BRITISH COLUMBIA

Ministry of Water, Land and Air Protection

P3 DRAFT

DIRECTOR'S CRITERIA FOR CONTAMINATED SITES

Criteria for Managing Contaminated Sediment in British Columbia

Prepared pursuant to Section 11 (1) (d) of the
Contaminated Sites Regulation under the
Waste Management Act

Approved: _____ _____

Director of Waste Management — Date

Effective:

DIRECTOR'S CRITERIA FOR CONTAMINATED SITES: CRITERIA FOR MANAGING CONTAMINATED SEDIMENT IN BRITISH COLUMBIA

1.0 INTRODUCTION

Traditionally, concerns relative to the management of aquatic resources in freshwater and marine systems have focussed primarily on water quality. However, contaminated sediments also represent an important environmental concern for several reasons:

- Sediment associated contaminants can be directly toxic to sediment-dwelling organisms.
- Contaminated sediments can impact fish communities through direct toxicity and reductions in the abundance of fish food organisms.
- Certain contaminants can bioaccumulate in the food web and, in so doing, adversely affect piscivorous wildlife and human health. Unacceptable levels of such bioaccumulative contaminates in fish and other aquatic organisms may lead to the imposition of consumption advisories for fish and shellfish which can adversely affect economic and recreational uses of aquatic ecosystems.
- Contaminated sediments can compromise human health due to direct exposure during wading or swimming.

As such, contaminated sediments in freshwater and marine ecosystems pose potential hazards to aquatic organisms, aquatic-dependent wildlife species, and human health.

In British Columbia, the federal and provincial governments share authority for assessing and managing contaminated sediments under the *Fisheries Act* (FA), the *Waste Management Act* (WMA), and the *Canadian Environmental Protection Act* (CEPA).
In recognition of the need to establish harmonized procedures for assessing and managing contaminated sites in British Columbia, the ***Federal/Provincial Technical Committee on the Development of Sediment Quality Criteria for Assessing and Managing Contaminated Sites*** (Sediment Technical Committee; consisting of representatives of the British Columbia Ministry of Water, Land, and Air Protection - BCWLAP, Environment Canada - EC, and Fisheries and Oceans Canada - DFO) was established in January, 1998. This committee was charged with the task of developing a joint federal-provincial framework for assessing and managing contaminated sediments, a guidance manual to support the design and implementation of sediment quality assessments at contaminated sites, and Sediment Quality Criteria (SedQC) to support the management of contaminated sediments.

2.0 REGULATORY AUTHORITY

The Contaminated Site Regulation (CSR) (BC 1997), as promulgated under the provincial *Waste Management Act,* provides detailed guidance on a range of issues related to the assessment and management of contaminated sites, including numerical standards for soil and water. While no specific guidance on the management of contaminated sediments was established in the CSR, the need to develop such guidance is indicated in the *Waste Management Act*. Specifically, Section 26 (1) of the *Act* (BC 1996) states that:

> *"a contaminated site means an area of land in which the soil or any groundwater lying beneath it, or the water or the underlying sediment, contains: a special waste; or, another prescribed substance in quantities or concentrations exceeding prescribed criteria, standards, or conditions."*

The regulatory authority under which the Director may establish standards for use in the assessment and remediation of contaminated sites can be found in section 26 (1) of the *Waste Management Act* (BC 1996) and section 11 (1) (d) of the Contaminated Sites Regulation (BC 1997).

This document represents the Ministry of Water, Land and Air Protection's (Ministry) policy for contaminated sediment management until cancelled or until legal standards for sediment contaminated sites are established under the *Waste Management Act*. This document presents Ministry criteria for managing contaminated sediment at sites in British Columbia. These criteria are to be used to determine if sediments are contaminated, to assess the need for remedial measures, and to develop remediation targets for sediments at contaminated sites.

These Director's criteria have legal standing under the provisions of the Contaminated Sites Regulation. The criteria herein represent the consensus of the Federal/Provincial Technical Committee.

3.0 DIRECTOR'S CRITERIA FOR MANAGING CONTAMINATED SEDIMENTS IN BRITISH COLUMBIA

The Director has established the following sediment quality criteria (SedQCs) and tissue residue criteria (TRCs) for use in the assessment and remediation of contaminated sediments under the CSR.

