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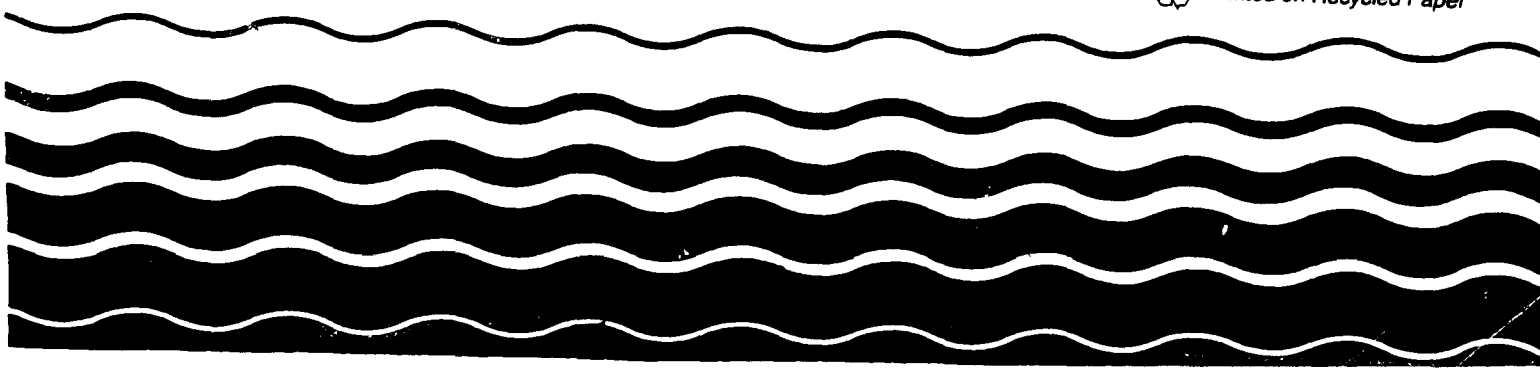
Guidelines for Deriving Site-Specific Sediment Quality Criteria for the Protection of Benthic Organisms



GUIDELINES FOR DERIVING SITE-SPECIFIC SEDIMENT QUALITY CRITERIA FOR THE PROTECTION OF BENTHIC ORGANISMS

(Office of Science and Technology
Office of Research and Development)

PURPOSE AND APPLICATION

The purpose of the "Guidelines for Deriving Site-Specific Sediment Quality Criteria (SQC) for the Protection of Benthic Organisms" is to provide guidance for the development of sediment quality criteria for nonionic organic chemicals which reflect local environmental conditions. These site-specific criteria may be utilized as a part of the basis for establishing site-specific sediment quality standards to protect the uses of a specific water body. These guidelines should be used only after understanding the National Water Quality Criteria (WQC) Guidelines (Stephan et al., 1985), response to public comment (U.S. EPA, 1985), Site-Specific WQC Guidelines (U.S. EPA, 1983), National SQC Guidelines (U.S. EPA, 1993a), the SQC Technical Support Document (U.S. EPA, 1993b) and SQC documents for the chemical of concern.

The sediment quality criteria have been developed specifically for use in the 304(a) criteria program. It is most appropriate that the need for a site-specific modification to a sediment quality criteria be evaluated during the development or updating of a States water quality standards. Application of a site-specific modification at the standards development stage helps alleviate both the burden on the permit writer to research and write permit modifications by permittees as a means to avoid strict effluent limitations.

The Office of Water recognizes, and has encouraged, that the criteria will be used by many other programs. The appropriate used of the site-specific modification procedures in these programs should be obtained from the implementation guidance developed by that program for inclusion in the "Guide for the Use and Application of Sediment Quality Criteria for Nonionic Organic Chemicals". (U.S. EPA, 1993b)

Rationale for the Development of Site-Specific Criteria

National sediment quality criteria guidance may be under or over protective if: (1) the species at the site are more or less sensitive than those included in the national criteria data set or (2) the sediment or chemical quality characteristics at that site alter the bioavailability consequently the toxicity of the sediment bound chemical predicted by Equilibrium Partitioning (EqP). Therefore, it is appropriate that site-specific guidelines procedures address each of these conditions separately, as well as jointly.

Site-specific criteria development is justified because species at a site may be more or less sensitive than those in the national document. For example, the national criteria data set may contain data for salmonids, daphnids, penaeids or mysids, families that have been shown to be especially sensitive to some chemicals. Since these, or other sensitive taxa, may not occur at a particular site, their sensitivities may not be representative of the sensitivities of those species that do occur there or at a similar non-degraded site. Conversely, untested uniquely sensitive species that are ecologically or economically important which need to be

protected may exist at the site. The "Deletion/Substitution Procedure" described in this document is intended to be used to modify national SQC to account for these differences in species sensitivity.

