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MEMORANDUM

***** N O T I C E *****

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TO: Regional Water Engineers, Bureau Directors, Section Chiefs

SUBJECT: Division of Water Technical and Operational Guidance Series (1.1.4)

PROCEDURES FOR DERIVATION OF BIOACCUMULATION FACTORS

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PURPOSE

Bioaccumulation Factors (BAFs) are needed to derive Health (Fish Consumption) and Wildlife type water quality standards and guidance values. BAFs are also used to identify Bioaccumulative Chemicals of Concern (BCCs) in Department programs. The purpose of this document is to provide detailed procedures for the derivation of such BAFs.

DISCUSSION

U.S. EPA (60 FR:15366-15425, March 23,1995) has promulgated, as final federal regulations, procedures for deriving bioaccumulation factors for the requirements of the Great Lakes Initiative. These procedures have been reviewed and are considered fundamentally appropriate for deriving statewide values. The procedures presented below are an adaptation of EPA's procedures as appropriate for New York State terminology and for statewide use. The user may further his or her understanding of BAFs by reviewing "Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors,"(TSD) EPA-820-B-95-005, March 1995.

GUIDANCE

I. INTRODUCTION

A. The purpose of this document is to describe procedures for deriving bioaccumulation factors (BAFs) to be used in the calculation of Health (Fish Consumption) and Wildlife type standards and guidance values. A subset of the human health BAFs is also used to identify the chemicals that are considered bioaccumulative chemicals of concern (BCCs).

B. Bioaccumulation reflects uptake of a substance by aquatic organisms exposed to the substance through all routes (i.e., ambient water and food), as would occur in nature. Bioconcentration reflects uptake of a substance by aquatic organisms exposed to the substance only through the ambient water. Both BAFs and bioconcentration factors (BCFs) are proportionality constants that describe the relationship between the concentration of a substance in aquatic organisms and its concentration in the ambient water. The water quality regulations require BAFs rather than BCFs because they better account for the total exposure of aquatic organisms to chemicals.

C. For organic chemicals, baseline BAFs can be derived using four methods. Measured baseline BAFs are derived from field-measured BAFs; predicted baseline BAFs are derived using biota-sediment accumulation factors (BSAFs) or are derived by multiplying a laboratory-measured or predicted BCF by a food-chain multiplier (FCM). The lipid content of the aquatic organisms is used to account for partitioning of organic chemicals within organisms so that data from different tissues and species can be integrated. In addition, the baseline BAF is based on the concentration of freely dissolved organic chemicals in the ambient water to facilitate extrapolation from one water to another.

D. For inorganic chemicals, baseline BAFs can be derived using two of the four methods. Baseline BAFs are derived using either field-measured BAFs or by multiplying laboratory-measured BCFs by a FCM. For inorganic chemicals, BAFs are assumed to equal BCFs (i.e., the FCM is 1.0), unless chemical-specific biomagnification data support using a FCM other than 1.0.

E. Because both humans and wildlife consume fish from both trophic levels 3 and 4, two baseline BAFs are needed to calculate either a human health or a wildlife value for a chemical. When appropriate, ingestion through consumption of invertebrates, plants, mammals, and birds in the diet of wildlife species to be protected may be taken into account.

II. DEFINITIONS

Baseline BAF. For organic chemicals, a BAF that is based on the concentration of freely dissolved chemical in the ambient water and takes into account the partitioning of the chemical within the organism; for inorganic chemicals, a BAF that is based on the wet weight of the tissue.

Baseline BCF. For organic chemicals, a BCF that is based on the concentration of freely dissolved chemical in the ambient water and takes into account the partitioning of the chemical within the organism; for inorganic chemicals, a BCF that is based on the wet weight of the tissue.

Bioaccumulation. The net accumulation of a substance by an organism as a result of uptake from all environmental sources.

Bioaccumulation factor (BAF). The ratio (in L/kg) of a substance's concentration in tissue of an aquatic organism to its concentration in the ambient water, in situations where both the organism and its food are exposed to the substance and the ratio does not change substantially over time.

Bioconcentration. The net accumulation of a substance by an aquatic organism as a result of uptake directly from the ambient water through gill membranes or other external body surfaces.

Bioconcentration factor (BCF). The ratio (in L/kg) of a substance's concentration in tissue of an aquatic organism to its concentration in the ambient water, in situations where the organism is exposed through the water only and the ratio does not change substantially over time.

