

November 1998
Evaluation Framework

Appendix 9-C

**BIOACCUMULATION
CONCENTRATIONS
AND STEADY STATE LEVELS**

Bioaccumulation Concentrations and Steady State Levels

The following tables contain information concerning bioaccumulation testing. The first contains the sediment chemistry trigger values. The second concerns the steady state tissue residue levels. These levels have been compiled from the relevant literature, and will updated as new information becomes available.

SEDIMENT CHEMISTRY TRIGGER VALUES FOR BIOACCUMULATION TESTING

CHEMICAL	LOG KOW ¹	CONCENTRATION ²
METALS (ppm dry weight basis)		
Arsenic	N/A	507.1
Mercury	N/A	1.5
Silver	N/A	4.6
ORGANIC COMPOUNDS (ppb dry)		
Fluoranthene	5.5	4,600
Benzo(a)pyrene	6.0	4,964
1,2-Dichlorobenzene	3.4	37
1,4-Dichlorobenzene	3.5	190
Dimethyl phthalate	1.6	1,168 ³
Di-n-butyl phthalate	5.1	10,220 ³
Bis(2-ethylhexyl) phthalate	4.2	13,870 ³
Hexachlorobutadiene	4.3	212
Phenol	1.5	876
Pentachloropenol	5.0	504
N-Nitrosodiphenylamine	3.1	161
Tributyltin		219
Total DDT	(5.7 - 6.0) ³	50
Aldrin	3.0	37 ³ 37
Chlordane	6.0	37 ³
Dieldrin	5.5	37 ³
Heptachlor	5.4	37 ³
Total PCBs	(4.0 - 6.9) ⁵	338 ⁴

¹ Octanol/Water Partitioning Coefficients (log KOW) for organic chemicals of concern.

² Concentration = 0.7 X (ML-SL) + SL. When the concentration of any chemical is above this value, bioaccumulation testing is required.

³ These chemicals do not have an ML value. Therefore, the concentration = ((10SL-SL) X 0.7) + SL = 7.3 X SL.

⁴ This value is normalized to Total Organic Carbon and is expressed in ppm (TOC normalized).

⁵ Range of individual congeners making up total.

Note: Polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) may also require bioaccumulation testing, although no bioaccumulation trigger has been established for PCDDs and PCDFs. The requirement to conduct bioaccumulation testing will be made by the agencies utilizing best professional judgment after reviewing the Tier II data.

PERCENT OF STEADY-STATE TISSUE RESIDUES OF SELECTED METALS AND NEUTRAL ORGANICS FROM 10 AND 28 DAY EXPOSURES TO BEDDED SEDIMENT¹

Compound	% of Steady State ² Tissue Residue		Species	Estimated By
	10-DAY	28-DAY		
METALS				
Copper	75	100	Macoma nasuta	G ⁵
Lead	81	100	Macoma nasuta	G
Cadmium	17	50	Callinassa australiensis	G
Mercury	ND ⁴	ND ⁴	Neanthes succinea	G
ORGANICS				
PCBs				
Aroclor 1242	18	87	Nereis virens	G
Aroclor 1254	12	82	Macoma balthica	G
Aroclor 1254	25	56	Nereis virens	K ⁶
Aroclor 1260	53	100	Macoma balthica	G
Total PCBs	21	54	Nereis virens	G
Total PCBs	48	80	Macoma nasuta	G
Total PCBs	23	71	Macoma nasuta	G
PAHs				
Benzo(a)pyrene	43	75	Macoma inquinata	G
Benzo(bk)fluoranthene	71	100	Macoma nasuta	G
Chrysene	43	87	Macoma inquinata	G
Fluoranthene	100	100	Macoma nasuta	G
Phenanthrene	100	100	Macoma inquinata	G
Phenanthrene	100	100	Macoma nasuta	G
Pyrene	84	97	Macoma nasuta	G

Note: See footnotes at end of table.

November 1998
Evaluation Framework

COMPOUND	% OF STEADY STATE ² TISSUE RESIDUE		SPECIES	ESTIMATED BY
	10-DAY	28-DAY		
TCDD/TCDF				
2,3,7,8-TCDD	6	22	Nereis virens	G
2,3,7,8-TCDD	63	100	Macoma nasuta	G
2,3,7,8-TCDF	43	62	Nereis virens	G
2,3,7,8-TCDF	92	100	Macoma nasuta	G
MISCELLANEOUS				
4,4-DDE	20	50	Macoma nasuta	G
2,4-DDD	31	56	Macoma nasuta	G
4,4-DDD	32	60	Macoma nasuta	G
4,4-DDT	17	10	Macoma nasuta	G

¹ Modified from draft Inland Testing Manual (Table C), using data updated from Boese and Lee (1992).

² Steady-state values are estimates, as steady-state is not rigorously documented in these studies.

