

Appendix 5C

Stock water criteria

1.1 Overview

The uptake of contaminants by stock is unlikely to be a limiting consideration compared to potable use of groundwater, however, it is an important consideration when the salinity is such that potable use is limited. Where the salinity of the groundwater limits use of groundwater to less sensitive uses, the impact of contaminated groundwater on stock health and human health may be an important consideration.

In deriving Tier 1 groundwater acceptance criteria for the protection of stockwater use consideration has been given to:

- protection of stock health
- protection of human health where livestock products (e.g. milk and meat) are consumed
- aesthetic considerations (e.g. palatability of the water).

The derivation of stockwater criteria is highly uncertain due to inadequate information regarding the accumulation of contaminants in stock and relevant thresholds for the palatability of water for stock. Due to limited information, consideration of palatability and other aesthetic considerations have not been included in the derivation of the Tier 1 groundwater acceptance criteria for stockwater use.

The basis for the derivation of stockwater criteria is presented in Section 5.4 of Module 5. This appendix focuses on the derivation of criteria based on the protection of human health where livestock products are consumed. Consideration of livestock health and aesthetic impact is presented in Section 5.4. In practice the uptake and accumulation of petroleum hydrocarbons by livestock and the associated impact on human health is not limiting compared to the impact on stock health (refer Section 5.4).

1.2 Uptake model

1.2.1 Summary

The uptake and accumulation of contaminants by stock is dependent on a range of complex biological processes affecting absorption, distribution, metabolism and elimination of contaminants. Simplified empirical formulae are available which provide an indication of the uptake of contaminants by stock. These formulae are presented in numerous research papers. The equations used for the derivation of the Tier 1 groundwater acceptance criteria can be found in Travis and Arms (1988).

The Travis and Arms model has been widely used however it is limited in that most of the data on which the correlations are based is for chlorinated pesticides. Chlorinated pesticides are generally resistant to metabolism in mammals whereas hydrocarbon compounds including PAHs are readily metabolised. Metabolism of PAHs and other hydrocarbons is expected to reduce accumulation in livestock and hence the Travis and Arms model is expected to overestimate uptake and accumulation.

1.2.2 Pathways

Contaminants are taken up by stock through ingestion of stock water. Contaminants may accumulate within animal tissue or fat reservoirs (e.g. milk) and through the consumption of animal products humans may be exposed to these contaminants. For the purposes of deriving criteria two main pathways, by which humans may ingest contaminants, have been assumed:

- ingestion of meat: beef, pork, etc
- ingestion of milk and dairy products

Travis and Arms present equations relating the uptake and accumulation of contamination in beef to the intake of contaminants, which for the purposes of deriving Tier 1 criteria have been assumed to apply to a range of livestock. Equations relating uptake to intake of contaminants are also presented for milk.

1.2.3 Equations

The biotransfer factors for beef (Bb) and milk (Bm) are defined as:

$$Bb = \frac{\text{concentration in beef (mg / kg)}}{\text{daily intake of organic (mg / d)}} \quad (C1)$$

$$Bm = \frac{\text{concentration in milk (mg / kg)}}{\text{daily intake of organic (mg / d)}} \quad (C2)$$

The calculation of the biotransfer factors are calculated as follows:

$$\log Bb = -7.6 + \log Kow \quad (C3)$$

$$\log Bm = -8.1 + \log Kow \quad (C4)$$

where:

Kow = Octanol Water Partition Coefficient.

1.3 Groundwater criteria calculation

1.3.1 Exposure parameters

Screening criteria calculations are made for both meat and milk pathways. The exposure parameters are presented in Table 5C1.

Table 5C1 Exposure parameters

Parameter	Value	Reference
Stock		
Stock water ingestion rate	55 L/d	Shell, 1994
Human		
Exposure frequency	365 d/y	
Exposure duration	70 yrs	
Averaging time	70 yrs	
Body weight	70 kg	ANZECC, 1992
Meat ingestion rate	152 g/d	Langley, 1993
Milk ingestion rate	269 g/d	Langley, 1993

1.3.2 Meat and milk concentrations

The contaminant concentrations in the meat and milk corresponding to the acceptable daily intake (e.g. RfD) are calculated using the following equations

$$C_i = \frac{ADI \times AT \times 365 \times BW}{EF \times IR \times ED} \quad (C5)$$

where:

C_i = Concentration of beef or milk (mg/kg)

ADI = Average daily intake (mg/kg/d)

IR = Ingestion rate of beef or milk (kg/d)

ED = Exposure duration (years)

AT = Averaging time (70 years for carc., ED for non-carc)

BW = Body weight (kg)

For carcinogenic contaminants:

$$ADI = \text{Target Risk} / SF \quad (C6)$$

For non-carcinogenic contaminants:

$$ADI = \text{Target Hazard Index} \times \text{RfD} \quad (C7)$$

where: SF = Slope factor (mg/kg/d)⁻¹

RfD = Reference dose factor (mg/kg/d)

