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Memorandum

Date: 2/16/07

To: Tim Drexler and Ed Karecki/USEPA

From: Dave Mitchell and Christine Archer

Subject: Pines Area of Investigation

Evaluation of ecological screening levels and risk values for boron in surface water

Distribution: Lisa Bradley/ENSR, Dan Sullivan / NiSource, Val Blumenfeld / Brown Inc.

ENSR is updating its evaluation of an appropriate ecological screening level for boron in surface water as well as other relevant risk-based screening levels for use in the screening ecological risk assessment (SERA) to be conducted at the Pines Area of Investigation, as discussed on December 6, 2006 teleconference between USEPA Region 5 (T. Drexler, E. Karecki) and ENSR risk assessors (L. Bradley, D. Mitchell, C. Archer). This memo describes additional relevant information for the boron screening level identified in the last few months that will be further developed and discussed with USEPA in 2007.

The ecological screening level for boron in surface water provided in the Remedial Investigation/Feasibility Study (RI/FS) Work Plan (ENSR, 2005a,b) is 1.6 ug/L. This level is one to two orders of magnitude lower than the natural background concentration of boron in the Brown Ditch tributary system (approximately 50-150 ug/L). The screening level of 1.6 ug/L is based on a Tier II value obtained from Oak Ridge National Laboratory (ORNL) database (Suter and Tsao, 1996) and incorporates considerable conservatism due to inherent uncertainty associated with the number of studies available upon which to base a screening level.

Recently, additional information regarding boron ecotoxicity has become available. At the annual meeting of the Society of Environmental Toxicology and Chemistry (SETAC) (11/06) there were two poster presentations containing new relevant information on boron surface water risk thresholds. These poster presentations include (see full abstracts in Attachment A):

- Rodolakis. T. 2006. *Revision to the Surface Water SCV for Boron*. MACTEC Wakefield, MA; and

- Damiri, B.R. and Rodgers, J. 2006. *Responses of Typha latifolia and Ceriodaphnia dubia to aqueous boron.* Clemson University.

The Rodolakis presentation (a copy of the SETAC poster is included as Attachment B) is important because it indicates that the 1.6 ug/L ORNL Tier II value is the result of a computational error, due to a mistake in transcription of units; thus the error resulted in a three orders of magnitude reduction in the

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reported value. As the information in the poster indicates, substitution of the ecotoxicological values with the proper units into the Tier II secondary chronic value (SCV) value calculation leads to a corrected Tier II value of 1,100 ug/L (1.1 mg/L). This correction and substitution was reviewed and acknowledged by Dr. Glenn Suter of the USEPA, a leading expert in ecotoxicology and one of the original authors of the ORNL source document (i.e., Suter and Tsao, 1996). It appears that this corrected Tier II SCV was submitted as part of a site-specific evaluation for a project in Connecticut.

The abstract by the Clemson University research team reports on the ecological effects levels for exposure to boron in water by the water flea (*Ceriodaphnia dubia*) and cattail (*Typha latifolia*). For the daphnid, a No Observable Effects Concentration (NOEC) of 16 mg/L for reproduction and a 70 mg/L level for survivorship was reported. For the cattail, the most sensitive endpoint response was reduction of root elongation at boron concentrations of 30 mg/L. We are in the process of contacting the researchers at Clemson to follow up on this information.

This new information is important because the Rodolakis abstract confirms that the original ORNL value of 1.6 ug/L is incorrect and should be discarded. The recalculated ORNL value using the USEPA approved toxicity results and methodology is 1,100 ug/L, which should be used instead as a screening value for surface water in the Pines Area of Investigation.

REFERENCES

ENSR Corporation, 2005a. Remedial Investigation/Feasibility Study Work Plan. Pines Are of Investigation AOC II Docket No. V-W'-04-C-784. Field Sampling Plan.

ENSR Corporation 2005b. Remedial Investigation/Feasibility Study Work Plan. Pines Are of Investigation AOC II Docket No. V-W'-04-C-784. Volume 6 Ecological Risk Assessment Work Plan.

Suter, G.W. and C.L Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects of Aquatic Biota: 1996 Revision. Prepared for the U.S. Department of Energy. ES/ER/TM-996/R2. June 1996.

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Attachment A

P366 Responses of Typha latifolia and Ceriodaphnia dubia to aqueous boron exposures. Damiri, B.R. and Rodgers, J. Forestry and Natural Resources, Clemson University, Clemson, SC, USA. In aqueous mixtures, boron can be toxic to plants or animals at relatively low concentrations. The objectives of this study were: 1) to measure responses of Typha latifolia (seed germination and root and shoot elongation) to aqueous exposures of boron in 7-day static experiments; and 2) to measure responses of Ceriodaphnia dubia (survival and reproduction) to aqueous boron concentrations in 7-day static/renewal experiments. The responses of these sentinel species can be contrasted for purposes of risk characterization. T. latifolia seeds were exposed to boron (boric acid) at concentrations of 30, 35, 40, 45, 50, 100, 300 mg/L. Root elongation was negatively affected at boron concentrations of 30, 35, and 40 mg/L, in comparison to shoot elongation for which concentrations ≥45 mg/L were statistically different from controls. Seed germination was not negatively affected at the highest boron concentration tested (i.e. 300 mg/L). C. dubia were exposed to aqueous boron concentrations of 10, 50, 100, 150, 200, and 300 mg/L. Survival was negatively affected for aqueous concentrations ≥100 mg/L (50% survival), and reproduction was impaired at a concentration ≥50mg/L. This study indicates that T. latifolia was more sensitive to boron concentrations for the measurement parameters versus responses of C. dubia. This study provides data for risk assessment of boron contaminated waters.