TABLE 1 GENERIC SEDIMENT QUALITY CRITERIA[1, 2]

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V
	FRESH WATER[3]		MARINE and ESTUARINE WATER[4]	
Substance	**Sensitive Contaminated Sites ($SedQC_{SCS}$)**	**Typical Contaminated Sites ($SedQC_{TCS}$)**	**Sensitive Contaminated Sites ($SedQC_{SCS}$)**	**Typical Contaminated Sites ($SedQC_{TCS}$)**
Inorganic Substances				
arsenic	12 000	20 000	25 000	50 000
cadmium	2 100	4 200	2 400	5 040
chromium	64 000	110 000	110 000	190 000
copper	120 000	240 000	65 000	130 000
lead	63 000	110 000	70 000	134 000
mercury	330	580	420	840
zinc	220 000	380 000	200 000	330 000
Polychlorinated Biphenyls (PCBs)				
PCBs	156	332	105	230
Polycyclic Aromatic Hydrocarbons (PAHs)				
Low Molecular Weight PAHs (LMW-PAHs)				
acenaphthene	48	110	48	110
acenaphthylene	67	150	67	150
anthracene	150	290	150	290
fluorene	83	170	83	170
naphthalene	210	470	210	470
2-methylnaphthalene	110	240	110	240
phenanthrene	310	620	320	650
High Molecular Weight PAHs (HMW-PAHs)				
benz[a]anthracene	210	460	380	830
benzo[a]pyrene	410	940	430	920
chrysene	460	1 030	480	1 020
dibenz[a,h]anthracene	71	160	71	160
fluoranthene	1 230	2 830	800	1 790
pyrene	460	1 050	780	1 680
Total PAHs[5]	9 230	20 200	9230	20 400
Pesticides				
chlordane	6.7	11	3.5	5.7
dieldrin	4.8	8.0	2.5	5.2

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V
	FRESH WATER[3]		MARINE and ESTUARINE WATER[4]	
Substance	**Sensitive Contaminated Sites ($SedQC_{SCS}$)**	**Typical Contaminated Sites ($SedQC_{TCS}$)**	**Sensitive Contaminated Sites ($SedQC_{SCS}$)**	**Typical Contaminated Sites ($SedQC_{TCS}$)**
DDT	3.0	5.7	3.0	5.7
DDE	4.1	8.1	188	450
DDD	6.0	10	4.5	9.4
lindane (gamma-bhc)	1.2	1.7	0.65	1.2
endrin	33	75	33	75
heptachlor epoxide	1.7	3.3	1.7	3.3
Chlorinated Phenols				
pentachlorophenol	400[6]	800[6]	360[7]	690[7]
Polychlorinated Dioxins and Furans (PCDDs and PCDFs)				
2,3,7,8-TCDD TEQs	0.013	0.026	0.013	0.026

Footnotes

1. All values are in ug/kg Dry Weight (DW) unless otherwise stated. Substances must be analyzed using methods specified in protocols approved under section 53 of the Contaminated Sites Regulation or alternate methods acceptable to the director.

2. Criteria are for total substance concentrations.

3. Standard to protect freshwater aquatic life.

4. Standard to protect marine and/or estuarine aquatic life.

5. Total PAHs includes:

1-methylnaphthalene	benz(a)anthracene	fluorene
1-methylphenanthrene	benzo(a)pyrene	fluoranthene
2,6-dimethylnaphthalene	benzo(e)pyrene	indeno(1,2,3-c,d)pyrene
2,3, 5-trimethylnaphthalene	benzo(b)fluoranthene	naphthalene
2-methylnaphthalene	benzo(ghi)perylene	perylene
acenaphthene	benzo(k)fluoranthene	phenanthrene
acenaphthylene	chrysene	pyrene
anthracene	dibenz(a,h)anthracene	

1. Adopted from New York Department of Environmental Conservation, 1994.

2. Adopted from Washington Department of Ecology, 1991.

TABLE 2 TISSUE RESIDUE CRITERIA (TRC) FOR BIOACCUMULATIVE SUBSTANCES [1, 2, 3, 4]

COLUMN I	COLUMN II
Substance	**Tissue Residue Criteria**
Organic Mercury	
methyl mercury	33
Polychlorinated Biphenyls (PCBs)	
PCBs mammalian	0.79 ng/TEQ[5] /kg
avian	2.4 ng TEQ[5] /kg
Pesticides	
DDD[6]	14
DDE[6]	14
DDT[6]	14
Polychlorinated Dioxins and Furans (PCDDs and PCDFs)	
2,3,7,8-TCDD TEQs mammalian	0.71 ng/TEQ[5] /kg
avian	4.75 ng TEQ[5] /kg

Footnotes

1. All values are in ug/kg unless otherwise stated. Substances must be analyzed using methods specified in protocols approved under section 53 of the Contaminated Sites Regulation or alternate methods acceptable to the director.

