carcinogenic Absorbed Dose (mg/kg-day)

$$= \frac{11.8\,\frac{mg}{kg} \times 1.0E^{-6}\,\frac{kg}{mg} \times 3{,}200\,cm^2/event \times 0.20\,\frac{mg}{cm^2} \times 0.03 \times 20\,\frac{events}{year} \times 2\,years}{31\,kg \times 25{,}550\,days}$$

$$= \boxed{1.14\,E^{-8}\,mg/kg\text{-}day}$$ ✓

ICR arsenic (unitless) $= 1.14E^{-8}\,mg/kg\text{-}day \times 1.5\,kg/mg\text{-}day = \boxed{1.7E^{-8}\ CTE}$ ✓

HQ arsenic (unitless) $= \frac{4.00E^{-7}\,mg/kg\text{-}day}{3.0\,E^{-4}\,mg/kg\text{-}day} = \boxed{1.3E^{-3}\ CTE}$ ✓

Reference

USEPA 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (PART A) Interim Final OSWER EPA/540/1-89/002.

TETRA TECH NUS, INC. CALCULATION WORKSHEET PAGE 1 OF 4

CLIENT		JOB NUMBER	
Raymark - Ferry Creek		7491	
SUBJECT			
Direct Dermal Contact with Surface Water - Wetland Marsh Receptor (Adult)			
BASED ON		DRAWING NUMBER	
BY	CHECKED BY	APPROVED BY	DATE
JMM	RJJ		11/10/00

Purpose: To calculate carcinogenic and noncarcinogenic risk via dermal exposure to surface water

Relevant Equations

$$\text{Absorbed Dose} = \frac{DA_{event} \times EV \times EF \times ED \times SA}{BW \times AT}$$

For Inorganic compounds:

$$DA_{event} = Kp \times Cw \times t_{event} \times CF$$

For Organic Compounds:

If $t_{event} \leq t^*$ then,

$$DA_{event} = 2 \times Kp \times Cw \times CF \times \sqrt{\frac{6 \times tau \times t_{event}}{\pi}}$$

If $t_{event} > t^*$ then,

$$DA_{event} = Kp \times Cw \times CF \left[\frac{t_{event}}{1+B} + 2 \times tau \times \left(\frac{1 + 3B + 3B^2}{(1+B)^2} \right) \right]$$

where: If $B \leq 0.6$ then $t^* = 2.4 \times tau$

BUT If $B > 0.6$ then $t^* = \frac{(b - \sqrt{b^2 - c^2 \times 0.000001})}{Dse}$

where $B = Kp \times \frac{\sqrt{mw}}{2.6}$

$$c = \frac{1 + 3B + 3B^2}{3(1+B)}$$

$$b = \left(\frac{2(1+B^2)}{\pi} \right) - c$$

$$Dse = 0.001 \times 10^{(-2.8 - 0.0056 \times mw)}$$

$$tau = 0.105 \times 10^{(0.0056 \times mw)}$$

CLIENT Raymark Ferry Creek		JOB NUMBER 7491	
SUBJECT Direct Dermal Contact w/ Surface Water - Wetland Marsh Receptor (adult)			
BASED ON		DRAWING NUMBER	
BY JNM	CHECKED BY RJ	APPROVED BY	DATE 9/10/00

Values for the organic compound Aroclor 1254 in surface water at area E for the Wetland Marsh Receptor (Adult) the following exposure assumptions are true:

Where:	SA = :	✓4,500	Skin surface available for contact (cm^2)
	DAevent = :		Chemical specific absorbed dose per event (mg/cm^2-event)
	EV = :	1	Event frequency (events/days)
	EF = :	✓20	Exposure frequency (days/year)
	ED = :	24	Exposure duration (years)
	BW = :	70	Body weight (kg)
	ATc = :	25,550	Averaging time for carcinogenic exposures (days)
	ATn = :	8,760	Averaging time for noncarcinogenic exposures (days)
	CF = :	0.001	Conversion Factor (L/m^3)
	Kp = :	$9.0E^{-1}$	Chemical specific permeability coefficient (cm/hr) 1254 Aroclor
	Cw = :	.0047	Concentration of chemical in water (mg/L) AROCLOR 1254
	tevent = :	✓1	duration of event (hr/event)
	tau = :		Chemical specific lag time (hr)
	t* = :		Chemical specific time it takes to reach steady state (hr)
	B = :		Chemical specific dimensionless constant
	Dsc = :		Effective diffusivity for chemical transfer through skin (cm^2/hr)
	b, c = :		chemical specific constants
	MW		molecular weight · Aroclor 1254 = 292

$$tau = 0.105 \times 10^{(0.0056 \times 292)} = \boxed{4.53\ hr}\ ✓$$

$$B = \frac{9.0E^{-1} \times \sqrt{292}}{2.6} = \boxed{5.92}\ ✓$$

$$C = \frac{1 + 3(5.92) + 3(5.92)^2}{3(1+5.92)} = \boxed{5.96}\ ✓$$

$$b = \left(\frac{2(1+(5.92))^2}{\pi}\right) - 5.96 = \boxed{2.45E^{+1}}\ ✓$$

$$Dsc = 0.001 \times 10^{(-2.8 - 0.0056 \times 292)} = \boxed{3.67E^{-8}\ cm^2/hr}\ ✓$$

and $B = 5.92$ which is greater than 0.6 hence

$$t^* = \frac{2.45E^{+1} - \sqrt{(24.5)^2 - (5.96)^2} \times 0.000001}{3.67E^{-8}} = \boxed{201E^{+1}}\ ✓$$

