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OFFICE OF
WATER

SUBJECT: Modifications to Guidance Site-Specific Criteria

Jeanette Wiltse

FROM: Jeanette Wiltse, Director
Health and Ecological Criteria Division

TO: Water Quality Branch Chiefs
Water Quality Standards Coordinators

Attached are three guidance documents, developed last year through the Aquatic Life Guidelines Committee, dealing with site-specific criteria development. These documents clarify and slightly modify the recommendations of the 1994 "Interim Guidance on Determination and Use of Water-Effect Ratios for Metals" (EPA-823-B-94-001). That document set forth recommendations on deriving site-specific criteria, accounting for the influence of site water quality on bioavailability and toxicity (Water-Effect Ratio), and accounting for the sensitivity of the local taxonomic assemblage (Recalculation Procedure).

The attached document titled "Use of the WER Procedure with Hardness Equations" clarifies but does not substantially change the recommendations on handling hardness during water-effect ratio determinations.

The other two attached documents deal with the Recalculation Procedure. These documents, titled "A Change in the Recalculation Procedure" and "Optional Consideration of Life Stage When the Recalculation Procedure is Used", slightly modify the recommendations of Appendix B of the 1994 guidance.

Technical questions about these documents may be directed to the primary author, Charles Stephan (phone 218-529-5219, or e-mail stephan.charles@epamail.epa.gov).

Attachments

11-19-97

# Use of the WER Procedure with Hardness Equations

The freshwater national aquatic life criteria for several metals are expressed as equations that relate the criterion concentrations to hardness. These hardness equations were derived using the procedure described in the Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses (the 1985 Guidelines; U.S. EPA 1985). The purpose of this document is to provide guidance concerning the application of the hardness equations when the Water-Effect Ratio (WER) Procedure is used.

For some metals, the relationship between hardness and toxicity is not due to hardness itself, but is wholly or partially due to constituents that are usually correlated with hardness, notably alkalinity and pH (Erickson et al. 1994; Mayer et al. 1994). If sufficient data were available, a multiparameter equation could simultaneously address all of the variables (and the interactions between them) that most affect the toxicity of a metal. This is important because the inorganic constituents are not well correlated in some dilution and surface waters. For example, some data were generated using waters in which hardness and pH were correlated, whereas other data were generated using waters that were formulated to have different hardnesses at the same pH. Because insufficient data are available to derive correlations with all of the important constituents, the hardness equation for a metal is most accurate when the relationships between hardness and the other important inorganic constituents are nearly identical in all of the dilution waters used in the toxicity tests and in the surface waters to which the equation is to be applied.

When the relation between hardness and the toxicity of a particular metal is investigated with different aquatic species, a range of slopes will be obtained, even if the slope is actually the same for all of the species, because of (1) experimental variation and (2) variations in the ratios between hardness and the other important inorganic constituents in the dilution waters used in the toxicity tests with the different species. For lack of a body of data or rationale to the contrary and because sufficient data are available to derive species-specific slopes for only a few species, the recommended approach (U.S. EPA 1985) is to calculate a pooled slope using the data available for a metal and apply the pooled slope to all species.

Unfortunately, it is sometimes claimed that the pooled slope is calculated from normalized data and therefore cannot be used in a hardness equation that uses data that are not normalized. As stated on page 34 of the 1985 Guidelines, the slope calculated for a species from data that are not normalized is the same as the slope that is calculated for the species from normalized data, except for roundoff error. Normalization allows data for different species to be used in a statistically appropriate manner in the calculation of the pooled slope. If data for different species are used to calculate a pooled slope without appropriate normalization, a statistically sound pooled slope will not be obtained.

## The Water-Effect Ratio Procedure

The purpose of using the WER Procedure (U.S. EPA 1994) is to account for any difference that exists between the toxicity of a pollutant in a laboratory dilution water and its toxicity in a site water. For metals whose criteria are expressed as hardness equations, use of the WER Procedure will generally be intended to account for effects of such water quality characteristics as total organic carbon on the toxicities of metals. The WER Procedure is equally useful for accounting for any deviation from a hardness equation in a site water.

When the WER Procedure is used to derive a site-specific criterion, a Final WER (FWER) is derived from the experimentally determined WERs and then the FWER is multiplied times the national criterion concentration that corresponds to the average hardness of the downstream site water at design flow. Not using the WER Procedure is equivalent to using a default FWER of 1; if they are correctly determined with appropriately sensitive toxicity tests, more experimentally determined FWERs are expected to be above 1 than below 1.