Biota-sediment accumulation factor (BSAF). The ratio (in kg of organic carbon/kg of lipid) of a substance's lipid-normalized concentration in tissue of an aquatic organism to its organic carbon-normalized concentration in surface sediment, in situations where the ratio does not change substantially over time, both the organism and its food are exposed, and the surface sediment is representative of average surface sediment in the vicinity of the organism.

Depuration. The loss of a substance from an organism as a result of any active or passive process.

Food-chain multiplier (FCM). The ratio of a BAF to an appropriate BCF.

Octanol-water partition coefficient (K_{ow}). The ratio of the concentration of a substance in the n-octanol phase to its concentration in the aqueous phase in an equilibrated two-phase octanol-water system. For log K_{ow}, the log of the octanol-water partition coefficient is a base 10 logarithm.

Uptake. Acquisition of a substance from the environment by an organism as a result of any active or passive process.

III. REVIEW AND SELECTION OF DATA

A. Data Sources. Measured BAFs, BSAFs and BCFs are assembled from available sources including the following:

1. EPA Ambient Water Quality Criteria documents issued after January 1, 1980.

2. Published scientific literature.

3. Reports issued by EPA or other reliable sources.

4. Unpublished data. One useful source of references is the Aquatic Toxicity Information Retrieval (AQUIRE) database.

B. Field-Measured BAFs. The following procedural and quality assurance requirements should be met for field-measured BAFs:

1. The field studies used should be limited to those with fish at or near the top of the aquatic food chain (i.e., in trophic levels 3 and/or 4).

2. The trophic level of the fish species is determined.

3. The site of the field study should not be so unusual that the BAF cannot be extrapolated to other locations where the values will apply.

4. For organic chemicals, the percent lipid shall be either measured or reliably estimated for the tissue used in the determination of the BAF.

5. The concentration of the chemical in the water should be measured in a way that can be related to particulate organic carbon (POC) and/or dissolved organic carbon (DOC) and should be relatively constant during the steady-state time period.

6. For organic chemicals with log K_{ow} greater than four, the concentrations of POC and DOC in the ambient water should be either measured or reliably estimated.

7. For inorganic and organic chemicals, BAFs should be used only if they are expressed on a wet weight basis; BAFs reported on a dry weight basis cannot be converted to wet weight unless aconversion factor is measured or reliably estimated for the tissue used in the determination of the BAF.

C. Field-Measured BSAFs. The following procedural and quality assurance requirements should be met for field-measured BSAFs:

1. The field studies used should be limited to those with fish at or near the top of the aquatic food chain (i.e., in trophic levels 3 and/or 4).

2. Samples of surface sediments (0-1 cm is ideal) should be from locations in which there is net deposition of fine sediment and which are representative of average surface sediment in the vicinity of the organism.

3. The K_{ow}s used should be of acceptable quality as described in section III.F below.

4. Te site of the field study should not be so unusual that the resulting BAF cannot be extrapolated to other locations where the criteria and values will apply.

5. The trophic level of the fish species is determined.

6. The percent lipid should be either measured or reliably estimated for the tissue used in the determination of the BAF.

D. Laboratory-Measured BCFs. The following procedural and quality assurance requirements should be met for laboratory-measured BCFs:

1. The test organism should not be diseased, unhealthy, or adversely affected by the concentration of the chemical.

2. The total or dissolved concentration of the chemical in the water should be measured and should be relatively constant during the steady-state time period.

3. The organisms should be exposed to the chemical using a flow-through or renewal procedure.

4. For organic chemicals, the percent lipid should be either measured or reliably estimated for the tissue used in the determination of the BCF.

5. For organic chemicals with log K_{ow} greater than four, the concentrations of POC and DOC in the test solution should be either measured or reliably estimated.

6. Laboratory-measured BCFs should be determined using fish species, but BCFs determined with molluscs and other invertebrates may be used with caution. For example, because invertebrates metabolize some chemicals less efficiently than vertebrates, a baseline BCF determined for such a chemical using invertebrates is expected to be higher than a comparable baseline BCF determined using fish.