Although a variety of sediments have been tested to ensure the EqP approach is applicable to a wide array of sediments, sites may possibly exist where EqP theory does not accurately predict the bioavailability and toxicity of contaminants in the sediments. Unique sediment characteristics, chemical speciation, or chemical form may make the criteria chemical more or less bioavailable thereby altering the toxicity of the sediment. For example, in some sediments PAHs are known to occur as particulates not partitioned to organic carbon. The "Bioavailability Procedure" described in this document is intended to be used to modify national SQC to account for these differences in bioavailability.

Finally, differences in species sensitivity and chemical bioavailability at a specific site may, in combination, make derivation of a more appropriate site-specific SQC desirable. For these reasons, EPA provides guidance for the derivation of site-specific SQC. The "Empirical Derivation Procedure" described in this document is intended to be used to modify national SQC to account for both of these differences.

If the sediments are toxic, the national SQC apply and site-specific criteria modifications are not permitted. If sediments are toxic, sediment Toxicity Identification Evaluations (Ankley et al., Draft) are recommended to attempt to identify chemicals causing observed effects.

Definition of Site:

The rationales for site-specific guidelines are based on either (1) potential differences in sensitivity of species resident at a site relative to those used to derive the national SQC; (2) potential differences in the characteristics of sediment or the chemical at the site that alter biological availability; or (3) a combination of these differences. The concept of site must be consistent with these rationales. Therefore, the definition of site is different for species sensitivity and biological availability.

Derivation of a site-specific SQC based on species sensitivity differences requires that resident species that occur at the site be identified. Because species that occur at the site includes pertinent, seasonal, intermittent and those species excluded because of anthropogenic causes, the spatial and temporal extent of the site must be large. Therefore, the definition site must be broad enough to include the immediate site of concern over time, other similar unimpacted or impacted sites and may include entire biogeographic providences. If the sediment is to be moved, the species at the site where sediments will be placed should be included as site-species.

Derivation of a site-specific SQC based on bioavailability differences requires that the site be narrowly defined to include the spatial extent of the site, where SQC are exceeded or

unique site-specific characteristics of the sediment or the chemicals form are believed to violate assumptions of biological availability that are fundamental to equilibrium partioning-based SQC. Therefore, the spatial extent of the site as applied to the Bioavailability Approach only includes the area containing sediments that are believed to be unique from a chemical availability perspective.

Derivation of a site-specific SQC based on the Empirical Derivation Approach requires a definition of site that is appropriately a mix of that used in the preceding two approaches. Selection of resident species for testing should use the same definition of site as the Deletion/Substitution Approach. Sediments to be tested should be selected from the site as defined by the Bioavailability Approach. Resultant site-specific SQC apply only to the site defined by the Bioavailability Approach.

Goals of Site-Specific Criteria Modification:

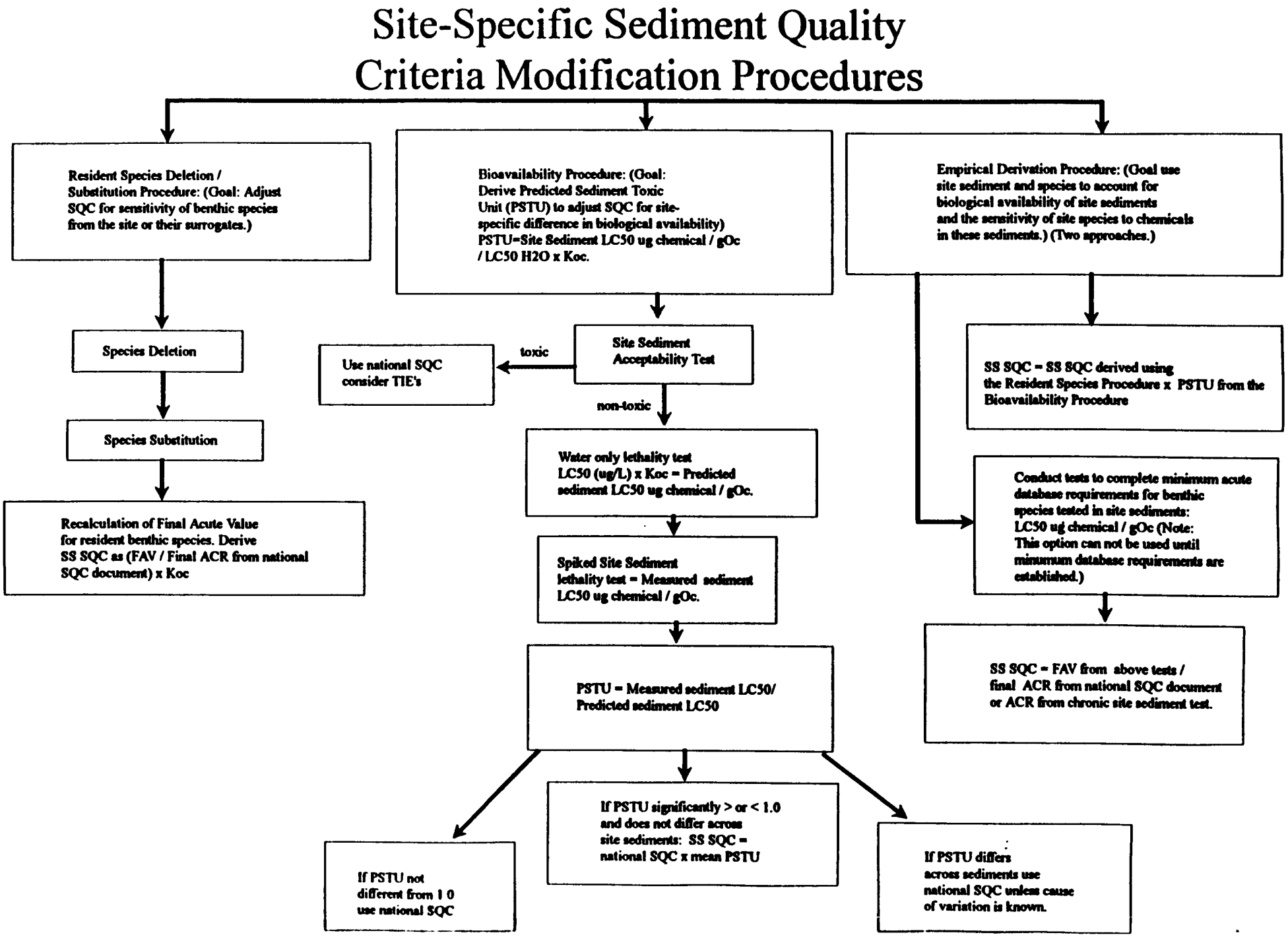
The goal of this document is to describe procedures which can be used to modify national SQC values. The procedures are similar to those recommended for use in modification of national water quality criteria values (U.S. EPA, 1983). They include (Figure 1): (1) a Resident Species Deletion/Substitution Procedure to adjust SQC for sensitivity of species found at the site; (2) a Bioavailability Procedure to derive a sediment effects ratio to adjust national SQC to account for site-specific differences in bioavailability; and (3) an Empirical Derivation Procedure to experimentally derive site specific SQC using toxicity tests with site sediments and resident benthic species (Figure 1). It is EPA's intent that modification of the national SQC will rarely be needed. Therefore, preliminary site specific evaluations are recommended prior to initiation of these site-specific modification procedures. For example, examination of sensitivities of major taxa related to a resident species list must occur prior to selecting species for substitution tests. In addition, it may be informative to conduct range-finding site sediment spiking tests prior to beginning definitive bioavailability testing.

Numerous efforts to conduct site-specific water quality criteria modifications have demonstrated that site-specific experimental designs and QA/QC concerns in the conduct of the tests, not the theoretical basis of the site-specific modification or required procedures, have caused failures to justify the need for site-specific water quality criteria (Brungs, 1991). Therefore, we strongly recommend that users of these guidelines for developing site-specific SQC consult early on and closely with the U.S. EPA Offices of Science and Technology, Research and Development and appropriate Regional Office in the design and conduct of these procedures. [Specific individual to contact will be listed here in the final document.]

PROCEDURES FOR CONDUCTING SITE-SPECIFIC SQC MODIFICATIONS:

Resident Species Deletion/Substitution Procedure:

Figure 1. Flow chart of approach for deriving site specific sediment quality criteria.



Description:

This deletion/substitution procedure is intended to result in a site-specific SQC that appropriately differs from the national SQC when there are pertinent differences in the sensitivities of benthic organisms that occur at the site and those used to derive the national SQC concentration. This procedure follows that of the WQC recalculation procedure discussed in "The Determination and Use of Water-Effect Ratios for Metals" (Stephan et al., Draft.)

Rationale:

This approach may be relevant because: (1) SQC are intended to protect benthic organisms so acute values for water column species or water column life-stages of species that also have benthic life stages may not be relevant to SQC derivation unless they are toxicological surrogates for taxonomically related untested resident benthic species or life-stages. (2) Sensitive or insensitive benthic species used to derive the national SQC may not occur at the site. (3) The species that occur at the site might be taxonomically limited because of the limited range of environmental conditions at the site.