The FWER is derived from three or more experimentally determined WERs, as described on pages 28 through 39 of U.S. EPA (1994). A WER that is determined using a sample of site water that was obtained when the flow was between 1 and 2 times higher than the design flow is a Type 1 WER. A WER that is determined using a sample of site water that was obtained when the flow was between 2 and 10 times higher than the design flow is a Type 2 WER and an hWER is also calculated. (As explained on page 31 of U.S. EPA [1994], an hWER is the highest WER that could be used to derive a site-specific criterion for the downstream water at design flow so that there would be adequate protection at the higher flow at which the WER was determined.) Type 1 WERs, Type 2 WERs, and hWERs are used in the derivations of FWERs.

It might seem that when a WER is determined for a metal whose criterion is expressed as a hardness equation, the WER should be determined using a laboratory dilution water whose hardness is the same as that of the site water. As explained on pages 39 through 43 of the 1994 WER guidance, a WER is just as useful when the hardness of the laboratory dilution water is not the same as that of the site water, if the calculations are performed correctly.

Because the hardness of the laboratory dilution water does not have to be the same as that of the site water, the hardness of the laboratory dilution water should satisfy two conditions:

1. The use of a hardness equation will be most accurate if the hardness of the laboratory dilution water is near the median or at least well within the range of the hardnesses used in the derivation of the hardness equation. (Similarly, for some metals the criterion will be most accurate if other inorganic constituents in the laboratory dilution water are related to hardness in the same way they were related in the waters used in the derivation of the hardness equation.)
2. As discussed on pages 39 through 43 of the 1994 WER guidance (U.S. EPA 1994), considerations concerning acclimation of test organisms are the basis of the following statements on page 50:

   > The hardness of the laboratory dilution water should be between 50 and 150 mg/L and must be between 40 and 220 mg/L. If the criterion for the metal is hardness-dependent, the hardness of the laboratory dilution water must not be above the hardness of the site water, unless the hardness of the site water is below 50 mg/L.

All of the Type 1 WERs, Type 2 WERs, and hWERs for a site must be calculated appropriately so that they can be used together in the derivation of the FWER.

a. In order for WERs to be compatible with the derivation of hWERs and FWERs, either the two waters used in the determination of a WER must have the same hardness or the LC50 determined in the laboratory dilution water will have to be adjusted to the hardness of the site water. Of course, the hardness of the laboratory dilution water should not equal the hardness of the site water if the site-water hardness does not satisfy the two conditions discussed above. When the two hardnesses are different, the LC50 determined in laboratory dilution water can be adjusted using the slope of the hardness equation, as described on pages 39 through 43 of U.S. EPA (1994) and demonstrated below.

b. Because FWERs are multiplied times the national criterion that corresponds to the average hardness of the downstream site water at design flow, hWERs must be based on this hardness.

Correct use of the WER Procedure will prevent double adjustment for hardness.

Special uses of the WER Procedure

If there is a regulatory requirement that a hardness of 25 mg/L be used in a hardness equation when the actual hardness of the downstream water at design flow is below 25 mg/L, the resulting level of protection will probably be below that intended by the 1985 guidelines. The WER Procedure can be used to provide the intended level of protection when hardness is below 25 mg/L if the WERs, hWERs, and FWER are determined as described above and if the FWER is multiplied times the national criterion concentration that corresponds to the average hardness of the downstream site water at design flow. The FWER must not be multiplied times the national criterion concentration for 25 mg/L.

If the hardness of the site water at design flow is above 400 mg/L and a default FWER of 1 is used, calculating the national criterion using a hardness of 400 mg/L in the hardness equation might provide a higher level of protection than that intended by the 1985 guidelines. The WER Procedure can be used to provide the intended level of protection when hardness is above 400 mg/L if the WERs, hWERs, and FWER are determined as described above and if the FWER is multiplied times the national criterion concentration that corresponds to the average hardness of the downstream site water at design flow. The FWER must not be multiplied times the national criterion for 400 mg/L.

The WER Procedure can be used to provide the level of protection intended by the 1985 guidelines when an effluent causes hardness to be inconsistent with alkalinity and/or pH in the downstream water. If the WER Procedure is used in this situation, the WERs, hWERs, and FWER are determined as described above, and the FWER must be multiplied times the national criterion concentration that corresponds to the average hardness of the downstream site water at design flow. The FWER must not be multiplied times the national criterion that applies to upstream water.

