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MaryAnn Stevens
Rules Development Branch
Office of Legal Counsel
Indiana Department of Environmental Management
100 North Senate Avenue
Indianapolis, IN 46204-2251

Via email

1 February 2018

Re: Comments on IDEM's Second Notice of Aquatic Life and Human Health Ambient Water Criteria for Metals (LSA Document #14-58)

Dear Ms. Stevens:

On behalf of Indiana-Michigan Power Company, American Electric Power (AEP) provides the following comments on proposed changes to the Aquatic Life and Human Health Ambient Water Quality Criteria (WQC) for metals. AEP is a member of the Indiana Energy Association and we endorse their comments.

Surface Water Quality Criteria for Select Metals (page 8, Table 6-2)

IDEM has proposed new aquatic life criteria for aluminum. Both the maximum (acute aquatic concentration) and average (chronic aquatic concentration) are expressed as WER (water effect ratio) values that are normalized by the (presumably) total hardness of a receiving stream. AEP requests that IDEM explain the derivation of these equations, especially the source of the underlying toxicity data. If the applicable maximum and average ambient aluminum criteria are to be based on site-specific information, AEP agrees with this approach.

AEP notes that US EPA issued draft revised aquatic life criteria for aluminum during 2017 (https://www.epa.gov/sites/production/files/2017-07/documents/aluminum-draft-criteria-factsheet.pdf). In the draft criteria documents the agency indicates that three water quality variables

have an effect on the bioavailability (and hence toxicity) of aluminum: pH, dissolved organic carbon, and total hardness. To account for the joint effect of these variables, the agency developed a multiple linear regression model (normalized at standard pH, DOC, and hardness values). Based on the water quality characteristics at a given site, the applicable freshwater acute and/or freshwater chronic criteria may be either less stringent or more stringent than the default criteria. AEP urges IDEM to withdraw the proposed WERs-based criteria for now and consider adopting – during a later triennial review cycle – the finalized US EPA revised criteria.

Lastly, IDEM has proposed that the WERs-based criteria be based on a total recoverable analytical measurement of aluminum. While this analytical method is straightforward, there is a concern that a moderately-acidified sample would result in the detection of both toxic and non-toxic aluminum forms (Santore et al. 2017). Recent research suggests that a more vigorous acidification step (termed "acid extractable" aluminum) would yield only the forms of aluminum that contribute to toxicity. For these reasons AEP recommends that IDEM delay adopting aquatic life criteria for aluminum, whether those that are WERs-based (proposed) or the existing US EPA currently recommend aquatic life criteria.

Surface Water Quality Aquatic Life Criteria for Selenium (page 10, Table 6-2a).

AEP commends IDEM for proposing new, tissue-based chronic aquatic life criteria for selenium. Levels of selenium measured in fish tissue are more closely associated with potential chronic effects relative to external water concentrations (Hodson et al., 2010). We agree with footnotes [2] and [3] of Table 6-2a which indicate that the fish tissue elements take precedence over the proposed water column criteria when both elements are measured. We offer the following specific comments on the criteria themselves and how they are implemented:

- A multi-stakeholder implementation workgroup should be established by IDEM to develop state-specific implementation guidance.

- The proposed US EPA-based water criteria are overly stringent and do not represent actual thresholds of adverse effects based on field studies. US EPA (2016) calculated several location-specific "protective" water criteria based on site-specific chemical and food web data. These data were inputted into a USGS-based food web model to predict water concentrations that would, theoretically, not result in the egg-ovary fish tissue criterion being exceeded. Nowhere in the criterion document does US EPA demonstrate adverse effects to sensitive aquatic life when lentic and lotic water bodies have water column selenium concentrations above 1.3 µg/L and 3.1 µg/L, respectively. AEP urges IDEM to not adopt these criteria, which would result in pervasive reasonable potential at facilities discharging detectable amounts of selenium. AEP recommends that IDEM adopt the current Great Lakes Water Quality Guidance average selenium water quality criterion of 5 µg/L. This criterion is based on measured water selenium concentrations in a lentic (lake) setting where the unaffected portion of the lake had healthy and sustaining fish populations.

- In footnote [5] of Table 6-2a the last sentence indicates that the proposed water criteria supercede the proposed fish tissue criteria "...in the absence of steady-state condition fish tissue data." We have concerns that IDEM permit writers could use this provision to incorporate water quality-based effluent limits (WQBELs) for selenium in NPDES permits ***before*** a permittee would be allowed to submit fish tissue data. Moreover, neither US EPA nor IDEM has defined what constitutes "steady state condition fish tissue data." Selenium tissue levels, even within the same species, vary somewhat on a temporal basis. This variability is not solely dependent on the loading of selenium from point-source discharges. We believe that this particular issue is one of several topics that should be discussed by the implementation workgroup.

Literature Cited

Hodson, P.V., R.J. Reash, S.P. Canton, P.V. Campbell, C.G. Delos, A. Fairbrother, N.P. Hitt, L.L. Miller, and H.M. Ohlendorf. 2010. Selenium Risk Characterization. Pp. 257 – 292 in P.M. Chapman et al., *Ecological Assessment of Selenium in the Aquatic Environment*. SETAC/CRC Press. Boca Raton, FL.

Santore, B., K. Croteau, A.C. Ryan, S. Tobiason, and A. Groffman. 2017. How does information about aluminum bioavailability inform what measure to compare with aluminum water quality criteria? Presented at 2017 North American Society of Environmental Toxicology and Chemistry conference, Minneapolis, MN.

US EPA. 2016. Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater. EPA 822-R-16-006. US Environmental Protection Agency, Office of Water.

AEP appreciates the opportunity to provide these comments. Should you have any questions or comments on these, feel free to contact me at 614-716-1237, or at rireash@aep.com.

Sincerely,

Robin J. Reash
Consulting Environmental Scientist
Certified Fisheries Professional
American Electric Power – Environmental Services Department

BINGHAM GREENEBAUM DOLL LLP BGD

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December 27, 2017

VIA EMAIL TO mstevens@idem.in.gov

LSA Document #14-58 Metals Criteria Revisions
MaryAnn Stevens
Rules Development Branch
Office of Legal Counsel
Indiana Department of Environmental Management
Indiana Government Center North
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RE: Comments of City of Greensburg, Indiana
Second Notice of Comment Period
LSA Document #14-58 Metals Criteria Revisions

Dear Ms. Stevens:

The following comments are submitted on behalf of our client, the City of Greensburg ("City"), with respect to the above-referenced rulemaking.

1. The City strongly supports the proposed changes to Human Health Criteria for nickel, as set forth in Table 6-1 of 327 IAC 2-1-6(a)(3). As proposed, the revised human health-based criteria for nickel would be continuous criteria concentrations ("CCCs") stated as follows in units of micrograms per liter (ug/l):

Outside of Mixing Zone	Point of Water Intake
Human Health (30-Day Average)	Human Health (30-Day Average)
4,600	610

These proposed revisions to Indiana's human health criteria for nickel are consistent with the U.S. Environmental Protection Agency's ("EPA's") National Recommended Water Quality Criteria for Human Health. These criteria values for nickel were first listed as national recommended human health criteria in 1998.

2. The following changes (in red font) are suggested by the City to the IDEM's proposed revisions to 327 IAC 2-6-1(a)(1)(E) (which are accepted in the text below):

> "(E) Occur in amounts sufficient to be acutely toxic to, or to otherwise severely injure or kill, aquatic life, other animals, plants, or humans. To ensure protection of aquatic life, concentrations of toxic substances must not exceed the final acute value (FAV = 2 (AAC)) in the undiluted discharge or the acute aquatic criterion (AAC) outside the zone

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of initial dilution or, if applicable, the zone of discharge –induced mixing. ~~The following apply where applicable:~~

(i) For certain substances, an AAC is specified in:
(AA) subdivision (3), Table 6-1;
(BB) subdivision (3), Table 6-2~~, which incorporates subdivision (4), Table 6-3~~; ~~and~~
(CC) subdivision (4), Table 6-3; and
(DD) subdivision (5),
(ii) An AAC may be calculated by the commissioner using the procedures in section 8.2 of this rule for substances for which an AAC is not specified in **item (i).** ~~:~~
~~(AA) subdivision (3), Table 6-1;~~
~~(BB) subdivision (3), Table 6-2, which incorporates subdivision (4), Table 6-3; and~~
~~(CC) subdivision (5).~~
. . .

The rationale for the City's suggested revisions is as follows:

- The City suggest the striking of the phrase "The following apply where applicable:" that IDEM proposes to add at the end of the opening portion of 327 IAC 2-1-6(a)(1)(E) for two reasons. First, the phrase seems inherently circular in nature, referring to criteria that apply where applicable. Second, the phrase seems superfluous, adding no additional substantive meaning.
- The City recommends deletion of the phrase "which incorporates subdivision (4), Table 6-3; and" from sub-item (BB) because subdivision (3), table 6-2 does not contain language expressly incorporating subdivision 4 or Table 6-3. While it is true that the specific values for certain metals criteria at certain hardness values illustrate the formulaic criteria statements of subdivision (3) and Table 6-2, there is nothing in subdivision (3) or Table 6-2 that expressly incorporates subdivision (4) or Table 6-3. Correspondingly, it seems to be clearer to simply list subdivision (4) and Table 6-3 as its own sub-item (CC), which requires subdivision (5) to be shifted to a new sub-item (DD).
- It is also suggested by the City that item (ii) of 327 IAC 2-1-6(a)(1)(E) could be readily simplified by referring to the use of the Tier II criteria procedures of Section 8.2 as available for substances for which an AAC is not specified in "item (i)." This is much simpler and just as clear as repeating sub-items (AA), (BB), and (CC) within item (ii).

3. The following changes (in red font) are suggested by the City to the proposed revisions to 327 IAC 2-1-6(a)(5):

(a) Proposed Footnote [1] to Table 6-3a should be revised to read as follows:

"The equation in clause (A) must be used instead of the criteria in this Table ~~clause~~ when chloride criteria are used as intermediate values in a calculation, such as in the calculation of WQBELs."

(b) Proposed Footnote [1] to Table 6-3b should be revised to read as follows:

"The equation in clause (B) must be used instead of the criteria in this Table ~~clause~~ when chloride criteria are used as intermediate values in a calculation, such as in the calculation of WQBELs."

The rationale for the City's suggestions is to improve clarity of the referenced footnotes. Since the footnote in each case is a footnote to the table, it seems more clear and straightforward for the footnotes to reference the "criteria in this Table" rather than the "criteria in this clause".

4. The following changes (in red font) are suggested by the City to the proposed revisions to 327 IAC 2-1-6(a)(6):

(a) Proposed Footnote [1] to Table 6-3c should be revised to read as follows:

"The equations in clause (A) must be used instead of the criteria in this Table ~~clause~~ when sulfate criteria are used as intermediate values in a calculation, such as in the calculation of WQBELs."

The rationale for the City's suggestions is to improve clarity of the referenced footnote. Since the footnote is to the table, it seems more clear and straightforward for the footnote to reference the "criteria in this Table" rather than the "criteria in this clause".

The City of Greensburg appreciates the opportunity to provide its comments on the proposed rulemaking described in LSA Document #14-58 -- Metals Criteria Revisions. It is respectfully requested by the City that its comments be given full consideration as the rulemaking proceeds.

Sincerely,

Larry J. Kane
Attorney for the City of Greensburg

cc: Jeffrey Smith, Superintendent
Greensburg Wastewater Utility

OFFICIAL COMMENT

CWA AUTHORITY, INC.
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Dept. of Environmental Management
Commissioner's Office

JAN 31 2018

Via Hand Delivery

January 31, 2018

Ms. Mary Ann Stevens
Rules Development Branch
Office of Legal Counsel
Indiana Department of Environmental Management (IDEM)
Indiana Government Center North
100 North Senate Avenue
Indianapolis, IN 46204-2251

RE: Comments for IDEM's Second Notice of Aquatic Life and Human Health Ambient Water Quality Criteria for Metals (LSA Document #14-58)

Dear Ms. Stevens

CWA Authority, Inc. (Authority) owns and operates the Belmont and Southport Advanced Wastewater Treatments (AWT) plants in Indianapolis that serve more than 225,000 households and businesses in Marion and other surrounding counties by safely collecting and treating wastewater while protecting our environment. We are committed to ensuring our wastewater facilities are continually updated and expanded to meet the needs of a growing economy and ever stringent regulations. The Authority appreciates the opportunity to offer comments on the proposed changes to the Aquatic Life and Human Health Ambient Water Quality Criteria (WQC) for Metals.

1. The draft WQC for selenium is unclear and no guidance has been provided on demonstrating compliance with the criteria. Such guidance is necessary to ensure quality data is appropriately collected for compliance given the stringent criteria. In lieu of such guidance, affected permittees may encounter undue expense or burden to achieve compliance. Many other states have included or drafted guidance as part of their WQC updates and the Authority believes this should be included with the update.

2. In conjunction with such guidance, the Authority believes a work group should be convened. The proposed selenium WQC affects a large number of industries with NPDES permits, including wastewater treatment plants. A discourse of regulators, industry representatives, and other interested parties is needed to appropriately develop guidance for purpose of compliance with the proposed WQC.

The Authority appreciates the opportunity to provides comments. If you wish to discuss anything further please feel free to contact me at (317) 927-4393 or by email at amciver@citizensenergygroup.com

Sincerely,

Ann W. McIver, QEP, Director
Environmental Stewardship

cc: Jeff Hansen, Director of Wastewater Plant Operations

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January 31, 2018

MaryAnn Stevens
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Indiana Government Center North
100 North Senate Avenue
Indianapolis, IN 46204-2251

Re: Comments for IDEM's Second Notice of Aquatic Life and Human Health Ambient Water Quality Criteria for Metals (LSA Document #14-58)

Dear Ms. Stevens,

Duke Energy Indiana, LLC (Duke) appreciates the opportunity to offer comments on the proposed changes to the Aquatic Life and Human Health Ambient Water Quality Criteria (WQC) for Metals. Duke's Indiana operations provide approximately 6,800 megawatts of owned electric capacity to approximately 820,000 customers in a 23,000-square-mile service area, making it the state's largest electric supplier. Duke owns and operates multiple facilities within Indiana that are subject to NPDES permitting requirements, and therefore is directly affected by the proposed WQC rule changes.

Duke is concerned regarding the selenium portion of the proposed WQC. Duke believes additional information and data should be evaluated before finalization of the selenium component of the WQC. Duke respectfully requests that the selenium component of the proposed metals WQC update be removed from the present rulemaking and addressed separately at a future date in order to develop implementation guidance in parallel to a new State selenium rulemaking. Federal draft technical support documents (TSDs) to guide implementation of EPA's (2016) selenium NRWQC have been developed. These documents are imperfect and multiple comments from interested parties have been submitted to EPA for consideration before the documents are made final. However, the federal draft documents can still be a resource to an IDEM-led work group in developing State implementation guidance for fish tissue sampling to inform Indiana's selenium WQC implementation and compliance.

Duke suggests a work group should be convened by IDEM to develop an implementation plan for the selenium WQC. The draft notice states that no work group is planned for this rulemaking, yet there is also no finalized Federal guidance or State specific guidance provided on implementing a WQC based on fish tissue. Implementation guidance is essential for collecting high quality, reliable, and reproducible data that can be used for regulatory

management decisions. Such guidance has been developed (i.e., Kentucky; KDEP 2014), drafted (West Virginia; WVDEP 2017), or included in draft WQC (i.e., Idaho; IDEQ 2017) by other states.

Recently Virginia has chosen to not move forward with the recommended selenium WQC from EPA (Vol 34, Issue 10, Virginia Register 2018-01-08 pp. 913-915). The VA Department of Environmental Quality (DEQ) State Water Control Board voted not to initiate a rulemaking to amend the selenium WQC until the final technical support guidance documents from the EPA become available. The VA DEC advised the board that EPA's technical support documents and implementation guidance are as important as the criteria themselves, and it would be premature to initiate a rulemaking without the documents and guidance.

IDEM's proposed WQC for selenium are based on the National Recommended Water Quality Criteria at Section 304(a) of the CWA. The EPA allows for state specific criteria based on local circumstances and reasonable scientific rationale. Towards those ends, Duke respectfully requests that IDEM review and incorporate findings from the report titled "Recommended Updates to Indiana's Selenium Aquatic Life Standards" (GEI Consulting 2017) into the proposed selenium portion of the WQC. Duke agrees with GEI Consulting's findings that the derivation of state-specific selenium standards for Indiana are justified based on a scientifically sound and robust alternative methodology. The derivation of state specific standards for Indiana are justified for the following reasons: 1) The 2016 Federal selenium criteria were driven by a limited number of data that were focused on a national scale and are not the most appropriate for Indiana. 2) The final values were driven by the inclusion of fish species that do not occur in Indiana. 3) Ambient selenium and sulfate levels in Indiana are not accounted for in Federal criteria. Duke supports the conclusions of the GEI Consulting report and requests that IDEM review and adopt the Indiana specific selenium criteria from this report.

Duke does not support the proposed selenium criteria that IDEM has proposed. IDEM should review and adopt the State specific criteria developed by GEI. The GEI report's proposed criteria are scientifically defensible and specific for Indiana's unique fauna, geology, and water quality. Finally, Duke does not support the imposition of selenium WQC without robust implementation guidelines. Duke suggests the proposed selenium WQC be delayed and addressed separately at a future date in order to develop implementation guidance in parallel to a new selenium WQC rulemaking.

Duke appreciates your consideration of these comments, and we would be happy to discuss further. If you have any questions, please feel free to contact me at (317) 838-1736 or bryan.kalb@duke-energy.com

Thank you,

Bryan Kalb

Bryan Kalb
Sr. Environmental Specialist
Duke Energy Indiana, LLC

References

GEI Consultants, Inc. Recommended Updates to Indiana's Selenium Aquatic Life Standards. Project 1704056. November 2017.

Idaho Department of Environmental Quality (IDEQ). 2017. Proposed changes to Water Quality Standards. IDAPA 58.01.02. Negotiated Rule Draft No. 2. Docket No. 58-0102-1701, Dated June 8, 2017. http://www.deq.idaho.gov/laws-rules-etc/deq-rulemakings/

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West Virginia Department of Environmental Protection (WVDEP). 2017. West Virginia Selenium Chronic Aquatic Life Criteria Implementation. http://www.dep.wv.gov/WWE/Programs/wqs/Documents/2017%20020617%20WV%20Se%20Implementation.pdf

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
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FEB 01 2018

REPLY TO THE ATTENTION OF:

WQ-16J

MaryAnn Stevens
Rules Development Branch
Office of Legal Counsel
Indiana Department of Environmental Management
Indiana Government Center North
100 North Senate Avenue
Indianapolis, IN 46204-2251

Subject: LSA Document #14-58 Metals Criteria Revisions

Dear Ms. Stevens:

On November 15, 2017, Indiana Department of Environment Management (IDEM) published a request for comments on draft amendments to Indiana's Administrative Code governing water quality standards at 327 IAC 2-1-6 and 327 IAC 2-1.5-8 to revise Indiana's aquatic life and human health ambient water quality criteria for select metals. The U.S. Environmental Protection Agency has reviewed revisions to 327 IAC 2-1-6 and 327 IAC 2-1.5-8 for consistency with the requirements of section 303(c) of the Clean Water Act (CWA) and federal regulations at 40 CFR 131 and 132. Our comments are enclosed. These comments do not constitute formal Agency action but are provided for your consideration as you prepare your rules for submittal for review and approval by EPA under section 303(c) of the CWA.

Thank you for the opportunity to comment on IDEM's draft rule revisions. If you have any questions regarding our comments, please contact Kay Edly of my staff at (312) 886-7090 or edly.kay@epa.gov or Tom Poleck of my staff at (312) 886-0217 or poleck.thomas@epa.gov.

Sincerely,

Andrew Tschampa, Acting Chief
Water Quality Branch

Enclosure

cc: Eileen Hack, IDEM

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Enclosure, EPA Comments on LSA Document #14-58 Metals Criteria Revisions

Aquatic Life Criteria

Aluminum: IDEM is proposing a hardness-based aluminum criteria based on criteria for aluminum adopted by New Mexico in December 2010. In 2017, EPA released a draft aluminum 304(a) criteria document (https://www.epa.gov/wqc/2017-draft-aquatic-life-criteria-aluminum-freshwater-documents). Whereas the criteria adopted by New Mexico and proposed by IDEM are hardness-based, EPA's draft document found that aluminum bioavailability and toxicity is influenced by pH and dissolved organic carbon in addition to hardness. EPA's draft document also describes that the relationship between pH and aluminum toxicity to aquatic life is nonlinear. Aluminum is least toxic to aquatic organisms at values around neutral pH (approximately 7) and increases as pH either increases or decreases.

EPA's 2017 draft document includes newly published toxicity data for aluminum, including new chronic data for the unionid mussel, fatmucket (*Lampsilis siliquoidea*). *Lampsilis* is ranked as the third most sensitive genus in the draft 304(a) aluminum chronic dataset when normalized to pH 7, hardness = 100 mg/L as CaCO3 and DOC =1.0 mg/L (USEPA 2017). According to the U.S. Fish and Wildlife Service website of federally-listed threatened, endangered and proposed species (revised July 25, 2017), there are 10 endangered or threatened mussel species and critical habitat for one mussel species in Indiana.

EPA recommends that IDEM revise its proposal to incorporate the most current scientific information about aluminum toxicity to aquatic organisms. IDEM may accomplish this by proposing to adopt EPA's 2017 draft document or by modifying its proposal based upon its own work to address the technical recommendations provided above.

Cadmium: We commend IDEM for proposing to adopt EPA's 2016 304(a) criteria recommendations for cadmium. EPA supports adoption of IDEM's proposed criteria for cadmium.