7. If laboratory-measured BCFs increase or decrease as the concentration of the chemical increases in the test solutions in a bioconcentration test, the BCF measured at the lowest test concentration that is above concentrations existing in the control water should be used (i.e., a BCF should not be calculated from a control treatment). The concentrations of an inorganic chemical in a bioconcentration test should be greater than normal background levels and greater than levels required for normal nutrition of the test species if the chemical is a micronutrient, but below levels that adversely affect the species. Bioaccumulation of an inorganic chemical might be overestimated if concentrations are at or below normal background levels due to, for example, nutritional requirements of the test organisms.

8. For inorganic and organic chemicals, BCFs should be used only if they are expressed on a wet weight basis. BCFs reported on a dry weight basis cannot be converted to wet weight unless a conversion factor is measured or reliably estimated for the tissue used in the determination of the BAF.

9. BCFs for organic chemicals may be based on measurement of radioactivity only when the BCF is intended to include metabolites or when there is confidence that there is no interference due to metabolites.

10. The calculation of the BCF should appropriately address growth dilution.

11. Other aspects of the methodology used should be similar to those described by ASTM (1990).

E Predicted BCFs. The following procedural and quality assurance requirements should be met for predicted BCFs:

1. The K_{ow} used should be of acceptable quality as described in section III.F below.

2. The predicted baseline BCF is calculated using the equation:

$$\text{predicted baseline BCF} = K_{ow}$$

where K_{ow} is the octanol-water partition coefficient.

F. Octanol-Water Partition Coefficient (K_{ow}).

1. The value of K_{ow} used for an organic chemical should be determined by giving priority to the experimental and computational techniques used as follows:

Log K_{ow} < 4:	Priority	Technique
	1	Slow-stir
	1	Generator-column
	1	Shake-flask
	2	Reverse-phase liquid chromatography on C18 chromatography packing with extrapolation to zero percent solvent
	3	Reverse-phase liquid chromatography on C18 chromatography packing without extrapolation to zero percent solvent
	4	Calculated by the CLOGP program

Log K_{ow} > 4:	Priority	Technique
	1	Slow-stir
	1	Generator-column
	2	Reverse-phase liquid chromatography on C18 chromatography packing with extrapolation to zero percent solvent
	3	Reverse-phase liquid chromatography on C18 chromatography packing without extrapolation to zero percent solvent
	4	Shake-flask
	5	Calculated by the CLOGP program

2. The CLOGP program is a computer program available from Pomona College. A value of K_{ow} that seems to be different from the others should be considered an outlier and not used. The value of K_{ow} used for an organic chemical should be the geometric mean of the available K_{ow}s with highest priority or can be calculated from the arithmetic mean of the available log K_{ow}s with the highest priority. Because it is an intermediate value in the derivation of a BAF, the value used for the K_{ow} of a chemical should not be rounded to fewer than three significant digits and a value for log K_{ow} should not be rounded to fewer than three significant digits after the decimal point.

G. This methodology provides overall guidance for the derivation of BAFs, but it cannot cover all the decisions that must be made in the review and selection of acceptable data. Professional judgment is required throughout the process. A degree of uncertainty is associated with the determination of any BAF, BSAF, BCF or K_{ow}. The amount of uncertainty in a baseline BAF depends on both the quality of data available and the method used to derive the BAF.

H. Hereinafter in this methodology, the terms BAF, BSAF, BCF and K_{OW} refer to ones that are consistent with the procedural and quality assurance requirements given above.

IV. FOUR METHODS FOR DERIVING BASELINE BAFs

Baseline BAFs are derived using the following four methods, which are listed from most preferred to least preferred:

A. A measured baseline BAF for an organic or inorganic chemical derived from a field study of acceptable quality.

B. A predicted baseline BAF for an organic chemical derived using field-measured BSAFs of acceptable quality.

C. A predicted baseline BAF for an organic or inorganic chemical derived from a BCF measured in a laboratory study of acceptable quality and a FCM.

D. A predicted baseline BAF for an organic chemical derived from a K_{OW} of acceptable quality and a FCM.For comparative purposes, baseline BAFs should be derived for each chemical by as many of the four methods as available data allow.

V. CALCULATION OF BASELINE BAFs FOR ORGANIC CHEMICALS

A. Lipid Normalization.

1. It is assumed that BAFs and BCFs for organic chemicals can be extrapolated on the basis of percent lipid from one tissue to another and from one aquatic species to another in most cases.