Examples of the calculation of WERs

For these examples, it will be assumed that the CMC hardness equation for the metal of concern is:

$$\text{National CMC} = e^{1.15[\ln(\text{hardness})]-2.69187}$$

It will also be assumed that the LC50 of the test species in laboratory dilution water can be calculated using the following equation:

$$\text{LC50 in lab dilution water} = e^{1.15[\ln(\text{hardness})]-2.1}$$

A large number of digits will be carried where necessary in these examples to minimize apparent discrepancies that are due to rounding off.

Example 1. For this example, it will be assumed that the sample of site water is obtained at design flow so that the hardness of the site water is the design hardness.

If the design hardness is 200 mg/L, the national CMC (nCMC) at the design hardness is 30 ug/L. If the hardness of the laboratory dilution water is 100 mg/L, the LC50 of the test species in this water is 24.43 ug/L. Adjusting this LC50 to a hardness of 200 mg/L gives:

$$\text{adj LC50} = (\text{LC50})(e^{1.15[(\ln 200) - (\ln 100)]}) = 54.21\ \text{ug/L}$$

If the LC50 in site water at the design hardness of 200 mg/L is 120 ug/L:

$$\text{WER} = (120\ \text{ug/L})/(54.21\ \text{ug/L}) = 2.214$$

Example 2. For this example, it will be assumed that the sample of site water is obtained at 1.5 times the design flow and that the hardness of the sample is 160 mg/L, which is substantially lower than the design hardness of 200 mg/L.

If the design hardness is 200 mg/L, the nCMC at the design hardness is 30 ug/L. If the hardness of the laboratory dilution water is 100 mg/L, the LC50 of the test species in this water is 24.43 ug/L. Adjusting this LC50 to a hardness of 160 mg/L gives:

$$\text{adj LC50} = (\text{LC50})(e^{1.15[(\ln 160) - (\ln 100)]}) = 41.94\ \text{ug/L}$$

If the LC50 in site water at a hardness of 160 mg/L is 71 ug/L:

$$\text{WER} = (71\ \text{ug/L})/(41.94\ \text{ug/L}) = 1.693$$

An example of the derivation of a FWER

This is a hypothetical example of the use of the WER Procedure to derive a site-specific CMC for a metal whose national CMC is expressed as a hardness equation. The following are assumed for the purpose of this example:

Upstream water
  design flow = 850 cfs
  design hardness = 182 mg/L
  concentration of the metal at all flows = 2 ug/L
Effluent
  flow at all times = 150 cfs
  hardness at all times = 302 mg/L
Downstream water
  design flow = 1000 cfs
  design hardness = 200 mg/L

The design hardness is the average hardness at design flow.

Mass balance of flow at design flow:
  850 cfs + 150 cfs = 1000 cfs

Mass balance of hardness at design flow:
  (850 cfs)(182 mg/L)+(150 cfs)(302 mg/L) = (1000 cfs)(200 mg/L)

Hypothetical side-by-side toxicity tests were conducted during three different months:

| M | Flow (cfs) | | | Hardness (mg/L) | | | Site water | | Lab water | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Up | Eff | Down | Up | Eff | Down | Hard (mg/L) | LC50 (ug/L) | Hard (mg/L) | LC50 (ug/L) |
| A | 1450 | 150 | 1600 | 164 | 302 | 177 | 177 | 154 | 100 | 22 |
| B | 950 | 150 | 1100 | 177 | 302 | 194 | 194 | 180 | 100 | 20 |
| C | 2350 | 150 | 2500 | 151 | 302 | 160 | 160 | 120 | 100 | 24 |

M = month
Down = downstream water
Up = upstream water
Eff = effluent
Hard = hardness

The assumed hardness equation for the metal of concern is:

$$\text{nCMC} = e^{1.15[\ln(\text{hardness})]-2.69187}$$

The nCMC is 30 ug/L at the downstream design hardness of 200 mg/L.