³ See Boese and Lee (1992) for complete citations.

⁴ ND = Not Determined. Observed AFs (accumulation factor) for field tissue levels compared with sediment levels (normalized to dry weight) averaged 4 for this species, but ranged from 1.3 to 45 among other benthic macroinvertebrate species. Laboratory 28-day exposures to bedded sediment indicated uptake fit a linear regression model over the exposure period and experimental conditions. Tissue levels observed (*N. succinea*) at 28 days amounted to only 2.5 % of the total sediment-bound Hg potentially available.

⁵ G = Steady-state residue estimated by visual inspection of graphs of tissue residue versus time.

⁶ K = Steady-state residue estimated from a 1st-order kinetic uptake model.

A problem with tissue chemistry data, which must be addressed prior to statistical analysis, is tissue concentrations which are quantitated below the detection limit. Such non-numeric data cannot be statistically analyzed unless numeric values are substituted for the less-than detection limit observations. For this evaluation, substituting one-half the detection limit for each less-than observation should be utilized. (Clarke 1996)

Test interpretation guidelines for both human health and ecological effects assessments are discussed below:

◆ **Human Health.** The bioaccumulation test results are compared to guideline values to determine exceedance of allowable tissue residue concentrations. If the 28-day bioaccumulation test results in tissue levels greater than the FDA action levels, (see Table 3), the sediment will be considered unsuitable for aquatic disposal. Chemicals of concern without or below FDA action levels will be evaluated by the RMT using best professional judgment and risk assessment approaches. Interpretation of test results requires an evaluation of the statistical significance of the mean bioaccumulation of contaminants in animals exposed to dredged material compared to a specified action level or standard. If the mean tissue concentration of one or more contaminants of concern is greater than or equal to the applicable action level, then no statistical testing is required. The conclusion is that the dredged material does not meet the guidelines associated with the particular action level. If the mean tissue concentration of a chemical of concern is less than the applicable action level, than a confidence-interval approach is used to determine if the mean is significantly less than the action level. One-tailed t-tests are appropriate since there is concern only if bioaccumulation from the dredged sediment is not significantly less than the action level. The one-sample t-test approach depicted below is appropriate to allow independent decisions to be made on each dredged material management unit tested:

$$t = \frac{\bar{x} - \text{action level}}{\sqrt{\frac{s^2}{n}}}$$

where "x", "s²", and "n" refer to the mean, variance, and number of replicates for contaminant bioaccumulation from the proposed dredged material.

◆ **Ecological Effects.** The results of a Tier III 28-day bioaccumulation test will be compared directly with reference results for statistical significance. If the results of a statistical comparison show that the tissue concentration of the chemical(s) of concern tested in sediments is statistically different (t-test, alpha level of 0.05) from the reference sediment, the dredged material will generally be considered unsuitable for unconfined aquatic disposal.

The five factors summarized below will be reviewed as part of the regulatory assessment process when statistical significance is shown. In reviewing these factors, the best regional guidance will be consulted to assess the relative importance of each factor to the regulatory decision.

- (1) How many contaminants demonstrate bioaccumulation from dredged material relative to reference sediments?
- (2) What is the magnitude of the bioaccumulation from dredged material compared to reference sediments?
- (3) What is the toxicological importance of the contaminants (e.g., do they biomagnify or have effects at low concentrations?). Examples of contaminants with biomagnification concerns are DDT, PCB, Hg/MeHg, and possibly dioxins and furans.
- (4) What is the potential for the identified contaminants to biomagnify within aquatic food webs?
- (5) What is the magnitude by which contaminants found to bioaccumulate in tissues exceed the tissue burdens of comparable species found at the vicinity of the disposal site?

FOOD AND DRUG ADMINISTRATION (FDA) ACTION LEVELS FOR POISONOUS AND DELETERIOUS SUBSTANCES IN FISH AND SHELLFISH FOR HUMAN FOOD

CHEMICAL	TISSUE GUIDELINES (ppm wet weight)
METALS	
Arsenic	TBD ¹
Mercury (Methyl Mercury)	1.0
Silver	TBD
ORGANIC COMPOUNDS	
Fluoranthene	TBD
Benzo(a)pyrene	TBD
1,2-Dichlorobenzene	TBD
1,4-Dichlorobenzene	TBD
Dimethyl phthalate	TBD
Di-n-butyl phthalate	TBD
Bis(2-ethylhexyl) phthalate	TBD
Hexachlorobutadiene	TBD
Phenol	TBD
Pentachloropenol	TBD
Ethylbenzene	TBD
N-Nitrosodiphenylamine	TBD
Total DDT + DDE	5.0
Aldrin	0.3
Chlordane	0.3
Dieldrin + Aldrin	0.3
Heptachlor + Heptachlor Epoxide	0.3
Total PCBs	2.0

"TBD" = To Be Determined, using best professional judgement and best available guidance.