Copper: IDEM is not proposing to adopt EPA's 2007 304(a) criteria recommendation, which is based upon the biotic ligand model (BLM) (https://www.epa.gov/wqc/aquatic-life-criteria-copper). In addition to updating the science on bioavailability of copper, the 2007 304(a) recommendation incorporates new toxicity data that is not incorporated into the prior hardness-based criteria equation. The copper BLM represents the EPA's most up-to-date science, intended to protect the biota in Indiana's waters. EPA recommends that IDEM adopt EPA's 2007 304(a) recommendations for copper as these reflect the most current science to protect aquatic life uses.

If IDEM chooses to adopt the BLM, EPA would be willing to work with IDEM to develop implementation procedures that address how the BLM would be applied where data for the BLM input parameters are not currently available. EPA's 2016 "Draft Technical Support Document: Recommended Estimates for Missing Water Quality Parameters for Application in EPA's Biotic Ligand Model" provides one method for addressing this situation. Alternatively, IDEM could use state-collected data to develop state-specific default input values, provided such default values would result in copper criteria that are protective of the aquatic life use. Such procedures

would simplify implementation of the BLM and provide greater specificity for permittees while ensuring that Indiana's copper criteria are protective of aquatic life.

New data on copper toxicity have been published subsequent to EPA's 2007 304(a) criterion recommendation. EPA would be able to assist in locating new data published subsequent to the 2007 304(a) criterion recommendation.

Lead: IDEM is proposing a hardness-based lead criteria based on addition of new data published subsequent to a partial revision of EPA's 304(a) criteria. 40 CFR 131.11(b)(1)(iii) allows states and tribes to, "[e]stablish numerical values based on: [o]ther scientifically defensible methods." To satisfy the requirements of 40 CFR 131.11(b)(1)(iii), a new or revised criteria should be updated to include new toxicity data published to date. New data on lead toxicity have been published subsequent to EPA's 1984 304(a) criteria recommendation (Wang *et al.* 2010, Mebane *et al.* 2012). EPA would be able to assist in locating new data published subsequent to the 1984 304(a) criteria recommendation. EPA is aware of at least one published study that includes new lead toxicity data for the sensitive unionid mussel, *Lampsilis siliquoidea* (Wang *et al.* 2010). In addition to providing toxicity data for previously untested species, Wang *et al.* 2010 demonstrates that enough data may be available to satisfy the 8 MDR requirements and derive criteria for lead consistent with EPA's preferred criteria derivation approach using least squares regression. EPA's 1985 Guidelines provide technical recommendations for developing and modifying criteria, and EPA would be able to assist should IDEM wish to pursue this.

Additionally, EPA is actively evaluating the most recent data and science for lead as part of a Cooperative Research and Development Agreement (https://www.epa.gov/wqc/cooperative-research-and-development-agreement-aquatic-life-bioavailability-modeling-metals). To address the issues identified above, EPA recommends that IDEM either conduct a literature review and update the lead criteria as appropriate or provide its rationale to show that the proposed criteria are based on a sound scientific rationale and protective of aquatic life uses.

Selenium: We commend IDEM for proposing to adopt EPA's 2016 304(a) criteria recommendations for selenium (USEPA 2016). As noted below, some aspects of IDEM's proposal appear to deviate from EPA's criteria recommendations for selenium. To ensure that IDEM proposal is scientifically defensible and protective of aquatic life uses, EPA recommends that IDEM revise the proposal as discussed below.

EPA notes that Tables 6-2a and 8-1a in IDEM's draft rule both contain significant changes/omissions from EPA's recommended national criterion. EPA specifically notes the following differences and recommends that IDEM address these changes before finalizing the state's rulemaking process:

1. Footnote 1, "fish tissue elements are expressed as steady-state", has been removed.
2. Footnote 4 has been modified and no longer includes the sentence "water column values are the applicable criterion element in the absence of steady-state condition fish tissue data."

3. Footnote 6, "fish tissue data provide instantaneous point measurements that reflect integrative accumulation of selenium over time and space in fish populations(s) at a given site", has been removed.
4. "Monthly average exposure" is not specified for the criterion element for lentic and lotic aquatic systems in Tables 6-2a and 8-1a and corresponding footnotes, instead IDEM simply refers to a "(30 day)". EPA recommends a monthly average exposure and duration of 30 days.

EPA emphasizes the importance of the steady state assumption to ensure that the selenium criterion is sufficiently protective of waterbodies with new inputs of selenium. New inputs are defined as anthropogenic activities that result in an increased load of selenium being released into a lentic or lotic waterbody. Fluctuations in selenium concentrations attributable to normal, expected seasonal and hydrologic variability are not considered to be departures from a "steady state" for purposes of implementing the selenium criterion. New anthropogenic inputs likely increase the selenium in the food web, resulting in increased bioaccumulation of selenium in fish over time. It could take months to years for selenium concentrations in fish tissue to fully reflect ambient water concentrations depending on many site-specific factors including site dynamics, hydrology, and the complexities of a specific food web at a given site. Thus, in waters that have new inputs of selenium, data on selenium concentrations in fish tissue may not fully reflect the eventual effects of increased selenium concentrations on the system. Assessing water bodies that have new selenium inputs using fish tissue that is not in steady state may not appropriately identify an impairment in a water body and will delay corrective actions for that water body. This results in the criterion not being protective of aquatic life. For this reason, EPA recommends that IDEM include the language "fish tissue elements are expressed as a steady-state" and "water column values are the applicable criterion element in the absence of steady-state condition fish tissue data" in the footnotes of tables 6-2a and 8-1a as these statements are critical components to ensuring that aquatic life is adequately protected from new discharges of selenium into a waterbody until a steady state is achieved.

Further, EPA seeks clarification on IDEM's decision to remove the language in footnote 6 "fish tissue data provide instantaneous point measurements that reflect integrative accumulation of selenium over time and space in fish tissue concentrations at a given site." EPA's criterion recommendation for selenium recognizes that appropriately representative fish tissue data are a valid and defensible method to assessing condition and attainment where loadings of selenium are not changing. EPA also acknowledges that a single fish tissue data point may not constitute a representative sample for a site for purposes of assessing attainment. For these reasons, EPA recommends that the language above be reinserted into the footnotes for tables 6-2a and 8-1a.

EPA also asks that IDEM more specifically define what 30 day means in the context of the duration of its proposed selenium criterion. EPA notes the inclusion of "(30 day)" for both the lotic and lentic aquatic systems, which seems to indicate that the State sees these values as either a 30-day average or that they have a 30-day duration. EPA requests that the "(30 day)" be clarified, and that IDEM indicate that these criterion elements are monthly average exposures and that the duration for these criterion elements are 30 days.

We also note the following:

Table 6-1, Table 8-1 and footnote 1 in Table 8-1 of IDEM's proposed rule specify a 4-day average duration for selenium; however, Tables 6-2a and 8-1a specify instantaneous and 30-day durations. It is our understanding that IDEM intends the durations specified in Tables 6-2a and 8-1a.

Table 8-1 of IDEM's proposed rule lists selenium as 'selenium (dissolved)'. However, Table 8-1a specifies that water column values are based on dissolved total selenium in water. It is our understanding that IDEM intends that water column values are based on dissolved total selenium in water.

To address the issues identified above, EPA recommends that IDEM change their proposal to be consistent with EPA's 2016 selenium criteria document, or provide rationale to show that the proposed changes to the 2016 selenium criteria are based on a sound scientific rationale and protective of aquatic life uses in Indiana.

Silver: IDEM is proposing EPA's existing 304(a) hardness-based equation for silver. However, this criterion is based on the 304(a) aquatic life criterion issued in 1980. The Minimum Data Requirements and derivation procedures were different in the 1980 Guidelines than in the 1985 Guidelines. A CMC derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the criteria should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines (USEPA 2002). Because IDEM's acute criterion for silver are expressed as an acute aquatic criterion (AAC) which equals the FAV/2, the proposed equation must be divided by 2. Footnote 3 in Table 6-2 is proposed to be deleted; however, footnote 3, "One half (1/2) of the FAV as calculated by procedures developed by U.S. EPA in 1980…" should be retained because it applies to silver. Please be aware that EPA is actively evaluating the most recent data and science for silver as part of a Cooperative Research and Development Agreement (https://www.epa.gov/wqc/cooperative-research-and-development-agreement-aquatic-life-bioavailability-modeling-metals).

Arsenic and Chromium (III): IDEM is proposing EPA's existing 304(a) criteria recommendations for arsenic and chromium (III) (USEPA 1996). EPA supports adoption of IDEM's proposed criteria for arsenic and chromium (III).

Zinc and Nickel: IDEM is proposing to adopt EPA's existing 304(a) criteria recommendations for zinc and nickel (USEPA 1996). Please be aware that EPA is actively evaluating the most recent data and science for these metals as part of a Cooperative Research and Development Agreement (https://www.epa.gov/wqc/cooperative-research-and-development-agreement-aquatic-life-bioavailability-modeling-metals) and expects that this reevaluation could lead to revisions to EPA's 304(a) recommendations for nickel and zinc.

Editorial clarifications: The label that applies to metals in Table 6-1 currently reads "(total recoverable)". However, not all of the metals criteria for aquatic life in the table are expressed as total recoverable. EPA recommends that IDEM update the label that applies to metals contained in Table 6-1 to be consistent with Tables 6-2 and 6-2a.

Human Health Criteria

EPA has no additional comments on the human health criteria changes in Table 6-1 except for arsenic which is discussed below. This includes the relocation of nitrate and nitrite criteria from Table 6-1 to Sec. 6(e)(6). We commend IDEM for proposing to update these criteria based on EPA's most recent 304(a) criteria recommendations.

Arsenic: IDEM is proposing to remove the "Outside the Mixing Zone" and "Point of Water Intake" human health criteria. Even though all drinking water use waters must also meet the SDWA MCL (327 IAC 2-1-6(e)(7)) after conventional treatment, this does not protect the organism-only human health use (Outside the Mixing Zone). EPA recommends maintaining the arsenic criteria update as proposed in the First Notice which changed the current older criteria to be consistent with the most recent 304(a) recommendations.

Comment from EPA's NPDES program:

Footnotes in tables 6-2 and 8-1 state, "The applicable pH range for determining the aluminum criterion is within 6.5 and 9.0." These footnotes imply there are no aluminum water quality criteria if the waterbody pH is above 9.0 or below 6.5. If this is not IDEM's intent then the footnotes need clarification.

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From: Hack, Eileen
To: Hack, Eileen
Subject: Greg Bright Comment Letter_2nd Notice Metals Rulemaking
Date: Wednesday, February 14, 2018 10:20:12 AM
Attachments: Acute_and_Chronic_Toxicity_of_Nickel_to.pdf

From: STEVENS, MARY ANN
Sent: Wednesday, December 27, 2017 12:20 PM
To: Hack, Eileen <EHack@idem.IN.gov>
Subject: FW: One comment on the proposed water quality criteria for metals changes

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From: Greg Bright [mailto:biomonitor@att.net]
Sent: Tuesday, December 26, 2017 3:33 PM
To: STEVENS, MARY ANN <MSTEVENS@idem.IN.gov>
Subject: One comment on the proposed water quality criteria for metals changes

**** This is an EXTERNAL email. Exercise caution. DO NOT open attachments or click links from unknown senders or unexpected email. ****

Greetings, MaryAnn. I'm glad to know you're still taking an active hand in protecting our water quality.

I have one quick comment pertaining to LSA 14-58 (water quality criteria for metals). The new proposed aquatic life criteria for nickel are lower than they used to be. But according to the attached information, the new criteria still won't come close to keeping one of our common effluent toxicity testing animals (Ceriodaphnia dubia) from failing the tests. The chronic criteria suggest that 100 ug/l of nickel should protect aquatic life. But the attached study found chronic effects to Ceriodaphnia at concenrations as low as 7 ug/l. We've had several instances of having to explain that nickel is the cause of effluent toxicity, even when the nickel limits are being met. I'm wondering if we shouldn't crank those criteria down a little lower yet.

Greg Bright
Biomonitor, Inc.

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ACUTE AND CHRONIC TOXICITY OF NICKEL TO A CLADOCERAN (*CERIODAPHNIA DUBIA*) AND AN AMPHIPOD (*HYALELLA AZTECA*)

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Abstract—This study evaluated acute and chronic nickel (Ni) toxicity to *Ceriodaphnia dubia* and *Hyalella azteca* with the objective of generating information for the development of a biotic ligand model for Ni. Testing with *C. dubia* was used to evaluate the effect of ambient hardness on Ni toxicity, whereas the larger *H. azteca* was used to derive lethal body burden information for Ni toxicity. As was expected, acute *C. dubia* median lethal concentrations (LC50s) for Ni increased with increasing water hardness. The 48-h LC50s were 81, 148, 261, and 400 μg/L at hardnesses of 50, 113, 161, and 253 mg/L (as $CaCO_3$), respectively. *Ceriodaphnia dubia* was found to be significantly more sensitive in chronic exposures than other species tested (including other daphnids such as *Daphnia magna*); chronic toxicity was less dependent on hardness than was acute toxicity. Chronic 20% effective concentrations (EC20s) were estimated at <3.8, 4.7, 4.0, and 6.9 μg/L at hardnesses of 50, 113, 161, and 253 mg/L, respectively. Testing with *H. azteca* resulted in a 96-h LC50 of 3,045 μg/L and a 14-d EC20 of 61 μg/L at a hardness of 98 mg/L (as $CaCO_3$). Survival was more sensitive than was growth in the chronic study with *H. azteca*. The 20% lethal accumulation effect level based on measured Ni body burdens was 247 nmol/g wet weight.

Keywords—Nickel Daphnids Amphipods Biotic ligand model

INTRODUCTION

Relative to other divalent metals, nickel (Ni) has not been well studied in terms of toxicity, mode of action, and bioavailability. When the ambient water-quality criteria for Ni were released [1], only six species had been tested in chronic exposures. Of these studies, three tests were with invertebrates—the cladoceran *Daphnia magna*, the caddisfly *Clistoronia magnifica*, and the snail *Juga plicifera*. No-observed-effect concentrations (NOECs) were relatively high for the latter two species, at 124 and 62 μg/L, respectively [1]. The sensitivity of *D. magna* appears to be strongly dependent on hardness, with NOECs of 10, 101, and 220 μg/L at water hardnesses of 51, 105, and 205 mg/L [1].

Since publication of the ambient water-quality criteria, two other invertebrates have been tested for their chronic sensitivity to Ni. Kszos et al. [2] studied chronic Ni toxicity to the cladoceran *Ceriodaphnia dubia* and Borgmann et al. [3] investigated chronic Ni toxicity in the amphipod *Hyalella azteca*. Kszos et al. [2] estimated an NOEC of 5 μg/L for *C. dubia*, whereas Borgmann et al. [3] estimated a 25% inhibition concentration of 17 μg/L for *H. azteca*. Given the limited chronic toxicity data available for Ni, additional data are needed to better characterize the hardness-dependent relationship between Ni and chronic toxicity, identify the toxic mode of action, and provide a calibration data set for development of the Ni biotic ligand model (BLM) [4]. To help achieve these objectives, we evaluated acute and chronic Ni toxicity to *C. dubia* at several different water hardnesses (nominal of 50, 100, 175, and 250 mg/L as $CaCO_3$). For calibration of the BLM, analyses of dissolved organic carbon (DOC), cations, and anions also were conducted. We also evaluated acute (96-h) and chronic (14-d) Ni toxicity and lethal body burden to the freshwater amphipod *Hyalella azteca*, because its larger size is more suitable for measurement of body burdens. In addition to standard toxicological endpoints, we measured Ni accumulation in *H. azteca* as a function of exposure concentration in the chronic study. We specifically selected a different set of exposure conditions and test duration from previously published studies with *H. azteca* to evaluate whether a similar lethal body burden could be derived. This would substantiate the concept that Ni effects can be predicted as a function of Ni body burden, regardless of exposure condition and duration.

METHODS AND MATERIALS

Experimental design

Nickel chloride pentahydrate (>97% pure; lot 015298) was obtained from Fisher Scientific (Pittsburgh, PA, USA). Stock solutions were prepared by dissolving the Ni salt in Milli-Q® deionized water (Millipore, Burlington, MA, USA). The dilution water for each test with *C. dubia* was prepared by adding the following reagent-grade salts to deionized water: calcium sulfate (dihydrate, 98%, Aldrich, Milwaukee, WI, USA), magnesium sulfate (All-World Scientific, Lynnwood, WA, USA), sodium bicarbonate (grade, Fisher Scientific), and potassium chloride (Fisher Scientific). Each water was formulated according to standard U.S. Environmental Protection Agency (U.S. EPA) moderately hard water [5] except that Ca and Mg were modified to achieve the desired water hardness. The four nominal hardness levels evaluated in the acute and chronic toxicity tests with *C. dubia* were 50, 100, 175, and 250 mg/L. The dilution water for *H. azteca* testing was natural spring water from Woodinville (WA, USA; hardness 91–98 mg/L).

Dissolved oxygen, pH, and temperature were measured dai-

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Table 1. Parameters for gill species in the nickel biotic ligand model

Gill species	Binding constant, log *K*
Ni	4.0
Ca	4.0
H	6.7
Na	3.0
Gill binding site density	1,000 nmol/g wet wt

ly in all tests. Dissolved oxygen was measured with an Orion meter and probe (model 835, Thermo-Orion, Waltham, MA, USA) and pH was measured with a Fisher meter and probe (model AP62, Fisher Scientific). Alkalinity and hardness were measured with Hach titration kits (Hach, Loveland, CO, USA) and were confirmed via analysis of cations and anions. Hardness results reported herein were calculated based upon Ca and Mg analysis.

All tests were conducted in general accordance to U.S. EPA or American Society for Testing and Materials guidelines, or both [5–7]. The different requirements of the two species tested necessitated slightly different experimental designs.

Acute tests with *C. dubia* were conducted according to standard U.S. EPA guidelines for conducting 48-h acute toxicity tests [5]. Organisms were obtained from laboratory cultures maintained at 25°C and 90 mg/L hardness and were <24-h-old at test initiation. Static, nonrenewal tests were conducted at 20°C and organisms were not fed during exposure. For each test, a control and six exposure concentrations were used. Four replicate test chambers (250-ml glass beakers) containing five neonates were prepared for each exposure. Nickel, Ca, Mg, organic carbon, K, Na, sulfate, bicarbonate, carbonate, and chloride were measured at test initiation. All measurements were performed on the dissolved fraction after filtration and samples were preserved after filtration. Survival was monitored at 24 and 48 h and mortality was defined as immobility after gentle prodding with a disposable pipet (i.e., the organism remained immobile after stimulation that would cause an avoidance response in a live organism).

Chronic tests with *C. dubia* were conducted in general accordance with standard U.S. EPA guidelines for conducting 7-d chronic toxicity tests [8]. Organisms were obtained from laboratory cultures maintained at 25°C and 90 mg/L hardness and were <24-h-old at test initiation. Static, daily renewal tests were conducted at 25 to 26°C and organisms were fed a standard mixture of yeast, cerophyll, and trout chow (YCT) and *Selenastrum capricornutum* during exposure [8]. For each test, a control and six or seven exposure concentrations were used. Ten replicate test chambers (25-ml polypropylene cups) containing one neonate were prepared for each exposure. Each test chamber contained 15 ml of test solution. Nickel, Ca, Mg, organic carbon, K, Na, sulfate, bicarbonate, carbonate, and chloride were measured at three times (test initiation, day 3 or 4, and at day 7). All measurements were performed on the dissolved fraction after filtration. Because of laboratory error, the Ni concentrations for the 50-mg/L hardness test were not measured and results are reported as nominal.

Table 3. Dilution water characteristics for toxicity tests with *Hyalella azteca*[a]

Water-quality parameter	Acute	Chronic
pH	7.7–8.0	8.0–8.3
Dissolved oxygen (mg/L)	8.0–8.4	7.2–8.3
Temperature (°C)	23	23–25
Na (mg/L)	30	8
Ca (mg/L)	14	14
Mg (mg/L)	2	<2
Chloride (mg/L)	6.2	6.4
Sulfate (mg/L)	14	12
Hardness (mg/L as $CaCO_3$)	98	91
Alkalinity (mg/L as $CaCO_3$)	64	70
DOC (without food)	0.61	0.66
DOC (with food)	NA	1.4

[a] DOC = dissolved organic carbon; NA = not applicable.

Because food was added to the test system in the chronic exposure, attempts were made to ensure that Ni was in equilibrium between the total and dissolved phases. Dissolved organic carbon complexation kinetics have been shown to be relatively slow for other metals [9], although DOC complexation kinetics have not been studied for Ni. To accomplish this, test concentrations were prepared 24 h before use and YCT were added to test solutions at this time. This was done to ensure that Ni was in equilibrium with DOC associated with the YCT. Although not a specific objective of this study, the equilibration likely also increased any dietary Ni exposure that may occur when the daphnids feed on YCT. In contrast, *S. capricornutum* was added 1 h before use of the test solution because adsorption to algal cells has been shown to be relatively fast for a number of metals [10,11]. Further, addition of *S. capricornutum* only 1 h before use reduced any effects Ni might have on algae quantity between treatment levels. Survival and reproduction were monitored daily and mortality was defined as immobility after gentle prodding.

The acute 96-h test for *H. azteca* followed standard American Society for Testing and Materials guidelines for conducting acute toxicity tests [6]. The 14-d chronic toxicity test followed U.S. EPA guidelines [7]. Test organisms were obtained from Chesapeake Cultures (Hayes, VA, USA). The amphipods were 10- to 12-d-old at test initiation for the 96-h test

Table 2. Water-quality conditions for toxicity tests with *Ceriodaphnia dubia*[a]

Dilution water hardness (mg/L as $CaCO_3$)	pH	DO (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)	CO_3 (mg/L)	Acute DOC (mg/L)	Chronic DOC (mg/L)
50	7.66	8.37	16	2.4	ND	14	1.1	51	31	ND	0.53	1.3
113	7.70	8.34	31	8.7	ND	15	0.85	99	31	ND	0.5	1.3
161	7.61	8.44	43	13	ND	17	2.1	180	29	ND	0.41	1.3
253	7.80	8.63	68	20	ND	16	8.6	226	31	ND	0.43	1.3

[a] DO = dissolved oxygen; DOC = dissolved organic carbon; ND = not detected.