The LC50s obtained in the laboratory dilution water have to be adjusted from the laboratory water hardness of 100 mg/L to the hardness of the site water using the equation:

$$\text{adj LC50} = (\text{LC50})(e^{1.15\{[\ln(\text{site-water hard})]-[\ln(\text{lab water hard})]\}})$$

| M | Laboratory water | | | Site-water | Exp detn | Adj |
|---|---|---|---|---|---|---|
| _ | Hard | LC50 | Adj LC50 | LC50 | WER | WER |
| A | 100 | 22 | 36.147 | 154 | 7 | 4.260 |
| B | 100 | 20 | 39.318 | 180 | 9 | 4.578 |
| C | 100 | 24 | 29.598 | 120 | 5 | 4.054 |

Exp. determined WER = (site-water LC50)/(lab-water LC50)
Adjusted WER = (site-water LC50)/(adj lab-water LC50)

The adjusted WERs are smaller than the experimentally determined WERs because the site-water hardnesses are higher than the hardness of the laboratory dilution water and the hardness equation gives higher LC50s at higher hardnesses.

Because the third WER was determined when the flow was 2 to 10 times higher than the downstream design flow, it is a Type 2 WER and an hWER has to be calculated as described on pages 30 and 31 of the ‘94 WER guidance; the HCME is calculated as an intermediate value. The HCME and the hWER apply at design flow, and so the nCMC used in these calculations must be the 30 ug/L that corresponds to the downstream design hardness of 200 mg/L.

$$\text{HCME} = \frac{[(\text{nCMC})(\text{WER})(\text{eFLOW} + \text{uFLOW})] - [(\text{uCONC})(\text{uFLOW})]}{\text{eFLOW}}$$

$$\text{HCME} = \frac{[(30\text{ ug/L})(4.054)(2500\text{ cfs})] - [(2\text{ ug/L})(2350\text{ cfs})]}{150\text{ cfs}}$$

$$\text{HCME} = 1995.7\text{ ug/L}$$

$$\mathrm{hWER} = \frac{[(\mathrm{HCME})(\mathrm{eFLOWdf})] + [(\mathrm{uCONCdf})(\mathrm{uFLOWdf})]}{(\mathrm{nCMC})(\mathrm{eFLOWdf} + \mathrm{uFLOWdf})}$$

$$\mathrm{hWER} = \frac{[(1995.7\ \mathrm{ug/L})(150\ \mathrm{cfs})] + [(2\ \mathrm{ug/L})(850\ \mathrm{cfs})]}{(30\ \mathrm{ug/L})(1000\ \mathrm{cfs})}$$

$$\mathrm{hWER} = 10.04$$

Because there are two Type 1 WERs and one Type 2 WER, the FWER is derived using option 1.a.1 on page 36 of U.S. EPA (1994). The two Type 1 WERs are 4.260 and 4.578 and the adjusted geometric mean WER, calculated as described on page 71 of U.S. EPA (1994), is 4.410, which is slightly lower than the geometric mean of 4.416. The adjusted geometric mean is lower than the hWER of 10.04, and so the FWER is 4.410. Thus, although they are both at a hardness of 200 mg/L, the nCMC is 30 ug/L whereas the site-specific CMC is (30 ug/L)(4.410) = 132.3 ug/L.

## Acknowledgments

This document was written by Charles Stephan (with substantial input from Bill Beckwith, Charles Delos, and Russ Erickson) under the auspices of the Aquatic Life Criteria Guideline Committee. Please submit comments or questions or both to: Charles Stephan, U.S. EPA, 6201 Congdon Blvd., Duluth, MN 55804 (TEL: 218-529-5219)(FAX: 218-529-5003)(email: stephan.charles@epamail.epa.gov).

## References

Erickson, R.J., T.D. Bills, J.R. Clark, D.J. Hansen, J. Knezovich, F.L. Mayer, Jr., and A.E. McElroy. 1994. Synopsis of Discussion Session on Physicochemical Factors Affecting Toxicity. IN: Bioavailability: Physical, Chemical, and Biological Interactions. J.L. Hamelink, P.F. Landrum, H.L. Bergman, and W.H. Benson (eds.). Lewis Publishers, Boca Raton, FL. pp. 31-38.

Mayer, F.L., Jr., L.L. Marking, T.D. Bills, and G.E. Howe. 1994. Physicochemical Factors Affecting Toxicity in Freshwater:

Hardness, pH, and Temperature. IN: Bioavailability: Physical, Chemical, and Biological Interactions. J.L. Hamelink, P.F. Landrum, H.L. Bergman, and W.H. Benson (eds.). Lewis Publishers, Boca Raton, FL. pp. 5-22.

U.S. EPA. 1985. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses. PB85-227049. National Technical Information Service, Springfield, VA.

