WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

SUMMARY OF GUIDELINES FOR CONTAMINATED FRESHWATER SEDIMENTS

This report and the accompanying data table are reference documents only. Publication of this information in no way implies that any numbers or methods contained herein are currently endorsed or recommended by the Department of Ecology.

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Summary of Guidelines For Contaminated Freshwater Sediments

Produced for Ecology's Sediment Management Unit
in Cooperation with Brett Betts

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I. Introduction

The Washington State Department of Ecology (Ecology) is developing biologically based criteria for evaluating contaminated freshwater sediments. As part of this effort, we have compiled sediment guidelines from various US and Canadian sources, and have summarized them in the accompanying table (Table 1). This table, called FSEDCRIT (Freshwater SEDiment CRITeria), is maintained in an Excel® worksheet file. The file is updated periodically as new data become available. This publication is the second edition of this compilation[1]. The following changes have occurred since the last FSEDCRIT survey: there are four new sets of guidelines, two guideline sets have been superseded by newer ones, one set remains unchanged, and one set was dropped.

Note: ***FSEDCRIT is a reference document only. The publication of this information in no way implies that any numbers or methods contained herein are currently endorsed or recommended by the Department of Ecology.***

In most cases, data are reported as follows:

Metals:	mg/kg dry weight (parts per million)
Organics:	µg/kg dry weight (parts per billion) or
	mg/kg OC (parts per million of organic carbon (OC normalized))

This report contains brief descriptions of the various guideline development methods reported and background information on the data sources. In most cases, we have obtained the original source documents and have presented information based on these source documents. However, the reader is encouraged to consult these original documents for more detailed explanations.

II. Guidelines/Criteria Development Methods

Below are summaries of methods used to derive the criteria and guidelines presented in FSEDCRIT.

Background Approach (BKG)

The background approach is the simplest and most straightforward of the guideline development methods. Concentrations for each contaminant of interest are determined for sites where the levels are considered to be acceptable. For metals, this is often a "pre-industrial" value derived from sediment cores. For anthropogenic organics, which should theoretically have background concentrations of zero, values from a suitable reference site are used. This approach strives to reduce pollutant loading to a point where the

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1 The last version of FSEDCRIT was published in 1991 (Bennett and Cubbage, 1991).

contaminant level of an impacted sediment is indistinguishable from that of a non-impacted sediment.

Advantages of the background approach are that it requires a minimum of field data and no quantitative toxicity assessments. The disadvantages are that it may be difficult both to find suitable reference sites and to determine what levels are acceptable "background", presumably non-toxic concentrations. This approach may also result in pollutant levels that are lower -- perhaps even far lower -- than are toxic to benthic organisms.

Equilibrium Partitioning Approach (EQP)

The EQP approach may be used for non-polar, non-ionic organics; it attempts to apply water quality criteria to sediment contaminant concentrations. EQP assumes that chemicals in interstitial water are the major source of toxicity, and tries to predict chemical concentrations in water from bulk sediment chemical concentrations. This approach can be used for non-polar organics which partition between liquid and solid sediment phases in fairly predictable ways.

EQP is based on particular chemicals' solubilities in octanol and water, how those chemicals partition between octanol and water once in solution, and how they partition between sediments and pore-water or overlying water. Briefly, the US EPA method for sediments with 0.2% or greater organic carbon content by weight is as follows (EPA, 1993g). For each compound of interest, an octanol/water partition coefficient (K_{ow}) is multiplied by the weight percent of organic carbon in the sediment to derive an organic-carbon-normalized partition coefficient (K_{oc}) which is used in turn to derive a quantifying partition coefficient (K_p). The K_p is multiplied by the final chronic value (FCV) water quality criterion for that compound to generate a sediment quality criterion (SQC).

A primary advantage of this approach is that it uses existing water quality criteria which are supported by extensive biological testing to predict no-effect levels for specific contaminants. It is also useful when adequate field data are not available, and is relatively inexpensive.

Disadvantages include the assumption that contaminants are bioavailable only through exposure to interstitial water. Body-wall absorption and ingestion effects are ignored. Additionally, results depend on the accuracy of the partitioning coefficients, how well the coefficients represent various chemical species, and total particle surface area (a function of depth and porosity) of sediment accessible to and in equilibrium with the pore water and the water column. Indeed, these confounding factors were apparent in one study where measured levels of dieldrin in water were 10-20 times higher predicted by the EQP approach (Hoke *et al*., 1995). Finally, the method cannot be applied to metals or polar and ionic organics.