For the purposes of these site-specific guidelines, resident organisms "that occur at the site" is defined as those benthic species, genera, families, orders, classes or phyla of organisms that periodically or commonly occur at the site. (See previous definition of site.) This includes organisms that occur continually, seasonally, intermittently and those that are now absent because of anthropogenic causes. Organisms absent because of physical changes such as impoundment of rivers are not considered resident. This will require use of historical species lists for the site and use of biological assessment databases from nearby reference sites.

Deletion begins at the life-stage and species level, proceeds through higher taxonomic levels and considers the need for acute values from test with nonresident benthic species or water column lifestages of benthic species to be toxicological surrogates for taxonomically related but untested resident benthic species. Testing with resident benthic species is required to complete minimum database requirements for deriving criteria, to obtain data on endangered or threatened species or their surrogates and to provide data when it is desirable to replace acute values for water column or nonresident species that serve as surrogates for untested resident species.

Use of this procedure may increase, decrease or fail to change the national criteria. If highly sensitive species are not present at the site an increase in the criterion is likely. If the number of acute values in decreased the criterion will likely decrease. Additional testing may reveal uniquely sensitive or resistant species that could lower or raise the criterion. Because water column and benthic species have similar sensitivities (Di Toro et al., 1991), deletion of acute values for water column species or lifestages and replacement with newly obtained data on benthic organisms would seem likely to not markedly alter the criterion.

Details of the Resident Species Deletion/Substitution Procedure:

The basic principals of the deletion substitution option are:

1. A literature search must be conducted so that all available acceptable data approved by EPA that are not in the SQC document Appendix A are used to recalculate the Final Acute and Final Chronic Values.

2. In all cases, deletion and substitution decisions must apply to the entire database not just sensitive species.

3. If data are not available for a rare or endangered species that occurs at the site, data must be available or generated for an acceptable surrogate species. (See Stephan et al., (1985) for details on test requirements.)

4. All acute values for benthic life-stages of resident species must be retained in the database.

5. It is only appropriate to delete acute values for water column lifestages of resident species if data on the sensitivity of benthic lifestages for that species exist or are produced. Further, acute values for water column species with no benthic life-stage can only be deleted if its' sensitivity is not a surrogate or co-surrogate (defined later) for taxonomically related benthic species. Water column life-stages of that species or related species until data are available on benthic life-stage sensitivity.

6. It is appropriate to delete acute values for benthic or water column life-stages of non-resident species if they are not surrogates or co- surrogates for benthic life-stages of resident species.

7. If a non-resident species is the only tested representative of a genus, family or higher taxon that is resident, deletion is not permitted unless a resident benthic species from that taxon is tested.

8. If one or more resident species in a genus, family or higher taxon have not been tested, data from non-resident species can not be deleted, even if data exist for resident species, because data for non-resident and resident species are viewed as co-surrogates for untested resident species.

9. Therefore, the following data can be deleted: (a) Acute values from tests with water column life-stages of resident species, providing acute values for benthic life-stages of that species are known or obtained. (b) Acute values for non-resident species when resident species from the same genus, family or higher taxon do not occur at the site. (c) Acute values for non-resident species when all other species in that genus or higher taxon have been tested. (d) Acute values can be obtained on benthic life stages of resident species to permit deletion of data on water column life-stages and on benthic life-stages of all non-resident species in a particular genus or higher taxon to eliminate need for data on non-resident to serve as a surrogate or co-surrogate for untested resident benthic species.

Derivation of the Site-Specific SQC:

1. Following the deletion substitution process steps for data analysis in Stephan et al. (1985) must be followed. Species Mean Acute Values (SMAV) and Genus Mean Acute

Values (GMAV) must be calculated . If minimum database requirements are met, except those that require water column species, a site-specific FAV is calculated. If an acute value for an endangered, threatened, commercially, recreationally or ecollogically important species is lower than the FAV, this value becomes the FAV. Finally, the FAV is divided by the Final Acute Chronic Ratio (FACR) from the SQC document to derive the site-specific Final Chronic Value (FCV).