Table 4. Acute toxicity test results for *Ceriodaphnia dubia*[a]

Hardness (mg/L)	LC50 (μg/L)	95% CI (μg/L)
50	81	55–118
113	148	107–192
161	261	212–323
253	400	311–515

[a] LC50 = median lethal concentration; CI = confidence intervals.

and 7- to 8-d-old for the 14-d test. The experimental design for the acute test consisted of four replicate test chambers (300-ml high-form lipless beakers) for each of eight Ni concentrations and a control. The acute test was conducted under static nonrenewal conditions without feeding. The endpoint was mortality, defined as immobility under gentle prodding.

The experimental design for the 14-d test consisted of 10 replicate test chambers for each of seven Ni concentrations and a control. The 14-d test was conducted under static renewal conditions by using a Zumwalt dilutor system with two volume additions per day [12]. To ensure that Ni was in equilibrium between the total and dissolved phases, test concentrations were prepared 24 h before use. As for testing with *C. dubia*, YCT equivalent to 1.0 ml per beaker was added to the test treatments 24 h before use. Each test chamber contained 10 amphipods and artificial substrate consisting of a 3 × 3-cm piece of coarse filter media from Aquatic Eco-Systems (Apopka, FL, USA). The endpoints for this study were mortality and growth (dry wt). Nickel concentrations also were analyzed in tissue of *H. azteca* at termination of the 14-d test. Test temperature was maintained at 23 ± 1°C by using a water bath with submerged aquarium heaters.

Analytical chemistry

Aqueous Ni, Ca, Mg, K, and Na concentrations were analyzed in filtered samples preserved with nitric acid (trace-metals grade, Fisher Scientific) via U.S. EPA Method 6010 (inductively coupled plasma emission spectrometry). The U.S. EPA Method 6020 (inductively coupled plasma–mass spectrometry) was used for Ni when lower detection limits were warranted. Organic carbon was determined by using U.S. EPA Method 9060 and U.S. EPA Method 300A was used for chloride and sulfate. Bicarbonate and carbonate were measured by using Standard Method 2320B. Filtration was performed at the time of sample collection by using 0.45-μm cellulose-nitrate filters (Whatman, Clifton, NJ, USA) for anions and cations. A 0.50-μm glass fiber filter (Gelman Labs/Pall Life Sciences, Ann Arbor, MI, USA) was used for analysis of organic carbon.

Tissue analyses for *H. azteca* were performed by digesting weighed tissue in precleaned vials on a hot plate with 5 ml of concentrated nitric acid (trace-metals grade, Fisher Chemical). A Teflon® conical cap was used to enhance refluxing. After digestion, samples were diluted to 20 ml with Milli-Q reagent water (Millipore). Quality-control samples (preparation blanks, duplicate blank spikes, and certified reference materials) were prepared at the same time as the sample preparation. Nickel was measured using inductively coupled plasma–mass spectrometry with a Perkin-Elmer ELAN 6100 (Norwalk, CT, USA).

Statistical analysis

Toxicity data were statistically analyzed by using the computer software program ToxCalc, Version 5.0 [13]. A number of different endpoints were calculated. Survival, reproduction, growth, and effective body burdens (i.e., 50% and 20% lethal concentrations [LC50s and LC20s, respectively], 20% effective concentrations [EC20s], and 50% and 20% lethal accumulation levels [LA50s and LA20s, respectively]) and corresponding 95% confidence intervals were statistically evaluated by using Probit analysis while the NOEC and lowest-observed effect concentrations (LOECs) were estimated by using Dunnett's test or Steel's many–one rank test.

Biotic ligand model

The BLM has been relatively well developed for Cu and Ag, and is in various phases of development for Cd, Pb, Ni, and Zn [4,14]. Meyer et al. [15] performed the initial studies with fathead minnows (*Pimephales promelas*) to demonstrate that the general principles of the BLM apply to Ni. Specifically, Meyer et al. [15] demonstrated that acute Ni toxicity was variable as a function of water concentration when ambient water-quality conditions (i.e., hardness) were varied, but was constant as a function of gill Ni burden under these same varying ambient water-quality conditions. By using data from this study along with several other studies with *P. promelas* [16,17], an initial calibration of the BLM for Ni has been made.

Using data generated in this study, along with data from a previous study with *D. magna* [18] and *C. dubia* [17], we constructed an initial Ni BLM for daphnids. The same general procedure that has been used with other metals was applied to each of these data sets [4,14]. That is, the binding site density and binding constants (log *K*s) for the biotic ligand were kept the same as for *P. promelas* (Table 1), the organism that provided surrogate accumulation data for the biotic ligand for model calibration purposes, and the LA50 was adjusted to simulate differences in organism sensitivity.

Table 5. Results for chronic tests with *Ceriodaphnia dubia*[a]

	Survival (μg/L)					Reproduction (μg/L)				
Hardness (mg/L)	NOEC	LOEC	Chronic value	LC20	95% CI	NOEC	LOEC	Chronic value	LC20	95% CI
50[b]	<3.8	3.8	<3.8	<3.8	NA	<3.8	3.8	<3.8	<3.8	NA
113	5.3	9.9	7.2	4.8	3.1–6.2	5.3	9.9	7.2	4.7	4.1–5.3
161	15.3	27.5	20.5	11.9	7.7–14.7	3.4	5.3	4.2	4.0	1.8–6.1
253	9.6	17.3	12.9	10.4	6.7–13.3	5.8	9.6	7.5	6.9	4.9–8.4

[a] NOEC = no-observed-effect concentration; LOEC = lowest-observed-effect concentration; LC20 = 20% lethal concentration; CI = confidence interval; EC20 = 20% effective concentration; NA = not applicable.
[b] Results for the chronic test with *C. dubia* at a hardness of 50 mg/L are based on nominal test concentrations.

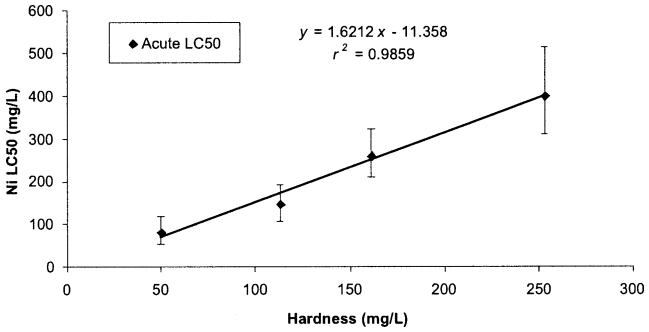

Fig. 1. Acute nickel toxicity to *Ceriodaphnia dubia* as a function of water hardness. Error bars are 95% confidence limits on median lethal concentration (LC50) estimates.

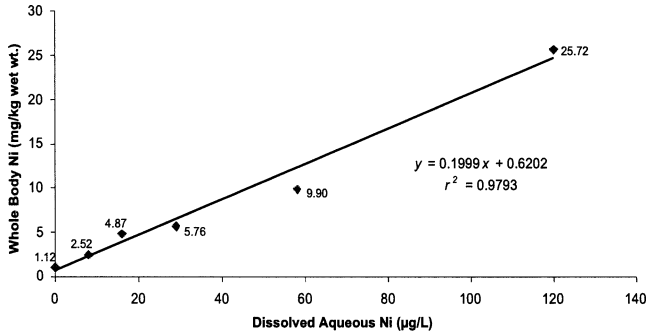

Fig. 3. Nickel body burdens (mg/kg wet wt) of *Hyalella azteca* as a function of waterborne Ni exposure (μg/L) for 14 d.

RESULTS

Water quality and analytical chemistry

Water-quality conditions for all tests are summarized in Tables 2 and 3. Test temperature, dissolved oxygen, and pH all met test acceptability requirements (i.e., per the cited methods). Mean measured dissolved Ni concentrations for each study were comparable to nominal concentrations. Measured concentrations across all tests remained stable for the duration of testing. All statistical analyses were performed based on the mean of the measured dissolved Ni test concentrations except for the acute study with *C. dubia* conducted at 50 mg/L hardness, which is based on nominal test concentrations.

Toxicity testing

The 48-h LC50 for *C. dubia* ranged from 81 to 400 μg/L and, consistent with studies of other organisms, toxicity decreased as water hardness increased from 50 to 253 mg/L (Fig. 1 and Table 4). Chronic results, reported as LC20s for survival and EC20s for reproduction are presented in Figure 2 and Table 5. The chronic hardness-dependent slopes for survival and reproduction were not significantly greater than zero ($p = 0.20$ for survival, $p = 0.14$ for reproduction), suggesting no hardness-dependent effect on the chronic toxicity of Ni to *C. dubia* at the Ca:Mg ratio evaluated in this study.

The 96-h LC50 for *H. azteca* was 3,045 μg/L. In the chronic study, survival was more sensitive than growth. The 14-d EC20 was 61 μg/L with an NOEC of 29 μg/L and an LOEC of 58 μg/L. Both tests had a strong dose–response relationship and <10% mortality in the controls. Nickel bioconcentration, as determined from Ni measured in the whole body tissue of *H. azteca* during the 14-d test, increased with increasing Ni test concentrations (Fig. 3). The LA20 was calculated by using toxicity data and Ni tissue concentrations from the 14-d test. The 14-d LA20 was 247 nmol/g wet weight (Fig. 4).

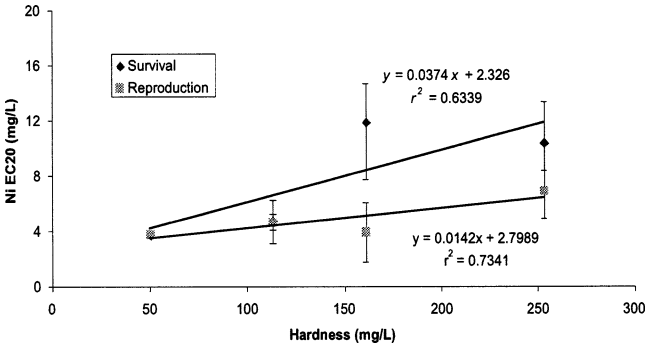

Fig. 2. Chronic nickel toxicity to *Ceriodaphnia dubia* as a function of water hardness. Error bars are 95% confidence limits on 20% effective concentration (EC20) estimates. Note slopes of regression lines are not statistically different from 0 ($p = 0.20$ for survival and $p = 0.14$ for reproduction).

Biotic ligand model

Results for the initial calibration of the acute Ni BLM for daphnids generally are encouraging, with all toxicity values except one being within a factor of two of the line of perfect agreement between measured and predicted LC50s (Fig. 5). The one exception to this result is the acute test with *C. dubia* conducted by Schubauer-Berigan et al. [17] at pH 8.6. To achieve the presented calibration, the two data sets for *C. dubia* required use of different LA50s. In fact, these LA50s are nearly an order of magnitude different at 0.21 and 1.92 nmol/g wet weight. Possible explanations for the pH 8.6 data point and the substantially different LA50s are discussed later.

DISCUSSION

Comparison to other freshwater nickel studies

To compare the results of this study to other published studies, all toxicity data were normalized to a hardness of 50 mg/L (as $CaCO_3$) by using the equation derived by U.S. EPA [19]

$$\text{hardness-normalized LC50} = \exp\{\ln(\text{LC50}) - 0.8460[\ln(\text{test hardness}) - \ln(50)]\}$$

For the acute studies, Schubauer-Berigan et al. [17] measured the acute sensitivity of *C. dubia* and *H. azteca* to Ni at three

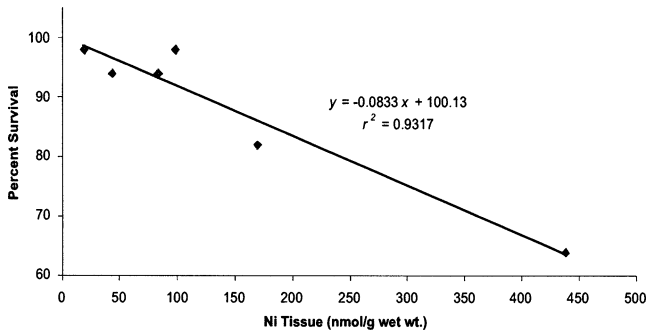

Fig. 4. Survival of *Hyalella azteca* after 14 d of exposure as a function of Ni body burdens (mg/kg wet wt).

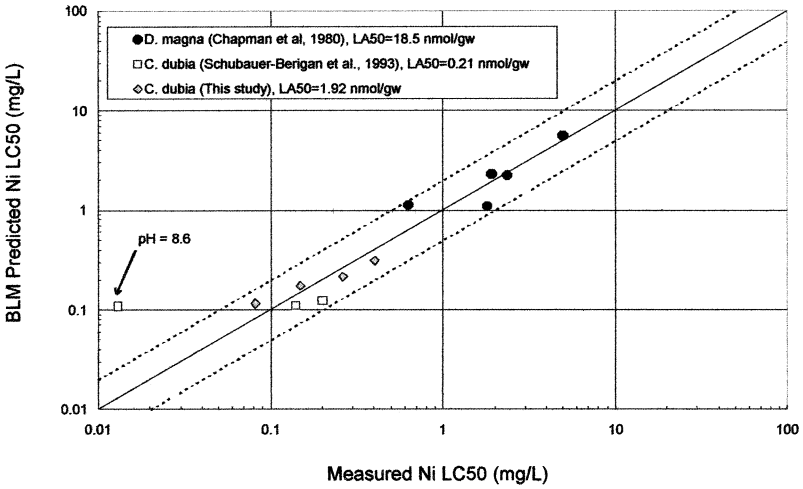

Fig. 5. Results of biotic ligand model predictions for *Daphnia magna* [18] and *Ceriodaphnia dubia* [17]. Binding constant (log *K*) gill-Ni = 4.0, log *K* gill-Ca = 4.0, log *K* gill-H = 6.7, log *K* gill-Na = 3.0. BLM = biotic ligand model; LC50 = median lethal concentration; LA50 = 50% lethal accumulation level.

pH levels. At pH 6.3, 7.1, and 8.6, the hardness-normalized 48-h LC50s for *C. dubia* were 45, 32, and 2.9 μg/L, respectively. The geometric mean LC50 for *C. dubia* from the present study, with a pH range of 7.6 to 7.8, was 89 μg/L. Accordingly, the hardness-normalized mean LC50 from the present study is approximately three times greater than that reported by Schubauer-Berigan et al. [17] at pH 7.1. A similar pattern was observed in the data for *H. azteca*. At pH levels 6.7, 7.5, and 8.5, 96-h LC50s for *H. azteca* were 452, 430, and 201 μg/L, respectively [17]. In the present study, the hardness-normalized LC50 was 1,723 μg/L at a pH of 7.9, or approximately four times greater than that reported by Schubauer-Berigan et al. [17] at pH 7.5. This difference is unlikely to be due to the small difference in pH (0.4 pH units). The basis for the differences between the two studies is unknown, but may be due to variability in the test organisms or slight differences in the test methodology (e.g., test temperature, organism age, or fed vs unfed). This observation is not unique to Ni. Of the other four metals tested by Schubauer-Berigan et al. [17] (Cd, Cu, Pb, and Zn), the hardness-normalized LC50s they reported for *C. dubia* and *H. azteca* were the lowest values reported in the U.S. EPA AQUIRE database (www.epa.gov/ecotox/) for those species (with the exception of acute Pb toxicity to *C. dubia*).

The only chronic study with *C. dubia* on Ni was performed by Kszos et al. [2]. They performed two tests at hardnesses of 42 and 117 mg/L as $CaCO_3$. The first test consisted of a control and two treatments, whereas the second test only had three treatments, making regression analysis of the data difficult. Hypothesis testing indicated chronic values (geometric mean of NOEC and LOEC) of 5.3 and 10.6 μg/L, respectively. These values are reasonably comparable to those observed in the present study where chronic values of Ni at <3.8 and 7.2 μg/L were observed at comparable ambient hardnesses (50 and 100 mg/L, respectively).

The only study comparable to the chronic 14-d test with *H. azteca* was conducted by Borgmann et al. [3]. They conducted a 28-d study that evaluated survival and growth, and also measured Ni accumulation and estimated an LA25. They estimated a hardness-normalized LC25 of Ni at 8 μg/L. This compares with the hardness-normalized LC20 of 37 μg/L obtained in the present study. Hence, the LC20 for the present study was approximately five times higher than the LC25 reported in the 28-d study by Borgmann et al. [3]. This is not surprising given the shorter duration of our study.

In contrast to the water-based comparison of the two studies, comparison of endpoints based on whole-body Ni are much more similar. We estimated an LA20 for the 14-d study of 247 nmol/g wet weight compared with the LA25 of 197 nmol/g wet weight reported in the 28-d study [3]. These results provide a good demonstration of the utility of the BLM approach in which approximately the same effective body burden is estimated for two studies with different exposure durations, aqueous Ni exposure concentrations, and ambient water-quality conditions.

Overall, *C. dubia* and *H. azteca* are relatively sensitive to Ni compared to other test organisms, being the first and third most sensitive genera tested, respectively. Similarly, for chronic toxicity, *C. dubia* and *H. azteca* represent the two most sensitive species tested to date (Fig. 6).

Application to biotic ligand model

The BLM for Ni is in the early stages of development. However, the initial calibration with daphnids shows the approach will be applicable to Ni (Fig. 5). Additionally, the congruence in the LA20 and LA25 between the two available studies on *H. azteca* provides evidence analogous to that de-

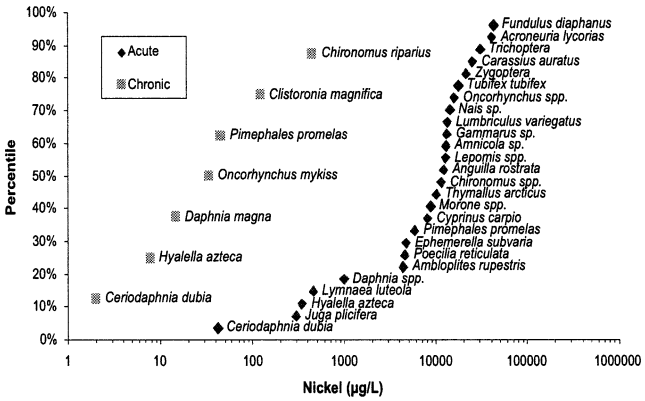

Fig. 6. Genus mean acute and chronic values for Ni. All data were normalized to a hardness of 50 mg/L by using the equation given by the U.S. Environmental Protection Agency [19].

veloped for fish regarding the applicability of a biotic ligand concept for Ni. These studies analyzed in concert with existing data identify several areas where further research is needed.

First, although we were able to develop a BLM including data from the present study and that of Schubauer-Berigan et al. [17], this was only accomplished by estimating significantly different LA50s for *C. dubia* for the two studies. Conceptually, only one LA50 should exist for a given species and life stage. The reason for the substantially different LA50s in this initial calibration is not immediately obvious. Although test conditions differed slightly, the differences are unlikely to account for the order of magnitude differences in LA50s. Some of the BLM water-quality input parameters (e.g., DOC) not available for the data of Schubauer-Berigan et al. [17] had to be estimated based on data from other studies conducted in the same laboratory. However, it again seems unlikely that these uncertainties would account for the significant differences in LA50s. Equally problematic is that the estimated LA50s are quite possibly below background Ni concentrations in most organisms. For example, the estimated LA50 for data from this study is 1.92 nmol/g wet weight, which translates to 0.113 mg/kg wet weight. This compares to a Ni concentration of 0.42 mg/kg wet weight in *D. magna* exposed to an aqueous Ni concentration of just 0.9 μg/L [20]. Clearly, additional study of *C. dubia* is needed to resolve this issue.

The second issue identified in this initial calibration is associated with the pH 8.6 data point from Schubauer-Berigan et al. [17] that is not well predicted by the BLM (Fig. 5). Under the test conditions employed by Schubauer-Berigan et al. [17] at pH 8.6, nickel carbonate ($NiCO_3$) is expected to be the dominant Ni species present. The present form of the Ni BLM assumes that this species is not bioavailable to aquatic organisms. Additional studies measuring Ni accumulation and toxicity at pH > 8.5 are needed to clarify the data of Schubauer-Berigan et al. [17] and the bioavailability of the Ni species forming at higher pH.

CONCLUSION

Ceriodaphnia dubia appears to be the most sensitive species tested with Ni to date in both acute and chronic exposures. Consistent with other species, Ni toxicity values are dependent on hardness for *C. dubia* under acute exposures, and to a lesser extent under chronic exposures. Initial calibration of the acute BLM for Ni and cladocerans is promising. However, further research, particularly with regard to directly measuring lethal accumulation levels in *C. dubia* and the bioavailability of Ni forms at high pH, is needed. Finally, when compared with the study of Borgmann et al. [3], the study with *H. azteca* demonstrates that the underlying principal of the BLM is applicable to Ni, because similar body burdens associated with effects were observed between the two studies despite significantly different water chemistry and exposure durations.

Acknowledgement—We acknowledge NiPERA, Parametrix, and EcoTox for the funding this study; Frontier Geosciences for providing analytical chemistry support for the tissue analyses; and Debbie Fetherston for assisting in manuscript preparation.

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Hoosier Environmental COUNCIL

All. Together. Now.

1 February, 2018

MaryAnn Stevens
Rules Development Branch
Office of Legal Counsel
Indiana Department of Environmental Management
mstevens@idem.in.gov

RE: LSA Document #14-58 Ambient Water Quality Criteria for Metals

Dear Ms Stevens;

The Hoosier Environmental Council appreciates the opportunity to respond to the proposed amendments to Indiana's ambient water quality criteria for select metals.

