Copper Biotic Ligand Model Workshop Proceedings

EPA Region 10 Office, Seattle WA
May 13-14, 2015

Contents

Executive Summary

On May 13th through 14th, 2015 a group met in Seattle, Washington to discuss the copper biotic ligand model (BLM) and current practices related to implementing copper water quality criteria at the state level. Bringing together experts from U.S. Environmental Protection Agency (EPA) headquarters, EPA Regional offices, U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (FWS), academia, and the private sector; as well as those with a knowledge of state standards, state permitting programs, and tribal water programs; workshop participants discussed lessons learned from implementing the BLM and other unique approaches to the adoption of statewide and site-specific copper criteria.

Technical presentations were given throughout the two days to provide participants with a basic understanding and overview of the BLM.[1] Additionally, presentations and discussions addressed state examples and lessons learned using the BLM, challenges and opportunities related to data availability and state adoption of the BLM, and permitting and listing considerations for BLM implementation. Discussions centered on potential hurdles to BLM implementation as well as common themes and questions.

Common themes and questions highlighted throughout the two-day workshop included:

- How can we transition to new copper criteria adoption with proposed updates and new data expected from the not-yet-released version of the BLM?
- There will be a transition process from hardness-based criteria to BLM adoption.
    - States should consider scientific defensibility *and* protectiveness.
    - Should EPA develop guidance for adopting and implementing BLM-based copper criteria?
- Transition process from hardness criteria to adopting the BLM approach – What lessons can we learn from Colorado's approach?
- Data availability is a factor.
    - Benefits and costs of using estimates vs. observed data.
    - How can states make decisions when it is known that the estimates are considered conservative?
- Spatial use of data: how far upstream and downstream can data be applied?
- How will moving to the copper BLM work in waters with threatened or endangered species affecting the consultation process?
- Anti-backsliding
    - How does anti-backsliding impact permit limits if a state adopts conservative defaults for some of the model input parameters?
- Site-specific criteria vs. statewide criteria adoption
    - Avoid cherry-picking sampling sites when adopting the BLM and incorporating a site-specific basis.
    - Use of a performance-based approach may help to lessen the administrative burden.
    - Consideration of Endangered Species Act (ESA) issues when recommending the continued use of hardness-based criteria.
- As states adopt criteria, which agency (i.e., state program) or entity (i.e., industry/permittee) should be doing the bulk of the BLM work, such as monitoring for input parameters, running the model, etc.?

[1] Presentations provided in Appendix C.

    - Is there a role for EPA guidance?
- Consultation with the services (e.g., USGS, FWS). What timeline constraints exist?

Introduction

Stakeholders met in Seattle, WA for two days in May 2015 to learn more about the copper biotic ligand model (BLM) and states' current practices related to implementing BLM-based copper water quality criteria. By bringing together experts from U.S. Environmental Protection Agency (EPA) headquarters, EPA Regional offices, U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (FWS), academia, and the private sector; as well as those with a knowledge of state standards, state permitting programs, and tribal water programs; workshop participants discussed lessons learned from implementing the BLM and approaches to the adoption of the copper BLM, both on a statewide and site-specific basis. Expectations for the workshop were highlighted by Angela Chung, EPA Region 10 Water Quality Standards Unit Manager:

- How can we assure that the criteria being adopted are protective of salmonids? This is something that is particularly important throughout Region 10.
- EPA Headquarters is in the process of updating the BLM. Two Region 10 states, Oregon and Idaho, are currently working on adopting the copper BLM. As a result, there are many questions as to how to best implement copper criteria.

Day 1: Summary Record of Presentations and Clarifying Questions

Overview of the Copper BLM

Luis Cruz, EPA Headquarters (HQ); Bob Santore, HDR, Inc.

Slides Provided in Appendix C

Luiz Cruz, EPA HQ

Luiz Cruz began the workshop with an overview of the copper BLM, a predictive tool that accounts for the effects of various chemical and physical characteristics of a waterbody on copper bioavailability. Mr. Cruz noted that water chemistry parameters which affect bioavailability include pH, dissolved organic carbon (DOC), a number of geochemical ions, and temperature. These parameters vary over time at a given location, leading to variable toxicity at the same total copper concentration. Mr. Cruz also discussed the history of the copper BLM at EPA, indicating that the current BLM-based freshwater aquatic life criteria is listed in EPA's "Aquatic Life Ambient Freshwater Criteria – Copper" 2007 Revision. EPA is currently updating its copper criteria.

Mr. Cruz noted that while the copper BLM is a useful tool for setting criteria, there are a number of limitations and challenges for BLM application. For example, the BLM:

- Requires ten input parameters: pH, DOC, Ca, Mg, Na, SO4, K, Cl, alkalinity, and temperature.
- Uses data from statewide water chemistry monitoring, and states have limited resources devoted to monitoring.
- Calls for parameters (i.e., geochemical ions, DOC) which may not be routinely collected.

In addition, the BLM parameters DOC and pH are very influential to copper availability and should be collected on a routine basis. Output of predicted instantaneous water quality criteria (IWQC) shows the effect of variations in water chemistry over time and space on copper bioavailability, but it is challenging to select a single defensible IWQC that best protects the designated use(s) at a site.

Mr. Cruz highlighted solutions to some of these challenges including the estimation of missing water quality parameters when there is insufficient monitoring data available and the use of the fixed monitoring benchmark (FMB) to establish a single, protective numeric criterion for implementation purposes.

Regarding the estimation of missing copper BLM parameters, Mr. Cruz noted that not all water chemistry input parameters should be estimated, and stated that EPA recommends that states measure pH and DOC for BLM calculations. EPA has developed conservative estimates of the BLM water quality input parameters, based on existing data drawn from large national surface water quality datasets such as the USGS National Water Information System (NWIS). Mr. Cruz noted that while these estimates are considered conservative, they are also realistic. To estimate some of the missing geochemical ions, the Kriging method, an interpolation which weights the surrounding measured values to derive a predicted value for an unmeasured location, can be used in combination with regression calculations from measured conductivity.