2. The site-specific SQC is the product of the site-specific FCV and the K_{oc} from the SQC document.

3. Use this SQC and the procedures in Section 5 of the SQC document to derive the 95% confidence intervals.

4. All steps in the derivation of a site-specific SQC must be documented in a report including: A table listing all species and their life-stages used to derive SMAVs, all species and lifestages deleted, test conditions SMAV, GMAV and references for source of acute values. This table should be similar to Appendix A in the SQC documents. The new calculated FAV, FACR, FCV SQC should appear after the tabular presentation of toxicity data. All resident commercially, recreationally and ecologically important, and threatened or endangered species must be listed to permit comparisons between their sensitivities and the FAV or FCV. All other species known to be resident to the site and the source of this information must also be listed.

$$\text{Site-Specific SQC} = (\text{Site-Specific FCV})K_{oc}$$

Bioavailability Procedure:

Description:

EPA sediment quality criteria for nonionic organic chemicals are based on the EqP model. It is possible that sediments may exist for which the EqP model for SQC may not apply. In this case, the toxicity of the sediment cannot be predicted from the water only tests and the K_{oc} because, in addition to organic carbon, other properties of the site sediments may alter bioavailabilty. For these sediments, site-specific criteria modification using the Bioavailability Procedure is warranted. The Bioavailability Procedure is analogous to the "Indicator Species" procedure employed for modifying national WQC for site-specific differences in bioavailability (U.S. EPA, 1983). The Bioavailability Procedure presented below employs a sediment effects ratio (Predicted Sediment Toxic Unit, PSTU) derived as the ratio of the EqP predicted effects concentration and the actual effects concentration from sediment toxicity tests using spiked sediments from the site. If the ratio is significantly different from the PSTU values used to derive the uncertainty of the SQC and uniform across sediments from the site , the site- specific SQC is the product of the national SQC value and the PSTU. It is important to note that the method may lower site-specific SQC because the sediment spiking tests required may measure interactions from other chemicals present in sediments from the site.

Details of the Bioavailability Procedure:

This method requires an initial sediment acceptability test, a flow-through measured water-only lethality test lasting at least 10 days and spiked-sediment lethality tests of the same duration using a minimum of three sediments from the site. These tests should be similar to tests employed in chemical-specific verification of the EqP prediction described in the sediment quality criteria documents. (See EPA criteria document Section 4, table 4-1, table 4-2, figure 4-2, Appendix C and references to these data as cited in the SQC document.) An acute sediment lethality test is selected which is appropriate for the water type (fresh or marine water), sediment type (sandy, muddy) and species sensitivity to the chemical. Table 1 lists the species tested in SQC documents, other appropriate tests and the references for the experimental procedures. Standardized biological tests using benthic species that have durations $\geq$ 10 days are prefered. Species selected for site-specific testing using the Bioavailability Procedure must, if possible, be selected from the list of benthic taxa demonstrated to be most sensitive to the chemical of concern even if they are not resident to the site or listed in Table 1. (See Table 3-1 or Appendix A of SQC documents.)

A minimum of 3 sediments that exceed the SQC, or that are believed to be chemically or physically unique, from the site should be selected for testing. If the size of the site is large, additional sediments may be required to span the range of physical/chemical sediment conditions. Procedures for sediment collection and storage required by ASTM (1992a) should be followed.

The first step in beginning the use of this site-specific modification method is to determine the acceptability of the sediments to the species to be tested. Survival of the selected species for the duration of the experiment must exceed 80% unless otherwise specified in specific methodologies. This procedure requires exposure of the test organism to sediments from each of three or more sites for a minimum of 10-days or the duration of the water-only and sediment tests described below. Use of acceptable sediments in tests in parts 2 and 3 should insure that these tests are completed successfully.

Secondly, conduct water-only toxicity tests with the species to be used in the sediment tests to determine, at a minimum, a 10-day LC50 using flow-through procedures in which tested concentrations are measured (ASTM, 1989). Compute the predicted 10-day LC50 on an organic carbon basis as the $LC50_{H20} \times K_{OC} = LC50_{sed,OC}$ and 95% confidence limits; using the K_{OC} from the SQC document.

Third, conduct sediment toxicity tests to determine sediment-specific 10 day LC50 values for the species tested in water-only experiments.

The experimental design for the series of sediment toxicity tests follows:

- Select sediment concentrations on an organic carbon basis to bracket the predicted sediment LC50. Generally, dilutions should be no greater than 0.5 $\log_{10}$ units with three treatments above and two below the predicted sediment LC50. For example, if the predicted LC50 is 8.4 $\mu g/g_{OC}$, treatments might be control 1.0, 3.2,

Table 1. - Toxicity tests that can be used to modify national sediment quality criteria using the Bioavailability or Emperical Derivation Procedures. (I = Infaunal; E = Epibenthic; CV = Chronic Value)