U.S. EPA. 1994. Interim Guidance on Determination and Use of Water-Effect Ratios for Metals. EPA-823-B-94-001 or PB94-140951. National Technical Information Service, Springfield, VA.

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# A Change in the Recalculation Procedure

When the U.S. EPA published Interim Guidance on Determination and Use of Water-Effect Ratios for Metals (U.S. EPA 1994), Appendix B on pages 90 through 97 presented the ‘94 version of the Recalculation Procedure. The purpose of using the Recalculation Procedure when deriving a site-specific criterion is to treat tested taxa that “occur at the site” (as defined on page 90 of U.S. EPA 1994) differently from tested taxa that do not occur at the site, when adequately justified. The purpose of this document is to present a change in the ‘94 Recalculation Procedure that results in a slightly different approach for addressing species and genera that occur at the site.

## Species in a genus that occurs at the site

In the new approach, if a genus occurs both at the site and in the national dataset, two rules determine whether the site-specific dataset must contain all, or only some, of the species in the national dataset that are in the genus:

Rule 1.

If a genus contains one or more species that occur at the site and if the national dataset contains every one of these species, the site-specific dataset must contain every one of these species that occur both at the site and in the national dataset, but must not contain any other species in the genus. In other words, if every species that is in the genus and occurs at the site is also in the national dataset, all of these species must be included in the site-specific dataset, but any other species in the national dataset that are in the genus must not be included in the site-specific dataset.

Rule 2.

If a genus contains one or more species that occur at the site but the national dataset does not contain every one of these species, the site-specific dataset must contain all of the species in the national dataset that are in the genus. In other words, if any species in the genus occurs at the site but not in the national dataset, all species in the national dataset that are in the genus must be included in the site-specific dataset.

The following four hypothetical examples are designed to illustrate these two rules using four hypothetical pollutants and four hypothetical sites. Each example lists all of the species in the genus *Lepomis* that occur at the site and/or are in the national dataset for the pollutant of concern:

| Site | Genus | Species | In nat'l dataset? | At site? | Deleted? |
|---|---|---|---|---|---|
| 1 | Lepomis | gibbosus | Yes | No | Yes |
| 1 | Lepomis | megaloris | Yes | Yes | No |
| 2 | Lepomis | cyanellus | No | Yes | NA |
| 2 | Lepomis | gibbosus | Yes | No | No |
| 2 | Lepomis | humilis | Yes | Yes | No |
| 3 | Lepomis | cyanellus | Yes | No | No |
| 3 | Lepomis | gibbosus | No | Yes | NA |
| 3 | Lepomis | humilis | Yes | No | No |
| 3 | Lepomis | megaloris | No | Yes | NA |
| 4 | Lepomis | cyanellus | Yes | No | Yes |
| 4 | Lepomis | gibbosus | Yes | Yes | No |
| 4 | Lepomis | humilis | Yes | No | Yes |
| 4 | Lepomis | megaloris | Yes | No | Yes |

NA = not applicable because the species is not in the national dataset.

No species are deleted at sites 2 and 3 because of Rule 2, but at least one species is deleted at sites 1 and 4 because of Rule 1.

Genera in a family are treated in the same way as species in a genus.

The above applies only to species, genera, and families that "occur at the site," as defined on page 90 of the '94 Recalculation Procedure. The above does not apply to species, genera, and families that do not occur at the site.

## A comparison of the new and old approaches

The difference between the new and old approaches can be illustrated with a hypothetical example. The following is a hypothetical list of all of the species in the family Centrarchidae that occur at a site and/or are in the national dataset for the pollutant of concern:

| Family | Genus | Species | In nat'l dataset? | At site? |
|---|---|---|---|---|
| Centrarchidae | Lepomis | cyanellus | Yes | Yes |
| Centrarchidae | Lepomis | gibbosus | Yes | No |
| Centrarchidae | Micropterus | salmoides | No | Yes |
| Centrarchidae | Pomoxis | annularis | Yes | No |

*L. cyanellus* is not deleted because it occurs at the site; it is a "circled" species according to the ‘94 Recalculation Procedure. *P. annularis* is not deleted because genera within a family are treated the same as species within a genus; it is retained to help represent the genus *Micropterus* that is in the same family, occurs at the site, and is not in the national dataset.

The difference between the old and new approaches affects *L. gibbosus*.