Mr. Cruz concluded by stating the following about estimation of missing BLM parameters:

- Users do not need to measure all parameters at all sites.
- In the absence of collected data, EPA is considering recommending 10th percentile DOC estimates as defaults. The 10th percentile DOC estimates will provide protective criteria but may, in some cases, be overly conservative.
- For best BLM calculations EPA recommends measurement of site-specific pH and DOC.

Clarifying questions and responses:

- Did you say earlier that the lower the ions concentration, the lower the criteria?
    - Yes, The higher the parameters, the higher the criteria.
- From where did you pull the conductivity data that you're using?
    - USGS NWIS, which contains data from more than 5,000 sampling locations across the U.S.

Bob Santore, HDR, Inc. (now at Windward Environmental, LLC)

Mr. Santore began by indicating that there are special challenges for metals criteria as metals are naturally occurring and have a complex chemistry. He indicated that the traditional hardness-based criteria generate a range of criteria values but do not consider some of the most important factors that affect metal bioavailability. Similarly to Mr. Cruz, Mr. Santore reiterated the pH impacts to copper toxicity, stating that at low pH values, copper is more toxic. He also noted that DOC is challenging to estimate and very important for calculating accurate criteria since the presence of DOC can mitigate metal toxicity. Factors like pH and DOC are not considered in hardness-based regressions but can be considered in the biotic ligand model (BLM). Regarding the BLM-based approach, it incorporates pH, DOC, major ions, and temperature parameters separately while capturing the individual toxicity effects and showing bioavailability relationships.

Mr. Santore then used information from the 303d list to summarize the most common reasons why water bodies in the U.S. have been listed as impaired. The second most common reason was due to the presence of metals (other than mercury) and the most commonly cited metal was copper. Mr. Santore concluded that it is critically important that water quality criteria for metals are developed to be as accurate as possible and to consider all major factors that affect bioavailability. If this does not happen, time and resources could be spent characterizing sites that were perceived to be impaired due to inaccurate criteria, while other sites that should be listed as impaired are not.

Mr. Santore stated that to characterize water quality, you must characterize major ions – even though those major ions might not impact copper concentrations. The BLM was developed with other metals in mind. Although chlorine concentrations may not impact copper toxicity, for example, chlorine concentrations may impact silver toxicity. If there is a change in the distribution of metal content, there will be a change in the bioavailability. For example, if copper gill accumulation can be predicted, the prediction of toxicity response relationships is also possible. Mr. Santore noted that as water chemistry changes, different toxicity is predicted because copper would be less bioavailable.

Mr. Santore also compared the BLM to the Water Effect Ratio (WER) approach. He indicated that the WER provides clear water toxicity information as sampling is conducted on a site-specific basis. However, this method is time consuming and expensive. The BLM focuses on bioavailability and provides similar information as a WER but may not be as comprehensive as a model WER.

Clarifying questions and responses:

- Have you ever looked at the BLM calculation compared to the WER or actual field data testing?
    - Yes, many times. The sub lethal effects (e.g., olfactory) may prevent spawning. There was no sufficient chronic data at the time of developing the 2007 BLM, but we are looking at new data to incorporate these considerations.
- Related to the slide on the “Comparison of Criteria Approaches,” what is the impact from changes in pH?
    - pH co-varies with hardness. If hardness varies and pH is held constant, the hardness effect is much greater.
- In the humic acid part of the BLM, are there effects on copper availability and can you enter that manually?
    - If you know the humic acid percentage, you can enter it. The BLM recommends using the default humic acid value.
- Is there a way to translate the inputs in the BLM into state water quality criteria?
    - This may be the defining question of the workshop. It will be interesting to see state presentations about proposals to do just that. Ultimately, states will need to look at the distribution between the model and numbers for state water quality criteria and choose something along that distribution.

State context for adopting BLM – Panel Discussion

Brock Tabor, Alaska Department of Environmental Conservation; Jason Pappani, Idaho Department of Environmental Quality; Andrea Matzke, Oregon Department of Environmental Protection; Cheryl Niemi, Washington State Department of Ecology; Lareina Guenzel, EPA Region 8 (on behalf of Colorado)

Slides Provided in Appendix C

Representatives from five states, Alaska, Idaho, Oregon, Washington, and Colorado, presented remarks on the current status of copper criteria and questions related to copper and the BLM in each state, respectively. The main questions and challenges suggested by each state representative are included below, and the combined presentation is included in Appendix C.

Brock Tabor (AK)

- Use of WER (lab) versus BLM (modeled).
- Data Restrictions – Can we think regionally?
- Are there specific things we should be aware of before we start collecting BLM data for site-specific criteria (SSC) purposes?

Jason Pappani (ID)

- What does the actual rule language look like? What about when the model is updated?
- What do we use as defaults when model inputs are missing?
- How do we transition from hardness-based to the BLM?
- What do we use for the Integrated Report (IR)?

Andrea Matzke (OR)

Oregon faces a unique situation as EPA disapproved the state's hardness-based criteria for copper in 2013 citing that it was not consistently protective. The National Marine Fisheries Service (NMFS) also issued a biological opinion that Oregon's proposed hardness-based copper criteria would jeopardize endangered and threatened species. As a result, Oregon anticipates adopting the BLM in some manner. However, Ms. Matzke raised various challenges related to BLM adoption in Oregon, including:

- Replacing hardness-based criteria with use of BLM criteria.
- Insufficient data.
- Potential inability to use hardness-based criteria.
    - Limited BLM datasets may lead to overly conservative BLM default values.
        - Permitting anti-backsliding concerns.
        - Determining spatial extent of BLM-based criteria.
- IR: maintenance of BLM database and re-evaluation of BLM criteria every two years.

Cheryl Niemi (WA)

Ms. Niemi indicated that Washington will probably move to adopt the copper BLM, but timing for adoption is still unknown. The focus at the state level is currently on human health criteria. Ms. Niemi highlighted outstanding questions on the process of Washington's adoption of the copper BLM including:

- Site-specific data requirements: Will these be phased in over time?
- If the SSC requirements are phased in, how will the water quality standards be structured to continue the use of hardness-based criteria and development and application of the BLM-based criteria without frequent rulemaking for SSC?
- How will we prioritize waterbodies for application of the BLM; for example, related to discharger requests, impaired waters and total maximum daily loads (TMDLs), ESA, etc.?
- If the hardness-based criteria are retained in the standards and the BLM is phased in, how will ESA consultation be affected?