Organism	Habitat	Test	Endpoint	Days Duration	References	
					Method	SQC Method
			Saltwater			
Polychaetes						
Neanthes arenaceodentata	I	Acute	LC50	10	Pesch et al., 1991	-
" "	I	Life-cycle	CV	150	Pesch et al., 1991	-
Amphipods						
Ampelisca abdita	E	Acute	LC50	10	ASTM, 1992b	DiToro, 1990
" "	E	Life-cycle	CV	56	Scott and Redmond, 1989	-
Eohaustorius estuarius	I	Acute	LC50	10	ASTM, 1992b	Swartz, 1991
Grandidierella japonica	I	Acute	LC50	10	ASTM, 1992b	-
Leptocheirus plumulosus	I	Acute	LC50	10	ASTM, 1992b	Swartz, 1991
" "	I	Life-cycle	CV	?	?	-
Rhepoxynius abronius	I	Acute	LC50	10	ASTM, 1992b	Swartz et al., 1990
			Freshwater			
Amphipods						
Hyalella azteca	E	Acute	LC50	10	ASTM, 1992c	Hoke and Ankley, 1991
" "	E	Life-cycle	CV	30	ASTM, 1992c	-
Insects						
Chironomus tentans	E	Acute	LC50	10	ASTM, 1992c	Hoke and Ankley, 1992
" "	E	Life-cycle	CV	25	ASTM, 1992c	-
Chironomus riparius	E	Acute	LC50	10	ASTM, 1992c	-
" "	E	Life-cycle	CV	30	ASTM, 1992c	-

10, 32 and 100 $\mu g/g_{OC}$. Range finding experiments may be desirable for selecting test concentrations, if EqP predicted bioavailability proves to be incorrect.

- For each of the three or more site-sediments tested there should be a control and a minimum of five spiked sediment treatments. Sediments should be spiked a minimum of 2 weeks before initiation of the spiked sediment toxicity test. Methods for chemical spiking have been recommended by ASTM (1992a), Environment Canada (1993) and U.S. EPA (1993b). For chemicals with high partition coefficients, chemical analyses to demonstrate stability of pore water concentrations or toxicity tests to demonstrate constancy of response may be required.

- Each treatment should contain 3 biology replicates and 2 replicates for chemical determination.

- Control survival in biology replicates must be greater than 80 percent unless otherwise stated in specific methodologies.

- Chemistry replicates are sampled for interstitial water chemical and DOC, and sediments for TOC and total chemical concentrations; the first replicate is sampled on day 0 and the second at test termination (day 10). The day 10 chemical replicate must contain the tested organism. Interstitial water is sampled by centrifugation using the method of Edmunds and Bath (1976). Freely dissolved chemical concentrations in interstitial should be quantified using the method of Landrum *et* al., 1984. If the EqP-based SQC are applicable to site-sediments, interstitial measurements are not necessary. However, they are essential if partitioning is not as predicted by the K_{OC} from the SQC document.

- A statistical test is employed to determine if the three site LC50s are statistically different from the prediction using EqP. The prediction is calculated as follows. For each sediment the predicted sediment toxic unit concentration (PSTU) is calculated:

$$PSTU = LC50_{sed,OC} / (K_{OC} \times LC50_{H20})$$

Where $LC50_{sed,OC}$ is the site sediment LC50 on an organic carbon basis, K_{OC} is the organic carbon partition coefficient from the sediment quality criteria document, and $LC50_{H20}$ is the water only LC50. The EqP model predicts that PSTU = 1 within the EqP model uncertainty for each site sediment. A statistical test is employed to test whether the PSTUs for each sediment are statistically different from the uncertainties of the PSTU prediction in the national SQC document (Table 2). The statistical analysis should incorporate variability in PSTU values from site-specific sediment tests and variability inherent in sediment tests used

to calculate the uncertainty of SQC values. If they are not statistically different, the EPA national criteria are used without modification.

If they are statistically different, then the geometric mean of the PSTU values is computed and it is used as the Site Sediment Effects Ratio.

A two sample t-test is used to determine if the "site" PSTU's come from the same population as the "database" PSTU's. First the PSTU's are log normalized. (The distribution of the logs of the 32 PSTU's (Table 2) in the existing database was not significantly different from normal; SAS, Proc Univariate.) An F-max test (Sokal and Rohlf, 1981) can be used to test if the variances of the "database" and "site" PSTU's are significantly different. If the variances of the "database" and "site" log PSTU's are not significantly different the means of the log PSTU's can be compared using the following formula:

$$t = \frac{x_d - x_s}{S_p (1/n_d + 1/n_s)^{1/2}}$$

Where:

t = t value of the difference between the means
x_d = mean of the log "database" PSTU's
x_s = mean of the log "site" PSTU's
S_p = pooled variance of the "database" and "site" PSTU's
n_d = number of "database" PSTU's
n_s = number of "site" PSTU's

If the variances are significantly different, an approximate t-test can be used (Sokal and Rohlf, 1981). A two-sided test is appropriate because it is being used to determine if there is a greater or lesser difference between the mean of the "database" PSTU's and the mean of the "site" PSTU's.