2. All values are expressed in terms of wet weight (WW).

3. Standards are for total substance concentrations.

4. All values are adopted from the Canadian Council of Ministers of Environment (CCME) 2001.

5. Expressed as Toxic Equivalent Unit (TEQ) based on World Health 1998 TEF values for fish

6. TRC is for total DDT, which is equal to DDD+DDE+DDT (CCME, 2001).

4.0 CRITERIA APPLICATIONS AND REMEDIATION OPTIONS

4.1 SPECIFIC APPROACHES AND APPLICATIONS

The Ministry has adopted two approaches for managing sediment contaminated sites in British Columbia: a numerical criteria-based approach and a risk-based approach. A responsible person, as defined under the CSR, may choose either approach for addressing contamination in sediments at a contaminated site.

4.2 CRITERIA - BASED APPROACH

The numerical criteria-based approach provides a basis for defining acceptable concentrations of substances at a site relative to the protection of aquatic life, wildlife, and/or human health (i.e., numerical sediment quality criteria). These criteria provide the basis for determining when a site is contaminated, when sediment remediation is needed, and when sediment remediation has been satisfactorily completed. The criteria-based approach is particularly relevant for establishing remediation targets when removal of contaminated sediments is the preferred remedial option. At such sites, numerical criteria can be adopted directly as remediation targets.

The criteria should be applied at sites with substance concentrations above background levels, with typical community assemblages of aquatic organisms, and typical levels of organic carbon (i.e., 0.4 to 10.1% for freshwater sediments; 0.1 to 4.7% for marine and estuarine sediments).

The procedures for calculating site-specific numerical criteria, are described in Ingersoll and MacDonald (2002).

4.3 RISK-BASED APPROACH

The risk-based approach can be used to support remedial action planning at any contaminated site in British Columbia. This approach is often used where the scale and scope of remedial efforts based on the numerical criteria approach may need to be reduced. Typically this is done by demonstrating to the satisfaction of the Ministry that risks are less than or equal to those upon which the numerical criteria are based. Where this can be satisfactorily demonstrated, a greater choice of risk management and remedial options generally becomes available for use at the site. Central to the Ministry's goal of restoring ecosystem health at contaminated sites is the view that control of contaminants at their source remains the primary imperative for remedial actions. It is only through the abatement of inputs of contaminants from sources to the

receiving environment that other sediment management actions, such as sediment removal, become economically viable, ecologically successful, and sustainable.

There are numerous procedures and methods that can be used in conducting risk assessments. Where the risk-based approach is used, exposures to a substance of concern at a site must be reduced to protect human health and the environment. To protect human health, exposures to substances must be reduced so that the level of risk associated with exposure to a substance is less than or equal to the risk-based standards of the CSR. Ecological risk assessments should be conducted in accordance with Contaminated Site Protocol #1: Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia (MELP 1998). The Tier 1 document provides specific guidance for addressing concerns related to exposures of aquatic organisms and aquatic-dependent wildlife species to toxic and bioaccumulative substances. For aquatic systems, risks resulting from exposure to substances must be reduced to the acceptable ecological risk levels specified in the Tier 1 protocol (i.e. typically the EC_{20} values). [Additional Tier 1 Guidance for sediments is anticipated to be developed by the Ministry at a future date.]

Assessment and Remediation Considerations:

It may be prudent to select the criteria-based approach at small sites where the cost of collecting the detailed data needed to support human and ecological risk assessments is likely to greatly exceed the costs for remediation. Also, the remediation of small sites based on the criteria-based approach may be technically less challenging and offer the potential for accelerated regulatory compliance over the alternative. At larger, more complex sites, however, the costs associated with conducting detailed risk assessments may be justified to reduce uncertainties and focus limited resources on the remedial actions that provide the greatest benefits. Regardless of the size or complexity of a site, the remediation of sediments **may not** be approved by the regulatory agencies if the resulting remedial impacts are more significant than leaving the sediments in place.

5.0 APPLICATION OF NUMERICAL CRITERIA FOR IDENTIFYING SITES WITH CONTAMINATED SEDIMENTS

The numerical sediment quality criteria for the protection of the designated uses of freshwater systems, and of estuarine and marine systems, must be used to determine if a site contains contaminated sediments, as defined under the *Waste Management Act.* As a first step, the designated uses of the aquatic ecosystem at and nearby the site must be established. Next, the COPCs are identified, using the procedures described in MacDonald and Ingersoll (2002). Subsequently, the concentrations of COPCs at the site are determined and compared to the sediment quality criteria that have been established

for each of the designated uses and the results interpreted based on the guidance provided in Sections 4.1 and 4.2.

A site is a "contaminated site" for the purposes of Part 5 of the CSR, if the concentration of any substance in sediments at the site is greater than or equal to the applicable sediment quality criteria (SedQC).