Ms. Niemi also raised questions as to whether or not the bioavailability component includes plankton and other food web-based species and how downstream protection should be considered when examining copper criteria.

Lareina Guenzel (EPA Region 8 – CO Example)
Because Colorado state representatives could not participate in person, Ms. Lareina Guenzel discussed the work that Colorado has been pursuing to implement the BLM since 2004. She also highlighted major points in regards to future BLM implementation in Colorado including:

- The desire to continue to focus revisions on site-specific needs.
- State-wide adoption constraints:
  - Data
  - Money/resources
- Requesting additional technical support from EPA to finalize CO's BLM guidance document.
  - Colorado prepared a list of technical questions for EPA.

In addition, Ms. Guenzel noted that FMB development in Colorado was initiated to address the temporal variability in the BLM-derived IWQCs and how to derive a protective permit limit. She noted that there are statewide adoption constraints, and future revisions to the BLM-FMB will continue to focus on site-specific needs.

Using the BLM: Demonstration, data considerations and model limitations

Bob Santore, HDR, Inc. (now at Windward Environmental, LLC)
Mr. Santore demonstrated the copper BLM, which is available for download at:
http://www.epa.gov/wqc/aquatic-life-criteria-copper

The BLM demonstrated during this session is a new, unreleased version that provides users with FMB values. Mr. Santore went on to explain that the sulfide input button was turned off. While it is important for determining metal bioavailability, sulfide is difficult to measure. If it is not done carefully, the output will be impacted. By leaving it out, the BLM is probably a little more conservative, but Mr. Santore noted that it is better to omit the sulfide concentration rather than arrive at potentially erroneous calculations. After running the BLM, Mr. Santore presented an example output file whereby the FMB value corresponded to protectiveness, as the FMB relates to time variable criteria.

Clarifying questions and responses:

- Is the FMB some sort of temporal statistical approximation?
  - Yes, the FMB looks at time variability. Given that water quality changes based on time of year, the FMB provides a single value that will allow you to meet the criteria every month. It provides a probabilistic result.
- Should you use total values or dissolved values?
  - Dissolved value data are better if available.
- Do you recommend 24 samples, minimum, to run the model biweekly for a year?
  - That was a Colorado-specific recommendation. EPA has not made a recommendation about sample numbers. I typically recommend at least nine samples.
- Can the BLM be used for marine waters?
  - Not with the freshwater software used in today's demonstration, but a BLM-FMB for marine waters has been developed and is undergoing the EPA review process for release sometime soon.

Instantaneous water quality criteria (IWQC) and the fixed monitoring benchmark (FMB)

Adam Ryan, HDR, Inc. (now at Windward Environmental, LLC)
Slides Provided in Appendix C

Mr. Ryan reiterated the history of the BLM, and mentioned that in 2007, EPA published the revised national recommended 304(a) freshwater criterion for copper based on the BLM. Mr. Ryan noted that the BLM is a site-specific tool that calculates IQWC taking into account the bioavailability of the toxicant. He also discussed the time variability IWQC and provided a description of the FMB. Mr. Ryan presented information from example model runs.

In summary, Mr. Ryan noted the following points:

- The BLM is used to calculate site-specific WQC.
- The FMB is a benchmark related to WQC.
- The FMB can occur at any percentile of IWQC distribution.
- The FMB is determined by relative variability of copper and IWQC and their correlation.
- Time-series plots should be prepared.
- Trends can affect distributional assumptions.
- Are more recent data more relevant, if a trend is present?

Clarifying questions and responses:

- Have you ever looked at a dataset with the FMB and analyzed how it would work with National Pollutant Discharge Elimination System (NPDES) or other effluent permitting?
  - We have tried to understand data commonalities. At one point, the FMB was designed to calculate flow using a load based approach, which would be consistent for wasteload allocation/permits, but that's not what the FMB actually does.
- It looks like you need a long period of record for the FMB, one in three-year exceedance frequency. Are there concerns that you don't know when the three years occurred or why you even chose three years?
  - If you aren't seeing a trending dataset, then more data are better.
- If you had multiple points during a day, would you average them?
  - Yes, I would average them in my opinion.

BLM case studies and discussion

The accuracy and protectiveness of BLM toxicity predictions

Chris Mebane, USGS
Slides Provided in Appendix C

Mr. Mebane's presentation began with a discussion of the BLM- and hardness-based copper criteria as those numbers compare to copper concentrations in real world settings in the Pacific Northwest. He discussed examples whereby the BLM- and hardness-based copper criteria do not rise and fall in synchrony. For instance, in the Clark Fork River the BLM-based criteria were highest in the spring (i.e., predicting copper is least toxic during spring) yet the hardness-based criteria were lowest in the spring (i.e., predicting copper is most toxic during spring). In the case of the Yukon River in Eagle, Alaska, the BLM-based criterion rises during spring runoff time, but the hardness criterion does not change much. DOC is high and tracks consistently with the BLM copper criterion.

Mr. Mebane also noted that there are untested assumptions in EPA's 2007 criteria document. His presentation provided examples of predicted toxics results compared to observed results, as well as information on the protectiveness of criteria regardless of the accuracy of model predictions.

There are many independent datasets with a diverse assortment of aquatic organisms and endpoints evaluated across a wide variety of natural and laboratory waters, as noted by Mr. Mebane. He also indicated that the BLM toxicity predictions were always at least correlated with empirical toxicity observations, and that the 2007 criteria were mostly protective. However, he stated that there is some ambiguity in protectiveness for community-level effects to primary producer and benthic invertebrates in results from field or model ecosystem studies.

Mr. Mebane posed the question "Is the BLM too complicated?" and offered the suggestion of using a less complicated regression equation instead. The multiple linear regression (MLR) variation performed well in some tests and is a viable simplified alternative to the 2007 BLM. He noted that following the traditional hardness-based criteria for copper may potentially lead to misguided application of pollution controls and remedial efforts.