Screening Level Concentrations Approach (SLC)

The SLC approach uses field data, combining contaminant concentrations with in-situ benthic invertebrate abundance, and a two-stage calculation to derive sediment criteria. A minimum number of sites and organism species are required; for example, there could be a requirement for at least ten organism species of interest at a minimum of ten sites. The first stage is to calculate an individual SLC for each organism for each chemical. This is called the Species SLC (SSLC). The sites are ranked and plotted according to increasing chemical concentration, and the 90th percentile concentration is found. The second stage is to rank and plot all species according to increasing SSLCs. 5th and 95th percentile contaminant concentrations are determined from this plot.

The 5th percentile SLC is the contaminant concentration above which 95% of the SSLCs are found; it is the highest level of a contaminant that can be tolerated by 95% of the benthic infaunal species. The 95th percentile SLC is the level of contaminant concentration that can be tolerated by 5% of the benthic infaunal species. Since the database is assumed to contain a complete range of contaminant concentrations for the species of interest, the reference is inherently "built-in". Exceptions in Table 1 are noted. Under the Ontario Provincial guidelines (Persaud, 1993) 10th and 90th SLC percentiles are used for PCBs, γ-BHC (*g*-BHC), and heptachlor epoxide. Under the Saint Lawrence River interim criteria, 15th and 90th percentiles are used in all cases.

A significant advantage of this approach is that it is based on chronic population-level effects on indigenous biota. An additional advantage is that, unlike the EQP method, it can be used to derive criteria for polar and ionic organics and metals as well as non-polar organics.

One major disadvantage is that it does not establish a direct cause-and-effect relationship between a single contaminant and benthic organism survival. Also, since an SLC is always produced regardless of the concentrations of contaminants or the tolerances of the species, the result may not reflect toxicity. Another disadvantage is that the method requires a large number of different kinds of data, including benthic species enumeration and sediment chemistry; it is quite expensive.

Spiked Sediment Toxicity Approach (SST)

The spiked sediment toxicity approach exposes a test organism to a contaminated sediment and observes any resulting toxic effects. Hart *et al.*, (1981) used the spiked bioassay to determine dose-response relationships of test organisms to levels of contaminants.

Spiked sediments are prepared by adding a known amount of the contaminant(s) of interest to a sediment sample and allowing time for equilibration. Test organisms are then exposed to the prepared sediment, and toxic effects can be directly related to the known contaminant concentrations.

An advantage of this method is that individual or combinations of contaminants can be tested in known concentrations and under controlled conditions. The main disadvantages are that considerable effort must be expended for each contaminant tested, and the spiked sediments may not realistically simulate natural conditions. Of the current round of criteria/guidelines in this report, only Environment Canada's NSTP approach (see below) states reliance in part on some SST studies.

Modified National Status and Trends Program Approach (NSTP)

The modified NSTP approach involves evaluation and compilation of chemical and biological data from multiple studies including EQP, SST, field sample bioassays, and sediment quality assessment values from other jurisdictions. The approach is based on US and Canadian sediment studies by Long and Morgan (1990), Long and MacDonald (1992), the Canadian Council of Ministers of the Environment (CCME, 1994), Long *et al.* (1994), and MacDonald (1994).

Sediment chemistry and bioassay data are stored in the **B**iological **E**ffects **D**ata Base for **S**ediments (BEDS) along with parameters that could affect bioavailability (TOC[2], AVS[3], grain size). Sediment was noted as freshwater or marine and (biological) effect or no effect.

The geometric mean of the 15th percentile concentration from the *effect* data set and the 50th percentile concentration from the *no effect* data set defines the Threshold Effect Level (TEL). The Probable Effect Level (PEL) is calculated from the geometric mean of the 50th percentile concentration of the *effect* data set and the 85th percentile concentration of the *no effect* data set. The TELs and PELs reviewed here were derived from freshwater sediments.

The advantage of the NSTP approach is that it maximizes the number of studies that are used to derive criteria.

The disadvantage of the NSTP approach is that the approaches applied in individual studies are not always comparable. Issues of geographic variation and differences in species sensitivity, pollutant bioavailability, and laboratory test methods are largely not addressed in this approach.

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2 Total Organic Carbon
3 Acid Volatile Sulfide

III. Guidelines/Criteria Sources

NOTE: Capital letters in parentheses refer to FSEDCRIT spreadsheet headings.