2. Because BAFs and BCFs for organic chemicals are related to the percent lipid, it does not make any difference whether the tissue sample is whole body or edible portion, but both the BAF (or BCF) and the percent lipid must be determined for the same tissue. The percent lipid of the tissue should be measured during the BAF or BCF study, but in some cases it can be reliably estimated from measurements on tissue from other organisms. If percent lipid is not reported for the test organisms in the original study, it may be obtained from the author; or, in the case of a laboratory study, lipid data for the same or a comparable laboratory population of test organisms that were used in the original study may be used.

3. The lipid-normalized concentration, C_t, of a chemical in tissue is defined using the following equation:

$$C_l = C_B \div f_l$$

where:

C_B = concentration of the organic chemical in the tissue of aquatic biota (either whole organism or specified tissue) (μg/g).

f_l = fraction of the tissue that is lipid.

B. Bioavailability. By definition, baseline BAFs and BCFs for organic chemicals, whether measured or predicted are based on the concentration of the chemical that is freely dissolved in the ambient water in order to account for bioavailability. For the purposes of this Guidance in this part, the relationship between the total concentration of the chemical in the water (i.e., that which is freely dissolved plus that which is sorbed to particulate organic carbon or to dissolved organic carbon) to the freely dissolved concentration of the chemical in the ambient water is calculated using the following equation:

$$C_w^{fd} = (f_{fd})(C_w^t)$$

where:

C_w^{fd} = freely dissolved concentration of the organic chemical in the ambient water;

C_w^t = total concentration of the organic chemical in the ambient water;

f_{fd} = fraction of the total chemical in the ambient water that is freely dissolved.

The fraction of the total chemical in the ambient water that is freely dissolved, f_{fd}, is calculated using the following equation:

$$f_{fd} = \frac{1}{1 + \frac{(DOC)(K_{OW})}{10} + (POC)(K_{OW})}$$

where:

DOC = concentration of dissolved organic carbon, kg of dissolved organic carbon/L of water.

K_{OW} = octanol-water partition coefficient of the chemical.

POC = concentration of particulate organic carbon, kg of particulate organic carbon/L of water.

Where the concentration of the chemical in the ambient water is measured as dissolved, a freely dissolved fraction of dissolved chemical is calculated using the above equation with a POC of zero. This freely dissolved fraction is used in subsequent calculations in lieu of the fraction based on total chemical.

C. Food-Chain Multiplier. In the absence of a field-measured BAF or a predicted BAF derived from a BSAF, a FCM should be used to calculate the baseline BAF for trophic levels 3 and 4 from a laboratory-measured or predicted BCF. For an organic chemical, the FCM used should be derived from Table 1 using the chemical's log K_{OW} and linear interpolation. A FCM greater than 1.0 applies to most organic chemicals with a log K_{OW} of four or more. The trophic level used should take into account the age or size of the fish species consumed by the human, avian or mammalian predator because, for some species of fish, the young are in trophic level 3 whereas the adults are in trophic level 4.

D. Calculation of a Baseline BAF from a Field-Measured BAF. A baseline BAF should be calculated from a field-measure BAF of acceptable quality using the following equation:

$$\text{Baseline BAF} = \left[\frac{\text{Measured BAF}_T^1}{f_{fd}} - 1 \right] \left(\frac{1}{f_l} \right)$$

where:

BAF_T^1 = BAF based on total concentration in tissue and water.
f_l = fraction of the tissue that is lipid.
f_{fd} = fraction of the total chemical that is freely dissolved in the ambient water.

The trophic level to which the baseline BAF applies is the same as the trophic level of the organisms used in the determination of the field-measured BAF. For each trophic level, a species mean measured baseline BAF is calculated as the geometric mean if more than one measured baseline BAF is available for a given species. For each trophic level, the geometric mean of the species mean measured baseline BAFs is be calculated. If a baseline BAF based on a measured BAF is available for either trophic level 3 or 4, but not both, a measured baseline BAF for the other trophic level is calculated using the ratio of the FCMs that are obtained by linear interpolation from Table 1 for the chemical.

E. Calculation of a Baseline BAF from a Field-Measured BSAF.

1. A baseline BAF for organic chemical "i" is calculated from a field-measured BSAF of acceptable quality using the following equation:

$$(\text{Baseline BAF})_i = (\text{Baseline BAF})_r \cdot \frac{(\text{BSAF})_i \cdot (K_{OW})_i}{(\text{BSAF})_r \cdot (K_{OW})_r}$$

where:

$(BSAF)_i$	=	BSAF for chemical "i".
$(BSAF)_r$	=	BSAF for the reference chemical "r".
$(K_{OW})_i$	=	octanol-water partition coefficient for chemical "i".
$(K_{OW})_r$	=	octanol-water partition coefficient for the reference chemical "r".