First, we would like to express our appreciation to the agency for its efforts to revise and update the metals criteria. The criteria are important for the continued health of Indiana's surface waters, their aquatic life, and the health of all Hoosiers who depend on surface water for drinking water, fishing, and recreation. A good deal of research and scientific expertise went into drafting this update, and we are sincerely grateful to the agency staff who have made it possible.

Selenium

Selenium is particularly toxic to aquatic life, but its regulation is complicated since the toxicity is most closely related to its concentration in fish eggs and tissues. There was an extensive process at the federal level to draft the national criteria for selenium (USEPA 2016 NRWQC), and we support IDEM's adoption of those criteria.

Nickel

We appreciate that the proposed change in the criteria for nickel are more stringent than the current criteria. However, we have seen evidence to suggest that some species are sensitive at even lower concentrations[i]. On this subject, we support the comments we understand were submitted by Greg Bright of Commonwealth Biomonitoring.

Arsenic

We are concerned by the removal of arsenic (III) from Indiana's water quality criteria for the protection of human health. We understand the national criteria are still under revision. In that case, it seems advisable to retain the existing criteria until the national criteria have been released.

We are similarly concerned with the removal of criteria for beryllium, cadmium, and chromium (III and VI).

Lead

We object to the less stringent criteria for lead and for the removal of the lead criteria for human health. Lead is extremely neurotoxic. The human toxicology and public health literature have lowered the 'safe' blood levels for lead repeatedly over the last 5 decades, and finally in 2012 the CDC adopted the statement that there is no safe level of lead exposure for children. In light of those findings in the human health literature, it is difficult to imagine that the science of aquatic life toxicology has found evidence that lead is less toxic than we used to believe. We request that the agency consider restoring the previous lead criteria.

General

At Section 6(a)(1)(C), we would like to suggest wording similar to that found at (D) such that item (iv) would read "other conditions to an extent that creates a nuisance or otherwise impairs the designated uses of the surface waters."

The Hoosier Environmental Council sincerely appreciates the opportunity to comment on this rulemaking. If there are any questions about these comments, please contact Indra Frank at ifrank@hecweb.org .

Sincerely,

Indra N. Frank, MD, MPH
Director of Environmental Health and Water Policy

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[i] Keithly, J. et al. (2004).Acute and chronic toxicity of nickel to a cladoceran (*Ceriodaphnia dubia)* and an amphipod (*Hyalella azteca). Environmental Toxicology and Chemistry,23(3);691-696.*

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January 29, 2018

LSA Document #14-58 Metals Criteria Revisions
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Indiana Department of Environmental Management
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Indianapolis, IN 46204-2251

Submitted via U.S. Postal Service and electronic mail to mstevens@idem.in.gov

Re: Comments on Indiana Department of Environmental Management Amendments to Aquatic Life and Human Health Ambient Water Quality Criteria for Metals

The Indiana Coal Council, Inc., (ICC) is the trade association representing Indiana coal producers and other related entities. The ICC is comprised of approximately 100 member companies producing coal in Indiana and providing goods and services to the industry.

On November 28, 2017, the Indiana Department of Environmental Management (IDEM) published the Second Notice of Comment Period for Aquatic Life and Human Health Ambient Water Quality Criteria (WQC) for Metals (the "Proposed Criteria"). The ICC appreciates opportunity to submit comments on these proposed amendments.

1. Aluminum:

ICC supports the application of the hardness-based aluminum criteria. The hardness based approach recognizes the effect that water hardness has on lessening toxicity. However, IDEM should consider the use of an analytical method other than total recoverable. It is widely known that aluminum is a primary component of the earth's crust and is present in measurable amounts in soils. However, the aluminum that is present in weathered soils and rocks is not bioavailable. The use of total recoverable methods can dissolve aluminosilicate clay particles, which biases results (He and Ziemkiewicz 2016). This was recognized by New Mexico Environment Department when implementing this hardness-based standard and was addressed by adding a clause in the regulations that stated "the criteria are based on analysis of total recoverable aluminum in a sample that is filtered to minimize mineral phases as specified by the department" (NMED 20.6.4.900).

Instead of using the total recoverable form, ICC recommends the use of the dissolved form of aluminum which would be consistent with Indiana regulations which state "The use of dissolved

metal to set and measure compliance with water quality standards for aquatic life is the recommended approach because dissolved metal more closely approximates the bioavailable fraction of metal in the water column than does total recoverable metal" (327 IAC 2-1-8.1(b)). Alternatively, ICC recommends the use of the acid soluble form of aluminum originally recommended by EPA in the 1988 criteria document which explained "measurement of acid-soluble aluminum will probably measure all forms of aluminum that are toxic to aquatic life or can be readily converted to toxic forms under natural conditions. In addition, this measurement probably will not measure several forms, such as aluminum that is occluded in minerals, clays, and sand or is strongly sorbed to particulate matter, that are not toxic and are not likely to become toxic under natural conditions." EPA recognizes that the nontoxic forms of aluminum associated with the sediment should be excluded from the analysis. IDEM must remove the use of the total recoverable form of aluminum and move to a more representative analysis method.

2. **Selenium**:

State Authority: IDEM has proposed a WQC for selenium that is based on the National Recommended Water Quality Criteria ("National Criteria") at Section 304(a) of the CWA. ICC urges IDEM to modify the 304(a) criteria to develop a State-specific criterion that accurately accounts for regional water quality and biological conditions and incorporates advances in the science that have occurred since the release of the EPA National Criteria.

EPA regulations require that criteria must be based on sound scientific rationale and explain that numerical values should be based on 1) §304(a) guidance, 2) modified §304(a) guidance to reflect site-specific conditions, or 3) other scientifically defensible methods (40 CFR §131.11). Based on the Federal regulations, it is clear that States have the regulatory authority to determine if it is appropriate to adopt the 304(a) guidance on a statewide basis or whether the State criteria need to diverge from the 304(a) guidance to account for State-specific conditions and / or new scientific information. (The National Criteria are the §304(a) guidance referenced in the federal rule.)

EPA guidance documents also clarify that the 304(a) National Criteria are only recommendations and that a state can pursue a state-standard that is independent of the National criteria. EPA guidance generally suggests that site, region, or state-specific criteria may be appropriate under circumstances such as:

- Waterbodies where background water quality parameters are different from the laboratory water used in developing the criteria. This could include differences in pH, hardness, temperature, or suspended solids (Federal Register Vol. 48, No. 217, November 8, 1983 page 51402, EPA 1985). This can also include waterbodies where the physical and/or chemical characteristics of the water at the site alter the biological availability and / or toxicity of the material (EPA 1984).
- Waterbodies where the types of species in the region differ from those actually tested in developing the Section 304(a) criteria including situations where the species may be more or less sensitive than those included in the national criteria (Federal Register Vol. 48, No. 217, November 8, 1983, EPA 1984). EPA guidance also recognizes ecologically important species (EPA 1985).

The ICC has commissioned an analysis of appropriate selenium water quality criteria for protection of aquatic life by GEI Consultants, Inc. ("GEI") of Denver, Colorado. The ICC has received GEI's report of this analysis dated November 2017 (the "GEI report") and submits a copy with these comments. The GEI report meets the criteria in both the Federal regulations and guidance as the basis for a state water quality criterion as follows. First, all of the issues identified in the GEI report are valid, use EPA methodology, and are based on scientific literature, some of which was available to EPA at the time of the National Criteria and some of which is new. Second, to account for background water quality in Indiana, the GEI report acknowledges the dampening of toxicity caused by competition with sulfate. Third, the GEI report is recommending that Indiana address waterbodies based on the presence or absence of sturgeon because it is ecologically relevant but also relatively rare. Lastly, the GEI report also includes fathead minnow in the species list, which will add a regionally significant species for warm water streams.

In summary, both EPA regulations and guidance make it clear that IDEM has authority to develop state water quality criteria that differ from the National Criteria if those state criteria are scientifically appropriate and protective of Indiana waterbodies.

Scientific Justification: There are a number of scientific reasons that justify IDEM's consideration of a State-specific standard. ICC directs IDEM to the GEI report that provides extensive detail on these issues. A summary of those issues is provided here:

- The National Criteria is extremely sensitive to a number of data usage decisions that are not appropriate for implementation on a statewide basis. These include:
    - The final criteria values are significantly influenced by inclusion of a white sturgeon toxicity study that became the most sensitive species in the database even though it showed only a *partial* dose response relationship. ICC recognizes that the sturgeon is ecologically relevant for the larger waterbodies in Indiana. However, sturgeon generally do not occupy the smaller streams, which are a large proportion of the total number of waterbodies in the State. Applying the sturgeon-based values to all waters would be an overly conservative approach for most of the state, particularly considering the significant impact it has on the final criteria. As a result, IDEM is obligated to apply a two part criteria, one for waters with sturgeon present and one for waters without sturgeon present.
    - Furthermore, in determining the appropriate threshold for sturgeon, the EPA used several conservative assumptions that deviate from typical practice. These analysis methods should be reviewed for consistency with IDEM derivation methods.
    - The National Criteria did not fully include available data for fathead minnows (cyprinid family). Because cyprinids are often a dominant taxa in smaller warm water streams they are ecologically significant to the state and it is important to include this species in the derivation procedure. Overall this will make the application of the criteria more accurate and protective.
    - The National Criteria included three studies for bluegill. Two of the studies showed very consistent results. However, one study showed inconsistent results and even showed toxicity response that intuitively and scientifically did not make

sense (i.e. increased concentration led to decreased toxicity). As such, this study must be excluded from the final criteria since bluegill are adequately protected by inclusion of the other two studies.

- Scientific literature published since the National Criteria offer a more robust calculation for conversion of fish tissue values to water column values (DeForest et. al. 2017). The fish tissue to water column conversion method used in the National Criteria was unconventional, was not adequately justified by EPA, and ignored the dynamic relationships between water concentration and uptake that have a significant influence on the resulting criteria.
- For no obvious reason, EPA diverged from its typical practice of using regression-based conversion factors in developing its recommended selenium criterion. Regression-based conversion factors are more accurate at the high and low ranges and should be used in the criteria development. IDEM should not default to EPA's methods for calculating conversion factors, particularly since they move away from traditional calculation methods with no justification.
- The water column concentrations are approaching the analytical limits of testing methods. These analyses can be complicated further by interferences from other parameters.
- Indiana is dominated by sedimentary geology. Sedimentary rocks, and particularly shales, are known to be natural sources of elevated selenium. Indiana will need to implement a standard that protects the aquatic life in these areas without imposing overly stringent criteria.
- Sulfate at levels typical of Indiana waters can significantly reduce selenium bioavailability and lessen selenium toxicity of a water column concentration. In the coal mining region of the State sulfate concentrations can be elevated due to the dissolution of pyrite and the amelioration of effects must be accounted for by IDEM's criteria. One method of accounting for this impact is to allow for calculation of a sulfate dependent criteria in selenate dominated waters.
- EPA used an intermittent equation to determine potential impacts from intermittent discharges. This is an oversimplification because it essentially applies the chronic criterion adjusted based on the number of days of discharge. This method does not account for the changes in selenium biodynamics that would occur during intermittent pulses. Another method of determining acute criteria resulting from short-term pulses of water is to use a biokinetic model to predict fish tissue concentrations resulting from intermittent pulses of selenium into the water column.
- Overall, a customized approach will aid in practical implementation into Indiana NPDES permits and allow the State and permittees to focus resources and efforts where they are necessary and have measurable environmental benefits.

The current IDEM Proposed Criteria would adopt the National Criteria with only slight modification, which is clearly not an appropriate approach for Indiana waters. The above issues emphasize the need for IDEM to take a close look at the National Criteria to determine its applicability at a statewide level. Criteria derivation methods that are applicable at the national scale often times are not appropriate for application at a State level. The ICC suggests that the selenium water quality criterion recommended in the GEI report would be a more appropriate basis for an Indiana water quality standard than the National Criteria.

Status of Implementation Guidance: EPA issued four draft guidance documents focused on implementation of the selenium standard. However, these guidance documents remain in the draft stage at this time. Therefore, IDEM and stakeholders cannot rely on the draft versions for guidance. This is particularly true after considering the importance of the guidance documents, which address 1) adopting and implementing the criterion through State water quality standards, 2) implementing the criterion in water quality based effluent limitations ("WQBELs") in CWA Section 402 NPDES permits, 3) implementing the criterion in 303(d) and 305(b) analyses, and 4) proper sampling and implementation of a fish tissue based criterion. It is difficult to imagine how a state can even partially implement a standard without answering these fundamental questions first. Therefore, if selenium standards are adopted, IDEM should immediately begin work on implementation guidance. IDEM should in no case apply the standard in permits prior to finalizing the implementation guidance. To do so would be irresponsible to stakeholders and permittees where the standard will potentially be applied.

Two additional implementation issues that EPA addressed in both the draft guidance documents and the criteria include application of the standard on 1) streams with no fish and 2) new discharges. These issues are directly related to implementation of the criteria in NPDES permits and assessing streams for attainment of the criteria in the 303(d) process. As such, both of these issues should be addressed in implementation, and should not be adopted as part of the criteria regulations.

Site-specific Criteria Development: Although not yet finalized, the EPA's Draft *Technical Support for Adopting and Implementing EPA's 2016 Selenium Criterion in Water Quality Standards* discusses the use of a performance-based approach for adopting site-specific water column elements. This is described as a set of procedures to facilitate translation of the fish tissue criterion to a water column criterion. This approach could streamline the development of site-specific standards at necessary sites in Indiana. IDEM should apply a performance based approach to site-specific standards development in Indiana.

The GEI report discusses three methods for determining appropriate water column concentrations. For chronic exposures to selenium, ICC believes the most defensible method for criteria derivation is the quantile regression approach discussed in detail in the GEI report and DeForest et al (2017). Another valid method for chronic exposures that may be appropriate on a site-specific basis is implementation of a sulfate-dependent criteria, outlined in both the GEI report and DeForest et al (2017). For intermittent pulses of selenium (i.e acute criteria), the GEI report recommends use of a selenium biokinetic model based on DeForest et al (2016). Lastly, although it oversimplifies selenium biodynamics, the EPA mechanistic model that is outlined in Appendix K of the EPA National Criteria document may be adequate and appropriate in limited situations. A performance based approach to site-specific criteria development should allow the above methodologies for site-specific criteria development. This will streamline the site-specific standards process and avoid requiring EPA approval of every individual site-specific standard that may be developed.

Selenium recommendation: In summary, IDEM should consider and account for the following issues regarding the selenium proposal:

- The Federal regulations and guidance are clear that Indiana may adopt a state-specific standard that is scientifically justified.
- The EPA 304(a) criteria were derived with numerous data usage decisions and calculation methods that are not scientifically appropriate for Indiana.

- The water quality, aquatic life, and geologic conditions of Indiana streams are not adequately accounted for in the National Criteria.
- EPA implementation guidance remains in draft form and cannot be relied upon. IDEM needs to prioritize the development of implementation guidance.
- IDEM should allow for a performance based approach to site-specific standard development.

The ICC cannot support adoption of the National Criteria because of the numerous issues identified above in the underlying science and its applicability to Indiana waters. Instead, IDEM should adopt the State-specific standard developed by GEI as Indiana's water quality criterion for selenium. This approach protects designated uses and addresses regional differences in aquatic life species, water quality, and geology and is based on assumptions and methodologies that are appropriate for the State. ICC recommends that IDEM withdraw the proposed selenium criterion and republish a selenium water quality criterion based on the GEI report. ICC also requests that if adoption of the IDEM Proposed Criteria are adopted as proposed, implementation of an updated selenium standard in WQBELs in NPDES permits be postponed until Indiana develops its own implementation plan with stakeholder involvement.

Thank you for the opportunity to provide comments on this important matter. Please contact me if there are any questions.

Sincerely,

Bruce A. Stevens
President

Enc: GEI Report

References:

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GEI Consultants

Consulting Engineers and Scientists

Recommended Updates to Indiana's Selenium Aquatic Life Standards

November 2017

Recommended Updates to Indiana's Selenium Aquatic Life Standards

GEI Consultants

Consulting Engineers and Scientists

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November 2017
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1. Introduction

It is our understanding that the Indiana Department of Environmental Management (IDEM) is currently considering updating their aquatic life water quality standards for selenium (Se) during its Triennial Review process by implementing the recently promulgated EPA 2016 selenium fish tissue-based criteria. At the request of the Indiana Coal Council, GEI Consultants, Inc. (GEI) has prepared this analysis and recommendations for state-wide water quality standards for Se.

1.1 Current Indiana State Selenium Standards and History of National Ambient Water Quality Criteria for Selenium

1.1.1 Indiana State Surface Water Quality Standards

The state of Indiana has adopted Se water quality standards for protection of aquatic organisms as set forth in Title 327 of the Indiana Administrative Code (IAC) Article 2 Water Quality Standards. Indiana has water quality standards applicable to all state waters except those within the Great Lakes System, and standards applicable to water within the Great Lakes System. For protection of aquatic life, Indiana utilizes an Acute Aquatic Criterion (AAC) equivalent to one-half the final acute value for toxic substances, and a Chronic Aquatic Criterion (CAC) which is a component of the Continuous Criterion Concentrations (CCC) that also include terrestrial and human health criteria.

Indiana's current aquatic life standards for Se for waters not within the Great Lakes System are based on recommendations from the EPA's 1986 Quality Criteria for Water, the "Gold Book" (EPA 1986), which pre-dates the prior 1987 selenium criteria document. The acute and chronic water quality standards are 130 and 35 µg/L total recoverable Se, respectively. These standards were based on very limited laboratory data available at the time. Indiana's aquatic life standard for Se for waters within the Great Lakes System is based on the 1987 criteria document, although it only uses the chronic value of 5 µg/L. The 1987 criteria document based the chronic value on a field-observed no-effect level from studies on Belews Lake, North Carolina.

In addition to aquatic life criteria, human health criteria have also been established. Indiana's human health Se criterion for point of water intake is 10 µg/L, which is also based on EPA's 1986 recommendations (EPA 1986). It is our understanding that Indiana intends to update this value to 170 µg/L, as well as incorporate a human health Se criterion for fish consumption of 4200 µg/L, to be consistent with EPA's current recommendations (EPA 2012).

1.1.2 History of National Ambient Water Quality Criteria for Selenium

The first national ambient water quality criteria (AWQC) for Se for the protection of aquatic life were published in 1976 (EPA 1976), updated in 1980 (EPA 1980), and then partially updated in 1987, 1995, and 1996 (EPA 1987 and 1995). These criteria were recommendations of water column limits for Se for the protection of aquatic life as required in the Clean Water Act (CWA). Under Section 304(a) of the CWA, the EPA must also periodically revise AWQC to incorporate the latest scientific knowledge on the kind and extent of all identifiable effects of pollutants on aquatic communities and human health. National AWQC are recommendations to states that must adopt water quality standards. Respective criteria can be modified to best reflect each state's unique aquatic communities and environmental conditions.

Prior to release of the 2016 criteria document, the acute (CMC) national AWQC (EPA 2012) for Se was:

$$CMC = 1/[f1/CMC1)+(f2/CMC2)],$$

where f1 and f2 are the fraction of total Se that are comprised as selenite (Se^{+4}) and selenate (Se^{+6}), respectively, and CMC1 and CMC2 (acute values) are 185.9 and 12.82 micrograms per liter (µg/L), respectively, based on acute toxicity data and calculations from the 1987 criteria document (EPA 2012). And prior to 2016, the chronic national AWQC for Se was 5 µg/L.

In 2002 and later in 2004, the EPA published draft criteria documents that recognized the differential acute toxicity of selenite and selenate, the relationship between selenate toxicity and ambient sulfate concentration, and the dietary pathway for chronic toxicity of Se (Canton 1999, Brix et al. 2001a,b, EPA 2002 and 2004). Se speciation is important in determining potential exposure routes and biogeochemical cycling in aquatic environments. Elemental Se and most metallic selenides have relatively low toxicities because of their low bioavailability. By contrast, selenate and selenite are very bioavailable. At pH values below 7.0, selenites are rapidly reduced to elemental Se under mildly reducing conditions (Faust and Aly 1981) that are common in most aquatic sediments. Selenate usually predominates in well-aerated surface waters, especially those with alkaline conditions (Faust and Aly 1981, Luoma et al. 1992). Selenite is more reactive than selenate because of its polarity and high attraction to other molecules. Because of this reactivity, selenite is more bioavailable, increasing exposure and potential toxicity to aquatic organisms.

The EPA 2004 draft derived two separate acute standards for selenite and selenate. The draft selenite criterion (258 µg/L) was derived using the established 5th percentile criteria derivation methodology (Stephan et al. 1985) based on an updated waterborne selenite acute toxicity database. The selenate criterion was derived using the same 5th percentile methodology on an updated acute toxicity database. Additionally, the acute selenate values

were normalized based on sulfate concentrations in the test, as data indicate sulfate has a significant influence on selenate acute toxicity (Brix et al. 2001a,b, EPA 2004). The result is a sulfate-based acute toxicity water quality criteria equation for selenate:

$$\text{Acute selenate} = e^{(0.5812[\ln(\text{sulfate})] + 3.357)}$$

Chronic Se toxicity, on the other hand, is related to dietary exposure and bioaccumulative properties of Se in aquatic biota rather than water column concentrations. Therefore, the 2004 draft criteria document proposed a national tissue-based chronic criterion. Fish are considered sensitive to chronic Se exposure (Coyle et al. 1993, Hamilton et al. 1990, Hermanutz et al. 1996), with early life history stages of fish development being most affected. Due to the bioaccumulative properties of Se, exposure routes in embryonic and larval fish can be from maternally derived yolk absorption or directly from the environment. Selective early life stage sensitivities in fish can create a scenario where significant population mortality occurs in Se affected waters, despite the presence of seemingly healthy adult populations (Lemly 2002).