(A) Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario (formerly Provincial Sediment Quality Guidelines)

Developed by: Ontario Ministry of Environment and Energy
Reference: Persaud *et al.*, 1993
Purpose: Sediment evaluation
Status: Final

These guidelines have undergone several revisions since their inception. They define three levels of chronic, long-term effects on benthic organisms.

1) No-Effect Level - No toxic effects have been observed on fish or sediment-dwelling organisms; there is no expected food chain biomagnification, and all water quality guidelines will be met. Not used for metals. Derived by EQP.

2) Lowest-Effect Level - Indicates a level of sediment contamination that can be tolerated by most benthic organisms. Derived by 5th percentile SLC except the 10th SLC percentile is used for PCBs, γ-BHC (*g*-BHC), and heptachlor epoxide

3) Severe-Effect Level - Pronounced disturbance of sediment-dwelling organisms can be expected. Contaminant concentration would be detrimental to the majority of benthic species. Acute toxicity testing is required when contamination exceeds this level. Derived by 95th percentile SLC except the 90th SLC percentile is used for PCBs, γ-BHC (*g*-BHC), and heptachlor epoxide.

(B) Interim Criteria for the Evaluation of Sediments of the St. Lawrence River

Developed by: Environment Canada St. Lawrence Center and the Québec Ministry of the Environment
Reference: EC and MOE, 1992
Purpose: Agency sediment management
Status: Current, Interim -- periodic updates expected as a result of future sampling efforts and developments in ecotoxicity

These are new criteria included in FSEDCRIT survey. They define three levels of acute and chronic, long-term effects on benthic organisms. The values are derived from the same data base as that used for the Guidelines for the Protection and Management of

Aquatic Sediment Quality in Ontario ((A), above), but use a higher percentile for the minimal (lowest) effect level, and lower percentile for the toxic (severe) effect level. This results less restrictive guidelines at the minimal level, and more restrictive guidelines at the toxic level[4].

1) No Effect Level - The concentration of a substance that will cause no chronic or acute effects in living organisms. Derived by BKG.

2) Minimal Effect Level - The concentration of a substance at which some effects are noticeable, but that is tolerated by most organisms. Derived by 15th percentile SLC.

3) Toxic Effect Level - The concentration of a substance that will cause adverse effects in most living organisms. Derived by 90th percentile SLC.

(C) Interim Sediment Quality Assessment Values (Draft)

Developed by: Environment Canada
Reference: EC, 1994
Purpose: Provides information pertinent to the development of national sediment quality guidelines that will ultimately cover the whole country -- both federal lands and provinces. Guidelines will be developed to be environmentally conservative, since they will be used on a national scale. They will not be intended to define nation-wide sediment quality values (SQGs), but will be used as nationally consistent screening tools. The Canadian Council of (provincial) Ministries of Environment (CCME) has accepted and is involved in the process.
Status: Draft (unpublished); being updated; values have not been evaluated against other supporting information and may change before being recommended as guidelines. An update may be published later in 1995.

These values have been arrived at using the NSTP approach, and are subject to change as the evaluation process continues. They define two levels of biological effects on living organisms, and a third implicit level in-between. The data base used for the NSTP approach contains freshwater, estuarine, and marine data, but only freshwater data were used for the development of the Interim Sediment Quality Assessment Values (Keenleyside, 1995).

1) Threshold Effect Level (TEL) - is calculated from the geometric mean of the 15th percentile concentration from the *effect* data set and the 50th percentile concentration from the *no effect* data set[5]. Adverse biological effects are rarely seen below the TEL level. Also referred to as the minimal effect level.

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4 Except as noted in ((A) above) and Table 1. where 10th and 90th percentiles are also used

5 $TEL = \sqrt{EffectDataSet_{15\%ile} \cdot NoEffectDataSet_{50\%ile}}$

2) Probable Effect Level (PEL) - is calculated from the geometric mean of the 50th percentile concentration of the *effect* data set and the 85th percentile concentration of the *no effect* data set[6]. Adverse biological effects are frequently seen above the PEL.

The range in between the TEL and the PEL is referred to as the "possible effect level"[7].

(D) Guidelines for the Pollutional Classification of Harbor Sediments

Developed by: US EPA Region V
Reference: EPA, 1977
Purpose: Dredged material classification
Status: Guidelines only, no regulatory basis, still in use as general indicators.

The EPA Region V Guidelines were originally released to classify Great Lakes harbor sediments. Since the values were somewhat arbitrary and not well founded scientifically, they were considered adequate only for determining the suitability of dredged material for open water disposal. If either mercury or PCBs were present in excess of the guidelines, the sediments were considered severely polluted and had to be disposed of by other means.