Clarifying questions and responses:

- Are you looking at predictive toxicity (i.e., the blue dots)?
    - We are comparing predicted toxicity with observed toxicity of copper to the organism.
- Multi-linear regression approach – is that just for acute data?
    - It was derived for acute data, and extrapolated to chronic data using the acute-to-chronic ratio from the 2007 criteria document
- Are you looking to publish this information any time soon?
    - Perhaps. It takes time.

Oregon case study

James McConaghie, Andrea Matzke, Oregon Department of Environmental Quality (DEQ)
Slides Provided in Appendix C

James McConaghie presented information about how Oregon DEQ is currently evaluating the BLM for the development of new copper standards. He discussed the development of a BLM database for Oregon and the range and characteristics of Oregon data due to varying eco-regions. Mr. McConaghie also noted that Oregon is trying to find out which parameters are the most sensitive and in what locations. The State is also looking at how best to estimate missing parameters where data are lacking. He also presented preliminary BLM results for Oregon.

Mr. McConaghie noted that Oregon DEQ looked at archived historic ambient water quality data and toxics data, as well as current monitoring data from 2000-present. He noted that the Oregon datasets are missing one or more parameters in various locations. There are potentially 360 “nearly complete” records and approximately 22,000 from NWIS. Mr. McConaghie discussed the parameters used in Oregon’s sensitivity analysis noting that results of this analysis indicated that DOC, pH, and to some extent Na are the most sensitive. Oregon DEQ conducted data conditioning which involved combining total and dissolved parameters and filtering data to exclude extremely high/low DOC, pH and high Na (i.e., high conductivity) in order to develop their database. To estimate missing parameters, Oregon utilized the document: “Development of Tools to Estimate Water Quality Parameters for the Biotic Ligand Model (EPA, 2012).” In particular, they used the regression on conductivity method to show the empirical relationship between ion concentration and conductivity. This was developed with data from Oregon. DEQ also used eco-regional defaults with an unbiased mean of 10th percentile concentrations to evaluate these methods against an Oregon-specific dataset. There is significant geographic variability among Level III eco-regions and hydrologic unit code (HUC) 4 watersheds, and as a result DEQ needed to estimate using regional parameters. Finally, in examining the IWQC against hardness-based criteria, DEQ found that when DOC and pH are simultaneously lower, hardness-based criteria are less protective than BLM.

Mr. McConaghie presented DEQ’s conclusions to date:

- DEQ is currently limited by data availability for a full evaluation of the BLM for developing criteria in Oregon.
- Estimation of missing parameters is essential.
  - High potential to use either regression or geographic/regional defaults.
- Model is sensitive to DOC, pH, Na in the Oregon DEQ dataset.
  - IWQC are extremely high for saline sites, waste streams.
  - Trim extreme values from the database.
  - Only use records where these parameters are measured.
- Restrict BLM to calibrated data ranges.
- IWQC value is typically higher than hardness-based criteria.

Clarifying questions and responses:

- You had 5,000 sites with DOC. Did you stratify those sites by basin or season to get some sort of estimate for the DOC that would not be within the conservative 10^{th} percentile?
  - We didn’t look as closely into estimated DOC because the parameter is so sensitive. However, that is the sort of analysis that we are trying to lead up to.

- Are other states adopting BLM statewide or is it on a site-specific basis?
    - Two states, Kansas and Delaware, adopted BLM-based criteria statewide. Virginia uses hardness-based criteria and adopted a few sentences in state regulations to indicate that site-specific criteria using the BLM may apply at specific sites. That can be done in addition to the hardness-based criteria.
- Did you have sufficient data to get at time series?
    - Not really – not like the Colorado example which will be discussed more on May 14th.
- *Follow Up:* The geographic focus of the Oregon assessment may hinder any temporal analysis of critical periods because you will see different impacts depending on the temporal scale.
    - Oregon response: We are looking at a two-pronged approach: 1) adopt the BLM as a performance-based standard; and 2) determine a default value for fairly large regions of the state. This is difficult as even within the coastal region we see a lot of diversity.

Day 2: Summary Record of Presentations and Clarifying Questions

Colorado case study

Jim Saunders, Patrick Bachmann & Blake Beyea, Colorado Water Quality Control Division-Standards Unit, (via teleconference and webinar)

Slides Provided in Appendix C

Although many workshop discussions focused on the use and adoption of copper BLM in EPA Region 10 states, this workshop session focused on a case study of the BLM-FMB in Colorado (EPA Region 8). The authority to adopt site-specific standards using the BLM is identified in several sections of Colorado's primary WQS (Regulation 31). Regulation 31 includes 1) a general site-specific standards provision, 2) a provision that acknowledges "other factors such as organic and inorganic ligands, pH, and other factors affecting the complex capacity of the waters may be considered in setting site-specific numeric stands," and 3) a provision that states that Colorado can use "other EPA approved methods" to develop water quality criteria.[2] Throughout this presentation case study examples were discussed from different sites in Colorado: Monument Creek, Plum Creek, Big Thompson River, and the South Platte River.

Monument Creek Example

Monument Creek is an ephemeral/intermittent creek north of Colorado Springs. This is the site of the first BLM-FMB based site-specific copper criterion adopted by Colorado's Water Quality Commission in 2013, and it applies to approximately 5.8 miles of a 28-mile stream segment. The hardness-based criteria continue to apply in the downstream portion of the segment.

The site-specific criteria were developed from a dataset representing the years 2004-2007 and 2012-2013 collected by the Tri-Lakes Treatment Facility. The facility recognized that a lot of copper was coming into the plant due to an uptick in development in the area. As a result, the facility attempted to reduce that amount of copper through various outreach efforts aimed at developers and plumbers to remove/eliminate copper plumbing. This led to a reduction of the plant's effluent concentration, on average, by about 4 mg/L. Ultimately, a copper BLM-based FMB was approved at FMBa = 28.4 mg/L and

[2] 31.16(2)(b)(iii) "Other approved EPA Methods"

FMBc = 17.8 mg/L for a sub-segment of Monument Creek from immediately above the Tri-Lakes Wastewater Treatment Facility to the North Gate Boulevard Bridge downstream.