The number and scope of available toxicity studies addressing tissue-based effects of chronic Se exposure remain limited. Twenty-four studies were evaluated in the 2004 Se draft document (EPA 2004) resulting in Se tissue thresholds for nine species in seven genera and one general family tissue threshold. The EPA 2004 document proposed the chronic criterion of 7.9 micrograms per gram (µg/g) Se whole-body (wb) dry weight (dw), which was derived from a single study that investigated juvenile bluegill mortality during winter months (Lemly 1993).

The EPA approach in the 2016 Se criteria document is more in line with standard water quality criteria development methodology (Stephan et al. 1985) and includes a critical evaluation of over 30 studies on various fish species and results in Se tissue thresholds for eleven fish species in ten genera. Criteria calculations follow recommendations by Stephan et al. (1985) and use the 5th percentile calculation accounting for the relative sensitivities of all species in the data set. This approach results in more scientifically defensible criteria than the previous draft tissue criterion based on a single study.

1.2 Justification for a State-Specific Ambient Water Quality Criteria for Selenium

Review of the 2016 Se criteria document indicates that there are multiple reasons that justify derivation of a state-specific standard for application across Indiana. Some of reasoning includes the following:

- The 2016 Se criteria are driven by a select number of data usage decisions that are focused on a national scale and, thus, are not necessarily the most appropriate

criteria for Indiana waters. Modification of these data usage decisions results in a more scientifically defensible fish tissue criterion for Indiana.

- The final criterion value is driven by inclusion of the sturgeon in the genera list. While sturgeon are present in some of Indiana's waterways, the majority of classified streams in Indiana do not support sturgeon. Application of the sturgeon-based criteria is not necessary to protect the uses of these streams.
- Recent scientific publications offer a more robust calculation method for conversion of fish tissue to water column values that would be protective of Indiana waters.
- The low concentrations of the water column values (on the order of parts per billion) are approaching the limit of analytical accuracy of current testing methods. As such, it is imperative that the water column number be representative of aquatic species within the state to avoid unnecessary expenditure of resources on behalf of permittees and the State.
- The customized approach will benefit the implementation of the standard in Indiana NPDES permits.
- The sedimentary rocks that dominate Indiana are likely sources of ambient selenium that can lead to elevated concentrations.
- The ambient concentrations of sulfate in Indiana's waterbodies have potential to affect selenium uptake in the aquatic ecosystem.

Further detail on these issues is provided in the subsequent sections.

2. Review of Selected Toxicity Studies and Data Used for EPA Criteria Development

The 2016 EPA Se criteria document includes reproductive toxicity study data for ten fish genera. Overall, we concur with most of the data usage decisions made by EPA. However, in our discussion below, we suggest some revisions to the data that were used to develop the egg/ovary chronic criterion (and subsequently, the whole-body and muscle criteria). We believe incorporation of these suggested changes would result in an egg/ovary chronic criterion that is even more scientifically defensible and have greater consistency with EPA's other data-usage decisions used elsewhere in their document. These changes are an integral part of the recommended selenium criteria for Indiana.

2.1 White Sturgeon

The 2016 Se criteria document EPA included data from the Linville (2006) White Sturgeon study. These data were not included in the original 2014 draft, but White Sturgeon was included in the 2015 draft document, and is now the most sensitive species in the database in the final 2016 Se criteria document. This study was a dietary exposure in which adult female sturgeon were fed a Se spiked diet, and effects on larvae were measured. Larval effects were observed for edema and deformities.

EPA calculated an EC_{10} for total deformities (edema + skeletal) and larval survival of 15.6 mg/kg using EPA's Toxicity Relationship and Analysis Program (TRAP). This value was calculated based on a partial dose response. When data from this study are analyzed, TRAP warns that data should only be used for "exploratory purposes." Due to the partial response in the data, the calculation is highly dependent on the initial guess used for the slope in TRAP. In fact, in Appendix C of the 2015 EPA draft document (EPA 2015), EPA showed how choice of initial slope can affect these calculations, with EC_{10} values ranging from 16.3 mg/kg to 19.1 mg/kg when using different slopes. In the 2015 draft document EPA selected the most conservative value for use in criteria development (16.3 mg/kg), even while acknowledging there was no scientific reason one value was more valid than another (and, in fact, all calculated values were statistically identical). In the final criteria document EPA reanalyzed the data by including larval survival along with abnormalities and interpolating the effect concentration since TRAP was unable to accurately model the dataset, this resulted in an updated EC_{10} of 15.6 mg/kg.

Generally, use of an EC_{10} based on a partial response is not appropriate for national criteria development, especially when it results in a value becoming the "most sensitive" and thereby driving the final criterion. In fact, on page 33 of the 2015 draft criteria document EPA states that "an EC10 based on only one partial response would not ordinarily be included in the data

set." A similar partial response was observed in the Fathead Minnow data from the GEI 2008 study; EPA excluded these Fathead Minnow data from the chronic dataset because of an "insufficient response." EPA's reasoning for using the White Sturgeon data that had only a partial response is that there are data that suggest that the federally-listed Green Sturgeon is also sensitive to selenium. However, the Green Sturgeon study (De Riu et al. 2014) consisted of effects on survival and percent body weight in juvenile sturgeon and is not comparable to the reproductive endpoints in all other studies used for criteria development. While we realize that EPA is concerned with protecting any threatened or endangered species, the criteria document states that the White Sturgeon serves as a surrogate for other sturgeon as well.

Although the White Sturgeon data are somewhat questionable, they are important data due to the threatened or endangered listings of other species of sturgeon. However, we do recommend revisions to the EC_{10} value used for criteria calculations. As stated previously, the EC_{10} is based on only a partial response, therefore when the threshold sigmoid nonlinear regression model in TRAP is used, several curves may be fit by varying the slope used in the calculation. In Appendix C of the 2015 EPA criteria document, four EC_{10} values have been calculated based on abnormalities, all with the same goodness of fit. While EPA later interpolated a different value, we believe the prior TRAP analyses capture the potential range of EC_{10} values and recommend use of the geometric mean of the four EC_{10}s, as they are statistically equally valid. This results in an egg/ovary EC_{10} of 17.8 mg/kg dw for White Sturgeon.

2.2 Bluegill

In the 2016 Se criteria document, EPA utilized three Bluegill studies in the derivation of the tissue-based criteria: Doroshov et al. (1992), Coyle et al. (1993), and Hermanutz et al. (1992, 1996). While we agree with the use of the Doroshov et al. (1992) and Coyle et al. (1993) studies, we had several concerns regarding the use of the Hermanutz et al. (1992, 1996) data.

EPA reported an egg/ovary EC_{10} of 14.7 mg/kg for the Hermanutz et al. (1992, 1996) field-based studies. This value was derived by combining results from Studies I, II, and III (Hermanutz et al. 1992, 1996) – in other words, they combined data from three different studies conducted over three years into one regression dataset, a data usage practice rarely used in criteria development. Our concerns with combining these studies include the following:

- The studies were each conducted 1 year apart, which resulted in significant variation in all of the measured water quality parameters between the three studies.
  - For example, hardness ranged from 162 to 193 mg/L and specific conductivity ranged from 261 to 421 µmhos/cm.
- There were significant differences in egg and larvae survival between studies (see pages C-122 through C-124 of the 2016 Se criteria document).

- For example, in the 10 µg/L treatment, the egg survival averaged 28.8%, 57.4%, and 74.5%, in Studies I, II, and III, respectively.
- Again in the 10 µg/L treatment, the percent dead larvae in Study I was 17.0, in Study II was 0.45, and was not reported for Study III.

- The ovary Se concentrations resulting from the same water exposures were quite different. These variations raise concerns that differences in Se uptake, bioaccumulation, exposure, or other factors could have been occurring between the studies.
  - In the 10 µg/L treatment the geometric mean ovary Se concentrations were 17.7 mg/kg in Study I, 36.3 mg/kg in Study II, and 16.3 mg/kg in Study III.

- In Studies I and III, geometric mean ovary Se concentrations were higher in the 10 µg/L exposures (17.7 and 16.3 mg/kg) than the 30 µg/L exposures (15.5 and 15.9 mg/kg). Related to the concerns discussed above, this unexpected result indicates there may have been an issue with study conditions that caused inconsistencies with Se uptake, bioaccumulation, or exposure.

- There were differences in how EPA analyzed and used the data from the two studies in Appendix C, replicate concentrations in Study I were averaged, but Studies II and III were not (see pages C-126 of the 2016 EPA Se criteria document).

Based on these concerns, we recommend the Hermanutz et al. (1992, 1996) data should be completely removed from the database used for criteria derivation. When the other two valid chronic values for Bluegill (22.6 mg/kg [Doroshov et al. 1992] and 26.3 mg/kg [Coyle et al. 1993]) are used, a Bluegill egg/ovary genus mean chronic value (GMCV) of 24.4 mg/kg is derived. This is a more appropriate value for bluegill and indicates that the value from the Hermanutz et al. studies is an outlier.

2.3 Fathead Minnow

While EPA included Fathead Minnows as part of the number of species included in the criteria calculations (N), they did not include an actual GMCV due to uncertainty in the Schultz and Hermanutz (1990) study, which resulted in an estimate of <25.6 mg/kg. Because cyprinids are often the dominant taxa of many warm water streams, and were only represented by the one undefined value in 2004 draft Se chronic database, GEI conducted a maternal Se transfer study for this species (GEI 2008). This study was modeled from the mesocosm and laboratory study conducted by Schultz and Hermanutz (1990) and a similar field and laboratory study using trout conducted by Holm et al. (2005). The 2016 Se criteria document did not utilize data from the Fathead Minnow maternal transfer study by GEI Consultants, Inc. (2008), citing high variability and insufficient response as the reasons for excluding this study. However, as shown in Table E-10 of the 2016 Se criteria document (page

E-36 in EPA 2016), deformity rates do increase with increasing whole-body Se exposure, consistent with other studies used by EPA. While percent deformities in the three lowest exposures were all below 10%, deformity rates range from 17.2% to 20.3% in the highest exposures. This would suggest an EC_{10} value occurs between the two highest exposures (TGC and ETC; Table E-10 in EPA 2016), which had whole-body Se concentrations of 35.9 and 44.5 µg/g dw. Using the data from Table E-10 in TRAP following the same approach used by EPA (e.g., see Doroshov et al. 1992, Appendix C in EPA 2016) we derived whole-body EC_{10} values of 42.1 mg/kg, 44.0 mg/kg, 42.3 mg/kg, and 42.3 mg/kg for larval craniofacial, skeletal, finfold, and edema effects, respectively. The lowest of these whole-body EC_{10} values, 42.1 mg/kg, is for craniofacial deformities; therefore, we recommend including the chronic whole-body value of 42.1 mg/kg in the derivation of a Fathead Minnow genus mean chronic value (GMCV). This chronic value is within the range of Fathead Minnow values from other studies reviewed by the EPA in criteria development (EPA 2004 and 2016). These values were used along with the Schultz and Hermanutz (1990) values to derive GMCVs for Fathead Minnows in our reanalysis of this species.

As the Schultz and Hermanutz (1990) study results in an egg/ovary value, and the GEI study (2008) results in a whole-body value, a conversion factor (CF) is needed to translate the values. EPA (2016) used a median value of 1.4 (ratio between egg/ovary and whole-body values) to convert between these tissues, however, using the same data in EPA's Appendix C, we calculated a CF of 1.43. If this species-specific CF is used, the GEI (2008) whole-body value of 42.1 mg/kg would be translated to an egg/ovary value of 60.2 mg/kg. Using this value with the Schultz and Hermanutz (1990) egg/ovary value of 25.6 mg/kg would result in a Fathead Minnow GMCV of 39.3 mg/kg.

2.4 Conversion Factors

In the 2016 Se criteria document EPA derived whole-body and muscle chronic criteria values by converting the egg/ovary chronic values using a CF derived from data for matched egg/ovary and whole-body or muscle tissue. EPA used two approaches, using the median of the ratios of egg/ovary values to whole-body values to derive the CF for each species, or using directly calculated whole-body values where data were available (Tables 3.4 and 3.6 of the 2016 Se criteria document).

In the past, EPA has used regression-based CFs (e.g., bluegill CF from EPA's 2004 draft Se criteria document) to translate egg/ovary values to whole-body values. We believe this approach provides a more accurate representation of the selenium concentrations in other tissue types, as long as the regression relationship between egg/ovary concentrations and whole-body concentrations has a relatively high goodness of fit (i.e., when R^2 is at least 0.70), and there are data over a varying range of tissue concentrations. Use of the regression approach better predicts tissue concentrations for individual data points, particularly at the high and low ends of the spectrum.

Using the data provided in the EPA appendices, we determined it would be appropriate to use egg/ovary to whole-body regression based CFs for Desert Pupfish, Rainbow Trout, Cutthroat Trout, Largemouth Bass and Bluegill. For *Oncorhynchus*, individual CFs were used to translate each species individually (Rainbow Trout and Cutthroat Trout), and the geometric mean of these two values was taken to get the whole-body GMCV. For Bluegill, the regression was only applied to the egg/ovary value from the Doroshov study, as the Coyle study had a directly calculated whole-body value. The geometric mean of the whole-body values from these two studies was used as the Bluegill whole-body GMCV. The egg/ovary to whole-body conversion factors used are provided in Table 1.

Table 1: Egg/Ovary to whole-body conversion factors for each taxon used in derivation of tissue criteria.

Taxon	EO/WB Regression or Median-based CF	R^2	Basis for EO/WB Conversion Factor
Bluegill	y=0.4239x+1.2392	0.82	Regression-based Bluegill EO/WB (Doroshov) Directly calculated (Coyle)
Brown Trout	n/a	0.47	Directly calculated EC_{10}
Cutthroat Trout	y=0.5891x+0.6921	0.83	Regression-based Cutthroat Trout EO/WB
Desert Pupfish	y=0.9040x-0.2725	1.00	Regression-based Desert Pupfish EO/WB
Dolly Varden	1.61	0.90[b]	Median Dolly Varden EO/M (1.26) x all fish M/WB (1.27)
Fathead Minnow	1.43	0.66	Median Fathead Minnow EO/WB
Largemouth Bass	y=0.4384x+2.161	0.76	Regression-based Centrarchidae (Bluegill, smallmouth bass, green sunfish) EO/WB
Northern Pike	2.39	0.83[a]	Median Northern Pike (includes M/WB conversion)
Rainbow Trout	y=0.6582x-0.0949	0.96	Regression-based Rainbow Trout (includes M/WB conversion)
White Sturgeon	1.69	0.86[b]	Median White Sturgeon EO/M (1.330) x median fish M/WB (1.274)

[a] Regression not used due to significant number of data points with very low tissue concentrations

[b] Regression not used as equation results in whole-body concentrations that exceed egg/ovary concentrations

We used the same approach for the egg/ovary to muscle CFs and determined it would be appropriate to use regression based CFs for Dolly Varden, Rainbow Trout, and Cutthroat Trout. For Cutthroat Trout the EC10 for muscle tissue was directly calculated for the Rudolph (2008) study, and the regression was applied to the value from the Nautilus (2011) study, the geometric mean was then determined and used as the SMCV. To calculate the *Oncorhynchus* GMCV, each species was converted individually (Rainbow Trout and Cutthroat Trout), and the geometric mean of these two values was taken to get the muscle GMCV. For Bluegill, the CF was only applied to the egg/ovary value from the Coyle study, as the Doroshov study had a directly calculated muscle value. The geometric mean of the whole-body values from these two studies was used as the Bluegill whole-body GMCV. The Fathead Minnow CF was calculated as the median Cyprinidae EO/M ratio, and the White Sturgeon CF was calculated using data from the Linville study, as our egg/ovary number

differs from EPA so it was not appropriate to use the directly calculated muscle number that EPA used.

Table 2: Egg/Ovary to muscle conversion factors for each taxon used in derivation of tissue criteria.

Taxon	EO/M Regression or Median-based CF	R^2	Basis for EO/M Conversion Factor
Bluegill	1.38	0.65	Median Bluegill EO/M
Brown Trout	n/a	0.17	Median Brown Trout EO/WB (1.45) / all fish M/WB (1.27)
Cutthroat Trout	y=0.3953x+2.6633	0.82	Regression-based Cutthroat Trout EO/M
Desert Pupfish	n/a	n/a	Desert Pupfish EO/WB reg / all fish M/WB (1.27)
Dolly Varden	y=0.7549x+4.3188	0.90	Regression-based Dolly Varden EO/M
Fathead Minnow	1.55	0.58	Median Cyprinidae EO/M
Largemouth Bass	1.19	0.14[a]	Median Smallmouth Bass EO/M
Northern Pike	n/a	0.83	Directly calculated
Rainbow Trout	y=0.5183x-0.0747	0.96	Regression-based Rainbow Trout
White Sturgeon	1.33	0.86[b]	Median White Sturgeon EO/M

[a] Regression not used due to P>0.05

[b] Regression not used as equation results in muscle concentrations that exceed egg/ovary concentrations

2.5 Summary of Studies Included in the Toxicity Database

Using the conversion factors described above, along with the modified chronic values for White Sturgeon, Bluegill, and Fathead Minnow, results in a slightly revised database from that presented in EPA 2016, now consisting of ten species in nine genera (Table 3). These toxicity values can be used to calculate state-wide tissue-based criteria for Indiana, including waters in the Great Lakes basin.

Table 3: Selenium tissue threshold values for fish. WB = whole-body, M = muscle, CF = conversion factor, EC = effect concentration.

Species	Reference	Notes	Chronic Value mg/kg dw		
			Egg/Ovary	Whole-body	Muscle
Bluegill, *Lepomis macrochirus*	Doroshov et al. 1992;	WB translated from egg using regression CF; M directly calculated	Egg EC_{10}: 22.6	WB EC_{10}: 10.8	M EC_{10}: 15.7
	Coyle et al. 1993;	WB directly calculated; M translated from egg using CF	Egg EC_{10}: 26.3	WB EC_{10}: 8.6	M EC_{10}: 19.1
Brown Trout, *Salmo trutta*	Formation Environmental 2011; AECOM 2012	WB directly calculated; M translated from egg using CFs	Egg EC_{10}: 21.0	WB EC_{10}: 13.2	M EC_{10}: 18.5
Cutthroat Trout, *Oncorhynchus clarki lewisi*	Nautilus Environmental 2011	WB translated from egg using regression; M translated from egg using CF	Egg EC_{10}: 27.7	WB EC_{10}: 17.0	M EC_{10}: 13.6
	Rudolph et al. 2008	WB translated from egg using regression; M directly calculated	Egg EC_{10}: 24.7	WB EC_{10}: 15.2	M EC_{10}: 16.6
Desert Pupfish, *Cyprinodon macularius*	Besser et al. 2012	Estimated EC_{10}; WB translated from egg using regression; M translated from egg using CFs	Egg EC_{10}: 27.0	WB EC_{10}: 24.1	M EC_{10}: 28.7
Dolly Varden, *Salvelinus malma*	Golder 2009	WB translated from egg using CFs; M translated from egg using regression	Egg EC_{10}: 56.2	WB EC_{10}: 34.9	M EC_{10}: 46.8
Fathead Minnow, *Pimephales promelas*	Schultz and Hermanutz 1990	WB and M translated from egg using CF	Egg LOAEC: <25.6	WB LOAEC: <17.9	M EC_{10}: 16.5
	GEI 2008	Egg/ovary translated from WB using CF; M translated from egg/ovary using CF	Egg/Ovary EC_{10}: 60.2	WB EC_{10}: 42.1	M EC_{10}: 38.8
Largemouth Bass, *Micropterus salmoides*	CP&L 1997	WB translated from ovary using regression; M translated from ovary using CF	Ovary EC_{10}: 26.3	WB EC_{10}: 13.7	M EC_{10}: 22.1
Northern Pike, *Esox lucius*	Muscatello et al. 2006	EPA notes EC10 cannot be estimated; WB translated from egg using CF; M directly calculated	Egg EC_{24}: 34.0	WB EC_{10}: 14.2	M EC_{10}: 21.7
Rainbow Trout, *Oncorhynchus mykiss*	Holm 2002; Holm et al. 2003; Holm et al. 2005;	WB and M translated from egg using regression	Egg EC_{10}: 24.5	WB EC_{10}: 16.0	M EC_{10}: 12.6
White Sturgeon, *Acipenser transmontanus*	Linville 2006	WB translated from egg using CF; M translated from egg using CF	Egg EC_{10}: 17.8	WB EC_{10}: 10.5	M EC_{10}: 13.4

2.6 Non-sturgeon Waters

The 2016 EPA selenium criteria document provides several recommendations for revising the national criteria to develop site-specific criteria (EPA 2016). One approach is to modify the tissue-based elements to better reflect species present at the site by applying the Recalculation Procedure (EPA 2013). Using this procedure, species not present at the site, or not serving as a surrogate for other species present at the site, are deleted from the toxicity database and the criterion is recalculated using appropriate species. The deletion process is designed to ensure that each species, genus, family, order, class, and phylum that occurs at the site and is in the toxicity database is retained in the site-specific dataset and that those species that occur at the site but are not in the toxicity database are represented by a closely related "surrogate" species.

The most sensitive species in the toxicity database, *Acipenser transmontanus* (White Sturgeon) is not found in Indiana, however, it can serve as a surrogate for other sturgeon species found in Indiana (Lake Sturgeon and Shovelnose Sturgeon). However, sturgeon in Indiana are generally found in larger waterbodies and would not be expected to be present in smaller creeks and streams. Therefore, it is not necessary to retain *Acipenser* in the selenium database to be protective of waterbodies that do not support sturgeon. As such, we have also provided tissue criteria values that are recommended for waters not containing, nor expected to contain sturgeon.