2. A BSAF is calculated using the following equation:

$$BSAF = C_l \div C_{soc}$$

where:

C_l	=	the lipid-normalized concentration of the chemical in tissue.
C_{soc}	=	the organic carbon-normalized concentration of the chemical in sediment.

3. The organic carbon-normalized concentration of a chemical in sediment, C_{soc}, is calculated using the following equation:

$$C_{soc} = C_s \div f_{oc}$$

where:

C_s	=	concentration of chemical in sediment (μg/g sediment).
f_{oc}	=	fraction of the sediment that is organic carbon.

4. Predicting BAFs from BSAFs requires data from a steady-state (or near steady-state) condition between sediment and ambient water for both a reference chemical "r" with a field-measured BAF_l^{fd} and other chemicals "n=i" for which BSAFs are to be determined.

5. The trophic level to which the baseline BAF applies is the same as the trophic level of the organisms used in the determination of the BSAF. For each trophic level, a species mean baseline BAF is calculated as the geometric mean if more than one baseline BAF is predicted from BSAFs for a given species. For each trophic level, the geometric mean of the species mean baseline BAFs derived using BSAFs is calculated.

6. If a baseline BAF based on a measured BSAF is available for either trophic level 3 or 4, but not both, a baseline BAF for the other trophic level is calculated using the ratio of the FCMs that are obtained by linear interpolation from Table 1 for the chemical.

F. Calculation of a Baseline BAF from a Laboratory-Measured BCF. A baseline BAF for trophic level 3 and a baseline BAF for trophic level 4 is calculated from a laboratory-measured BCF of acceptable quality and a FCM using the following equation:

$$\text{Baseline BAF} = (\text{FCM})\left[\frac{\text{Measured } BCF_T^t}{f_{fd}} - 1\right]\left(\frac{1}{f_l}\right)$$

where:

BCF_T^t	=	BCF based on total concentration in tissue and water.
f_l	=	fraction of the tissue that is lipid.
f_{fd}	=	fraction of the total chemical in the test water that is freely dissolved.
FCM	=	the food-chain multiplier obtained from Table B-1 by linear interpolation for trophic level 3 or 4, as necessary.

Where a measured BCF is based on a dissolved concentration in water, the freely dissolved fraction is calculated on a dissolved basis as previously described.

For each trophic level, a species mean baseline BAF is calculated as the geometric mean if more than one baseline BAF is predicted from laboratory-measured BCFs for a given species. For each trophic level, the geometric mean of the species mean baseline BAFs based on laboratory-measured BCFs should be calculated.

G. Calculation of a Baseline BAF from an Octanol-Water Partition Coefficient. A baseline BAF for trophic level 3 and a baseline BAF for trophic level 4 are calculated from a K_{ow} of acceptable quality and a FCM using the following equation:

$$\text{Baseline BAF} = (\text{FCM})(\text{predicted baseline BCF}) = (\text{FCM})(K_{ow})$$

where:

FCM	=	the food-chain multiplier obtained from Table 1 by linear interpolation for trophic level 3 or 4, as necessary.
K_{ow}	=	octanol-water partition coefficient.

VI. HUMAN HEALTH AND WILDLIFE BAFs FOR ORGANIC CHEMICALS

A. To calculate human health and wildlife BAFs for an organic chemical, the K_{ow} of the chemical should be used with a POC concentration of 0.00000004 kg/L and a DOC concentration of 0.000002 kg/L to yield the fraction freely dissolved:

$$f_{fd} = \frac{1}{1 + \frac{(DOC)(K_{ow})}{10} + (POC)(K_{ow})}$$

$$= \frac{1}{1 + \frac{(0.000002\ kg/L)(K_{ow})}{10} + (0.00000004\ kg/L)(K_{ow})}$$

$$= \frac{1}{1 + (0.00000024\ kg/L)(K_{ow})}$$

B. The human health BAFs for an organic chemical are calculated using the following equations:

For trophic level 3:

$$BAF_{TL3}^{HH} = [(\text{baseline BAF})(0.0182) + 1](f_{fd})$$

For trophic level 4:

$$BAF_{TL4}^{HH} = [(\text{baseline BAF})(0.0310) + 1](f_{fd})$$

where:

0.0182 and 0.0310 are the standardized fraction lipid values for trophic levels 3 and 4, respectively, that are used to derive human health values..