TETRA TECH NUS, INC. CALCULATION WORKSHEET

CLIENT Raymark Ferry Creek	JOB NUMBER 7491
SUBJECT Direct Dermal Contact with Surface Water - Wetland Marsh Receptor - Adult	
BASED ON	DRAWING NUMBER
BY JMM / CHECKED BY HP	APPROVED BY / DATE 9/10/00

And t^* (20.1) is greater than t_{event} (1.0) therefore

$$DA_{event} = 2 \times 9.0E^{-1}\left(\frac{cm}{hr}\right) \times .007\,(mg/L) \times .001\,\frac{L}{m^3} \times \sqrt{\frac{6 \times 4.53\,hr \times 1.0\,\frac{hr}{event}}{\pi}}$$

$$DA_{event} = \boxed{3.71\,E^{-5}\ mg/cm^2\text{-event}}$$ ✓

Aroclor

Absorbed Dose noncarcinogen

$$= \frac{3.71E^{-5}\ mg/cm^2\text{-event} \times 1\,\frac{event}{day} \times 20\,\frac{days}{year} \times 24\,years \times 4500\,cm^2}{70\,Kg \times 8760\,days}$$

$$= \boxed{1.31\,E^{-4}\ mg/Kg\text{-day}}$$ ✓

Absorbed Dose Carcinogen

$$= \frac{3.71E^{-5}\ mg/cm^2\text{-event} \times 1\,\frac{event}{day} \times 20\,\frac{days}{year} \times 24\,years \times 4500\,cm^2}{70\,Kg \times 25{,}550\,days}$$

$$= \boxed{4.5\,E^{-5}\ mg/Kg\text{-day}}$$ ✓

The cancer slope factor (CSF) for Arochlor is 2.0
The Reference dose (RFD) for Arochlor 254 is $2.0E^{-5}$

Lifetime Cancer Risk - $\boxed{9.0\,E^{-5}}$

Hazard Quotient - $\frac{\text{absorbed dose noncarcinogen}}{RFD}$
unitless

$$= \frac{1.31\,E^{-4}\ mg/Kg\text{-day}}{2.0\,E^{-5}\ mg/Kg\text{-day}} = \boxed{6.5}$$ ✓

CLIENT	JOB NUMBER
Raymark - Ferry Creek	7491
SUBJECT: Direct Dermal Contact w/ Surface water, - Wetland Marsh Receptor	
BASED ON	DRAWING NUMBER
BY: JMM / CHECKED BY: RJV	APPROVED BY / DATE: 9/10/00

Values for the inorganic compound Arsenic in surface waters at Area E for the Wetland Marsh Receptor were also calculated for which the following assumptions are true:

K_p = 1.0E^{-3} cm/hr permeability coefficient for As
C_w = 0.0429 mg/L concentration of As in surface H_2O
CF = 0.001 $4m^3$ - conversion factor
t_{event} = 1.0 hr/event duration of event

For inorganics $DA_{event} = K_p \times C_w \times CF \times t_{event}$

$DA_{event\ As} = 1.0E^{-3}\ cm/hr \times 0.0429\ mg/L \times 0.001\ 4m^3 \times 1.0\ hr/event$

$= \boxed{4.29\ E^{-8}\ mg/cm^2\text{-event}}$ ✓

Absorbed Dose noncarcinogen $= \dfrac{4.29E^{-8}\ \frac{mg}{cm^2\text{-event}} \times 1\ \frac{event}{day} \times 20\ \frac{days}{yr} \times 24\ years \times 4500\ cm^2}{70\ Kg \times 8760\ days}$

$= \boxed{1.51\ E^{-7}\ mg/Kg\text{-day}}$ ✓

Absorbed Dose Carcinogen $= \dfrac{4.29E^{-8}\ \frac{mg}{cm^2\text{-event}} \times 1\ \frac{event}{day} \times 20\ \frac{days}{yr} \times 24\ years \times 4500\ cm^2}{70\ Kg \times 25{,}550\ days}$

$= \boxed{5.18\ E^{-8}\ mg/Kg\text{-day}}$ ✓

The cancer slope factor for As = 1.5 Kg/mg-day
The Reference dose for As = 3.0E^{-4} mg/Kg-day

Lifetime Cancer Risk (unitless) = 1.5 Kg/mg-day × 5.18 E^{-8} mg/Kg-day = $\boxed{7.8\ E^{-8}}$ ✓

Hazard Quotient (unitless) = $\dfrac{1.51\ E^{-7}\ mg/Kg\text{-day}}{3.0\ E^{-4}\ mg/Kg\text{-day}} = \boxed{5.0E^{-4}}$ ✓