1. The intent of the '94 Recalculation Procedure is not clear concerning *L. gibbosus*. According to steps 1 and 2 on page 94, this species is not deleted because the genus *Micropterus* is in the same family, occurs at the site, and is not in the dataset. In contrast, item c on page 95 says:

   > Each genus that occurs at the site but does not occur in the national dataset is represented in the site-specific dataset by all genera in the national dataset that are in the same family.

   It says "all genera," not "all species."
2. In the new approach, *L. gibbosus* is deleted because *L. cyanellus* is in the national dataset and is the only species in the genus that occurs at the site. Thus, *L. gibbosus* is deleted because all of the species in this genus that occur at the site are in the national dataset.

The new approach makes it easier to use, explain, and understand this aspect of the Recalculation Procedure. Deletion of species such as *L. gibbosus* will not change the number of genera in the site-specific dataset and will not raise or lower the GMAV or the FAV on the average over a large number of datasets.

To implement this new approach, two changes need to be made on page 94 of the ‘94 Recalculation Procedure:

A. The second time that

   If "No", go to step 2.

   occurs in step 1 on page 94, it should be changed to

   If "No", delete the uncircled species.*

B. The second time that

   If "No", go to step 3.

   occurs in step 2 on page 94, it should be changed to

   If "No", delete the uncircled species.*

## Acknowledgments

This document was written by Charles Stephan and Dave Hansen (with substantial input from Joel Hansen and Fritz Wagener) under the auspices of the Aquatic Life Criteria Guideline Committee. Please submit comments or questions or both to: Charles Stephan, U.S. EPA, 6201 Congdon Blvd., Duluth, MN 55804 (TEL: 218-529-5219)(FAX: 218-529-5003)(EMAIL: stephan.charles@epamail.epa.gov).

## References

U.S. EPA. 1994. Interim Guidance on Determination and Use of Water-Effect Ratios for Metals. EPA-823-B-94-001 or PB94-140951. National Technical Information Service, Springfield, VA.

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# Optional Consideration of Life Stage
When the Recalculation Procedure is Used

The purpose of using the Recalculation Procedure (U.S. EPA 1994) when deriving a site-specific criterion is to treat tested taxa that occur at the site differently from tested taxa that do not occur at the site, when adequately justified. The Recalculation Procedure defines the concept of "occur at the site" and applies it to species, genera, families, orders, classes, and phyla, but not to life stages. The purpose of this document is to provide guidance concerning the optional application of the concept of "occur at the site" to life stages when the Recalculation Procedure is used.

## Modification of the Recalculation Procedure

When national aquatic life criteria are derived, known differences between the acute sensitivities of the life stages of a species are taken into account in the calculation of the Species Mean Acute Value (SMAV) as described in section IV.G of U.S. EPA (1985):

> If the available data indicate that one or more life stages are at least a factor of two more resistant than one or more other life stages of the same species, the data for the more resistant life stages should not be used in the calculation of the Species Mean Acute Value because a species can only be considered protected from acute toxicity if all life stages are protected.

For species that occur at the site, the Recalculation Procedure uses SMAVs calculated according to U.S. EPA (1985), which are called "national SMAVs" herein.

This new guidance allows deletion of data for individual life stages that do not occur at the site, if specified conditions are satisfied. When such a deletion is made in the data for a species, the site-specific SMAV for the species will be higher than the national SMAV for the species. This new guidance does not allow deletion of all of the data for any species that is not deleted using the deletion process described in U.S. EPA (1994).

Whenever the Recalculation Procedure is used, consideration of life stage should be optional. If life stage is considered, two changes are to be made in the Recalculation Procedure:

a. The deletion process described on pages 92 through 95 of U.S. EPA (1994) is to be applied; the deletion process is not optional when deletion of life stages is considered.
b. The life-stage process described below is to be applied immediately after the deletion process is applied.

All other aspects of the Recalculation Procedure are to be followed as described in U.S. EPA (1994). For example, corrections and additions are to be made as described on page 92 and the Minimum Data Requirements are to be checked as described on page 95. (If corrections and/or additions are made, the “national SMAVs” are calculated from the revised dataset.)

