Training materials on Copper BLM: Data Requirements

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Training materials on the Biotic Ligand Model for copper

1. Data Requirements

1.1 What water quality parameters (model inputs) are used in the BLM?

The ten water quality input parameters needed to run the BLM model for copper, are: pH; DOC; alkalinity; temperature; major cations (calcium, magnesium, sodium, and potassium); and major anions (sulfate, chloride).

1.2 Under what conditions does EPA recommend that the BLM be used? Are there any conditions under which EPA does not recommend the BLM be used?

Currently, EPA only recommends that the BLM be used to develop copper criteria for freshwater systems. EPA has not yet developed recommendations regarding BLM-based copper criteria for saltwater systems. The ranges of water chemistry parameters under which the BLM was developed and calibrated for copper are defined in the BLM interface (HydroQual, 2005) and are shown in Table 1.1 below. These ranges reflect the conditions in the toxicity tests supporting the recommended copper criteria development. The BLM can be used when the parameters, particularly temperature, fall outside these ranges, as these ranges reflect data available at time of model calibration.

Table 1.1: Ranges of Input Parameters Used to Develop the Copper BLM

Parameter	Lower Bound	Upper Bound
Temperature (°C)	10	25
pH	4.9	9.2
DOC (mg/L)	0.05	29.65
Calcium (mg/L)	0.204	120.24
Magnesium (mg/L)	0.024	51.9
Sodium (mg/L)	0.16	236.9
Potassium (mg/L)	0.039	156
Sulfate (mg/L)	0.096	278.4
Chloride (mg/L)	0.32	279.72
Alkalinity (mg/L)	1.99	360

Source: HydroQual, 2005

1.3 What information does one model run provide?

The BLM can be run with one set of input parameters (one "data set") to calculate an instantaneous criterion or it can be run with multiple data sets to calculate numerous instantaneous criteria. An instantaneous criterion is a "snapshot in time;" that is, it is a criterion that reflects the water chemistry values for each of the ten parameters at one specific instant in time and at one specific location. Using the BLM with one data set is similar to using the hardness-based equation with only one value for hardness.

1.4 What are the limitations of an instantaneous criterion?

EPA does not recommend deriving a criterion based on a single ambient sample. An instantaneous criterion would not take into account variations in the BLM input parameters, some of which may vary substantially on a temporal and/or spatial scale. The variable nature of a BLM-derived instantaneous criterion is not a problem unique to the BLM or copper, as other water quality parameters (e.g., nutrients) vary spatially and temporally.

1.5 How many sampling events are preferred for using the BLM to develop site-specific criteria?

Because of the diversity of water bodies to which the BLM might be applied, EPA is not providing a specific recommendation on the preferred number of sampling events that should be used with the BLM. In developing a site-specific criterion, enough data should be collected to characterize and manage the spatial and temporal variability of the site.

Instantaneous copper criteria predicted using the BLM may not reflect intrinsic temporal variability caused by seasonal changes in water quality parameters and other natural sources of variability. Because some of the BLM input parameters are known to vary seasonally, EPA suggests a possible starting point of at least one sampling event per season. EPA analyzed thirteen river and stream segments and found that BLM-predicted copper criteria in this study were generally higher in the spring and summer and lower in the fall and winter. (See "Training materials on Copper BLM: Implementation" for an example of how a state has addressed seasonal variability in its monitoring recommendations.)

Spatial variability in the BLM input parameters caused by physical factors such as watershed size or the presence or absence of a point source discharge(s) to a water body should also be considered when determining how many sampling events should be collected when using the BLM to develop site-specific copper criteria. Spatial variability in the BLM input parameters should also be considered when determining how many sampling locations should be selected for development of site-specific copper criteria using the BLM (see question 1.6 below).

Regardless of the number of sampling events involved, data collection should reflect site-specific characteristics and consider special circumstances that may affect copper toxicity throughout the expected range of receiving water conditions.

EPA suggests that states develop Quality Assurance Project Plans (QAPPs) for sampling protocols, in order to assure that representative data are collected. Further information on QAPPs may be found at http://www.epa.gov/quality/qapps.html.