1.3.3 Groundwater concentration

The contaminated concentrations in beef and milk corresponding to the acceptable intake are used to calculate the groundwater acceptance criteria. The beef and milk concentrations are substituted into equations C1 and C2 to calculate the allowable daily intake of contaminants by stock. From this the groundwater concentration is calculated from the equation:

$$\text{Groundwater Concentration (mg / L)} = \frac{\text{Daily intake of contaminants by stock (mg / d)}}{\text{Ingestion rate of stock water (L / d)}} \quad (C8)$$

(C8)

Groundwater concentrations are calculated for both exposure pathways (i.e. beef and milk consumption). However, risk calculations should combine both sources to determine the groundwater concentration. The combined pathway groundwater acceptance criteria is calculated by:

$$\text{Groundwater Acceptance Criterion (mg / L)} = \frac{1}{\frac{1}{C_b} + \frac{1}{C_m}} \quad (C9)$$

1.4 References

ANZECC/NHMRC. 1992. **Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites.**

Langley A. 1993. **Refining Exposure Assessment.** Proc 2nd Nat Workshop on the Health Risk Assessment and Management of Contaminated Land.

Shell, 1994.

Travis C.C., and A.D. Arms. 1988. **Bioaccumulation of Organics in Beef, Milk and Vegetation,** Environ Sci Technl. Vol 22, No 3.

Table 5C2
Stock water calculations
Risk to human health - meat

Water Conc 1 mg/L Meat cons. 152 g/d Exp. Freq. 365 d/y
Stock Ing Rate: 55 L/d BW 70 kg ED 70
Daily Intake: 55 mg/d AT 70

Chemical	Kow	log Bb	Bb	beef conc mg/kg	LADD mg/kg.d	CDI mg/kg.d	Screening mg/L
C7-C9	1.41E+05	-2.4500	3.55E-03	1.95E-01	4.24E-04	5.00E+00	11799.51309
C10-C14	3.72E+07	-0.0300	9.33E-01	5.13E+01	1.11E-01	1.00E-01	0.897205158
C15-C36	2.09E+09	1.7200	5.25E+01	2.89E+03	6.27E+00	1.50E+00	0.239322219
benzene	132	-5.4794	3.32E-06	1.82E-04	3.96E-07	3.45E-04	870.8028334
toluene	537	-4.8700	1.35E-05	7.42E-04	1.61E-06	2.00E-01	124150.214
ethylbenzene	1413	-4.4499	3.55E-05	1.95E-03	4.24E-06	1.00E-01	23591.17655
xylene	1820	-4.3399	4.57E-05	2.51E-03	5.46E-06	1.80E-01	32968.02112
naphthalene	2344	-4.2300	5.89E-05	3.24E-03	7.03E-06	4.00E-03	568.7897401
pyrene	151356	-2.4200	3.80E-03	2.09E-01	4.54E-04	3.00E-02	66.07132516
benzo(a)pyrene	1096478	-1.5600	2.75E-02	1.51E+00	3.29E-03	1.37E-06	0.000416497

Table 5C3
Stock water calculations
Risk to human health - milk

Water Conc 1 mg/L Milk Cons. 269 g/d Exp. Freq. 365 d/y
Stock Ing Rate: 55 L/d BW 70 kg ED 70
Daily Intake: 55 mg/d AT 70

Chemical	Kow	log Bm	Bm	beef conc mg/kg	LADD mg/kg.d	CDI mg/kg.d	Screening mg/L
C7-C9	1.41E+05	-2.9500	1.12E-03	6.17E-02	2.37E-04	5.00E+00	21084.11588
C10-C14	3.72E+07	-0.5300	2.95E-01	1.62E+01	6.24E-02	1.00E-01	1.603182891
C15-C36	2.09E+09	1.2200	1.66E+01	9.13E+02	3.51E+00	1.50E+00	0.42763607
benzene	132	-5.9794	1.05E-06	5.77E-05	2.22E-07	3.45E-04	1556.005549
toluene	537	-5.3700	4.27E-06	2.35E-04	9.02E-07	2.00E-01	221839.4503
ethylbenzene	1413	-4.9499	1.12E-05	6.17E-04	2.37E-06	1.00E-01	42154.20553
xylene	1820	-4.8399	1.45E-05	7.95E-04	3.06E-06	1.80E-01	58909.34415
naphthalene	2344	-4.7300	1.86E-05	1.02E-03	3.94E-06	4.00E-03	1016.349463
pyrene	151356	-2.9200	1.20E-03	6.61E-02	2.54E-04	3.00E-02	118.0604204
benzo(a)pyrene	1096478	-2.0600	8.71E-03	4.79E-01	1.84E-03	1.37E-06	0.000744224