5.1 APPLICATION OF NUMERICAL CRITERIA FOR DEFINING REMEDIATION TARGETS

The sediment quality criteria for bulk sediments and tissues, listed in Tables 1 and 2 provide a basis for establishing remediation targets (i.e. target clean-up levels) under the numerical criteria-based approach for sites with contaminated sediments in British Columbia. Remediation targets specify tolerable concentrations of substances in bulk sediments and where applicable, aquatic organism tissue. Generally, the numerical criterion for the most sensitive designated use of the aquatic ecosystem is the remediation target for each substance of concern. Details respecting the application of the $SedQC_{SCS}$ and $SedQC_{TCS}$ can be found in Section 4.0 of the Technical Appendix (Macfarlane and MacDonald 2002- Draft).

Where approved by the agencies, the $SedQC_{TCS}$ criteria can be adopted directly as the remediation targets within the approved sediment zone. The remediation targets for each substance of concern represent the numerical criterion for the most sensitive applicable designated use.

Where site-specific sediment quality criteria have been established by a responsible person, and have been approved following review by the Ministry and/or federal agencies, site-specific numerical criteria can be adopted as the remediation targets.

6.0 CRITERIA FOR SUBSTANCES FOR WHICH GENERIC CRITERIA ARE NOT AVAILABLE

Tables 1 and 2 contain numerical thresholds for a variety of substances that have the potential to contaminate sediments and aquatic organisms in freshwater, estuarine, and marine systems. While these tables provide criteria for many of the substances that occur in sediment at contaminated sites, other substances may be encountered for which numerical criteria are not listed in the tables. The Ministry should be consulted for guidance regarding the significance of such non-scheduled substances at a site.

Additional guidance on the assessment of Non Scheduled Toxic Substances (NSTS) is available from the Ministry (WLAP 2002 in preparation).

7.0 BACKGROUND LEVELS OF CONTAMINANTS OF POTENTIAL CONCERN

At certain sites, background levels of COPCs may exceed the numerical criteria for bulk sediments listed in Table 1. In such cases, the background levels of those substances (i.e. based on the median or the 95th percentile concentration - depending on whether background data is obtained from existing studies or by the reference site approach) is used to establish numerical criteria for assessing and remediating contaminated sediments.

If the risk-based approach has been selected to support remedial action planning, then the risk levels associated with exposure to background concentrations of COPCs in sediments become the applicable risk-based standard for the site.

Contaminated media must not be used as a reference for determining background concentrations.

Ingersoll and MacDonald (2002) describes recommended procedures for establishing background levels of sediment-associated contaminants at sites.

8.0 RELEASES OF CONTAMINANTS FROM A SITE

The criteria provided in this document are primarily intended to apply to *in situ* bulk sediments at sites with contaminated sediments. However, contaminants in sediments may also be released from a site by a number of means, including:

- sediment transport by natural processes, such as tidal action and erosion (i.e. the hydrodynamics of the aquatic system in question);
- evaporative losses of volatile organic chemicals from exposure of contaminated sediments to air (e.g. due to tidal effects or draw-down effects in lakes or rivers);
- surface water recharge from contaminated pore-water;
- sediment re-suspension from the wash from propellers of pleasure craft and commercial vessels;
- excavation and redeposition of contaminated sediments; and,
- transfer of bioaccumulative substances to sediment-dwelling organisms and, subsequently, into the food web.

For this reason, the criteria contained in this document are not intended to be the sole basis for assessing the environmental quality at sites if contaminants may be released from sediments or if contaminated sediments may be released and re-deposited elsewhere. At such sites, additional factors (such as off-site impacts, etc.) also need to be assessed and applicable policy and regulatory requirements need to be considered. For example, the provisions of the Special Waste Regulation (BC 1988) provides a basis for *in situ* management and classification of special wastes. The CSR defines maximum acceptable concentrations for COPCs in sediments that may be deposited to land. The CSR (BC 1997 and BC 2002) also lists the Ministry's standards for the protection of groundwater and groundwater flow to surface waters. In addition, interim contaminant testing guidelines have been specified by Environment Canada to determine the acceptability of contaminated sediments for disposal at designated open water disposal sites.

9.0 SPECIAL WASTE REGULATION

The sediment quality criteria presented in Tables 1 and 2 are intended to provide a basis for evaluating sediment contamination, identifying the need for remedial actions, and establishing remediation targets at contaminated sites in British Columbia. These criteria should be used in conjunction with the requirements of the Special Waste Regulation (SWR; BC 1988). Sediments with COPC concentrations in excess of the levels specified in the SWR must be removed to the extent feasible and disposed of in accordance with the provisions of the SWR. In addition, in accordance with the provisions of the CSR, sediments containing certain types of substances (e.g., non-aqueous phase liquid; NAPL) should typically be removed to the extent feasible and disposed of in an appropriate manner.

Additional guidance, interpretation can be found in Technical Appendix (Macfarlane and MacDonald 2002 - Draft).

For more information, contact the Environmental Management Branch, (250) 387-4441.

10.0 REFERENCES

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