1.6 How many sampling locations are preferred within a water body or water segment?

Because BLM input parameters may vary spatially within a water segment or water body, multiple sampling locations may be appropriate. The unique characteristics of each site should be considered, including variability in BLM input parameters. For example, relatively homogenous systems may require fewer sampling locations as compared with more heterogeneous water bodies. If necessary, larger water segments could be divided into smaller segments.

1.7 What are the options for calculating a single numeric site-specific criterion from multiple BLM-derived instantaneous criteria?

The BLM calculates a copper criterion value for each set of input parameters (e.g., each 'data set'). For example, if a state has 10 data sets or sampling events for a particular site, then the BLM will calculate 10 unique instantaneous copper criteria values. A state has several options for developing a single numeric site-specific criterion from the BLM output. The site-specific criterion should protect the water body, i.e., its designated use for aquatic life, under a variety of circumstances (e.g., seasonal conditions, high and low flows) and should not be exceeded more than the time allowed by the state standard (e.g., once every three years, on average). Site-specific conditions may influence the selection of an appropriate statistical metric for calculating a numeric criterion for copper.

If the water quality parameters and BLM-derived copper criteria are relatively constant over a range of seasonal and flow conditions, (i.e., there is little variation in the input parameters and instantaneous criteria), then using the geometric mean of all instantaneous criteria may be appropriate. A geometric mean is a measure of central tendency and is less likely to be affected by outliers than an arithmetic mean.

If a water body exhibits significant seasonal variations in the BLM input parameters and BLM-derived instantaneous copper criteria, then it may be best to develop seasonal criteria using seasonal geometric means. In such water bodies, averaging on an annual basis could result in a criterion value that is potentially under-protective during parts of the year (e.g., fall and winter).

If the BLM-derived copper criteria vary significantly for reasons that cannot be easily explained (e.g., are not seasonal), then a lower percentile value (e.g., 5^{th}) may be best to ensure that the water body is sufficiently protected and the criterion is not exceeded more than the state standard allows.

If there are significant spatial differences in the instantaneous BLM-derived criteria for a water segment, then dividing the segment into smaller sections may be appropriate, as described in Question 1.6.

1.8 To which of the water quality parameters is the BLM most sensitive?

The sensitivity of various input parameters can vary depending on site-specific characteristics. Generally, the BLM model, when applied to copper, is most sensitive to pH and DOC (EPA, 2002a).

1.9 How do variations in DOC and pH affect model output?

Although the effects of variations of DOC and pH will vary by water body, generally higher concentrations of DOC and higher pH values will lead to higher (less stringent) criteria values for copper.

1.10 How much do pH and DOC typically vary within a water body?

EPA conducted a preliminary analysis of thirteen river and stream segments over ten years with data obtained from the United States Geological Survey (USGS). EPA selected the sites, which included large rivers and smaller streams, based on their rich data records containing monthly measurements of all BLM input parameters. At these sites, pH typically varied temporally by one unit. Most of the sites had DOC values that varied by a factor of two. However, the variability of these and other parameters may be different for different water bodies. EPA's Metals Translator Guidance notes that "pH may vary over several units as a result of acidic precipitation in the watershed, photosynthetic activity in the water body (lowest pH at dawn and highest pH in early afternoon coincident with peak photosynthetic activity of phytoplankton and other aquatic vegetation), or effluent discharge to the water body" (EPA, 1996b).

1.11 What are the preferred analytical methods to measure the water quality parameters required by the BLM? What methods are available for DOC?

EPA provides Guidelines Establishing Test Procedures for the Analysis of Pollutants at 40 CFR Part 136. Information on these analytical methods is available at http://www.epa.gov/waterscience/methods/ . Although DOC is not regulated as a contaminant, there are several scientifically-defensible methods available to measure DOC, such as EPA Method 415.3 (Dissolved and Total Organic Carbon and UV Absorbance at 254 nm in Source Water and Drinking Water), as well as methods developed by ASTM International and *Standard Methods for the Examination of Water and Wastewater*.

1.12 Are there ways to estimate parameter values where the needed measurements are missing?

EPA is currently assessing the feasibility of developing parameter estimation techniques. Such values may be based on geographical location (e.g., water hardness and alkalinity exhibit noticeable geographic trends) or correlations between parameters (e.g., alkalinity can be readily predicted from hardness). In the meantime, EPA suggests using the BLM only where data are available, as is further explained in Question 1.1 of "Training materials on Copper BLM: Implementation."