(E) Sediment Quality Values for Non-polar Organics (Draft)

Developed by: US EPA Offices of Water and Research and Development
References: Federal Register, 1994 and EPA, 1993a - 1993g
Purpose: Guidance for the development of sediment quality criteria which reflect local environmental conditions. Developed specifically for use in the federal 304(a) criteria program.
Status: Draft proposals (according to the Federal Register), although EPA feels these values have undergone extensive review and will be finalized.

The sediment quality values (SQVs) are valid only when used in conjunction with EPA Guidelines for Deriving Site-Specific Sediment Quality Criteria for the Protection of Benthic Organisms (EPA-822-R-93-017, September 1993). These SQVs will not have any regulatory weight except if adopted by a state, or if a state does not have a regulatory program for freshwater sediments, and responsibility defaults to the US EPA.

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6 $PEL = \sqrt{EffectDataSet_{50\%ile} \cdot NoEffectDataSet_{85\%ile}}$

7 $TEL < PossibleEffectLevel < PEL$

This document modifies the published SQVs (or SQC (criteria)) according to appropriate bioassays and local total organic carbon (TOC) values. If a determination is made that the EQP is inappropriate for local sediments, a bioavailability procedure is provided in this document. The EQP derived SQVs are presented as:

1) Criteria -- Protective of benthic species

2) Upper and lower 90% Confidence Interval values -- Estimate of the uncertainty associated with the degree to which the observed pollutant concentration in sediment, which may be toxic, can be predicted using the organic carbon partition coefficient (K_{oc}) and the water-only effects concentration. Confidence limits do not incorporate uncertainty associated with water-quality criteria.

(F) Interim Guidance -- Freshwater Navigational Dredging

Developed by: New York Department of Environmental Conservation
Reference: New York DEC, 1994
Purpose: Dredged material classification
Status: In use as screening guidelines for dredging projects.

These values are derived from best professional judgment from the Sediment Assessment and Management group, made up of the Departments of Fish & Wildlife and Solid Waste. Values are based on data and literature review, and personal knowledge and experience of the group members. The values define three levels of biological effects on benthic organisms.

1) No appreciable contamination (Class A) -- Dredging and disposal can generally proceed under multiple options with minimal restrictions.

2) Moderate contamination (Class B) -- Dredging and disposal can be conducted within several restrictions. These restrictions can be applied considering site-specific concerns and knowledge, coupled with sediment evaluation.

3) High contamination (Class C) -- Disposal requirements can be stringent and require handling of the material as hazardous waste.

Because the dredged material and disposal levels are based on a limited number of screening parameters, one or more exceedances of a threshold in any level should be considered presumptive evidence that dredging disposal should meet the restrictions of the more stringent level.

IV. Other Guidelines/Criteria Not Listed in FSEDCRIT

Several other guidelines/criteria have been derived and proposed. We list below other sources of values; but we have not included them in FSEDCRIT because they are no longer used by the issuing entity, do not directly apply to freshwater environments, or have been superseded by the values that appear in the current iteration of FSEDCRIT.

Bioeffects/Contaminant Co-Occurrence Analyses (COA) Approach or the Weight of Evidence Approach

These values are described by Long and Morgan (1990). This approach was not included because results are based predominantly on marine data, which FSEDCRIT does not address. Also, the small amount of freshwater information it does report are included in other FSEDCRIT tables.

Federal Water Pollution Control Administration (FWPCA) Chicago Guidelines for the Degree of Pollution of Harbor Sediments (1968) and the Jensen criteria (1971)

These sets were not included in FSEDCRIT because the values either appear elsewhere, or have been superseded by more recent efforts. Both can be found in Pavlou and Weston (1983).

Wisconsin Department of Natural Resources Criteria

This listing appeared in FSEDCRIT 1991, but has been dropped. The values were developed by the Wisconsin Department of Natural Resources in 1985, and revised 1990. The 1985 values were derived for classification of dredged material for in-water disposal, 1990 data were derived for cleanup at an EPA Superfund site. The State of Wisconsin is no longer using these values, but is evaluating sediments on a case-by-case site-specific basis.

Sediment Quality Guidelines, Beak Consultants (Hart *et al.*), 1988

This listing appeared in FSEDCRIT 1991, but has been dropped. These guidelines were produced for the Ontario Ministry of the Environment. At the time, values had been partially incorporated into the Provincial Sediment Quality Guidelines (SQG) (A). At this time the Provincial Guidelines are final, and supersede all previous values and development documents.