P86 Revision to the Surface Water SCV for Boron. Rodolakis, T. MACTEC Engineering, Wakefield, MA, USA. In 1996, Oak Ridge National Laboratory (ORNL) published secondary chronic values (SCVs) for surface water (Suter and Tsao, 1996). Although SCVs were originally developed as screening benchmarks, regulators have applied the SCVs to a variety of uses. For example, at one radiological site, the Connecticut Department of Environmental Protection (CTDEP) based an action level for boron in surface water on the published SCV (1.6 ug/L). Exceeding the action level would have resulted in expensive monitoring, investigation, and potential remediation. However, during a comment period, it was discovered that the boron SCV had been inadvertently miscalculated; units in the fish study from which the SCV was derived (Hamilton, 1995) had accidentally been transcribed in the ORNL document as ug/L instead of mg/L. The SCV was re-calculated using the corrected concentrations, and the results were corroborated by Dr. Suter. The recalculated boron SCV should be 1,100 ug/L.

Revision to the Surface Water SCV for Boron

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Abstract: In 1996, Oak Ridge National Laboratory (ORNL) published secondary chronic values (SCVs) for surface water (Suter & Tsao, 1996). Although SCVs were originally developed as screening benchmarks, regulators have applied the SCVs to a variety of uses. For example, at one site, the Connecticut Department of Environmental Protection (CTDEP) proposed a surface water protection criterion for boron based on the published SCV (1.6 µg/L). Exceeding the criterion would have resulted in expensive monitoring, investigation, and potential groundwater remediation. However, during the submittal of the proposed criterion, a MACTEC ecological risk assessor discovered that the boron SCV had been inadvertently miscalculated; units in the fish study from which the SCV was derived (Hamilton, 1995) had accidentally been transcribed in the ORNL document as µg/L instead of mg/L. Dr. Suter confirmed the inadvertent transcription error, and the SCV was then re-calculated. The boron SCV should be 1,100 µg/L.

Text: Boron-impacted groundwater was identified during the hydrogeologic characterization of a nuclear power plant located on the banks of the Connecticut River. Boron is a site related chemical and was used in both the service water and in the spent fuel pool water as a shielding agent to absorb radioactive (high energy) particles. Because boron in groundwater could potentially discharge to the river adjacent to the site, the Connecticut Department of Environmental Protection (CTDEP) proposed a surface water protection criterion based on the SCV of 1.6 µg/L (Suter & Tsao, 1996; Table A.1), multiplied by a 10-fold dilution factor to account for mixing with surface water.

During the submittal of the proposed criterion, a MACTEC ecological risk assessor discovered an error in the SCV calculation. The SCV calculation was based on the results of three toxicity studies. Two studies (Gersich, 1984; Lewis & Valentine, 1981) reported LC50 values for *Daphnia magna*. The third study (Hamilton, 1995) reported LC50 values for three species of freshwater fish. In reviewing the original studies, it was noted that data from Hamilton (1995) appeared to have been mistakenly transcribed. Although the numbers were correct, the *units* of concentration used in the SCV calculation were in µg/L, but should have been mg/L.

Dr. Hamilton confirmed that units in his original publication were correctly reported in mg/L (Hamilton, 2006), and Dr. Suter confirmed the inadvertent transcription error (Suter, 2006). The values and units in Gersich (1984) and Lewis & Valentine (1981) were confirmed to be correct by reviewing the original papers.

MACTEC followed the Tier II Methodology presented in Suter & Tsao (1996) Appendix B to recalculate the boron SCV. Recalculating the SCV using the correct units results in the basis of the SCV shifting from *X. texanus* to *D. magna*, and results in an SCV of 1,100 µg/L. A side-by-side comparison of the original calculation and the revised calculation is shown in Table 2.

The revised SCV is consistent with other toxicity values reported for boron in the scientific literature, including the aquatic life protection criterion of 1,000 µg/L recommended by Eisler (1990). The CTDEP subsequently accepted the revised surface water protection criterion based on the revised SCV.