The next two proposals (Plum Creek and Big Thompson) primarily relied on mined data sources. However, because of issues with these datasets, such as missing parameters and lengthy periods of data collection where changes in water quality can be observed, questions still remain on the appropriate use of large mined datasets when developing BLM-FMB proposals.

Plum Creek Example

Plum Creek included data collected upstream and downstream of the discharger, as well as sites that were downstream of a tributary that contributes equal flow to the main stem of Plum Creek. The probability plot from this presentation illustrated variability in the distribution of copper and the IWQC among the sampling sites, which resulted in variable distributions of the toxicity units. The consultant proposed the BLM-FMBs derived from an aggregated dataset that did not appear to be protective of the entire regulatory segment. No decision was made on the appropriate copper criteria at the time of the proposal, and Colorado's Water Quality Control Commission expressed a need for additional data to characterize the relationship between the IWQCs and copper in this system.

At the same hearing, Colorado was reviewing a proposal for the Big Thompson River near Estes Park, which had considerably less variability in the IWQCs, copper and toxicity units – which resulted in less variable FMBs. However, there were other questions about the certainty of the FMBs calculated in this system because the datasets did not fit a lognormal distribution.

Big Thompson River

The Big Thompson River has headwaters in Rocky Mountain National Park. Looking at the map presented during this session, segments M50-M70 are the most representative of capturing the ligands after the outfall. The Big Thompson River has data from more than two years, at more than 24 samples per site, but none of the sites exhibited log-normal copper distribution. Ultimately, Colorado decided that looking at the IWQC or dominant input variables was not the best way to evaluate if each site has a different sensitivity to copper. The state evaluated each FMB by examining the confidence intervals around each FMBa and FMBc at each site as well as with aggregated data from all sites. Site M50 had the lowest FMB (11.0 µg/L FMBa and 7.5 µg/L FMBc) and Colorado proposed that the FMBs from this site would be the protective copper standards for the entire segment.

Overall, after reviewing the Plum Creek and Big Thompson River proposals, Colorado determined the aggregation of data collected from multiple sampling locations within a regulatory segment is not scientifically defensible when calculating an FMB. The FMB was ultimately developed to characterize the temporal variability at a specific sampling site and not for the spatial variability within an entire stream reach. Therefore, proposals utilizing the BLM-FMBs should evaluate the variability of the FMBa and FMBc for each sampling location to develop strong site-specific standards.

Clarifying questions and responses:

- In regards to effluent impacts downstream, you see an increase in DOC, which is obvious, but pH decreased? Was that a trend or wet weather effects from stormwater runoff?
    - The low pH in the effluent was presumably due to the increase in CO_2 concentrations. This is common especially with larger dischargers - pH will be depressed.

Lareina Guenzel, EPA Region 8 (in person)

Colorado BLM Guidance Development

There were a large number of comments and issues raised on the Big Thompson River and Plum Creek proposals. Colorado also knew that additional proposals were underway. As a result, the Colorado Standards Division decided to summarize their preferred approach and expectations for BLM-FMB proposals in a draft guidance document, focusing on the development of FMB-based site-specific standards, minimum data requirements, the selection of sampling sites, data handling, and interpreting the model output. The draft guidance document addresses the following questions:

1. *What are the minimum data requirements?*
    a. The document suggests 24 useable sampling events to capture seasonal and annual variability, with at least two years represented in the dataset.
2. *How should sampling sites be selected?*
    a. The number of sites will depend on site-specific conditions.
    b. Colorado recommends considering significant hydrologic features in a segment and sampling downstream of the regulatory mixing zone. Colorado also recommends sampling from a site in the next regulatory segment downstream to ensure downstream use protection.
3. *What preparations or requirements precede model operation?*
    a. Sites are to be processed individually (i.e., no aggregation of data across sites).
    b. pH values are to be capped at nine. Exceedances of the standard cannot be used to derive the IWQC.
    c. Data handling issues – preliminary screening can be done with the "Check Inputs" feature of the BLM.
    d. Missing values, missing parameters, and non-detects need to be addressed.
    e. Copper data should be tested for log normality. "Trimming" the upper and lower ends of the copper data to conform to model's lognormality assumption may be warranted.
4. *How should model output be interpreted?*
    a. Revise FMBs when copper data are not log-normally distributed.
    b. Calculate FMBc after revising the standard error.
    c. For multiple sites, plot FMBs in downstream sequence and base interpretation on the confidence intervals. The site with the most stringent FMBs will be protective of the aquatic life use at the 1 in 3 exceedance frequency in the rest of the segment.

After the initial standards are set, additional questions need to be answered to address what data are needed to justify continuance of the standard at the next triennial review. In addition, Colorado will need to also consider the continuation of monitoring for just DOC, pH, and copper, and whether or not measuring effluent quality is protective enough or if in-stream data collection is needed. Stream chemistry and flow changes from new or altered discharges or changes to existing water rights/augmentation may change in-stream conditions influencing copper toxicity.

Colorado representatives indicated that comments from this workshop will inform revisions to the draft guidance document.

Clarifying questions and responses:

- Who is sampling?
    - All permittees/dischargers are conducting the data collection where dischargers represent 100% of the flow. Since the focus is downstream of the outfall, the mixing zone doesn't require additional study. We want to focus on the area below the outfall with mixing zone characteristics.
- These facilities were interested in site-specific criteria. Did this result in effluent limits?
    - The site-specific criteria were essentially implemented like other standards. The values were used to develop a water quality based effluent limit (WQBEL).
- Did you look at the mixing zone or further downstream?
    - We will be looking at that in the permits. That's why we are focused on sampling sites downstream from the outfall closer to the mixing zone. The goal is to translate this information so that when permits are issued they use the FMB for specific segments of a reach.
- Where does a translator fit in here to deal with dissolved content?
    - We did not use translator studies, but they could be done. Maybe in the future it might be requested by the permitting program.
- In Utah, the site-specific WER and the BLM studies were initiated in response to a permit compliance issue, but the state felt that a translator study provided enough information to come up with appropriate effluent limits.
    - Interesting. That might explain why some of Colorado's dischargers have not looked into a study. A translator can often be put right into a permit and eliminate the need for a rulemaking.
- Who funds this work? Is this part of Colorado's Standards Program work?
    - Yes, the Colorado Standards Program devotes staff time to this effort. Those staff pay attention to site-specific criteria development and provide information to the Water Quality Control Commission. Dischargers often look to the state for guidance on this. In addition, EPA is trying to provide Colorado staff with additional technical answers and, in conjunction with HDR, Inc., potentially produce a Frequently Asked Questions (FAQ) document.
- Oregon is struggling to come up with the same amount of data that Colorado is recommending, 24 sampled points over two years. If you have nine samples at a site versus the conservative default, would you use the samples you have or the conservative value estimates?
    - One thing that we have seen in Colorado with the cases where we apply the confidence limits is that you can use a smaller dataset and apply confidence limits to assess whether the smaller dataset seems reliable.