C. The wildlife BAFs for an organic chemical are calculated using the following equations:

For trophic level 3:

$$BAF_{TL3}^{WL} = [(\text{baseline BAF})(0.0646) + 1](f_{fd})$$

For trophic level 4:

$$BAF_{TL4}^{WL} = [(\text{baseline BAF})(0.1031) + 1](f_{fd})$$

where:

0.0646 and 0.1031 are the standardized fraction lipid values for trophic levels 3 and 4, respectively, that are used to derive wildlife values.

VII. HUMAN HEALTH AND WILDLIFE BAFs FOR INORGANIC CHEMICALS

A. For inorganic chemicals, the baseline BAFs for trophic levels 3 and 4 are both assumed to equal the BCF determined for the chemical with fish, i.e., the FCM is assumed to be 1 for both trophic levels 3 and 4. However, a FCM greater than 1 might be applicable to some metals, such as mercury, if, for example, an organometallic form of the metal biomagnifies.

B. BAFs for Human Health Values.

1. Measured BAFs and BCFs used to determine human health BAFs for inorganic chemicals should be based on edible tissue (e.g., muscle) of freshwater fish unless it is demonstrated that whole-body BAFs or BCFs are similar to edible-tissue BAFs or BCFs. BCFs and BAFs based on measurements of aquatic plants and invertebrates should not be used in the derivation of human health criteria and values.

2. If one or more field-measured baseline BAFs for an inorganic chemical are available from studies conducted with the muscle of fish:

   a. For each trophic level, a species mean measured baseline BAF is calculated as the geometric mean if more than one measured BAF is available for a given species; and

   b. For each trophic level, the geometric mean of the species mean measured baseline BAFs is used as the human health BAF for that chemical.

3. If an acceptable measured baseline BAF is not available for an inorganic chemical and one or more acceptable edible-portion laboratory-measured BCFs are available for the chemical, a predicted baseline BAF should be calculated by multiplying the geometric mean of the BCFs times a FCM. The FCM will be 1.0 unless chemical-specific biomagnification data support using a multiplier other than 1.0. The predicted baseline BAF is used as the human health BAF for that chemical.

C. BAFs for Wildlife Values

1. Measured BAFs and BCFs used to determine wildlife BAFs for inorganic chemicals should be based on whole-body freshwater fish and invertebrate data unless it is demonstrated that edible-tissue BAFs or BCFs are similar to whole-body BAFs or BCFs.

2. If one or more field-measured baseline BAFs for an inorganic chemical are available from studies conducted with whole body of fish or invertebrates:

   a. For each trophic level, a species mean measured baseline BAF is calculated as the geometric mean if more than one measured BAF is available for a given species.

   b. For each trophic level, the geometric mean of the species mean measured baseline BAFs is used as the wildlife BAF for that chemical.

3. If an acceptable measured baseline BAF is not available for an inorganic chemical and one or more acceptable whole-body laboratory-measured BCFs are available for the chemical, a predicted baseline BAF is calculated by multiplying the geometric mean of the BCFs times a FCM. The FCM will be 1.0 unless chemical-specific biomagnification data support using a multiplier other than 1.0. The predicted baseline BAF is used as the wildlife BAF for that chemical.

VIII. FINAL REVIEW

For both organic and inorganic chemicals, human health and wildlife BAFs for both trophic levels should be reviewed for consistency with all available data concerning the bioaccumulation, bioconcentration, and metabolism of the chemical. For example, information concerning octanol-water partitioning, molecular size, or other physicochemical properties that might enhance or inhibit bioaccumulation should be considered for organic chemicals. BAFs derived in accordance with this methodology should be modified if changes are justified by available data.

IX. SITE-SPECIFIC MODIFICATIONS

A. The preceding procedures will generally be used to derive BAFs to derive state-wide standards or guidance values. Site-specific modifications to such BAFs are required or allowed as described below.

B. BAFs may be modified on a site-specific basis to larger values, where reliable data show that local bioaccumulation is greater than the state-wide value.