## The optional life-stage process

The optional life-stage process consists of recalculation of each national SMAV that satisfies the following six conditions:

1. The national SMAV was not deleted during the deletion process.
2. The national SMAV is in a genus whose GMAV is one of the four lowest in the site-specific dataset. (Application of the life-stage process to more species than required is acceptable, but it might substantially increase the amount of work, especially if it is difficult to determine whether a life stage occurs at the site, and it will not affect the site-specific FAV).
3. The national SMAV is based on a sensitive life stage because of the factor of two difference discussed in section IV.G of U.S. EPA (1985). This condition cannot be satisfied if data are available for only one life stage of a species, but it is acceptable to conduct an acute toxicity test with a different life stage, add the new acute value to the dataset as described on page 92 of U.S. EPA (1994), and derive a new national SMAV using the procedure described in section IV of U.S. EPA (1985). If the sensitivities of the two life stages differ by more than a factor of two, this condition will then be satisfied.
4. The life stage that is the basis of the national SMAV does not "occur at the site" as defined on pages 90 and 91 of U.S. EPA (1994).
   a. The life stage is said to occur at the site if (1) it has been collected from the site, (2) it occurs under similar conditions at nearby sites, and/or (3) earlier and later life stages of the same species occur at the site and it is not certain that migration and/or drifting (i.e., active and/or passive transport) will remove the life stage from the site.

b. It can be said that the life stage does not occur at the site only if (1) negative data are available from one or more high quality field surveys that were conducted during the proper season(s) during a year when site conditions were not unusual, used appropriate sampling procedures, and included sampling of all of the habitats in which the life stage might be found, and/or (2) the physical habitat and/or natural water quality characteristics at the site are totally inconsistent with the life stage. It should be clear that the life stage would not occur at the site even if all pollutants occurring at the site were removed.

Experts on local aquatic fauna can usually provide reliable information concerning whether a species or life stage occurs at the site. If expert opinion indicates reasonable doubt, the life stage should usually be assumed to occur at the site; a field survey may, of course, be conducted to resolve the doubt. It is certainly possible that a year that seems to be usual might actually be unusual; thus, if expert opinion indicates that the life stage should be present but it is not found in a field survey, the field survey should be repeated the following year.

5. Toxicity data for the life stage that is the basis of the national SMAV are in the national dataset for every species that is in the same family as the species of concern and for which the life stage of concern occurs at the site. (It is reasonable to assume that the same life stage of different species in the same family have similar sensitivities.) If this condition is not satisfied, the needed acute toxicity tests may be conducted with the appropriate life stage of species that are in the same family and occur at the site.
6. The dataset from which the national SMAV was derived contained an acute value for the first-feeding stage of the species of concern, if the first-feeding stage occurs at the site. (It is reasonable to assume that the first-feeding stage is at least as acutely sensitive to a pollutant as any other life stage of the same species, if an acute toxicity test with the first-feeding stage is defined to begin (a) at hatch for species for which the time from hatch to first feeding is less than 48 hours and (b) just before or at the beginning of the first-feeding stage for all other species.) If this condition is not satisfied, it is acceptable to conduct an acute toxicity test with the first-feeding stage, add the new acute value to the dataset as described on page 92 of U.S. EPA (1994), and derive a new national SMAV using the procedure described in section IV of U.S. EPA (1985).

Each SMAV that satisfies all six conditions is to be recalculated without using the data for the sensitive life stage that does not occur at the site. Two or more sensitive life stages of the same species are to be addressed simultaneously in this life-stage process if all six conditions are satisfied for more than one life stage.

After the appropriate SMAVs are recalculated, the GMAVs are recalculated and reranked as necessary. If a GMAV that was one of the four lowest is raised sufficiently that its new value is not among the four lowest, there is now at least one GMAV whose SMAVs have not been examined to determine whether they satisfy the six conditions listed above. These SMAVs are to be examined and recalculated if necessary. When the four lowest GMAVs in the dataset have been recalculated and reranked as necessary, then the site-specific FAV is calculated.

### Example

The following example uses a hypothetical dataset to demonstrate several features of the optional life-stage process. The GMAVs and SMAVs in this dataset are those that were not deleted during application of the deletion process to a national dataset. The genera in this dataset satisfy the Minimum Data Requirements. All of the LC50s in this dataset are from “flow-through, measured” acute toxicity tests.