3. Derivation of Tissue Criterion Elements

3.1 Egg/Ovary Criteria

Implementing the data usage modifications discussed above (Section 2) results in slight changes to the criteria calculations presented in the EPA 2016 Se criteria document. The following is a summary of our recommended modifications to the egg/ovary data:

- Update the White Sturgeon egg/ovary SMCV to 17.8 mg/kg
  - Result of calculating the geometric mean of the four EC10s calculated by EPA
- Update the Bluegill egg/ovary GMCV to 24.4 mg/kg
  - Result of excluding the Hermanutz et al. (1992, 1996) studies
- Include the Fathead Minnow egg/ovary GMCV of 38.8 mg/kg

3.1.1 Sturgeon Waters

Use of these revisions result in scientifically defensible egg/ovary criteria that are protective of all fish species present in the state of Indiana. The final calculated criterion value for egg/ovary tissue is 17.3 mg/kg Se (Table 4 and Table 5) compared to the 15.1 mg/kg Se value in EPA 2016.

Table 4: Ranked genus mean chronic values for calculated fish egg-ovary endpoints.

Rank	SMCV (mg Se/kg dw EO)	Species	GMCV (mg Se/kg dw EO)
9	56.2	Dolly Varden, *Salvelinus malma*	56.2
8	39.3	Fathead Minnow, *Pimephales promelas*	39.3
7	<34	Northern Pike, *Esox lucius*	<34
6	27.0	Desert Pupfish, *Cyprinodon macularius*	27.0
5	26.3	Largemouth Bass, *Micropterus salmoides*	26.3
4	26.2	Cutthroat Trout, *Oncorhynchus clarki*	25.3
	24.5	Rainbow Trout, *Oncorhynchus mykiss*	
3	24.4	Bluegill Sunfish, *Lepomis macrochirus*	24.4
2	21.0	Brown Trout, *Salmo trutta*	21.0
1	17.8	White Sturgeon, *Acipenser transmontanus*	17.8

Table 5: Calculation of egg/ovary fish tissue-based Se criterion (N = 15 genera, R = sensitivity rank in database).

Rank	Genus	GMCV	ln GMCV	$(\ln GMCV)^2$	P = R/(N+1)	√P
1	*Acipenser*	17.8	2.8792	8.2898	0.0625	0.2500
2	*Salmo*	21.0	3.0445	9.2691	0.1250	0.3536
3	*Lepomis*	24.4	3.1946	10.2054	0.1875	0.4330
4	*Oncorhynchus*	25.3	3.2308	10.4381	0.2500	0.5000
		Sum	12.3491	38.2024	0.6250	1.5366

Calculations:
Chronic Egg/Ovary Criterion

$$S^2 = \frac{\sum(\ln GMCV)^2 - (\sum \ln GMCV)^2/4}{\sum P - (\sum \sqrt{P})^2/4} = \frac{38.2024 - (12.3491)^2/4}{0.6250 - (1.5366)^2/4} = 2.2233 \qquad S = 1.4911$$

$L = [\sum \ln GMCV - S(\sum \sqrt{P})]/4 = [12.3491 - 1.4911(1.5366]/4 = 2.5145$

$A = S(\sqrt{0.05}) + L = (1.4911)(0.2236) + 2.5145 = 2.8479$

Final Chronic Value = FCV = e^A = **17.2517**

3.1.2 Non-sturgeon Waters

Use of the revisions described above, and the exclusion of White Sturgeon data, results in criteria that are protective of all waters in the state of Indiana in which sturgeon are not present. The final calculated criterion value for egg/ovary tissue for non-sturgeon waters is 20.7 mg/kg Se (Table 6 and Table 7). The genera that remain after removal of the sturgeon are still a conservative representation of the majority of Indiana streams.

Table 6: Ranked genus mean chronic values for calculated fish egg/ovary endpoints.

Rank	SMCV (mg Se/kg dw EO)	Species	GMCV (mg Se/kg dw EO)
8	56.2	Dolly Varden, *Salvelinus malma*	56.2
7	39.3	Fathead Minnow, *Pimephales promelas*	39.3
6	<34	Northern Pike, *Esox lucius*	<34
5	27.0	Desert Pupfish, *Cyprinodon macularius*	27.0
4	26.3	Largemouth Bass, *Micropterus salmoides*	26.3
3	26.2	Cutthroat Trout, *Oncorhynchus clarki*	25.3
	24.5	Rainbow Trout, *Oncorhynchus mykiss*	
2	24.4	Bluegill Sunfish, *Lepomis macrochirus*	24.4
1	21.0	Brown Trout, *Salmo trutta*	21.0

Table 7: Calculation of egg/ovary fish tissue-based Se criterion (N = 14 genera, R = sensitivity rank in database).

Rank	Genus	GMCV	ln GMCV	$(\ln GMCV)^2$	P = R/(N+1)	√P
1	*Salmo*	21.0	3.0445	9.2691	0.0667	0.2582
2	*Lepomis*	24.4	3.1946	10.2054	0.1333	0.3652
3	*Oncorhynchus*	25.3	3.2308	10.4381	0.2000	0.4472
4	*Micropterus*	26.3	3.2696	10.6901	0.2667	0.5164
		Sum	12.7395	40.6027	0.6667	1.5870

Calculations:
Chronic Egg/Ovary Criterion

$$S^2 = \frac{\sum(\ln GMCV)^2 - (\sum \ln GMCV)^2/4}{\sum P - (\sum \sqrt{P})^2/4} = \frac{40.6027 - (12.7395)^2/4}{0.6667 - (1.5870)^2/4} = 0.7846 \qquad S = 0.8858$$

$L = [\sum \ln GMCV - S(\sum \sqrt{P})]/4 = [12.7395 - 0.8858(1.5870]/4 = 2.8334$

$A = S(\sqrt{0.05}) + L = (0.8858)(0.2236) + 2.8334 = 3.0315$

Final Chronic Value = FCV = e^A = **20.7285**

3.2 Whole-body Criteria

Whole-body criteria were calculated using the data modifications described above along with the CFs in Table 1.

3.2.1 Sturgeon Waters

The final calculated criterion value for whole-body tissue that is protective of all fish species in the state of Indiana is 9.0 mg/kg Se (Table 8 and Table 9) compared to the 8.5 mg/kg Se value in EPA 2016.

Table 8: Ranked genus mean chronic values for calculated fish WB endpoints.

Rank	SMCV (mg Se/kg dw WB)	Species	GMCV (mg Se/kg dw WB)
9	34.9	Dolly Varden, *Salvelinus malma*	34.9
8	27.5	Fathead Minnow, *Pimephales promelas*	27.5
7	24.1	Desert Pupfish, *Cyprinodon macularius*	24.1
6	16.1	Cutthroat Trout, *Oncorhynchus clarki*	16.1
	16.0	Rainbow Trout, *Oncorhynchus mykiss*	
5	14.2	Northern Pike, *Esox lucius*	14.2
4	13.7	Largemouth Bass, *Micropterus salmoides*	13.7
3	13.2	Brown Trout, *Salmo trutta*	13.2
2	10.5	White Sturgeon, *Acipenser transmontanus*	10.5
1	9.7	Bluegill Sunfish, *Lepomis macrochirus*	9.7

Table 9: Calculation of whole-body fish tissue-based Se criterion (N = 15 genera, R = sensitivity rank in database).

Rank	Genus	GMCV	ln GMCV	$(\ln GMCV)^2$	P = R/(N+1)	√P
1	*Lepomis*	9.7	2.2721	5.1626	0.0625	0.2500
2	*Acipenser*	10.5	2.3514	5.5290	0.1250	0.3536
3	*Salmo*	13.2	2.5802	6.6575	0.1875	0.4330
4	*Micropterus*	13.7	2.6174	6.8508	0.2500	0.5000
		Sum	9.8211	24.1998	0.6250	1.5366

Calculations:
Chronic Whole-body Criterion

$$S^2 = \frac{\sum(\ln GMCV)^2 - (\sum \ln GMCV)^2/4}{\sum P - (\sum \sqrt{P})^2/4} = \frac{24.1998 - (9.8211)^2/4}{0.6250 - (1.5366)^2/4} = 2.4821 \qquad S = 1.5755$$

$L = [\sum \ln GMCV - S(\sum \sqrt{P})]/4 = [9.8211 - 1.5755(1.5366]/4 = 1.8501$

$A = S(\sqrt{0.05}) + L = (1.5755)(0.2236) + 1.8501 = 2.2024$

Final Chronic Value = FCV = e^A = **9.0463**

3.2.2 Non-sturgeon Waters

The final calculated criterion value for whole-body tissue that is protective of all waters in the state of Indiana where sturgeon are not present is 9.6 mg/kg Se (Table 10 and Table 11).

Table 10: Ranked genus mean chronic values for calculated fish WB endpoints.

Rank	SMCV (mg Se/kg dw WB)	Species	GMCV (mg Se/kg dw WB)
8	34.9	Dolly Varden, *Salvelinus malma*	34.9
7	27.5	Fathead Minnow, *Pimephales promelas*	27.5
6	24.1	Desert Pupfish, *Cyprinodon macularius*	24.1
5	16.1	Cutthroat Trout, *Oncorhynchus clarki*	16.1
	16.0	Rainbow Trout, *Oncorhynchus mykiss*	
4	14.2	Northern Pike, *Esox lucius*	14.2
3	13.7	Largemouth Bass, *Micropterus salmoides*	13.7
2	13.2	Brown Trout, *Salmo trutta*	13.2
1	9.7	Bluegill Sunfish, *Lepomis macrochirus*	9.7

Table 11: Calculation of WB fish tissue-based Se criterion (N = 14 genera, R = sensitivity rank in database).

Rank	Genus	GMCV	ln GMCV	$(\ln GMCV)^2$	P = R/(N+1)	√P
1	*Lepomis*	9.7	2.2721	5.1626	0.0667	0.2582
2	*Salmo*	13.2	2.5802	6.6575	0.1333	0.3652
3	*Micropterus*	13.7	2.6174	6.8508	0.2000	0.4472
4	*Esox*	14.2	2.6532	7.0397	0.2667	0.5164
		Sum	10.1230	25.7105	0.6667	1.5870

Calculations:
Chronic Whole-body Criterion

$$S^2 = \frac{\sum(\ln GMCV)^2 - (\sum \ln GMCV)^2/4}{\sum P - (\sum \sqrt{P})^2/4} = \frac{25.7105 - (10.1230)^2/4}{0.6667 - (1.5870)^2/4} = 2.4785 \qquad S = 1.5743$$

$L = [\sum \ln GMCV - S(\sum \sqrt{P})]/4 = [10.1230 - 1.5743(1.5870]/4 = 1.9062$

$A = S(\sqrt{0.05}) + L = (1.5743)(0.2236) + 1.9062 = 2.2582$

Final Chronic Value = FCV = e^A = **9.5657**

3.3 Muscle Criteria

Muscle tissue criteria were calculated using the data modifications described above along with the conversions factors in Table 2.

3.3.1 Sturgeon Waters

The final calculated criterion value for muscle tissue that is protective of all fish species in the state of Indiana is 12.3 mg/kg Se (Table 12 and Table 13) compared to the 11.3 mg/kg Se value in EPA 2016.

Table 12: Ranked genus mean chronic values for calculated fish muscle endpoints.

Rank	SMCV (mg Se/kg dw WB)	Species	GMCV (mg Se/kg dw WB)
9	46.8	Dolly Varden, *Salvelinus malma*	46.8
8	28.7	Desert Pupfish, *Cyprinodon macularius*	28.7
7	25.4	Fathead Minnow, *Pimephales promelas*	25.4
6	22.1	Largemouth Bass, *Micropterus salmoides*	22.1
5	21.7	Northern Pike, *Esox lucius*	21.7
4	18.5	Brown Trout, *Salmo trutta*	18.5
3	17.3	Bluegill Sunfish, *Lepomis macrochirus*	17.3
2	15.0	Cutthroat Trout, *Oncorhynchus clarki*	13.8
	12.6	Rainbow Trout, *Oncorhynchus mykiss*	
1	13.4	White Sturgeon, *Acipenser transmontanus*	13.4

Table 13: Calculation of muscle fish tissue-based Se criterion (N = 15 genera, R = sensitivity rank in database).

Rank	Genus	GMCV	ln GMCV	$(\ln GMCV)^2$	P = R/(N+1)	√P
1	*Acipenser*	13.4	2.5953	6.7353	0.0625	0.2500
2	*Oncorhynchus*	13.8	2.6247	6.8889	0.1250	0.3536
3	*Lepomis*	17.3	2.8507	8.1265	0.1875	0.4330
4	*Salmo*	18.5	2.9178	8.5134	0.2500	0.5000
		Sum	10.9884	30.2641	0.6250	1.5366

Calculations:
Chronic Muscle Criterion

$$S^2 = \frac{\sum(\ln GMCV)^2 - (\sum \ln GMCV)^2/4}{\sum P - (\sum\sqrt{P})^2/4} = \frac{30.2641 - (10.9884)^2/4}{0.6250 - (1.5366)^2/4} = 2.2426 \qquad S = 1.4975$$

$L = [\sum \ln GMCV - S(\sum\sqrt{P})]/4 = [10.9884 - 1.4975(1.5366]/4 = 2.1718$

$A = S(\sqrt{0.05}) + L = (1.4975)(0.2236) + 2.1718 = 2.5067$

Final Chronic Value = FCV = e^A = **12.2643**

3.3.2 Non-sturgeon Waters

The final calculated criterion value for muscle tissue that is protective of all waters in the state of Indiana where sturgeon are not present is 13.1 mg/kg Se (Table 14 and Table 15).

Table 14: Ranked genus mean chronic values for calculated fish muscle endpoints.

Rank	SMCV (mg Se/kg dw WB)	Species	GMCV (mg Se/kg dw WB)
8	46.8	Dolly Varden, *Salvelinus malma*	46.8
7	28.7	Desert Pupfish, *Cyprinodon macularius*	28.7
6	25.4	Fathead Minnow, *Pimephales promelas*	25.4
5	22.1	Largemouth Bass, *Micropterus salmoides*	22.1
4	21.7	Northern Pike, *Esox lucius*	21.7
3	18.5	Brown Trout, *Salmo trutta*	18.5
2	17.3	Bluegill Sunfish, *Lepomis macrochirus*	17.3
1	15.0	Cutthroat Trout, *Oncorhynchus clarki*	13.8
	12.6	Rainbow Trout, *Oncorhynchus mykiss*	

Table 15: Calculation of muscle fish tissue-based Se criterion (N = 14 genera, R = sensitivity rank in database).

Rank	Genus	GMCV	ln GMCV	$(\ln GMCV)^2$	P = R/(N+1)	√P
1	*Oncorhynchus*	13.8	2.6247	6.8889	0.0667	0.2582
2	*Lepomis*	17.3	2.8507	8.1265	0.1333	0.3652
3	*Salmo*	18.5	2.9178	8.5134	0.2000	0.4472
4	*Esox*	21.7	3.0773	9.4699	0.2667	0.5164
		Sum	11.4705	32.9986	0.6667	1.5870

Calculations:
Chronic Muscle Criterion

$$S^2 = \frac{\sum(\ln GMCV)^2 - (\sum \ln GMCV)^2/4}{\sum P - (\sum \sqrt{P})^2/4} = \frac{32.9986 - (11.4705)^2/4}{0.6667 - (1.5870)^2/4} = 2.8550 \qquad S = 1.6897$$

$L = [\sum \ln GMCV - S(\sum \sqrt{P})]/4 = [11.4705 - 1.6897(1.5870]/4 = 2.1973$

$A = S(\sqrt{0.05}) + L = (1.6897)(0.2236) + 2.1973 = 2.5751$

Final Chronic Value = FCV = e^A = **13.1323**

4. Derivation of Water Column Criteria

Based on the current science, it is known that tissue Se concentrations better represent actual Se exposure and uptake by aquatic life. However, implementation of a tissue-based threshold is potentially difficult for regulators and the regulated community, as attainment assessments would require collection of fish tissue data on a regular basis in a wide variety of aquatic habitats – and potentially collection during the reproductive cycle of multiple resident fish species, given potential use of egg/ovary Se criteria. Therefore, a water column criterion is helpful for use as an initial screening threshold in permits and compliance determinations.

4.1 EPA's 2016 Water Column Criteria

As noted in our comments on EPA's draft Se criteria (GEI 2014a, b and 2015), we do not agree with the general approach EPA used to derive the two default water column concentrations meant to be protective of fish-tissues, 3.1 µg/L for lotic waters and 1.5 µg/L for lentic waters. Table 3.13 on page 89 of the 2016 Se criteria document presents site-specific data for 26 lentic and 39 lotic species-site combinations and includes site-specific enrichment factors (EF), species-specific whole-body to egg/ovary conversion factors (CF), and composite trophic transfer factor ($TTF^{composite}$) values based on expected trophic levels at the site. The data were used in the following equation to determine protective water column criteria (C_{water}) using the egg-ovary criterion ($C_{egg\text{-}ovary}$):

$$C_{water} = \frac{C_{egg-ovary}}{TTF^{composite} \times EF \times CF}$$

The final water quality criteria EPA selected for lotic and lentic systems were based on Figure 3.9, page 92 of the 2016 Se criteria document. This figure is a probability distribution of the water column concentrations for lentic and lotic sites after being translated from the final egg/ovary tissue criterion (data from EPA Table 3.13). This figure and the choice of a 20th percentile values as the recommended water column criteria were used as if these represented sensitivity distribution curves, in which protectiveness can be predicted based on selecting a certain percentile value from the curve. However, these are not sensitivity distribution curves – in fact, each value on these curves is a translated water concentration value that was specifically calculated to be protective of the egg/ovary tissue criterion at that site. Therefore, each and every point on this graph (and those values in the far-right column of EPA Table 3.13) is protective of the egg/ovary criterion based on the site-specific parameters at that site (given site-specific EF, CF, TTF). Thus, the analysis by EPA actually demonstrates that water concentrations that are protective of the tissue criterion can range from 0.27 µg/L to 52.0 µg/L for lentic sites, and 0.11 µg/L to 55.3 µg/L for lotic sites, depending on the site-specific factors used in Equation 18. The significant range that is observed in protective values highlights the variability in site-specific conditions that can be found in the field.

In addition, the dataset used to derive EPA's water column values is very limited, especially when considering this is supposed to be the basis for a national criterion, and most of the data were collected more than 20 years ago. To demonstrate how sample size can significantly affect the end result, GEI supplemented the dataset with more recent data collection efforts. Using additional data from several GEI projects across the U.S. (and other GEI updates previously discussed in this document), we recalculated the lotic water column value using EPA's method and derived a value of 4.2 µg/L, compared to EPA's 3.1 µg/L. Paired data from GEI projects were available for 47 additional sites, which more than doubles the database used by EPA. Protective values for these lotic sites range from 1.18 µg/L to 81.03 µg/L. While we still believe this method for calculating a nationwide water column value is over-conservative, this recalculation demonstrates how inclusion of additional data can substantially affect the final value.

4.2 Appropriateness of EPA Water Column Criteria for Indiana

There are many locations in the U.S. which have naturally occurring Se deposits that may leach Se into groundwater and consequently into surface waters. Previous publications and reports have presented the potential for underlying geology, rich in Se, to contribute to naturally elevated surface water Se concentrations which can be significantly greater than the default water column values recommended in the 2016 EPA Se criteria document (GEI 2013a, b, Herring and Walton-Day 2007, and Burau 1985). Burau (1985) states that of general parent-rock types, shales have the highest Se content (500-28,000 µg/kg). Due the large areas of Se rich geology throughout certain regions of the U.S., a water column criteria developed on a regional basis might be more appropriate than EPA's default national water column criteria.

For example, if the EPA dataset and methods used for back calculation of water quality criteria is narrowed down to just samples collected in Colorado (a region with underlying selenium rich shales), the resulting protective lotic water column concentration would be 10.0 µg/L based on 13 samples (out of 39 in the complete EPA lotic dataset). This value is three times the proposed nationwide value, demonstrating that inclusion or exclusion of only a few data points can cause a significant change in the calculated criterion, as well as highlighting the importance of consideration of regional and site-specific water quality characteristics. We were unable to perform a similar exercise using Indiana specific data as the EPA dataset is limited and does not contain data from Indiana.

In addition, as was noted previously, sulfate reduces acute toxicity and was incorporated into the 2004 draft of the EPA Se acute selenite criteria. In addition to sulfate limiting the acute effects of selenate exposure, it has been shown that increasing sulfate concentrations reduce the bioavailability of Se to organisms at the base of the food web, which in turn reduces dietary concentrations for higher trophic level organisms (DeForest et al. 2014). This protective effect of sulfate occurs in selenate-dominated lotic systems. As Indiana waters may often have elevated sulfate, as is frequently found in regions with naturally elevated Se, it is likely that EPA's water column criteria are overprotective for some Indiana waters. Data

from 2000-2010 show a minimum sulfate concentration of 7.3 mg/L, and a maximum of 723 mg/L, indicating a wide range of measured values, with an average of 59 mg/L (Risch et al. 2014). Site or regional specific water column criteria may be appropriate depending on ambient sulfate concentrations.

4.3 Alternative Water Column Criteria Development

4.3.1 Chronic Criteria

There are a number of valid approaches to translate an egg/ovary criterion to a water column value, such as use of a partitioning model such as that described above, or a site-specific bioaccumulation factor, but only if the proper data are used in the equations. The key is to properly characterize the base of the food chain and consider of other factors that influence Se biodynamics. The approach used by EPA above assumes that all EFs and TTFs are constants across all water concentrations. However, several studies have indicated that enrichment factors and trophic transfer factors can be inversely related to selenium concentrations, with uptake or assimilation efficiency decreasing at higher waterborne or dietborne concentrations (DeForest et al. 2017); i.e., not constant.

The study by DeForest et al. 2017 presents a regression-based approach for developing water column criteria which takes into consideration the influence of exposure concentrations as well as other factors. In their study, they used collocated Se data for water, particulates, invertebrates, and fish tissue, with quantile regression methods to derive protective water column values, using the model described in Section 4.1. The quantile regression methods were applied at each step in the model to derive protective water column concentrations from fish tissue criteria (DeForest et al. 2017).

