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16th July 2007

Mr Calton Frame
Gunns Ltd
By email attachment

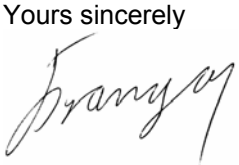
RE: Model for calculating dioxin concentrations in sediment, and biota for submission to DEWR.

Dear Calton,

as agreed with Dr Barry Reville of the Department of the Environment and Water Resources (DEWR) please find attached, for submission to DEWR, the calculation of the dioxin sediment calculation (Figure 11) presented in the Toxikos report "Response on submission citing dioxin calculation concerns" (Toxikos reference number TR170607-RJF). This calculation was performed using site specific parameters for the fraction organic carbon in suspended particulates and in sediment and also site specific measurement of baseline (background) dioxin concentration in sediment (refer Table 1 of Toxikos report TR170607-RJF). Any references cited in this reply can be found within the abovementioned Toxikos reports. References to US EPA equations are consistent with both the Marine Impact Assessment report and recently supplied spreadsheet.

DEWR can contact me on 03 9571 2140 if clarification is required on any aspect relating to the calculation or the previously supplied spreadsheet.

Yours sincerely



Principal Consultant

Dioxin Sediment Calculation (Calculation parameters are described in Table 1)

1. Calculate Kd_{sw} (US EPA Equation A-2-11)

$$Kd_{sw} = f_{OC,sw} \times k_{OC} \qquad Kd_{sw} = 0.000004 \times 3890000 = 15.56$$

2. Calculate Kd_{bs} (US EPA Equation A-2-12)

$$Kd_{bs} = f_{OC,bs} \times k_{OC} \qquad Kd_{sw} = 0.0012 \times 3890000 = 4668$$

3. Calculate d_z (Text supporting US EPA Equation 5-36A)

$$d_z = d_{wc} + d_{bs} \qquad d_z = 26 + 0.03 = 26.03$$

4. Calculate f_{wc} (US EPA Equation 5-36A)

$$f_{wc} = \left[\frac{\left(1 + Kd_{sw} \times TSS \times 1 \times 10^{-6}\right) \times \frac{d_{wc}}{d_z}}{\left(\left(1 + Kd_{sw} \times TSS \times 1 \times 10^{-6}\right) \times \frac{d_{wc}}{d_z} \right) + \left(\left(\theta_{bs} + Kd_{bs} \times C_{BS}\right) \times \frac{d_{bs}}{d_z} \right)} \right]$$

$$f_{wc} = \left[\frac{\left(1 + 15.56 \times 8.6 \times 1 \times 10^{-6}\right) \times \frac{26}{26.03}}{\left(\left(1 + 15.56 \times 8.6 \times 1 \times 10^{-6}\right) \times \frac{26}{26.03} \right) + \left(\left(0.6 + 4668 \times 1\right) \times \frac{0.03}{26.03} \right)} \right] = 0.16$$

5. Calculate f_{bs} (US EPA Equation 5-36B)

$$f_{bs} = 1 - f_{wc}$$

$$f_{bs} = 1 - 0.16 = 0.84$$

6. Calculate C_{sb} incremental (US EPA Equation 5-47)

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$$C_{sb} = \frac{f_{bs} \times C_{wtot} \times Kd_{bs}}{\theta_{bs} + Kd_{bs} \times C_{BS}} \times \frac{d_{wc} + d_{bs}}{d_{bs}}$$

$$C_{sb} = \frac{0.84 \times 0.034 \times 4668}{0.6 + 4668 \times 1} \times \frac{26 + 0.03}{0.03} = 25$$

incorporating 'missing factor'

$$Cwtot = \frac{1}{fwc} \times C_{wctot}$$

C_{wctot} is the concentration of dioxin released at a 1:100 dilution (0.034)

$$C_{sb} = \frac{0.84 \times 0.22 \times 4668}{0.6 + 4668 \times 1} \times \frac{26 + 0.03}{0.03} = 159$$

Total $C_{sb} = C_{sb\ incremental} + C_{sb\ background}$:

$C_{sb\ total}$ = 25 +3.8 = **28.8**

$C_{sb\ total}$ = 159 + 3.8 = **162.8**

($C_{sb\ background}$ is the mean TEQ concentration measured at the outfall site during recent baseline sampling –refer Table 1 Toxikos Report TR170607RJF

Table 1: Summary of equations and equation parameters used to calculate dioxin concentrations in sediment.

Parameter Symbol	Value	Units	Description / Reference
Text supporting US EPA Equation 5-36A: Total water body depth			
d_{wc}	26	metres	Depth of water column (m). Site specific. Refer to Table 13.6 of the Marine Impact Assessment report for a more detailed description..
d_{bs}	0.03	metres	Depth of upper benthic sediment layer. A default 0.03 m has been adopted based on the median of values cited by US EPA (2005).
d_z	26.03	metres	Total water body depth. Site specific.
US EPA Equation A-2-11: Suspended sediments/surface water partition coefficient			
$f_{OC,sw}$	0.000004	Unitless	Fraction of organic carbon in suspended particulate. Site specific. Measured during recent baseline sampling program.
Kd_{sw}	291,750	L water / kg suspended sediment	Partition coefficient of TCDD between suspended sediments and water (mg chemical/kg suspended sediment ÷ mg chemical/L water = L/kg).
k_{OC}	3,890,000	L/kg	Organic carbon (OC) partition coefficient (mg TCDD/kg OC ÷ mg TCDD/L water = L/kg OC) for TCDD US EPA (2005b).
US EPA Eq A-2-12: Partition coefficient between sediment particles and bed sediment water			
$f_{OC,bs}$	0.0012	Unitless	Fraction of organic carbon in bottom sediment. Site specific. Measured during recent baseline sampling program.
Kd_{bs}	12,480	L water / kg bed sediment	Partition coefficient of TCDD between bed sediment particulates and bed sediment pore water.
US EPA Eq 5-36A: Fraction of total water body pollutant concentration in water			
TSS	8.6	mg/L	Total suspended solids (TSS) concentration. This is site specific Refer to Table 13.6 of the Marine Impact Assessment report for a more detailed description..
θ_{bs}	0.6	Unitless	Bed sediment porosity for the sediment a default US EPA value of 0.6 is adopted (US EPA 2005).
C_{BS}	1.0	L/kg	Bed sediment bulk density in the DV_{100}. US EPA (2005) expects this value to be reasonable in most cases.
f_{wc}	0.019	Unitless	Fraction of total water body TCDD concentration in the water.
US EPA Eq 5-47: Fraction of total water pollutant concentration in benthic sediment			
f_{bs}	0.80	Unitless	Fraction of total contaminant discharged to water body that partitions to bed sediment.
US EPA : Estimation of equilibrium sediment pollutant concentration from water concentration			
C_{wtot}	0.034	pg TEQ/L	Total dioxin concentration in DV_{100} water, taken to be the TEQ estimate for discharged mill effluent with 100x dilution.
C_{sb} incremental	25 (Toxikos) 159	pg TEQ / kg	TCDD TEQ sediment conc. as per Toxikos method. TCDD TEQ sediment conc. incorporating Wadsley suggestion .