Screening Level Concentrations for Freshwater Sediments, Neff *et al.*, 1986

This listing appeared in FSEDCRIT 1991, but has been dropped. The values were developed by the Battelle Environmental Program Office to evaluate the SLC approach for the US EPA. The method was never accepted by the US EPA, although it was accepted by Ontario. The Ontario Provincial Guidelines are final, and supersede all previous values and development documents from Ontario.

Dredged Material Disposal Classification Criteria, Ontario Ministry of Environment, 1988 superseded by the Handbook for Dredging and Dredged Material Disposal in Ontario (Evaluating Construction Activities Impacting on Water Resources, 1994

The new document specifies dredged materials considerations based on Guidance for the Protection and Management of Aquatic Sediment Quality in Ontario (1994). Though these numbers are applied to dredging issues, values are identical to the Ontario Guidance numbers, and are not repeated as a separate listing in FSEDCRIT 1994.

Five parameters originate in the Open Water Disposal Guidelines and reappear in the Guidance for the Protection and Management of Aquatic Sediment Quality in Ontario (1994). However, they are not calculated guidelines, and chemical analysis for these is only performed where specifically requested by the Ministry of Environment (MOE).

Inland Testing Manual (Draft), US EPA, 1994(a)

This document is to be used for evaluation of potential contaminant-related impacts associated with the discharge of dredged material in fresh, estuarine, and saline waters per requirements of the Clean Water Act Section 404(b)(1). Procedures are provided, but no numeric criteria.

Great Lakes Dredged Material Testing and Evaluation Manual (Draft -- for public comment), Region 5 EPA, 1994(b)

This document is produced by the US EPA and the US Army Corps of Engineers in order to provide guidance on procedures for testing dredged materials proposed for discharge into the US waters of the Great Lakes. It is to be used to determine the potential for contaminant-related impacts from proposed dredged material discharges as part of evaluations conducted under Section 404(b)(1) of the Clean Water Act. Procedures are provided, but no numeric criteria. This regional manual is a supplement to the (draft) national Inland Testing Manual.

Table 1. Review of criteria and guidelines for contaminated freshwater sediments. See text for sources and methods.