The DeForest et al. analysis used a substantially larger dataset than EPA used, with the majority of the data having been collected in more recent years (i.e. <20 years ago). Several observations were made regarding the EFs, lentic EFs were approximately two times greater than lotic EFs, and the highest EFs were associated with low Se water concentrations and the lowest EFs were associated with higher Se water concentrations (DeForest et al. 2017). Significant inverse relationships were also seen between invertebrate trophic transfer factors and dietborne Se concentrations, and fish trophic transfer factors and dietary Se (DeForest et al. 2017). This indicates that higher selenium concentrations in the water column result in lower uptake by aquatic organisms.

As the quantile regression method takes into account more factors that affect Se biodynamics, we recommend use of this model for calculating appropriate water column criteria based on the 75th quantile, as described in DeForest et al. 2017. An Excel spreadsheet was included as part of the Supplemental Data for the DeForest et al. 2017 study, and this was used to calculate default lotic and lentic water column criteria values for Indiana based on the egg/ovary criteria values calculated in Section 3.1. For lotic waters with sturgeon

present the recommended water column criteria is 4.2 µg/L, for non-sturgeon lotic waters the recommended water column criteria is 7.2 µg/L. In lentic waters containing sturgeon the recommended water column criteria is 2.2 µg/L, for lentic waters in which sturgeon are not present the recommended water column criteria is 3.2 µg/L.

4.3.2 Acute Criteria

In the EPA 2016 criteria document there are no criteria for acute Se exposure. However, EPA has attempted to address acute pulses of elevated Se concentrations that could contribute to chronic effects using an intermittent exposure component of the water column-based criterion. The equation EPA uses to calculate the intermittent exposure criterion seems to be an oversimplification as it is essentially just a rearrangement of the chronic bioaccumulation equation to calculate a 30-day average concentration. We feel a more appropriate way to determine limits for short-term elevated pulsed Se exposures would use a scientifically-based biokinetic model.

We propose allowance for use of a Se biokinetic model using a food chain consisting of periphyton, mayflies, and minnows in order to evaluate the concentrations and durations of Se pulses that would be required to potentially achieve whole-body fish Se concentrations of interest (e.g., a tissue-based criterion), such as the recently updated model of DeForest et al. (2016). Inputs to their model included the background waterborne Se concentration, the Se concentration in the pulse, and the duration of the pulse. These models can be used to predict the fish tissue Se concentrations that could result from Se pulses into a water body and can potentially be used to derive an acute (or "intermittent") water column-based Se criterion that is protective of the chronic fish tissue-based criterion. In addition, these models can differentiate between selenate and selenite, which has previously been recommended by the EPA for water column-based Se criteria, and is part of the current Se criteria.

Approximations of protective Se concentrations for 1-day and 4-day pulses (Table 16) using a background Se concentration of 1 µg/L were calculated using two different versions of the biokinetic model, a periphyton-mayfly-fathead minnow model, and a phytoplankton-daphnia-bluegill model (DeForest et al. 2016).

Table 16: Selenium concentrations protective of the whole-body fish tissue criterion calculated using variations of the DeForest et al. (2016) biokinetic model for 1-day and 4-day pulses.

	Selenium µg/L	
Model/Pulse Duration	**1-day**	**4-day**
Periphyton-Mayfly-Fathead (selenate)	1850	337
Phytoplankton-Daphnia-Bluegill (selenite)	385	100

Although selenate and selenite are not specific to either lotic or lentic systems and cannot be directly applied as lotic or lentic criteria, selenate does tend to predominate in well-aerated lotic systems and selenite is more prevalent in slow-moving lentic waters. Therefore, the periphyton-mayfly-fathead model could be considered representative of a lotic value and phytoplankton-daphnid-bluegill model could be representative of a lentic value.

We recommend Indiana Se criteria include general guidance allowing for use of a biokinetic model in calculating acute Se criteria. This approach is a more complete and scientifically valid way of determining potential chronic effects from acute exposures.

4.3.3 Sulfate-dependent Criteria

The quantile regression approach used by DeForest et al. 2017 to develop chronic water quality criterion was also used to derive sulfate-dependent criteria for selenate-dominated waters by compiling data in which both selenate and sulfate, in addition to particulate Se were measured. This results in a model that can applied to egg/ovary criteria along with ambient sulfate concentrations to derive a water quality criterion that is protective in selenate-dominated systems that are often found in flowing waters[1]. Estimated protective Se concentrations for a range of sulfate concentrations and the sturgeon and non-sturgeon egg/ovary numbers were calculated using the sulfate-dependent model (DeForest et al. 2017) (Table 17). Modeled sulfate-dependent Se criteria values range from 5.7 mg/L to 102 mg/L for sturgeon waters with sulfate concentrations from 50 mg/L to 400 mg/L. For non-sturgeon waters with the same sulfate concentrations, sulfate-dependent Se criteria values range from 8.8 mg/L to 158 mg/L. The sulfate-dependent model is capped at the lower end with a sulfate concentration of 43 mg/L, which would result in protective concentrations similar to the chronic criteria values proposed in Section 4.3.1. Even a modest increase in sulfate, such as the mean statewide concentration of 59 mg/L reported in USGS 2014, would result in a water column criteria of 7.1 mg/L for sturgeon waters, and 11.1 mg/L for non-sturgeon waters.

Table 17: Modeled sulfate-dependent criteria values for a range of sulfate concentrations (DeForest 2017). Se criteria values are in µg/L.

Water Type	50 mg/L SO_4	100 mg/L SO_4	200 mg/L SO_4	300 mg/L SO_4	400 mg/L SO_4
Sturgeon	5.7	14.8	38.9	68.2	102
Non-sturgeon	8.8	23.0	60.3	106	158

[1] The model can be downloaded in the Supporting Information section as etc3793-sup-0002-SuppInfo-S2.xlsx at http://onlinelibrary.wiley.com/doi/10.1002/etc.3793/full .

5. Recommended Water Quality Criteria for Indiana

Indiana's current aquatic life standards for Se for waters not within the Great Lakes System are based on outdated recommendations from the EPA's 1986 Quality Criteria for Water, the "Gold Book" (EPA 1986). These aquatic life standards do not represent the best available scientific information. Tissue-based Se criteria are the most toxicologically and ecologically relevant, and represent the best science. Tissue-based Se criteria are protective of aquatic life and should be implemented in Indiana, based on the modifications discussed above.

EPA derived nationwide lentic and lotic water column-based criteria to supplement their tissue-based criteria. However, as discussed in Section 4.1 it is not possible or appropriate to derive a single nationwide or statewide standard for water column-based criteria for only two water body types (lentic or lotic), and such an effort is not supported by EPA's own data and analysis. We agree that use of a mechanistic modeling approach to translate a water column criterion from the egg/ovary criterion can be a valid approach, if the right data are input and the evaluation is thorough. Therefore, we recommend use of the model presented in DeForest et al. 2017 to derive water column criteria. Alternately, this model, or the bioaccumulation factor approach discussed in EPA's Appendix K of the 2016 criteria document could be used to develop site-specific standards using available data.

Regarding implementation of the tissue-based criteria, we recommend including specific guidelines for tissue sampling requirements and use of an approach such as the geometric or arithmetic mean of fish tissue samples collected, with an allowable exceedance frequency of no more than once every three years on average.

Based on the results of our analysis, we recommend implementing the proposed egg/ovary, whole-body, and muscle chronic criteria described in this document and summarized in Table 18 for waters with sturgeon present, and the criteria summarized in Table 19 for non-sturgeon waters.

Table 18: Recommended Se criterion elements for waters containing sturgeon in Indiana.

Media Type	Fish Tissue			Water Column[3]	
Criterion Element	**Egg/Ovary[1]**	**Fish Whole-Body[2]**	**Muscle[2]**	**Monthly Average Exposure**	**Intermittent Exposure**
Magnitude[4]	17.3 mg/kg	9.0 mg/kg whole-body	12.3 mg/kg muscle (skinless, boneless filet)	4.2 µg/L in lotic systems[5] 2.2 µg/L in lentic systems	Site-specific
Duration	Seasonal average	Seasonal average	Seasonal average	30 days	Site-specific
Frequency	Not more than once in three years on average	Not more than once in three years on average	Not more than once in three years on average	Not more than once in three years on average	Site-specific

1. Overrides any whole-body, muscle, or water column elements when fish egg/ovary concentrations are measured.
2. Overrides any water column element when both fish tissue and water concentrations are measured.
3. Water column values are based on dissolved selenium in water.
4. Magnitude is the geometric mean of tissue samples collected.
5. In selenate dominated waters the sulfate-dependent model is allowed for site-specific water column criteria.

Table 19: Recommended Se criterion elements for waters not containing sturgeon in Indiana.

Media Type	Fish Tissue			Water Column[3]	
Criterion Element	**Egg/Ovary[1]**	**Fish Whole-Body[2]**	**Muscle[2]**	**Monthly Average Exposure**	**Intermittent Exposure**
Magnitude[4]	20.7 mg/kg	9.6 mg/kg whole-body	13.1 mg/kg muscle (skinless, boneless filet)	7.2 µg/L in lotic systems[5] 3.2 µg/L in lentic systems	Site-specific
Duration	Seasonal average	Seasonal average	Seasonal average	30 days	Site-specific
Frequency	Not more than once in three years on average	Not more than once in three years on average	Not more than once in three years on average	Not more than once in three years on average	Site-specific

1. Overrides any whole-body, muscle, or water column elements when fish egg/ovary concentrations are measured.
2. Overrides any water column element when both fish tissue and water concentrations are measured.
3. Water column values are based on dissolved selenium in water.
4. Magnitude is the geometric mean of tissue samples collected.
5. In selenate dominated waters the sulfate-dependent model is allowed for site-specific water column criteria.

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THE VOICE FOR INDIANA ENERGY

January 30, 2018

Mary Ann Stevens
Rules Development Branch
Office of Legal Counsel
Indiana Department of Environmental Management (IDEM)
Indiana Government Center North
100 North Senate Avenue
Indianapolis, IN 46204-2251

Re: Comments for IDEM's Second Notice of Aquatic Life and Human Health Ambient Water Quality Criteria for Metals (LSA Document #14-58)

Dear Ms. Stevens:

The Indiana Energy Association (IEA) appreciates the opportunity to offer comments on the proposed changes to the Aquatic Life and Human Health Ambient Water Quality Criteria (WQC) for Metals.

The IEA represents 13 investor-owned electric and gas utility companies and one public charitable trust energy utility that represent 97% of the base load electric generation in the state of Indiana as well as the district steam system in Indianapolis. We are an association of electric power companies and natural gas companies that provide Indiana consumers with affordable and reliable energy, benefiting families and businesses across the Hoosier state. Our mission is to advocate for policies that promote the general welfare of the energy industry to enhance its role in contributing to the economy and quality of life in Indiana.

IEA's Comments

1. A workgroup should be convened by IDEM to develop an implementation plan for the selenium WQC. The draft notice states that no work group is planned for this rulemaking, yet there is also no guidance provided on implementing a WQC based on fish tissue. Implementation guidance is essential for collecting high quality, reliable, and reproducible data that can be used for regulatory management decisions and has been developed (i.e., Kentucky; KDEP 2014), drafted (West Virginia; WVDEP 2017), or included in draft WQC (i.e., Idaho; IDEQ 2017) by other states.

2. Draft technical support documents (TSDs) to guide implementation of EPA's (2016) selenium NRWQC have been developed. These documents are imperfect, and comments have been submitted to EPA for consideration before the documents are made final. Our chief concern is EPA's decision to not give primacy of the fish tissue criteria over the new stringent water criteria for NPDES permitting purposes. However, the draft documents can still be a resource to an IDEM-led workgroup developing State implementation guidance for fish tissue sampling to inform Indiana's selenium WQC implementation and compliance.

3. The water CAC are differentiated on the basis of "lentic" and "lotic" aquatic systems and exposure duration. The lentic WQC will result in pervasive reasonable potential to exceed for all industries. This is of great concern to the IEA and as such the IEA encourages the IDEM to consider Indiana specific data and/or alternative model(s) to derive WQC representative of Indiana waters. In addition, a footnote should be added to this table defining lentic aquatic systems as non-flowing surface waters (i.e., lakes) and lotic aquatic systems as flowing surface waters (i.e., rivers and streams).

4. The water column values are nearing the limit of analytical accuracy regarding current test methods. As such, the IEA is concerned that incorporating the federally recommended WQC in lieu of developing WQC that represent Indiana waters may present unnecessary resources and expenditures. The IEA encourages the IDEM to consider developing state specific WQC to eliminate the possibility of these unnecessary resources.

The IEA appreciates your consideration of these comments, and we would be happy to discuss further. If you have any questions, please feel free to contact me at (317) 632-4406 or trushenberg@indianaenergy.org.

Thank you,

Tim Rushenberg
Vice President
Indiana Energy Association

Indiana Manufacturers Association, Inc.

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January 30, 2018

LSA Document #14-58 Metals Criteria Revisions
MaryAnn Stevens
Rules Development Branch
Office of Legal Counsel
Indiana Department of Environmental Management
Indiana Government Center North
100 North Senate Avenue
Indianapolis, IN 46204-2251

Submitted via electronic mail to mstevens@idem.in.gov

Re: Comments on Indiana Department of Environmental Management Amendments to Aquatic Life and Human Health Ambient Water Quality Criteria for Metals

The Indiana Manufacturers Association (IMA) was formed in 1901 and is the only trade association in Indiana that exclusively focuses on manufacturing. The IMA is dedicated to advocating for a business climate that creates, protects and promotes quality manufacturing jobs in Indiana. Environmental regulations have a direct impact on Indiana manufacturers' ability to compete in the global market. Rules promulgated by the Indiana Department of Environmental Management to achieve the shared goals of improving environmental quality and protecting human health should be narrowly focused and minimize the costs of compliance as much as possible.

On November 28, 2017, IDEM published the Second Notice for the Comment Period for Aquatic Life and Human Health Ambient Water Quality Criteria (WQC) for Metals (the "Proposed Criteria"). The IMA appreciates opportunity to submit comments on these proposed amendments.

IMA and other stakeholders have worked with IDEM to develop the proposed rule and reach agreed upon WQC for metals except for selenium. IDEM has proposed WQC for selenium that are based on the National Recommended Water Quality Criteria ("National Criteria") at Section 304(a) of the CWA. These criteria do not account for specific conditions in Indiana. The Environmental Protection Agency (EPA) and federal regulations allow for state specific criteria to take into account specific circumstances when based on reasonable scientific rationale. Furthermore, IDEM has yet to develop implementation policies that would allow regulated entities to realistically meet the proposed selenium criteria. Therefore, IMA urges IDEM to modify the 304(a) criteria to develop State-specific selenium criteria that account for local conditions.

Comments made by the Indiana Coal Council point out some significant issues with the EPA's National Criteria in more detail. Their comments show that the national criteria values are significantly influenced by 1) inclusion of a white sturgeon toxicity study that became the most sensitive species; 2) not fully including available data for fathead minnows – often a dominant species in Indiana streams; and 3) inconsistent data from bluegill testing. The GEI Consultants, Inc. (GEI) analysis commissioned by the Indiana Coal Council provides a robust scientific alternative methodology to adjust the national

selenium criteria to address these shortcomings. IMA supports the conclusions of the GEI report and recommends IDEM adopt changes to the proposed selenium criteria consistent with those conclusions.

EPA guidance generally suggests that state-specific criteria may be appropriate for waterbodies where background water quality is different from the laboratory water used and where the types of species in the region differ from those actually tested in developing the criteria. In addition to using fish species more representative of Indiana's waterbodies, the proposed criteria should also recognize that Indiana is dominated by sedimentary geology known to be natural sources of elevated selenium. In addition, it has been shown that sulfate at levels typical of Indiana waters can significantly lessen selenium toxicity in water columns. IDEM also needs recognize this when adopting state-specific standards for selenium.

The IMA is particularly concerned that IDEM will adopt an onerous standard for selenium without first adopting workable implementation guidance. Even if IDEM makes the changes to the selenium criteria suggested by the GEI analysis, these criteria should not be applied until reasonable implementation guidance is in place. EPA currently has draft guidance documents available. Two implementation issues that EPA addressed in both the draft guidance documents and the criteria include application of the standard on 1) streams with no fish and 2) new discharges. These issues are directly related to implementation of the criteria in NPDES permits and assessing streams for attainment of the criteria in the 303(d) process. As such, IDEM needs to address both of these issues in implementation guidance and should not adopt this guidance as part of the criteria regulations.

In conclusion, IMA does not support the current proposed criteria for selenium due for scientific reasons that do not account for Indiana waterbodies and for the lack of implementation guidance. IDEM should adopt the State-specific criteria developed by GEI as Indiana's water quality criterion for selenium.

Thank you again for the opportunity to provide comments on this important matter.

Sincerely,

Andrew Berger
Senior Vice President, Governmental Affairs

Peabody
Peabody Plaza
701 Market Street
St. Louis, MO, 63101-1826

February 1, 2018

LSA Document #14-58 Metals Criteria Revisions
MaryAnn Stevens
Rules Development Branch
Office of Legal Counsel
Indiana Department of Environmental Management
Indiana Government Center North
100 North Senate Avenue
Indianapolis, IN 46204-2251

Submitted via Postal Service and electronic mail to mstevens@idem.in.gov

Re: Comments on Indiana Department of Environmental Management Amendments to Aquatic Life and Human Health Ambient Water Quality Criteria for Metals

On November 28, 2017, the Indiana Department of Environmental Management (IDEM) published the Second Notice of Comment Period for the Aquatic Life and Human Health Ambient Water Quality Criteria (WQC) for Metals. Peabody Energy Corporation ("Peabody") appreciates the opportunity to submit comments on these proposed amendments.

Peabody is a private sector coal company that has four active operations and eleven inactive operations in various phases of reclamation in the state of Indiana. These coal mining facilities operate within the requirements of the Clean Water Act (CWA) permitting programs and are directly impacted by changes to the WQC. Peabody fully supports comments submitted by the Indiana Coal Council (ICC) on the proposed changes. The primary issues and Peabody's position are outlined in the following comments.

- **Selenium aquatic life standard:**

  IDEM has proposed the aquatic life criteria in a form identical to that published by EPA in the recent National Criteria document. ICC has submitted compelling evidence that the EPA National Criteria is not appropriate for application in Indiana for numerous reasons. These include 1) the EPA's data selection and analysis methods were not always consistent with recommended methods, 2) Indiana's aquatic life communities justify application of a modified species list with inclusion of fathead minnow data and selective application of sturgeon data, 3) the EPA's translation of fish tissue to water column concentrations is based on a flawed interpretation of the data and can be significantly improved using more recent research methods, 4) EPA's recommendations for intermittent pulses of selenium are an oversimplification of selenium biodynamics in these systems, and 5) EPA's criteria

ignores potential impacts of common background constituents such as sulfate on the toxicity of selenium. These significant issues cannot be ignored when applying the standard to the aquatic environments found in Indiana.

IDEM must review and incorporate recommended changes to the selenium standard consistent with the analysis provided by ICC and GEI. This will lead to a more accurate, flexible, and protective standard for aquatic life communities present in Indiana.

- **Aluminum aquatic life standard:**

  IDEM has proposed an aluminum standard in the total form of aluminum. Use of the total analytic method will ultimately measure nontoxic forms of aluminum present in suspended sediments. Results using this method will overestimate the actual toxicity of the aluminum present in the sample. The analytic method must be changed to use a less rigorous acid digestion, such as the dissolved analytic method, or allow for prefiltration of the sample to remove the nontoxic forms of aluminum associated with suspended sediments in the sample.

Peabody appreciates IDEM's consideration of the attached comments. Please direct any comments or questions to me or Jimmy Boswell at jboswell@peabodyenergy.com.

Sincerely,

Bryce West
Vice President Environmental Services – Americas

January 30, 2018

MaryAnn Stevens
Rules Development Branch
Office of Legal Counsel
Indiana Department of Environmental Management
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100 North Senate Avenue
Indianapolis, IN 46204-2251

Re: Comments for IDEM's Second Notice of Aquatic Life and Human Health Ambient Water Quality Criteria for Metals (LSA Document #14-58)

Dear Ms. Stevens:

The Indianapolis Power & Light Company (IPL) appreciates the opportunity to offer comments on the proposed changes to the Aquatic Life and Human Health Ambient Water Quality Criteria (WQC) for Metals.

I. Background

Selenium is a naturally occurring metalloid which exists in several forms in surface water and has a complex biogeochemistry (Chapman et al., 2010). Aqueous selenium in surface water is biotransformed as it moves through the food web where selenium uptake primarily occurs through ingestion of food. Selenium bioaccumulates to differing degrees at each stage of the food web due to differing uptake rates among organisms, oxidation state/form of aqueous selenium (e.g., selenate [+6], selenite [+4], organo-selenium [-2]), water cycling rates, and water quality (Figure 1). Uptake models for selenium have multiple compartments which include (1) empirically determined environmental partitioning factors between water and particulate material (i.e., enrichment factors [EFs]) that quantify the effects of dissolved speciation and phase transformation; (2) concentrations of selenium in living and non-living particulates at the base of the food web that determine selenium bioavailability to invertebrates; and (3) Se biodynamic food web trophic transfer factors (TTFs) that quantify the physiological potential for bioaccumulation from particulate matter to consumer organisms and from prey to their predators (Presser and Luoma 2010a,b). These models are highly site-specific and make it challenging to associate aqueous selenium concentrations with adverse effects.

Chronic toxicity from selenium primarily affects reproduction in egg-laying vertebrates (e.g., fish and birds). This can result in embryotoxicity, teratogenic effects, reductions in growth, tissue pathologies, oxidative stress, or mortality. Acute toxicity from selenium is uncommon in aquatic organisms (Chapman et al., 2010). Therefore, it is appropriate, protective of all aquatic organisms, and supported by the current science, for selenium concentrations closest to the location of toxic effect in the most sensitive aquatic species (i.e., fish eggs or tissues) to be the most relevant environmental measure for the protection of beneficial uses from adverse effects due to selenium (EPA 2016).