| Rank | GMAV (ug/L) | SMAV (ug/L) | Species | LC50 (ug/L) | Life stage | Does the life stage occur at the site? |
|---|---|---|---|---|---|---|
| 9 | 87 | 87 | V. sew | 87 | adult | yes |
| 8 | 65 | 65 | M. hop | 65 | embryo | yes |
| 7 | 59 | 59 | K. car | 59 | embryo | yes |
| 6 | 43 | 43 | Q. tree | 43 | adult | yes |
| 5 | 37 | 37 | J. sun | 37 | juvenile | no |
| | | | J. sun | 80 | 1st-feeding | yes |
| 4 | 30 | 30 | P. fine | 36 | adult | yes |
| | | | P. fine | 25 | 1st-feeding | no |
| 3 | 27 | 27 | Z. bad | 62 | adult | yes |
| | | | Z. bad | 27 | juvenile | no |
| | | | Z. bad | 62 | 1st-feeding | yes |
| 2 | 20 | 20 | F. good | 50 | adult | yes |
| | | | F. good | 20 | juvenile | no |
| 1 | 10 | 10 | W. well | 10 | embryo | yes |

For the consideration of life stage, all of the SMAVs satisfy condition #1, and ranks 1, 2, 3, and 4 satisfy condition #2. Of these four, only ranks 2 and 3 satisfy conditions #3 and #4. It will be assumed that both of these ranks satisfy condition #5. It will be assumed that the first-feeding stage of the species *F. good* occurs at the site; thus, rank 2 does not satisfy condition #6. Rank 3 satisfies condition #6 and therefore is the only rank that satisfies all six conditions; its SMAV and GMAV change from 27 ug/L to 62 ug/L because the sensitive juvenile life stage does not occur at the site; the rank of this genus changes from 3 to 7. The revised dataset is:

| Rank | GMAV (ug/L) | SMAV (ug/L) | Species | LC50 (ug/L) | Life stage | Does the life stage occur at the site? |
|---|---|---|---|---|---|---|
| 9 | 87 | 87 | V. sew | 87 | adult | yes |
| 8 | 65 | 65 | M. hop | 65 | embryo | yes |
| 7 | 62 | 62 | Z. bad | 62 | adult | yes |
| | | | Z. bad | 27 | juvenile | no |
| | | | Z. bad | 62 | 1st-feeding | yes |
| 6 | 59 | 59 | K. car | 59 | embryo | yes |
| 5 | 43 | 43 | Q. tree | 43 | adult | yes |
| 4 | 37 | 37 | J. sun | 37 | juvenile | no |
| | | | J. sun | 80 | 1st-feeding | yes |
| 3 | 30 | 30 | P. fine | 36 | adult | yes |
| | | | P. fine | 25 | 1st-feeding | no |
| 2 | 20 | 20 | F. good | 50 | adult | yes |
| | | | F. good | 20 | juvenile | no |
| 1 | 10 | 10 | W. well | 10 | embryo | yes |

The life-stage procedure has not yet been applied to the new genus at rank 4. The new genus at rank 4 satisfies all six conditions, so its SMAV and GMAV change from 37 to 80 ug/L, resulting in a new revised dataset:

| Rank | GMAV (ug/L) | SMAV (ug/L) | Species | LC50 (ug/L) | Life stage | Does the life stage occur at the site? |
|---|---|---|---|---|---|---|
| 9 | 87 | 87 | V. sew | 87 | adult | yes |
| 8 | 80 | 80 | J. sun | 37 | juvenile | no |
| | | | J. sun | 80 | 1st-feeding | yes |
| 7 | 65 | 65 | M. hop | 65 | embryo | yes |
| 6 | 62 | 62 | Z. bad | 62 | adult | yes |
| | | | Z. bad | 27 | juvenile | no |
| | | | Z. bad | 62 | 1st-feeding | yes |
| 5 | 59 | 59 | K. car | 59 | embryo | yes |
| 4 | 43 | 43 | Q. tree | 43 | adult | yes |
| 3 | 30 | 30 | P. fine | 36 | adult | yes |
| | | | P. fine | 25 | 1st-feeding | no |
| 2 | 20 | 20 | F. good | 50 | adult | yes |
| | | | F. good | 20 | juvenile | no |
| 1 | 10 | 10 | W. well | 10 | embryo | yes |

Again, the life-stage procedure has not yet been applied to the new genus at rank 4, but this genus does not satisfy condition #3. Thus, this is the revised dataset from which the site-specific FAV should be calculated after consideration of life stage.

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## References

U.S. EPA. 1985. Guidelines for Deriving National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses.

PB85-227049. National Technical Information Service, Springfield, VA. p. 29.

U.S. EPA. 1994. Interim Guidance on Determination and Use of Water-Effect Ratios for Metals. EPA-823-B-94-001 or PB94-140951. National Technical Information Service, Springfield, VA. pp. 90-97.