Text reference=>			A			B			C		D			E		F		
			(Persaud *et al*., 1993) Guidlines for the Protection and Mgmt.of Aqu. Sed. Quality in Ontario			(EC and MOE, 1992) Interim Criteria for the Evaluation of Sediments of the St. Lawrence River			(EC, 1994) Interim Sediment Quality Assessment Values (Draft)		(EPA, 1977) Guidelines for the Pollutional Classification of Harbor Sediments			(EPA, 1993, 1994) Sediment Quality Values for Non-polar Organics (Draft)		(New York DEC, 1994) Interim Guidance; Freshwater Navigational Dredging		
			No Effect Level	Lowest Effect Level	Severe Effect Level	No Effect (SSE)	Minimal Effect (SEM)	Toxic Effect (SEN)	TEL	PEL	Non Polluted	Moderately Polluted	Heavily Polluted	Criteria	Crit.90% CI	No Appreciable Contam.	Moderate Contam.	High Contam.
	METHODS=>		EQP	SLC	SLC	BKG	SLC 15 % ile	SLC 90% ile	SST/NSTP Note 1	SST/NSTP Note 1	BKG	BKG	BKG	EQP	EQP	BPJ Note 2	BPJ Note 2	BPJ Note 2
COMPOUND NAME	PP	Mol Wt.																
METALS	UNITS=>			mg/kg dry	mg/kg dry	mg/kg dry	mg/kg dry	mg/kg dry	mg/kg dry	mg/kg dry	mg/kg dry	mg/kg dry	mg/kg dry	----------	----------	mg/kg dry	mg/kg dry	mg/kg dry
Antimony	Y	121.8	-	-	-				-		-	-	-	-	-	-	-	-
Arsenic	Y	74.9	-	6	33	3.0	7	17 ✥	5.9	17.0	< 3	3-8	> 8	-	-	-	-	-
Barium	N	137.3	-	-	-	-	-	-	-	-	< 20	20-60	> 60	-	-	-	-	-
Cadmium	Y	112.4	-	0.6	10	0.2	0.9	3 ✥	0.596	3.53	-	-	> 6	-	-	< 0.6	0.6 - 10	> 10
Chromium	Y	52.0	-	26	110	55	55	100 ✥	37.3	90.0	< 25	25-75	> 75	-	-	-	-	-
Cobalt	N	58.9	-	50 ✢	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	Y	63.5	-	16	110	28	28	86 ✥	35.7	196.6	< 25	25-50	> 50	-	-	< 16 ✻	16 - 110 ✻	> 110 ✻
Iron (%)	N	55.9	-	2	4	-	-	-	-	-	< 1.7	1.7-2.5	> 2.5	-	-	-	-	-
Lead	Y	207.2	-	31	250	23	42	170 ✥	35.0	91.3	< 40	40-60	> 60	-	-	< 30	30 - 100	> 100
Manganese	N	54.9	-	460	1100	-	-	-	-	-	< 300	300-500	> 500	-	-	-	-	-
Mercury	Y	200.6	-	0.2	2	0.05	0.2	1 ▲	0.174	0.486	< 1	>= 1	>= 1	-	-	< 0.1	0.1 - 4	> 4
Nickel	Y	58.7	-	16	75	35	35	61 ✥	18.0	35.9	< 20	20-50	> 50	-	-	-	-	-
Silver	Y	107.9	-	0.5 ✢	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	Y	65.4	-	120	820	100	150	540 ✥	123.1	314.8	< 90	90-200	> 200	-	-	-	-	-
PESTICIDES/CHLOR ORGS	UNITS=>		µg/kg dry	µg/kg dry	mg/kg OC ✷	µg/kg dry	µg/kg dry	mg/kg OC ✷	µg/kg dry	µg/kg dry	----------	----------	----------	mg/kg OC	mg/kg OC	µg/kg dry	µg/kg dry	µg/kg dry
PCBs (total)	Y	M	10	70	530	20	200	100	34.1	277.2	-	-	-	-	-	< 100	100 - 10000	> 10000
PCB-1016	Y	M	-	7 ☆✪	53 ♦✪		10	40	-	-	-	-	-	-	-	-	-	-
PCB-1248	Y	M	-	30 ☆✪	150 ♦✪	-	50	60	-	-	-	-	-	-	-	-	-	-
PCB-1254	Y	M	-	60 ☆✪	34 ♦✪	-	60	30	-	-	-	-	-	-	-	-	-	-
PCB-1260	Y	M	-	5 ☆✪	24 ♦✪	-	5	20	-	-	-	-	-	-	-	-	-	-
2,3,7,8-TCDD or TEQ	Y	322.0	-	-	-	-	-	-	-	-	-	-	-	-	-	< .0045 ✻	.0045 - .05 ✻	> .05 ✻
Aldrin	Y	362.0	-	2	8	0.6	2	4	-	-	-	-	-	-	-	-	-	-
BHC (benzene Hexachloride)	Y	288.0	-	3	12	-	5	10	-	-	-	-	-	-	-	-	-	-
a-BHC	Y	288.0	-	6	10	0.3	10	8	-	-	-	-	-	-	-	-	-	-
b-BHC	Y	288.0	-	5	21	0.2	30	20	-	-	-	-	-	-	-	-	-	-
g-BHC (Lindane)	Y	288.0	0.2	3 ☆✪	1 ♦✪	0.9	3	0.9	0.94	1.38	-	-	-	-	-	-	-	-
Chlordane	Y	M	5	7	6	1	7	3	4.5	8.9	-	-	-	-	-	-	-	-
Dieldrin	Y	380.9	0.6	2	91	0.1 - 0.8	2	30	2.85	66.7	-	-	-	11	5.2 - 24	< 3	3 - 44	> 44
Endrin	Y	380.9	0.5	3	130	1	8	50	2.67	62.4	-	-	-	4.2	2.0 - 9.1	-	-	-
Hexachlorobenzene	Y	284.8	10	20	24	1	30	10	-	-	-	-	-	-	-	-	-	-
Heptachlor	Y	370.0	0.3	-	-	0.3	0.3	1	-	-	-	-	-	-	-	-	-	-
Heptachlor epoxide	Y	386.0	-	5 ☆	5 ♦	1	5	3	-	-	-	-	-	-	-	-	-	-
Mirex	N	545.6	-	7	130	0.1	11	80	-	-	-	-	-	-	-	< 2 ✻	2 - 200 ✻	> 200 ✻
DDT (total)	Y	M	-	7	12	6	9	5	7.0	4450	-	-	-	-	-	-	-	-
op+pp'-DDT	Y	M	-	8	71	-	-	-	-	-	-	-	-	-	-	-	-	-
p,p'-DDD	Y	318.0	-	8	6	2	10	6	3.54	8.51	-	-	-	-	-	-	-	-
p,p'-DDE	Y	316.0	-	5	19	2	7	5	1.42	6.75	-	-	-	-	-	-	-	-

METHODS=> Means all entries in that column were derived using the method indicated unless otherwise noted.