C. BAFs may be modified on a site-specific basis to lower values, where scientifically defensible, if::

   1. The fraction of the total chemical that is freely dissolved in the ambient water is different than that used to derive the state-wide BAFs (i.e., the concentrations of particulate organic carbon and the dissolved organic carbon are different than those used to derive the state-wide BAFs);

2. Input parameters of the Gobas model, such as the structure of the aquatic food web and the disequilibrium constant, are different at the site than those used to derive the state-wide BAFs (the Gobas model was used to derive FCMs and further information on input parameters are found in the TSD);

3. The percent lipid of aquatic organisms that are consumed and occur at the site is different than that used to derive the state-wide BAFs; or

4. Site-specific field-measured BAFs or biota-sediment accumulation factor (BSAFs) are determined. If site-specific BAFs are derived, they should be derived using the procedures in this document.

D. Any more stringent modifications to protect threatened or endangered species should be derived using procedures set forth in this document.

X. APPORTIONMENT OF HUMAN FISH CONSUMPTION RATE

The water quality regulations, Part 702, provide for a human fish consumption rate of 0.033 kilograms per day, but do not apportion it to various trophic levels. For the purpose of deriving Health (Fish Consumption) standards and guidance values, this fish consumption should be apportioned as 24 percent trophic level 3 and 76 percent trophic level 4.

Table 1. Food-chain Multipliers for Trophic Levels 2, 3 & 4

$LogK_{ow}$	Trophic Level 2	Trophic[a] Level 3	Trophic Level 4
2.0	1.000	1.005	1.000
2.5	1.000	1.010	1.002
3.0	1.000	1.028	1.007
3.1	1.000	1.034	1.007
3.2	1.000	1.042	1.009
3.3	1.000	1.053	1.012
3.4	1.000	1.067	1.014
3.5	1.000	1.083	1.019
3.6	1.000	1.103	1.023
3.7	1.000	1.128	1.033
3.8	1.000	1.161	1.042
3.9	1.000	1.202	1.054
4.0	1.000	1.253	1.072
4.1	1.000	1.315	1.096
4.2	1.000	1.380	1.130
4.3	1.000	1.491	1.178
4.4	1.000	1.614	1.242
4.5	1.000	1.766	1.334
4.6	1.000	1.950	1.459
4.7	1.000	2.175	1.633
4.8	1.000	2.452	1.871
4.9	1.000	2.780	2.193

$LogK_{ow}$	Trophic Level 2	Trophic[a] Level 3	Trophic Level 4
5.0	1.000	3.181	2.612
5.1	1.000	3.643	3.162
5.2	1.000	4.188	3.873
5.3	1.000	4.803	4.742
5.4	1.000	5.502	5.821
5.5	1.000	6.266	7.079
5.6	1.000	7.096	8.551
5.7	1.000	7.962	10.209
5.8	1.000	8.841	12.050
5.9	1.000	9.716	13.964
6.0	1.000	10.556	15.996
6.1	1.000	11.337	17.783
6.2	1.000	12.064	19.907
6.3	1.000	12.691	21.677
6.4	1.000	13.228	23.281
6.5	1.000	13.662	24.604
6.6	1.000	13.980	25.645
6.7	1.000	14.223	26.363
6.8	1.000	14.355	26.669
6.9	1.000	14.388	26.669
7.0	1.000	14.305	26.242
7.1	1.000	14.142	25.468
7.2	1.000	13.852	24.322

$LogK_{ow}$	Trophic Level 2	Trophic[a] Level 3	Trophic Level 4
7.3	1.000	13.474	22.856
7.4	1.000	12.987	21.038
7.5	1.000	12.517	18.967
7.6	1.000	11.708	16.749
7.7	1.000	10.914	14.388
7.8	1.000	10.069	12.050
7.9	1.000	9.162	9.840
8.0	1.000	8.222	7.798
8.1	1.000	7.278	6.012
8.2	1.000	6.361	4.519
8.3	1.000	5.489	3.311
8.4	1.000	4.683	2.371
8.5	1.000	3.949	1.663
8.6	1.000	3.296	1.146
8.7	1.000	2.732	0.778
8.8	1.000	2.246	0.521
8.9	1.000	1.837	0.345
9.0	1.000	1.493	0.226

[a] The FCMs for trophic level 3 are the geometric mean of the FCMs for sculpin and alewife.

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