Table A.1 from Suter & Tsao, 1996

Compound	Genus/species	Requirements	Endpoint	Concentration (µg/L)	GMAV	A-C Ratio	Reference
Boron							
	Daphnia magna	4	LC50	133,000			Gersich, 1984
	Daphnia magna		CV	9,330			Gersich, 1984
	Daphnia magna	4	LC50	226,000	173,400		Lewis and Valentine, 1981
	Daphnia magna		CV	8,832		19.10[a]	Lewis and Valentine, 1981
	Ptychocheilus lucius	2,3	LC50	279			Hamilton, 1995
	Ptychocheilus lucius	2,3	LC50	>100			Hamilton, 1995
	Ptychocheilus lucius	2,3	LC50	527	383.4		Hamilton, 1995
	Xyrauchen texanus	2,3	LC50	>100			Hamilton, 1995
	Xyrauchen texanus	2,3	LC50	233			Hamilton, 1995
	Xyrauchen texanus	2,3	LC50	279	255.0		Hamilton, 1995
	Gila elegans	2,3	LC50	>100			Hamilton, 1995
	Gila elegans	2,3	LC50	280			Hamilton, 1995
	Gila elegans	2,3	LC50	552	393.1		Hamilton, 1995

Tier II Parameters	Tier II Values
FAVF	8.6
SAV	29.65
SACR	18.29
SCV	1.6

[a] A-C Ratio for *D. magna* is the geometric mean of A-C Ratios from Gersich, 1987 and Lewis and Valentine, 1981.

Table 2. Calculating the Revised Boron SCV Using Tier II Methodology

1. Identify references from scientific literature which pass selection criteria described in Suter & Tsao (1996). The three references identified by Suter & Tsao were:
   a) Gersich, 1984.
   b) Lewis & Valentine, 1981.
   c) Hamilton, 1995.
2. List LC50 values from 48-hr and 96-hr tests for each genus/species.
3. Calculate the genus mean acute value (GMAV)
   GMAV = geometric mean of the 48-hr and 96-hr LC_{50} by genus/species
   Note: CV values or values proceeded by ">" are not used to calculate the GMAV.
   Revised calculations are shown in the right column.
   Changes from Suter & Tsao (1996) are shown in **red**.

	SCV with Data from Suter & Tsao, (1996)			Revised SCV with Data from Hamilton (1995)	
D. magna	LC50	133,000 µg/L	GMAV=173,400 µg/L	133,000 µg/L	GMAV=173,400 µg/L
	LC50	226,000 µg/L		226,000 µg/L	
	CV	9,330 µg/L		9,330 µg/L	
	CV	8,832 µg/L		8,832 µg/L	
P. lucius	LC50	279 µg/L	GMAV=383 µg/L	279,000 µg/L	GMAV=383,000 µg/L
	LC50	527 µg/L		527,000 µg/L	
	LC50	>100 µg/L		> 100,000 µg/L	
X. texanus	LC50	233 µg/L	GMAV=255 µg/L	233,000 µg/L	GMAV=255,000 µg/L
	LC50	279 µg/L		279,000 µg/L	
	LC50	>100 µg/L		>100,000 µg/L	
G. elegen	LC50	280 µg/L	GMAV=393 µg/L	280,000 µg/L	GMAV=393,000 µg/L
	LC50	552 µg/L		552,000 µg/L	
	LC50	>100 µg/L		>100,000 µg/L	

4. Select the lowest GMAV:

GMAV = 255 µg/L from *X. texanus*	GMAV = 173,000 µg/L from *D. magna*

5. Derive the Final Acute Value (FAV) from Table B.1. in Suter & Tsao (1996). Because only three of the eight data requirements are met, and one study includes a daphnid, the FAV = 8.6

FAV = 8.6 (unitless)	FAV = 8.6 (unitless)

6. Calculate the secondary acute value (SAV) by dividing the lowest GMAV by the FAV.

$SAV = \frac{GMAV}{FAV} = \frac{255\ \mu g/L}{8.6} = 29.65\ \mu g/L$	$SAV = \frac{GMAV}{FAV} = \frac{173{,}000\ \mu g/L}{8.6} = 20{,}160\ \mu g/L$

7. Derive the secondary acute-chronic ratio (SACR) by calculating the geometric mean of the acute-to-chronic ratios for at least three genera/species. In the case of boron, only the *D. magna* studies provide enough information to calculate a study-specific SACR of 19.1 (unitless). Therefore, the default value of 17.9 is used for the two other studies:

Acute-chronic ratio = 19.1 (D. magna)	Acute-chronic ratio = 19.1 (D. magna)
17.9 (default)	17.9 (default)
17.9 (default)	17.9 (default)
Geometric mean = 18.29	Geometric mean = 18.29
SACR = 18.29 (unitless)	SACR = 18.29 (unitless)

8. Derive the Tier II secondary chronic value (SCV) by dividing the SAV by the SACR:

$SCV = \frac{SAV}{SACR} = \frac{29.65\ \mu g/L}{18.29} = 1.6\ \mu g/L$	$SCV = \frac{SAV}{SACR} = \frac{20{,}160\ \mu g/L}{18.29} = 1{,}100\ \mu g/L$

References:

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Gersich, F. 1984. Evaluation of a static renewal chronic toxicity test method for Daphnia magna Straus using boric acid. Environmental Toxicology and Chemistry. Vol. 3: 89-94.

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