Derivation of the Site-Specific SQC:

Following completion of acceptable toxicity tests demonstrating a PSTU greater or less than PSTU values used to derive the uncertainty of the national SQC concentration, the site-specific SQC can be derived:

Site-Specific SQC = National SQC X Mean PSTU

If the PSTU is significantly different from one, then the chemical in site sediments is less bioavailable than is predicted by EqP, and the national SQC is appropriately increased. This would be the case if, the organic carbon is more sorptive than the K_{OC} used, there are

TABLE 2: PREDICTED SEDIMENT TOXIC UNITS (PSTU)[a]
(Note: For additional information see Sediment Quality Criteria Documents.)

Chemical	Common/Sci Name	Method[a] Duration (days)	Sediment TOC (%)	Water Only LC50 µg/L	K_{oc} L/Kg_{oc}	Sediment LC50 Measured µg/g_{oc}	Sediment LC50 Predicted[b] µg/g_{oc}	Ratio: Measured/ Predicted (PSTU)[c]	Reference
Acenaphthene	Amphipod, Eohaustorius estuarius	FT,M/10	1.23 0.82	374	3.78	4,330	2,250	1.92	Swartz,1991
"	Amphipod, Eohaustorius estuarius	FT,M/10	2.49	374	3.78	1,920	2,250	0.85	Swartz,1991
"	Amphipod, Eohaustorius estuarius	FT,M/10	4.21	374	3.78	1,630	2,250	0.72	Swartz, 1991
"	Amphipod, Leptocheirus plumulosus	FT,M/10	1.62 0.82	678	3.78	>23,500	4,080	>5.76	Swartz, 1991
"	Amphipod, Leptocheirus plumulosus	FT,M/10	2.52	678	3.78	7,730	4,080	1.89	Swartz, 1991
"	Amphipod, Leptocheirus plumulosus	FT,M/10	3.66 2.97	678	3.78	11,200	4,080	2.74	Swartz, 1991
Dieldrin	Amphipod, Hyalella azteca	FT,M/10	1.7	7.3	5.16	1,073	1,060	1.01	Hoke and Ankley, 1991
"	Amphipod, Hyalella azteca	FT,M/10	2.9	7.3	5.16	1,111	1,060	1.05	Hoke and Ankley, 1991
"	Amphipod, Hyalella azteca	FT,M/10	8.7	7.3	5.16	3,682	1,060	3.47	Hoke and Ankley, 1991
Endrin	Amphipod, Hyalella azteca	S,M/10	3.0	4.2	4.82	147	277	0.53	Nebeker et al., 1989
"	Amphipod, Hyalella, azteca	S,M/10	6.1	3.8	4.82	78.7	251	0.31	Nebeker et al., 1989
Endrin	Amphipod, Hyalella azteca	S,M/10	11.2	4.3	4.82	53.6	284	0.19	Nebeker et al., 1989
"	Amphipod, Hyalella azteca	S,M/10	3	4.1	4.82	170	271	0.63	Schuytema et al., 1989

"	Amphipod, *Hyalella azteca*	S,M/10	3	4.1	4.82	257	271	0.95	Schuytema et al., 1989
"	Amphipod, *Hyalella azteca*	S,M/10	11	4.1	4.82	178	271	0.66	Schuytema et al., 1989
"	Amphipod, *Hyalella azteca*	S,M/10	11	4.1	4.82	197	271	0.73	Schuytema et al., 1989
"	Amphipod, *Hyalella azteca*	S,M/10	11	4.1	4.82	93.6	271	0.35	Schuytema et al., 1989
"	Amphipod, *Hyalella azteca*	S,M/10	11	4.1	4.82	89.1	271	0.33	Schuytema et al., 1989
Fluoranthene	Amphipod, *Rhepoxynius abronius*	S,M/10	0.18	27.2	5.10	1,890	3,420	0.553	Swartz et al., 1990
"	Amphipod, *Rhepoxynius abronius*	S,M/10	0.31	27.2	5.10	2,100	3,420	0.614	Swartz et al., 1990
"	Amphipod, *Rhepoxynius abronius*	S,M/10	0.48	27.2	5.10	2,230	3,420	0.652	Swartz et al., 1990
"	Amphipod, *Rhepoxynius abronius*	S,M/10	0.34	27.2	5.10	5,620[f]	3,420	1.64	DeWitt et al., in press
"	Amphipod, *Rhepoxynius abronius*	S,M/10	0.34	27.2	5.10	4,410	3,420	1.29	DeWitt et al., in press
"	Amphipod, *Rhepoxynius abronius*	S,M/10	0.40	27.2	5.10	3,150	3,420	0.921	DeWitt et al., in press
"	Amphipod, *Rhepoxynius abronius*	S,M/10	0.31	27.2	5.10	3,080	3,420	0.900	DeWitt et al., in press
"	Amphipod, *Rhepoxynius abronius*	S,M/10	0.31	27.2	5.10	2,790	3,420	0.816	DeWitt et al., in press
Phenanthrene	Amphipod, *Eohaustorius estuarius*	FT,M/10	1.02 0.82	131	3.78	4,050	2,550	1.59	Swartz, 1991
"	Amphipod, *Eohaustorius estuarius*	FT,M/10	2.47	131	3.78	3,920	2,550	1.54	Swartz, 1991
"	Amphipod, *Eohaustorius estuarius*	FT,M/10	3.33 2.97	131	3.78	3,820	2,550	1.50	Swartz, 1991
"	Amphipod, *Leptocheirus plumulosus*	FT,M/10	1.96 0.82	185	3.78	8,200	3,610	2.27	Swartz, 1991
"	Amphipod, *Leptocheirus plumulosus*	FT,M/10	2.50	185	3.78	6,490	3,610	1.80	Swartz, 1991

