

CLARIFICATION PAPER

SEDIMENT BIOACCUMULATION TESTING REFINEMENTS: SAMPLE VOLUME REQUIREMENTS, SIMULTANEOUS CO-TESTING OF TWO SPECIES WITHIN A SINGLE AQUARIUM, AND SPECIES SUBSTITUTION

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INTRODUCTION

To be consistent with Environmental Protection Agency / U.S. Army Corps of Engineers guidance contained in the 1994 draft "Inland Testing Manual" (EPA/COE, 1994), the PSDDA program adopted bioaccumulation testing with two species (ARM 1994 Issue paper). The two species must represent different trophic niches: a suspension-feeding/filter-feeding organism and a burrowing deposit-feeding organism. A test exposure of 28 days is followed by tissue analysis for chemicals of human health and ecological effects concern following the EPA protocol (Lee et al., 1993; ASTM 1995). Ecological effects are evaluated through a statistical comparison with a reference area sediment.

A bioaccumulation test will be conducted on those dredged materials in which a "reason to believe" has been established that specific chemicals of concern may be accumulated in the tissues of target organisms. A bioaccumulation test using two species is required if any one of twenty-nine identified chemicals of concern are shown to have concentrations exceeding the bioaccumulation trigger value established under the PSDDA program (Table 1). These values establish the "reason to believe" levels for chemicals likely to bioaccumulate in marine organisms. Organic compounds with octanol water partition coefficients (K_{ow}) greater than 5.5 are considered much more likely to bioaccumulate in tissues than less hydrophobic chemicals (Table 1).

PROBLEM IDENTIFICATION

Sediment volume requirements. There has been some confusion concerning the amount of sediment needed to conduct the bioaccumulation test. The PSDDA program generally requires applicants to address contingencies for exceedances of biological testing triggers including bioaccumulation testing in their sampling and analysis plan. In high concern areas, PSDDA agencies generally recommend archiving sufficient sample for potential biological testing (acute/chronic bioassays and bioaccumulation tests) requirements. Sediment archival requirements necessary to conduct the 28-day bioaccumulation test are quite onerous as depicted in Table 2 below. Depending on the species selected, the total test sediment volume requirement can exceed 32.5 liters for each dredged material management unit (DMMU) if each of the two required species are tested separately. A similar volume must also be collected and archived for the reference sediment and negative control sediment. Large projects can become unmanageable with respect to sampling volumes and storage requirements needed.

Table 1. Sediment chemistry trigger values for bioaccumulation testing.

CHEMICAL	log Kow	CONCENTRATION
METALS (ppm dry weight basis)		
Antimony	NA	146
Arsenic	NA	507.1
Mercury	NA	1.5
Nickel	NA	1,022
Silver	NA	4.6
ORGANIC COMPOUNDS (ppb dry weight basis)		
Fluoranthene	5.5	4,600
Benzo(a)pyrene	6.0	4,964
1,2-Dichlorobenzene	3.4	37
1,3-Dichlorobenzene	3.4	1,241
1,4-Dichlorobenzene	3.5	190
Dimethyl phthalate	1.6	1,168
Di-n-butyl phthalate	5.1	10,220
Bis(2-ethylhexyl) phthalate	4.2	13,870
Hexachloroethane	3.9	10,220
Hexachlorobutadiene	4.3	212
Phenol	1.5	876
Pentachlorophenol	5.0	504
Ethylbenzene	3.1	27
N-Nitrosodiphenylamine	3.1	161
Hexachlorobenzene	5.2	168
Tributyltin	-	219
Trichloroethene	3.9	1,168
Tetrachloroethene	2.4	10
Total DDT	(5.7 - 6.0)	50
Aldrin	3.0	37
Chlordane	6.0	37
Dieldrin	5.5	37
Heptachlor	5.4	37

Total PCBs	(4.0 - 6.9)	38 (carbon-normalized)
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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.

Table 2. Species specific testing volume requirements.

Species	Sediment Volume Requirements
<i>Macoma nasuta</i>	>250 ml/beaker x 10 beakers/8 L-aquarium = 2.5 L/aquarium 5 replicate aquaria = >12.5-20 liters
<i>Nereis virens</i>	200 mL per worm x 20 worms per 20 gallon aquarium = 4 L/aquarium 5 replicate aquaria = >20 liters
<i>Arenicola marina</i> or <i>Abarenicola sp.</i>	>500 mL per beaker x 4 beakers per 8 L-aquarium = 2 L/aquarium 5 replicate aquaria = >10 liters
<i>Co-testing:</i> <i>Macoma/Nephtys</i>	3.87 L per 37.8 liter aquarium (10 gallon) 5 replicate aquaria = >20 liters

Because of the prohibitively high volumes of material needed to conduct this test with two species, dredging applicants may elect not to archive material necessary to conduct the bioaccumulation test against the risk of exceeding a chemical bioaccumulation trigger. If a bioaccumulation trigger is exceeded for one or more of the twenty-nine chemicals of concern, an applicant must remobilize to collect the sediment needed to conduct the bioaccumulation test.

In the event resampling is necessary the sediment sample must be reanalyzed for the chemical(s) exceeding bioaccumulation triggers to properly assess the actual test exposure levels. A recent experience where resampling was necessary resulted in a five-fold difference between the initial and resampled sediment chemical concentration. In this case, the agencies, utilizing best professional judgment, adjusted the bioaccumulation tissue concentrations proportionally upward based on the ratio between the first and second round sediment chemical concentrations.

Species substitution /Co-testing of two species. The current PSDDA testing protocol calls for conducting a 28-day bioaccumulation test with a facultative deposit/suspension-feeding adult bivalve (*Macoma nasuta*) and a deposit-feeding adult polychaete (i.e., either *Nereis virens* or *Arenicola marina/Abarenicola* sp. Conducting bioaccumulation tests with either of the aforementioned adult polychaete species will generally require conducting separate tests (e.g., adult bivalve and adult polychaete tests).

The "Green Book", (EPA/COE, 1991) also recognizes *Nephtys* sp. as an approved adult polychaete species suitable for evaluating acute toxicity and bioaccumulation concerns in dredged material for ocean disposal. *Nephtys* sp. may be conducted in aquaria with *Macoma nasuta*. The PSDDA agencies recently conducted a successful bioaccumulation test co-testing *Macoma nasuta* and *Nephtys caecoides* within the same aquaria following the protocol developed by Battelle (1992). This reduced sediment testing volume requirements and setup costs. The general co-testing setup volume requirements are noted in Table 2.

PROPOSED ACTION/MODIFICATION

To provide flexibility and enable co-testing of two species in a single testing chamber (aquarium), the PSDDA program will allow the substitution of *Nephtys* sp. in place of either *Nereis virens* or *Arenicola/Abarenicola* sp. when conducting the bioaccumulation test. Applicants proposing to co-test species within the same aquarium should follow the Battelle (1992) protocol, and must articulate their bioaccumulation testing approach in a PSDDA approved sampling and analysis plan.

Applicants electing not to archive samples for potential bioaccumulation testing, and where resampling is necessary to accomplish bioaccumulation testing, will be required to reanalyze the targeted chemical(s) triggering the bioaccumulation testing.

REFERENCES

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