BLM adoption and implementation

Lars Wilcut and Joe Beaman, EPA HQ

Slides Provided in Appendix C

Lars Wilcut began this session by pointing out that adoption and implementation of the copper BLM are closely intertwined and asked participants to keep in mind that the intended implementation of the criteria in listing and permits affects what should be adopted, and vice versa. He also noted that states should be specific in standards. For example, it may not be sufficient to state that "freshwater criteria will be calculated using EPA BLM." Mr. Wilcut also discussed the role of a performance-based approach as a way to streamline criteria adoption. This may be particularly useful for the implementation of site-specific criteria.

Mr. Wilcut provided an example copper criterion for group discussion, commenting that the language is very much a work in progress, and that data and references could be added to indicate that a state may rely on implementing programs/dischargers for data collection in some cases.

Clarifying questions and responses:

- Can Oregon adopt its copper criterion by describing the state's approach and not use the EPA example criterion?
    - Yes, assuming that it is scientifically defensible and that the state is specific about what is incorporated by reference.
- What about a zinc document?
    - A zinc document would be site-specific. This has happened for other metals. For example, Region 5 is looking to implement site-specific nickel criteria. The state may use performance-based BLM.
    - There's also an example of cadmium in Idaho, which is site-specific as well. This effort may be replicated with zinc.
    - Colorado uses the FMB. However, EPA has not justified that approach, but if it is determined to be scientifically defensible, it may work.
    - New Mexico and Colorado implement full statewide standards updates.

Joe Beaman, EPA HQ

Slides Provided in Appendix C

Mr. Beaman provided an overview of the current status of the copper BLM at EPA, and noted that EPA is in the process of updating the copper BLM and beginning the development of a BLM-based copper criterion for saltwater systems. He noted that EPA is updating the BLM to add new underlying toxicity data and chronic data and sensitivity distribution to replace the acute to chronic ratio (ACR). In regards to the missing parameters document mentioned earlier in the workshop by Luis Cruz, Mr. Beaman indicated that the intended use of this document is to support states and others who want to use the copper BLM but who do not have data for all of the BLM parameters.[3] EPA may recommend using the 10th percentile values for ions and DOC if data are not available. In addition, this document will likely recommend the measurement of site pH. Mr. Beaman also indicated that the latest BLM has the ability to calculate a FMB value for acute and chronic criteria.

Clarifying questions and responses:

- Who owns the BLM?
    - EPA
- Since the last BLM update have behaviors such as olfactory response been examined? This has been an important factor in consultations and has been brought up by many groups in regards to permits. Will that be addressed in the EPA criteria document?
    - Yes, EPA has looked at survival, growth and reproduction, which touch upon olfactory response.

[3] EPA published the above-referenced document following the Copper BLM Workshop: Technical Support Document: Recommended Estimates for Missing Water Quality Parameters for Application in EPA's Biotic Ligand Model, March, 2016.
http://www.epa.gov/sites/production/files/2016-02/documents/draft-tsd-recommended-blm-parameters.pdf

ESA consultation considerations

Chris Mebane, USGS

Slides Provided in Appendix C

Mr. Mebane discussed the BLM-based copper criteria and associated hazards to threatened or endangered species. Some endangered species are quite sensitive to copper including Chinook salmon, steelhead, certain snails, and some freshwater mussels in the central and eastern U.S. to name a few. Mr. Mebane cited a 1967 study of a salmon spawning river and impacts from mining operations. When the mine discharged effluent containing copper, salmon runs stopped. After the mine closed, salmon runs resumed. He also noted sub-lethal effects from copper including olfactory impacts to the lateral cilia, which allow fish to move together in a current in a straight line. When the fish skin is damaged, the alarm cue in fish to stop moving as a survival behavior to visual predators is damaged. In short, copper contamination blocks the alarm receptors that would allow salmon to freeze/hide. According to Mr. Mebane, the existing hardness-based acute copper criteria are not protective of olfactory impairment. Mr. Mebane also described a study by Jenifer McIntyre of the University of Washington which illustrates the impact of copper on olfactory response and links copper contamination to effects on behavior and survival.

Regulatory Consultations - 2014 NMFS Biological Opinion on Idaho Toxics Criteria

According to the 2014 NMFS Biological Opinion, if surface waters were to actually contain the amount of copper authorized by the Idaho criteria that EPA has proposed for approval throughout the action area, it would jeopardize the continued existence of the species and/or delay the recovery of listed salmon or steelhead. The consultation was not based on ambient conditions, which in most cases are considerably lower than the criteria. In other words, the biological opinion focused on criteria assessment, not environmental status assessment. The opinion concluded that in most cases the 2007-BLM based copper criteria were protective for listed species.

Clarifying questions and responses:

- Is olfactory response sensitive to DOC concentrations?
    - Yes. DOC has been shown to reduce the effects of copper on olfactory receptors. Olfactory receptors and gills do not exhibit strong changes in behavior from ion interactions, such as calcium and copper. The competition is at the ion level. As such, the BLM that was derived from gill binding studies might not produce accurate results for olfactory organs. It seems that DOC still plays a role in reducing copper toxicity, but calcium does not necessarily provide much protection.
- Is the regression model that Mr. Mebane has been discussing acceptable or not? Are the results comparable to the BLM? How long would it take to go through the evaluation of whether that would be a defensible solution? If EPA and the services agree that the regression model is a scientifically defensible approach, Oregon would like to know that.
    - From an EPA perspective, there are no plans to adopt the regression model for criteria.