II. Summary of Draft Proposed Changes to the Selenium WQC

IDEM's proposed revisions to Tables 6-1, 6-2a, 8-1, and 8-1a describe Surface Water Quality Aquatic Life Criteria for selenium that include EPA's (2016) recommended aquatic life criteria. Selenium acute aquatic criterion (AAC) and chronic continuous concentrations (CCC) have been removed from Tables 6-1 and 8-1 and are now presented separately in Tables 6-2a and 8-1a. The CCC for human health outside of the mixing zone and at the point of water intake (both expressed as 30-day average of total recoverable selenium) continue to be presented in Table 6-1 and are 4,200 and 170 µg/L, respectively. Tables 6-1a and 8-1a present Indiana's recommended Surface Water Quality Aquatic Life Criteria for Selenium based on EPA's (2016) National Recommended Water Quality Criteria (NRWQC).

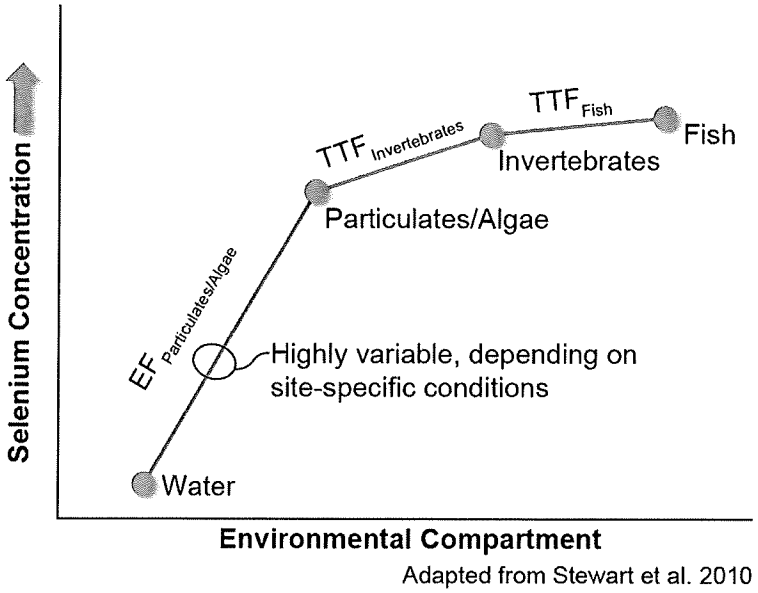

Figure Error! No text of specified style in document. Generalized Aquatic Selenium Uptake Pathway

III. IPL Comments

a. IDEM's 2016 fish tissue sampling program provides ambient fish tissue selenium concentrations (fillets) within the White River basin (Figure 2). These data did not exceed the proposed fish tissue WQC for selenium when converted to a dry weight basis. In addition, Indiana has not identified waters where beneficial uses are impaired by the presence of selenium. Therefore, Indiana's current selenium chronic aquatic criterion (CAC) of 35 µg/L - except at water intakes where the criterion is 10 µg/L – appears to be protective of beneficial uses in the White River. These data would support IDEM adopting the EPA (2016) fish tissue-based WQC but continuing to use the current water column criteria or one that is recalculated to be appropriate for Indiana waters.

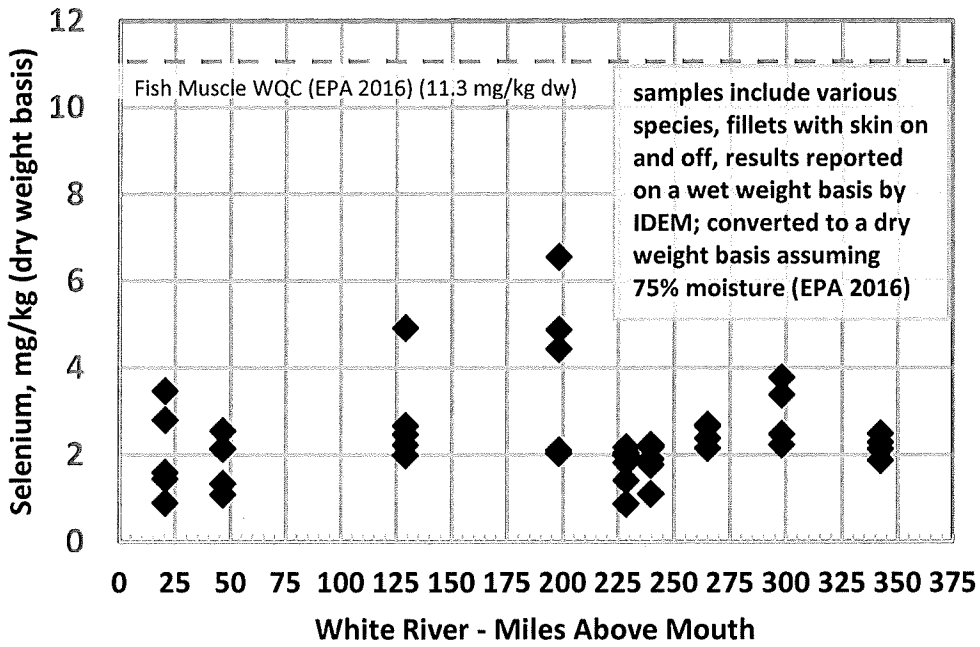

Figure 2. Fish Tissue Selenium Concentrations in White River Fish Fillets (collected by IDEM in 2016; https://www.waterqualitydata.us/)

b. Site-specific WQC (SSC) that are protective of beneficial uses can be developed under the recalculation procedure (327 IAC 2-1-13 - Development of site-specific aquatic life criteria using the recalculation procedure). However, this procedure depends on calculations based on data requirements from multiple taxa. EPA (2016) selenium WQC were developed based on a different approach using fish tissue-based effects data. Aqueous WQC for selenium were then back-calculated from tissue concentrations associated with threshold effects using a broad dataset. Fish are the most sensitive species to effects from selenium and other taxa are not necessary for developing SSC that are protective of all aquatic organisms. IDEM should clarify that the recalculation procedure can be used with available and relevant fish tissue toxicity data and selenium uptake models (e.g., as described in EPA, 216) or based on the best available science. An improvement on EPA's model could be made by including the interaction between selenium and sulfate (DeForest et al., 2017).

c. A workgroup should be convened by IDEM to develop an implementation plan for the selenium WQC. The draft notice states that no work group is planned for this rulemaking, yet there is also no guidance provided on implementing a WQC based on fish tissue. Implementation guidance is essential for collecting high quality, reliable, and reproducible data that can be used for regulatory management decisions and has been developed (i.e., Kentucky; KDEP 2014), drafted (West Virginia; WVDEP 2017), or included in draft WQC (i.e., Idaho; IDEQ 2017) by other states.

d. Draft technical support documents (TSDs) to guide implementation of EPA's (2016) selenium NRWQC have been developed by EPA and are listed below. These documents are imperfect and comments have been submitted to EPA for consideration before the documents are made final. However, they can still be a resource to an IDEM-led workgroup developing State implementation guidance for fish tissue sampling to inform Indiana's selenium WQC implementation and compliance.

- *Technical Support for Fish Tissue Monitoring for Implementation of EPA's 2016 Selenium Criterion.* EPA-820-F-16-007. USEPA. 2016. DRAFT. September.
- *Frequently Asked Questions (FAQs): Implementing the 2016 Selenium Criterion in Clean Water Act Sections 303(d) and 305(b) Assessment, Listing, and Total Maximum Daily Load (TMDL) Programs.* EPA-820-F-16-008. USEPA. 2016. DRAFT. September.
- *Frequently Asked Questions (FAQs): Implementing WQS that Include Elements Similar or Identical to EPA's 2016 Selenium Criterion in Clean Water Act Section 402 NPDES Programs.* EPA 820-F-16-009. USEPA. 2016. DRAFT. September.
- *Technical Support for Adopting and Implementing EPA's 2016 Selenium Criterion in Water Quality Standards.* EPA-820-F-010. USEPA. 2016. DRAFT. September.

Likewise, EPA (2010) Guidance *for Implementing the January 2001 Methylmercury Water Quality Criterion* may also be a helpful resource for describing how a tissue-based WQC can be implemented.

e. Implementation guidance describing fish collection and analysis methodologies will provide a reliable and consistent basis for determining compliance with the proposed selenium WQC. The following recommendations may also be helpful in developing such an implementation document.

- Species targeted for selenium tissue analysis should be relatively abundant and commonly encountered at the target sampling locations so they are available during successive sampling efforts and selenium analysis results can be compared among locations (e.g., reference location and receiving water). Target species should also have a known and sufficiently small home range so tissue concentrations can be associated with a likely exposure area, and should not be listed as threatened, endangered, or rare by the Indiana Department of Natural Resources or the U.S. Fish & Wildlife Service. Fish species selection criteria could also consider species that are easy to identify, those sensitive to selenium, and those that may accumulate high concentrations of selenium, if information is available to support these selection criteria.
- Tissues should be composited from multiple (e.g., 3 to 10) individual fish of the same species, especially if smaller fish are caught, to be consistent with standard practice for collecting fish data used in regulatory reporting (IDEQ 2017, WVDEP 2017, EPA 2016, OEHHA 2005, EPA 2000). Composited whole fish or fillets should also follow the 75 percent rule where fish are of similar size so that the length of the smallest fish should be at least 75% of the length of the largest fish of a species.
- A minimum number of composites samples/locations (e.g., 5) should be targeted in waters to be characterized (IDEQ 2017, Hitt and Smith 2014, OEHHA 2005, EPA 2000). Hitt and Smith (2014) reported that sample sizes of fewer than 5 fish did not achieve 80% power to detect near-threshold values and that larger sample sizes may be necessary (e.g., 8) if tissue concentrations are near the criterion.

- Alternatively, averaging tissue results from individual fish for comparison to the criterion should be acceptable if data can be obtained from individual fish.
- Fish collection methods that have minimal impact on non-target species are preferred. WVDEP (2017) and KDEP (2014) provide sampling guidance that includes fish collection by standard electroshocking methods over at least 100 meters starting as close as possible to the source.
- Reference sites may be included in fish tissue sampling programs to establish background selenium concentrations, where practical.
- Quality control samples for chemical analysis of selenium in tissues should include standard reference materials (SRM), duplicates, and matrix spike samples, consistent with EPA methods (2016), for quality assurance.
- Dry-ashing digestion (high temperature) is not recommended for analysis of selenium in tissues as it will cause loss of selenium from the sample (Ohlendorf et al. 2011). Oven drying at 60 degrees C could also result in loss of selenium from the sample, although less likely as demonstrated by Adams (1976). Freeze drying minimizes selenium losses and should be the standard for selenium analysis along with closed vessel microwave digestions to minimize selenium losses. Alternatively, analyses of wet tissue can be conducted, with dry weight values calculated based on a tissue moisture determination. Freeze drying, however, allows for the moisture content and selenium analyses to be conducted on the same tissue, whereas analyses of wet tissue require separate tissues to be analyzed to estimate moisture content to convert measurements to dry weight.
- Implementation guidance should recommend how frequently fish tissue should be collected. Although a typical NPDES permit may require monthly sampling of an effluent or surface water for metals, monthly sampling of fish tissue would be a costly and likely unnecessary effort since fish tissue concentrations respond slowly to changing water concentrations. Rather, fish tissue sampling could be considered as part of a tiered approach, where fish tissue samples are only required if aqueous selenium concentrations exceed the WQC. This approach was adopted in Kentucky (KDEP 2014). Alternatively, fish tissue selenium concentrations could be required less frequently than constituents monitored in surface water or effluent samples. For comparison, EPA recommends biennial sampling of fish tissues to evaluate compliance with EPAs (2001) NRWQC for mercury, if resources allow, or a minimum of every 5 years (EPA 2010).
- Guidance should consider how compliance will be determined if there are, for example, quarterly receiving water samples that exceed the aqueous WQC but annual fish tissue samples do not exceed the tissue-based WQC.

f. IDEM should clarify how multiple fish tissue samples (e.g., 5 composite fish tissue concentrations) would be compared to the fish tissue WQC. Each of these samples would be considered a contemporaneous replicate (e.g., consisting of the same species collected at roughly the same location and at the same time), so a statistical measure of the data would be appropriate for comparison with the fish tissue WQC. Presumably an exceedance would need to be statistically significant for any action to occur.

g. The water CAC are differentiated on the bases of "lentic" and "lotic" aquatic systems and exposure duration. A footnote should be added to tables defining lentic aquatic

systems as non-flowing surface waters (i.e., lakes) and lotic aquatic systems as flowing surface waters (i.e., rivers and streams).

h. The proposed selenium WQC states in footnotes 1 and 3 of Tables 6-2a and 8-1a that:

"[1] Egg or ovary supersedes any whole-body, muscle, or water column element when fish egg or ovary concentrations are measured." and

"[3] Fish whole-body or muscle tissue supersedes water column element when both fish tissue and water concentrations are measured."

Fish are the most sensitive species to selenium exposure and effects, and EPA derives its aqueous WQC directly from fish toxicity data. Fish tissue concentrations, on their own, are sufficient to assess compliance with the selenium WQC regardless of surface water concentrations. Therefore, measuring selenium in the tissues of fish inhabiting receiving waters is a direct and reliable approach to assessing compliance with selenium WQC and protection of beneficial uses without the need for water concentration data. IDEM should revise footnote 3 to delete the need for measuring water concentrations when fish whole-body or muscle tissues are collected or clarify why selenium measurements in water are needed to evaluate compliance with the WQC when fish whole-body or muscle tissues are collected. This would also be consistent with the requirements associated with fish egg or ovary tissues.

i. The allowable selenium concentration for intermittent exposure is calculated using the applicable 30-day average criterion, the average background selenium concentration, and the number of days during the month (30-day period) during which "elevated" selenium concentrations occur. However, there is no definition of the term "elevated" which is used in Footnotes 6 and 7.

"[6] ...f_{int} is the fraction of any 30-day period during which elevated selenium concentrations occur, with f_{int} assigned a value ≥ 0.033 (corresponding to one (1) day).

[7] Duration: Number of days per month with an elevated concentration."

In this case, "elevated" is not describing exceedances, potential adverse effects, or impairment. Rather, this term is describing the number of days when there is a discharge or other anthropogenic activity potentially increasing selenium concentrations. The term "elevated selenium concentration" in Footnotes 6 and 7 (Tables 6-2a and 8-1a) should be replaced with "discharge", "...potentially increased selenium concentration caused by anthropogenic activity...", or otherwise expanded to define the term "elevated".

IPL appreciates your consideration of these comments, and we would be happy to discuss these issues further. If you have any questions, please feel free to contact me at (317) 864-5473 or nysa.hogue@aes.com.

Thank you,

Nysa Hogue
Senior Environmental Specialist
AES US Services, LLC

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NIPSCO

February 1, 2018

LSA Document #14-58 Metals Criteria Revisions
Ms. MaryAnn Stevens
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Office of Legal Counsel
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RE: **LSA Document #14-58 Metals Criteria Revisions**

Dear Ms. Stevens:

The Northern Indiana Public Service Company (NIPSCO) generates, transmits, and distributes electricity to more than 468,000 customers in 20 counties in the northern part of Indiana. NIPSCO owns and operates three coal-fired electric generating stations with a net capacity of 2,540 megawatts (MW)—Bailly,[1] Michigan City, and R.M. Schahfer. NIPSCO also owns and operates Sugar Creek Generating Station, a natural gas combined cycle plant with net capacity of 535 MW. Each generating station is subject to IDEM water quality standards (WQS).

NIPSCO supports appropriately developed WQS that are protective of human health and the environment and are tailored to Indiana's waters. We believe the amendments to rules at 327 IAC 2-1-6 and 327 2-1.5-8 to revise Indiana's aquatic life and human health ambient water quality criteria (WQC) for select metals should be synchronized with EPA's Effluent Limitation Guidelines (ELG) rule revisions that are currently in process. For these reasons, we encourage consideration of the comments below:

1) Discussion with IDEM Office of Water Quality (OWQ) indicates the (proposed) new limitations will be implemented via NPDES permits upon the next renewal, scheduled or otherwise. The electric utility industry is a regulated industry requiring approval by the Indiana Utility Regulatory Commission (IURC) prior to capital expenditures that will affect rates, financing, and environmental compliance. Ensured compliance with the proposed WQS will require a process including development of cost estimates, design engineering, potential field studies, and implementation of compliance technology. Moreover, at the same time these WQS are being proposed, similar criteria are being considered as part of the federal Steam Electric Power ELG Rule, which is currently being reviewed by EPA. It is anticipated that any compliance technology required to meet a new WQS could also contribute to meeting a new ELG standard. Alignment of compliance schedules between Indiana's WQS and the ELG Rule would allow the regulated community to consider both rules when selecting a method of compliance. This would provide for a consistent approach, reduce reliability risk, and reduce administrative burden for all stakeholders. We request that IDEM develop a guidance document addressing their intent on timing as well as implementation options available, such as a compliance schedule.

[1] Bailly Generating Station Units 7 and 8 will retire on or before May 31, 2018.

2) In 2016, U.S. EPA updated its national recommended chronic aquatic life criterion for selenium in freshwater. EPA's *Aquatic Life Ambient Water Quality Criterion for Selenium–Freshwater 2016* contains a recommendation that states adopt into their WQS a selenium criterion that includes the elements used to prepare the recommended criterion. Through Section 304(a) of the Clean Water Act, EPA develops WQC. These criteria are recommendations, and states may directly implement these criteria or use them as guidance in developing their own. Accordingly, IDEM is not required to adopt the WQC verbatim, in whole or in part, and may adopt their own WQS for inclusion in the Indiana Administrative Code. We request that IDEM not adopt the standards as proposed in Tables 6-2a and 8-1a, and work with the regulated community and all Indiana stakeholders to establish WQS representative of the state of Indiana.

3) The EPA 2016 selenium criteria are based on a select number of data usage decisions that are focused on a national scale and, thus, are not necessarily the most appropriate criteria for Indiana waters. In fact, the EPA dataset is limited in sampling locations and does not contain data from Indiana. We request that IDEM work with the regulated community and all Indiana stakeholders to establish a set of WQS appropriate to waters in the state of Indiana.

4) The final criterion values for fish-related tissue (egg & ovary, whole body, and muscle) are driven by inclusion of the sturgeon in the genera list. While sturgeon, the most sensitive species in the dataset, are present in some of Indiana's waterways, the majority of classified streams in Indiana do not support sturgeon. Application of the sturgeon-based criteria is overly conservative and not necessary to protect the uses of Indiana streams. We request that IDEM develop fish-tissue criterion representative of the fish populations present in the applicable water bodies.

5) Fish tissue sampling plans are largely new and may not be well understood by this NPDES-regulated community. We request IDEM establish specific guidelines for fish-tissue sampling requirements in order to support consistent and appropriate implementation of the fish-tissue criteria. Further, we request an implementation guidance work group be created. NIPSCO will support the efforts of this group.

6) Footnote [1] in each table (6-2a and 8-1a) reads "*Egg or ovary supersedes any whole-body, muscle, or water column element when fish egg or ovary concentrations are measured.*" We believe this clearly states that fish-tissue criterion take precedence over water column criterion provided fish-tissue data are available. Discussion with IDEM OWQ indicates that IDEM will default to the proposed water criteria for inclusion in NPDES permits. We request that IDEM develop implementation guidance to encourage and assist the regulated community to evaluate the fish-tissue criterion.

7) The low concentrations of the water column values (e.g. 1.5 µg/L, i.e. 1.5 parts per billion, in lentic water bodies) are approaching the limit of analytical accuracy of current testing methods. By way of example, the minimum reporting limit for selenium measured using EPA Method 200.8 is 1.0 µg/L, as reported by one of our contract laboratories. Further, it should be noted that this minimum reporting level is attainable only in the absence of routinely present chemical interferences detected by the instrument. The presence of inter-element interferences will likely make proof of compliance challenging if not impossible. For example, the appropriate laboratory reporting limit may be elevated above 1.5 µg/L to respond to the inter-element interferences and will prohibit

assessment at the compliance level. We request that IDEM implement criteria that are realistic relative to analytical determinations and which do not risk non-compliance due to analytical uncertainty.

8) The final water quality criteria EPA selected for lotic and lentic systems are based on a probability distribution curve of the water column concentrations attained from the egg/ovary tissue criterion. This methodology is very prescriptive for such a wide range of environments. The data actually demonstrates that water concentrations protective of the tissue criterion can range from 0.27 µg/L to 52.0 µg/L for lentic sites, and 0.11 µg/L to 55.3 µg/L for lotic sites, depending on the site-specific factors. This range supports studies and standards specific to Indiana waters. We request that IDEM consider alternative methodologies that will better represent site specific conditions in Indiana for establishing Indiana WQS.

Sincerely,

Maureen Turman

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Re: LSA Document #14-58 Metals Criteria Revisions

Dear Ms. Stevens:

The Hoosier Chapter of the Sierra Club strongly supports the proposed revisions to Indiana's aquatic life and human health ambient water quality criteria for select metals. While people will probably always disagree about the scientific validity of any proposed change in pollutant criteria, we believe it is in Indiana's best interest to keep up with the latest generally accepted values for these criteria. The proposed criteria, based on current science and National Recommended Water Quality Criteria (NRWQC) achieve that goal.

The Sierra Club is the country's largest grassroots environmental organization, with more than three million members and supporters nationwide. In Indiana we have more than 10,000 members. Our members value clean water and approve of this effort to refine our pollution standards in keeping with the most current science.

Thank you for the opportunity to comment.

Sincerely,

Bowden Quinn
Director
Sierra Club Hoosier Chapter