Note 1: Unpublished Draft Report; values may change before being recommended as Canadian SQGs
Note 2: Values derived from the Best Professional Judgement from Sediment Assessment and Management group, Departments of Fish & Wildlife and Solid Waste; based on literature review, personal knowledge, and experience

Abbreviations appear in alphabetical order

BIO - Bioassay method (Spiked)
BKG - Background method
EQP - Equilibrium Partitioning method
ERL - Effects Range Low
ERM - Effects Range Medium
M - Mixture, precise molecular weight is indeterminable.
NSTP - National Status and Trends Program approach
OC - Organic Carbon
PEL - Probable Effect Level
PP - Priority Pollutant
SEM - Seuil d'Effets Mineurs; from the source document
SEN - Seuil d'Effets Néfastes; from the source document
SLC - Screening Level Concentration method
SQG - Sediment Quality Guideline
SSE - Seuil Sans Effet; from the source document
SST - Spiked Sediment Toxicity method
TEL - Threshold Effect Level
TEQ - Toxic Equivalent
TOC - Total Organic Carbon

mg/kg = ug/g = parts per million (dry weight)
µg/kg = parts per billion (dry weight)
mg/kg dry = mg/kg dry weight (dry weight)
mg/kg OC = mg/kg organic carbon

✢ - Not SQGs, but equivalent to the Lowest Effect Level for management decisions
 - from the Open Water Disposal Guidelines -- see p. 10 in text
☆ - 10% SLC
✪ - Tentative guideline
♦ - 90% SLC
✥ - Recoverable
✷ - To a maximum of 10% OC -- units have been changed for comparison purposes. For St. Lawrence R., originally reported as per % OC
▲ - Total
✻ - Site-specific parameter

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Table 1. Review of criteria and guidelines for contaminated freshwater sediments. See text for sources and methods.