303(d) listing and integrated reporting considerations

Jill Fullagar, Marty Jacobson, EPA Region 10

Slides Provided in Appendix C

Ms. Fullagar presented on implications of implementing the copper BLM for the 303(d) listing program. States will need to know if they should be looking at defaults. Ms. Fullagar first provided a brief overview of the impaired waters listing process and illustrated how WQS updates are incorporated into listing methodology. More specifically, she noted how numeric and narrative criteria are incorporated into the listing process. Ms. Fullagar focused on data translation and what format changes might be necessary so that data compilation for reporting can be consistent. She acknowledged that there are challenges for states including:

- Releasing tracked data to the public;
- Deciding whether or not to develop criteria and limits within or outside of regulations; and
- Confirming how data should be handled by the state if stakeholders are submitting data and some parameters are set as defaults.

Clarifying questions and responses:

- How would the criteria be used in listing reports? Exceedances would need to be documented, correct? If someone could present the water chemistry at a site in real time, would it trump defaults?
    - For interpreting a standard, we would use the default first, and then use a real-time measurement.

NPDES permitting and reasonable potential analysis

Susan Poulsom and Brian Nickel, EPA Region 10

Slides Provided in Appendix C

Ms. Poulsom and Mr. Nickel discussed implementing the copper BLM in NPDES permits. When establishing WQBELs for copper using the BLM, the following considerations apply:

- Will the permit writer calculate the limit using site-specific characteristics?
- Will the permit writer need to characterize the effluent and receiving water?
- Is there a need for WQBELs? Consider reasonable potential.

Permit writers calculate end-of-pipe WQBELs to ensure that water quality standards are attained in the receiving water. In developing chemical-specific WQBELs, permit writers look at water quality criteria based on magnitude, frequency, and duration, and translate that information into effluent limits based on magnitude and averaging period.

The presenters offered permitting considerations when using the BLM.

- Limits are based on total recoverable copper. Criteria are based on dissolved copper, and permit writers use a metals translator. Some permittees already use translator studies, but there may be opportunities to use different translators with the BLM.
- Seasonal limits with FMB/BLM already deal with variability. Sometimes this variability is taken into account when issuing permits.

- Monitoring requirements – permit writers would require that facilities collect data and revisit that when the permit is renewed.
- Influence of discharge on water chemistry and BLM criteria – especially on a state-to-state basis.
- States should consider anti-backsliding provisions and antidegradation.

Clarifying questions and responses:

- Do you think that using the BLM will trigger more monitoring requirements for permittees?
    - We already have significant receiving water monitoring requirements, except for DOC. That would be added.
- For permit writers, what is your critical high flow condition? If this year's high flow is during a drought, you still may see seasonally adjusted criteria for spring runoff. Don't dischargers have a tough time with that?
    - You don't always have a typical seasonal cycle, but many places have seasonal critical conditions.

BLM use beyond our borders and beyond copper

Bill Stubblefield, Oregon State University

Slides Provided in Appendix C

Mr. Stubblefield provided a unique perspective at the workshop by illustrating the wide variety of BLM approaches and implementation strategies, including those used internationally.

He noted that the European approach is currently considered the "state-of-the-science" for developing water quality standards by most of the world regulatory authorities, while the EPA approach is approximately 30 years old and generally considered to be in need of an update/revision. Although approximately 129 criteria were developed in the U.S. using the 1984 derivation process, the majority of these were developed during the period from the mid-1980s until the early-1990s. Since that time there have been few AWQC developed for "new" materials, although some updates have occurred with existing criteria. One reason he cited for the lack of movement on criteria development in the U.S. is that there is little impetus/support to develop new data. EPA's internal funds for developing data for criteria development were severely curtailed in the early 1990's and, although a great deal of new data have been developed for compliance with the REACH regulations in Europe, EPA has not typically considered those data for the purposes of deriving new AWQC. Currently, Canada, Australia, New Zealand and many Asian countries all model their derivation approach after the European model. In the European Union (EU), standards are derived and countries adopt those standards – similar to the relationship between federal and state governments in the U.S.

Mr. Stubblefield noted that similar to the U.S., most international criteria are derived from lab toxicity tests. He noted that, unlike the U.S., in Europe only chronic data are typically considered in the criteria derivation process and the Acute-to-Chronic ratio (ACR) approach commonly used in the US (due to the shortage of available chronic data) is not recognized in the European system. In addition, the EU calculates criteria for "data rich" substances similarly to the approach used in the U.S., but uses a statistical method (i.e., two-tailed lognormal distribution), that is affected by data for species that are both sensitive and insensitive to the test material. This generally results in criteria that are lower than U.S.-based AWQC. Mr. Stubblefield elaborated on what makes an acceptable BLM in the EU and commented on the lack of guidance for BLM acceptability in the U.S.

Bob Santore demonstrated the EU Metals Risk Assessment for Aluminum. This software uses a database of toxicity values in a Microsoft Excel-based spreadsheet. The software automates the application of the BLM to the database and calculation of the water quality guideline. The software reads the parameters and shows details for endpoints and bioavailability. For all measurements the user must specify the conditions. The tool uses recent chronic data, and every input was measured. The tool offers a simplified approach with fewer parameters. It's not a regression equation, but it looks at geochemical composition. Mr. Santore noted that this tool is more reflective of present day conditions.

In addition, Mr. Stubblefield passed along a link to a video on metals bioavailability and global BLM approaches, available at: https://www.youtube.com/watch?v=yzp_wTzfPZY.

Appendices A and B of these proceedings contain the Copper BLM Workshop participant list and final agenda, respectively.