"	Amphipod, Leptocheirus plumulosus	FT,M/10	2.97	185	3.78	8,200	3,610	2.27	Swartz, 1991

[a]FT = flow-through, M= measured concentration, s = static

[b]Predicted LC50 $\mu g/g^{OC}$ = water-only $LC50_{\mu g/L}$ X $K_{OC,L/Kg_{OC}}$ X $1Kg_{OC}/1000g$

cPredicted Sediment Toxic Units (PSTU): Measured LC50 in a sediment divided by the predicted LC50 in sediment (water-only LC50 ($\mu g/L$) x K_{OC} (L/Kg_{OC}) x 1 $Kg_{OC}/1000g_{OC}$)

additional significant sediment sorption phases in addition to organic carbon or if the chemical has unique phases. If the PSTU is significantly less than one, then the chemical in site sediments is more bioavailable than is predicted by EqP, for example if organic carbon was less sorptive than indicated by K_{oc} or if additional chemicals in the sediment are contributing to sediment toxicity, and the national SQC is appropriately decreased.

Empirical Derivation Procedure

Desciption:

The Empirical Derivation Procedure can be used to experimentally derive a site-specific SQC from the results of acute and chronic toxicity tests with resident benthic species exposed to the chemical spiked into site sediments.

Details of the Empirical Derivation Procedure:

The Empirical Derivation Procedure utilizes data from acute and chronic toxicity tests with resident species and spiked sediments from the site to derive a site-specific SQC. The procedure assumes organic carbon normalization of the chemical concentration in sediments from the site appropriately adjusts for the bioavailability of the nonionic organic chemical. A sediment acceptability test, as described for the Bioavailability Procedure, is required prior to beginning the Empirical Derivation Procedure. Sediments from the site are spiked with the chemical and a specified number of acute lethality tests with benthic species are conducted to complete minimum database requirements. EPA is in the process of selecting this minimum database to be representative of the range of phylogeny, sensitivity, habitat/feeding type and community function of benthic species and meet the spirit of the minimum database requirements contained in WQC Guidelines (Stephan et al., 1985). This procedure can not be used until this database is specified. Guidance for collection, holding, spiking, testing and test acceptability contained in ASTM (1992 a,b,c), Environment Canada (1993) and U.S. EPA (1993b), should be followed. Valid data from acute lethality tests that meet minimum database requirements will be used to calculate a Final Acute Value (FAV) using the procedure in the national WQC guidelines (Stephan et al., 1985).

Life-cycle toxicity tests with benthic species, under development by EPA and others, can be conducted with site sediments spiked with the chemical. Valid chronic toxicity data that meets minimum database requirements can be used to experimentally derive a Final Acute-Chronic Ratio. Alternatively, the Acute-Chronic Ratio from the SQC document derived from water-only tests can be used to derive the Final Chronic Value from the empirically derived FAV. Future development of a suite of chronic tests with representative benthic species may permit direct testing to derive a Final Chronic Value.

Derivation of the Site-Specific SQC:

The site-specific SQC is calculated by dividing the Final Acute Value (FAV) derived

from sediment toxicity tests by the mean Acute-Chronic Ratio (ACR) from the SQC document or from chronic sediment tests. If the geometric mean of the Predicted Sediment Toxic Unit (Mean PSTU) value is significantly different from that expected from the EqP prediction, the site-specific SQC can be appropriately adjusted.

$$\text{Site-Specific SQC} = \text{FAV}\mu g/g_{oc} \div \text{ACR}$$

or

$$\text{Site-Specific SQC} = (\text{FAV}\mu g/g_{oc} \div \text{ACR})\ \text{Mean PSTU}$$

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