Text reference=>			A			B			C		D			E		F		
			(Persaud *et al*., 1993) Guidlines for the Protection and Mgmt.of Aqu. Sed. Quality in Ontario			(EC and MOE, 1992) Interim Criteria for the Evaluation of Sediments of the St. Lawrence River			(EC, 1994) Interim Sediment Quality Assessment Values (Draft)		(EPA, 1977) Guidelines for the Pollutional Classification of Harbor Sediments			(EPA, 1993, 1994) Sediment Quality Values for Non-polar Organics (Draft)		(New York DEC, 1994) Interim Guidance; Freshwater Navigational Dredging		
			No Effect Level	Lowest Effect Level	Severe Effect Level	No Effect (SSE)	Minimal Effect (SEM)	Toxic Effect (SEN)	TEL	PEL	Non Polluted	Moderately Polluted	Heavily Polluted	Criteria	Crit.90% CI	No Appreciable Contam.	Moderate Contam.	High Contam.
		METHODS=>	EQP	SLC	SLC	BKG	SLC 15 % ile	SLC 90% ile	SST/NSTP Note 1	SST/NSTP Note 1	BKG	BKG	BKG	EQP	EQP	BPJ Note 2	BPJ Note 2	BPJ Note 2
COMPOUND NAME	PP	Mol Wt.																
PAH		UNITS=>		µg/kg dry	mg/kg OC ✷	µg/kg dry	µg/kg dry	mg/kg OC ✷	µg/kg dry	µg/kg dry	----------	----------	----------	mg/kg OC	mg/kg OC	µg/kg dry	µg/kg dry	µg/kg dry
PAH (Total)	-	M	-	4000	10000	-	-	-	-	-	-	-	-	-	-	< 1000	1000 - 35000	> 35000
LPAH (mw < 200)	-	M	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	Y	128.2	-	-	-	20	400	60	-	-	-	-	-	-	-	-	-	-
2-Methylnapthalene	N	142.2	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-
Acenaphthylene	Y	152.2	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
Acenaphthene	Y	154.2	-	-	-	10	-	-	-	-	-	-	-	130	62 - 280	-	-	-
Fluorene	Y	166.2	-	190	160	10	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	Y	178.2	-	560	950	30 - 70	400	80	41.9	514.9	-	-	-	180	85 - 390	-	-	-
Anthracene	Y	178.2	-	220	370	20	-	-	-	-	-	-	-	-	-	< 100	100 - 1000	> 1000
HPAH (mw > 200)	-	M	-	-	-	1000	-	-	-	-	-	-	-	-	-	-	-	-
Fluoranthene	Y	202.3	-	750	1020	20 - 200	600	200	111.3	2354.9	-	-	-	620	290 - 1300	-	-	-
Pyrene	Y	202.3	-	490	850	20 - 100	700	100	53.0	875.0	-	-	-	-	-	-	-	-
Benzo(a)anthracene	Y	228.3	-	320	1480	50 - 100	400	50	31.7	384.7	-	-	-	-	-	< 40	40 - 220	> 220
Chrysene	Y	228.3	-	340	460	100	600	80	57.1	861.7	-	-	-	-	-	< 400	400 - 2800	> 2800
Benzofluoranthene(s)	Y	M	-	-	-	300	-	-	-	-	-	-	-	-	-	-	-	-
Benzo[k]fluoranthene	Y	252.0	-	240	1340	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	Y	252.3	-	370	1440	10 - 100	500	70	31.9	782.0	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	Y	276.0	-	200	320	70	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	Y	276.0	-	170	320	100	-	-	-	-	-	-	-	-	-	-	-	-
Dibenzo(a,h)anthracene	Y	278.0	-	60	130	5	-	-	-	-	-	-	-	-	-	-	-	-
OTHER		UNITS=>		mg/kg dry	mg/kg dry	-	-	-	-	-	mg/kg dry	mg/kg dry	mg/kg dry	----------	----------	mg/kg dry	mg/kg dry	mg/kg dry
Oil & Grease	N	M	-	1500 ✣	-	-	-	-	-	-	< 1000	1000-2000	>2000	-	-	-	-	-
Volatile Solids (%)	N	M	-	-	-	-	-	-	-	-	< 5	5-8	>8	-	-	-	-	-
COD	N	M	-	-	-	-	-	-	-	-	< 40000	40000-80000	> 80000	-	-	-	-	-
Cyanide	Y	26.0	-	0.1 ✣	-	-	-	-	-	-	< 0.10	0.10-0.25	> 0.25	-	-	-	-	-
Total Phosphorous	N	M	-	600	2000	-	-	-	-	-	< 420	420-650	> 650	-	-	-	-	-
Ammonia	N	17.0	-	100 ✣	-	-	-	-	-	-	< 75	75-200	> 200	-	-	< 40	40 - 200	> 200
TOC (%)	N	M	-	1	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Kjeldahl Nitrogen	N	M	-	550	4800	-	-	-	-	-	< 1000	1000-2000	> 2000	-	-	-	-	-
Methyl Ethyl Ketone	N	72.1	-	-	-	-	-	-	-	-	-	-	-	-	-	< 1	1 - 100	> 100
Trichloroethylene	Y	131.4	-	-	-	-	-	-	-	-	-	-	-	-	-	< 0.1	0.1 - 10	> 10
BTX	Y	M	-	-	-	-	-	-	-	-	-	-	-	-	-	< 0.05	0.05 - 10	> 10
Benzene	Y	78.1	-	-	-	-	-	-	-	-	-	-	-	-	-	< 0.014	0.014 - 10	> 10

METHODS> Means all entries in that column were derived using the method indicated unless otherwise noted.

Note 1: Unpublished Draft Report; values may change before being recommended as Canadian SQGs

Note 2: Values derived from the Best Professional Judgement from Sediment Assessment and Management group, Departments of Fish & Wildlife and Solid Waste; based on literature review, personal knowledge, and experience

Abbreviations appear in alphabetical order

BIO - Bioassay method (Spiked)
BKG - Background method
EQP - Equilibrium Partitioning method
ERL - Effects Range Low
ERM - Effects Range Medium
M - Mixture, precise molecular weight is indeterminable.
NSTP - National Status and Trends Program approach
OC - Organic Carbon
PEL - Probable Effect Level
PP - Priority Pollutant

SEM - Seuil d'Effets Mineurs
SEN - Seuil d'Effets Néfastes; from the source document
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8 Canadian Council of Ministers of the Environment
9 EC: Environment Canada
10 SLC: Saint-Lawrence Center
11 EPA: US Environmental Protection Agency

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12 COE: Corps of Engineers

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13 DEC: Department of Environmental Conservation
14 MOE: Ministry of Environment
15 MOEE: Ministry of Environment and Energy

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