Appendix A

Participant List

Copper Biotic Ligand Model (BLM) Workshop
Seattle, WA
May 13 - 14, 2015

Workshop Participant List

Name	Organization	Day Phone	Email
Adam Ryan	HDR	607-423-4886	adam.ryan@hdrinc.com
Andrea Matzke	Oregon Department of Environmental Protection	503-229-5384	matzke.andrea@deq.state.or.us
Angela Chung	U.S. EPA	206-553-6511	chung.angela@epa.gov
Angela Vincent	U.S. EPA, Region 10	206-553-2578	vincent.angela@epa.gov
Bill Stubblefield	Oregon State University	541-737-2565	bill.stubblefield@oregonstate.edu
Blake Beyea	Colorado Standards Unit	720-220-9212	blake.beyea@state.co.us
Brandee Era-Miller	Washington State Department of Ecology	360-407-6771	bera461@ecy.wa.gov
Brock Tabor	Alaska Department of Environmental Conservation	907-465-5185	brock.tabor@alaska.gov
Cheryl Niemi	Washington State Department of Ecology	360-407-6440	cheryl.niemi@ecy.wa.gov
Chris Mebane	USGS	208 387 1308	cmebane@usgs.gov
David DeForest	Windward Environmental	206-812-5426	DavidD@windwardenv.com
Debra Sturdevant	Oregon Department of Environmental Quality	503-229-6691	sturdevant.debra@deq.state.or.us
Dino Marshalonis	U.S. EPA, Region 10	206-553-1519	marshalonis.dino@epa.gov
Don Essig	Idaho Department of Environmental Quality	208-373-0119	Don.Essig@DEQ.Idaho.gov
Doug Endicott	GLEC	231-941-2230	dendicott@glec.com
Erica Fleisig	U.S. EPA	202-566-1057	fleisig.erica@epa.gov
Hanna Winter	Lummi Indian Business Council	360-312-2312	hannaw@lummi-nsn.gov
James Bloom	Oregon Department of Environmental Quality	503-229-5877	bloom.james@deq.state.or.us
James McConaghie	Oregon Department of Environmental Quality	503-229-5656	mcconaghie.james@deq.state.or.us
Jamie Mattson	Lummi Indian Business Council	360-312-2313	JAMIEM@LUMMI-NSN.GOV
Jason Pappani	Idaho Department of Environmental Quality	208-373-0515	jason.pappani@deq.idaho.gov
Jeff Lockwood	National Marine Fisheries Service	503-231-2249	jeffrey.lockwood@noaa.gov
Jill Fullagar	U.S. EPA	206-553-2582	fullagar.jill@epa.gov
Jill Nogi	U.S. EPA, Region 10, OWW	206 553 1841	nogi.jill@epa.gov
Jim Good	GEI Consultants	206-757-3230	jgood@geiconsultants.com
John Palmer	U.S. EPA	206-553-6521	palmer.john@epa.gov
Joseph Beaman	U.S. EPA HQ/OW/OST	202-566-0420	beaman.joe@epa.gov
Julianne McLaughlin	U.S. EPA, ORISE	352-672-2612	mclaughlin.julianne@epa.gov
Kathleen Collins	U.S. EPA, Region 10	206-553-2108	collins.kathleen@epa.gov
Kathleen McAllister	Horsley Witten Group, Inc.	404 600 4924	kmcallister@horsleywitten.com
Lareina Guenzel	U.S. EPA, Region 8	303-312-6610	guenzel.lareina@epa.gov
Lars Wilcut	U.S. EPA	202-566-0447	wilcut.lars@epa.gov
Lisa Macchio	U.S. EPA	206 553 1834	macchio.lisa@epa.gov
Luis Cruz	U.S. EPA	202-566-1095	cruz.luis@epa.gov
Maja Tritt	U.S. EPA	206-553-6265	tritt.maja@epa.gov
Mark Nelson	Horsley Witten Group, Inc.	508-833-6600	mnelson@horsleywitten.com
Matt Szelag	U.S. EPA, Region 10	206-553-5171	szelag.matthew@epa.gov
Michael Mulvey	Oregon Department of Environmental Quality	503-693-5732	Mulvey.michael@deq.state.or.us
Robert Santore	HDR	315-656-9039	robert.santore@gmail.com
Scott Tobiason	Windward Environmental	206-812-5424	ScottT@windwardenv.com
Steve Schnurbusch	Oregon Department of Environmental Quality	503-378-8306	schnurbusch.steve@deq.state.or.us
Vincent McGowan	Washington State Department of Ecology	360-407-6433	vmcg461@ecy.wa.gov

Appendix B

Final Agenda

AGENDA

Copper Biotic Ligand Model (BLM) Workshop

EPA Region 10 Offices
1200 6th Ave, 21st Floor – Denali Room
Seattle, WA 98101

Day 1: May 13, 2015

Welcome and introductions EPA R10 and HQ	**8:00 – 8:15 am**
Overview of the copper BLM Luis Cruz, Bob Santore	**8:15 – 9:15 am**
State context for adopting BLM Panel discussion led by Brock Tabor	**9:15 – 10:00 am**
Break	**10:00 – 10:15 am**
Using the BLM: Demonstration, data considerations and model limitations Bob Santore, Luis Cruz	**10:15 – 12:00 pm**
Lunch (On your own)	**12:00 – 1:00 pm**
Instantaneous water quality criteria (IWQC) and the fixed monitoring benchmark (FMB) Adam Ryan, Bob Santore	**1:00 – 2:00 pm**
BLM case studies and discussion (Part 1)	
The accuracy and protectiveness of BLM toxicity predictions Chris Mebane	**2:00 – 3:00 pm**
Break	**3:00 – 3:15 pm**
Oregon case study James McConaghie, Andrea Matzke	**3:15 – 5:15 pm**

HAPPY HOUR – Tap House Grill

Day 2: May 14, 2015

BLM case studies and discussion (Part 2)

Colorado case study Lareina Guenzel, Others TBD	**8:00 – 10:00 am**
Break	**10:00 – 10:15 am**
BLM adoption and implementation EPA R10 and HQ	**10:15 – 11:15 pm**
ESA consultation considerations Chris Mebane	**11:15 – 12:00 pm**
Lunch (On your own)	**12:10 – 1:00 pm**
303(d) listing and integrated reporting considerations Jill Fullagar, Marty Jacobson	**1:00 – 1:30 pm**
NPDES permitting and reasonable potential analysis EPA R10 and HQ	**1:30 – 2:15 pm**
Break	**2:15 – 2:30 pm**
BLM use beyond our borders and beyond copper Bill Stubblefield	**2:30 – 3:30 pm**
Wrap-up Mark Nelson	**3:30 – 4:30 pm**