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FILE NO: 29142.050216

September 3, 2010

Office of Environmental Information (OEI) Docket
Mail Code 2822T
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., N.W.
Washington, D.C. 20460

Comments on EPA's Draft Report: A Field-based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams
Docket ID No. EPA-HQ-ORD-2009-0934

Dear Sir/Madam:

Attached are the comments of the Utility Water Act Group on EPA's Draft Report: A Field-based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams.

Please call me if you have any questions.

Sincerely,

Brooks M. Smith

Attachment

COMMENTS OF THE UTILITY WATER ACT GROUP (UWAG) ON EPA'S DRAFT REPORT: A FIELD-BASED AQUATIC LIFE BENCHMARK FOR CONDUCTIVITY IN CENTRAL APPALACHIAN STREAMS
Docket ID No. EPA-HQ-ORD-2009-0934
75 Fed. Reg. 18,499 (April 12, 2010)

September 3, 2010

Utility Water Act Group (UWAG)[1] appreciates this opportunity to comment on EPA's draft report "*A Field-Based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams*" (EPA/600/R-10/023A), which was released for public review on April 12, 2010 (75 Fed. Reg. 18499) (defined here as the "Benchmark Report"). As described in more detail below, UWAG has significant legal and technical concerns about the Benchmark Report, as well as its immediate, indiscriminate use for permitting purposes.

In addition to the comments presented here, UWAG is a member of the Federal Water Quality Coalition and endorses the Coalition's separate comments. UWAG also endorses the National Mining Association's comments and related technical reports, as presented to EPA and EPA's Science Advisory Board ("SAB"). While UWAG's members typically do not engage in the types of coal mining activities immediately subject to EPA's Benchmark Report, they do rely on the coal produced from those activities to supply much of the Nation's energy needs and thus will be indirectly affected by EPA's action. Moreover, if applied to other regions and industries, as contemplated by EPA, the Benchmark Report could have direct and adverse effects on UWAG's members.

The Benchmark Report establishes a "chronic aquatic life benchmark value" for conductivity of 300 µS/cm, applicable to parts of West Virginia and Kentucky, and "expected to

[1] UWAG is a voluntary, *ad hoc*, non-profit, unincorporated group of 212 individual energy companies and three national trade associations of energy companies: the Edison Electric Institute, the National Rural Electric Cooperative Association, and the American Public Power Association. The individual energy companies operate power plants and other facilities that generate, transmit, and distribute electricity to residential, commercial, industrial, and institutional customers. The Edison Electric Institute is the association of U.S. shareholder-owned energy companies, international affiliates, and industry associates. The National Rural Electric Cooperative Association is the association of nonprofit energy cooperatives supplying central station service through generation, transmission, and distribution of electricity to rural areas of the United States. The American Public Power Association is the national trade association that represents publicly owned (municipal and state) energy utilities in 49 states representing 16 percent of the market. UWAG's purpose is to participate on behalf of its members in EPA's rulemakings under the CWA and in litigation arising from those rulemakings.

be applicable to the same regions of Ohio, Pennsylvania, Tennessee and Maryland." Report at p. xiii. EPA derived this value using a novel, field-based adaptation of EPA's standard methodology for deriving water quality criteria. Report at p. xii.

EPA's conductivity value does not "represent any Agency determination or policy" and remains subject to independent review by the Science Advisory Board ("SAB").[2] Moreover, as a matter of law, EPA's conductivity value is neither a recommended water quality criterion under Section 304(a) of the Clean Water Act, nor a binding water quality criterion under Section 303 of the Act.[3] However, EPA has directed federal and state permitting authorities to apply this new conductivity value as if it has ***immediate and presumptive legal effect***. *See, e.g., EPA's Detailed Guidance: Improving EPA Review of Appalachian Surface Coal Mining Operations under the Clean Water Act, National Environmental Policy Act, and the Environmental Justice Executive Order*, April 1, 2010 (defined here as the "April 1 Guidance"):

> During the SAB review process, EPA believes that [the Benchmark Report] should be considered by Appalachian states as relevant information per 40 CFR Section 122.44(d)(1)(vi) in implementing applicable state narrative water quality standards in NPDES permits, and by Regions in your review of these permits.

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[2] When EPA released the Benchmark Report, it did so with an explicit caveat: "[t]his information is distributed solely for the purpose of predissemination peer review under applicable information quality guidelines. It has not been formally disseminated by the U.S. EPA. It does not represent and should not be construed to represent any Agency determination or policy." EPA also committed to subject both the Benchmark Report and a related literature compendium, "*The Effects of Mountaintop Mines and Valley Fills on Aquatic Ecosystems of the Central Appalachian Coalfields*," (EPA/600/R-09/138A), to review by an independent panel convened by the SAB.

[3] EPA has not issued a determination or proposal under Section 303(b) or (c), which serves as a prerequisite to establishing binding federal criteria. Moreover, EPA has conceded that the Benchmark Report does not qualify as a 304(a) criterion. In fact, as part of its presentation to the SAB, EPA noted that "looking to the future," the Agency would "consider need for additional conductivity reviews for other locations and ***need for 304(a) criteria for conductivity***." Presentation of Denise Keehner, Director, Office of Wetlands, Oceans and Watersheds, July 20, 2010 (emphasis added).

> As a general matter, EPA expects that the conductivity impacts of projects with predicted conductivity levels below 300 µS/cm generally will not cause a water quality standard violation and that in-stream conductivity levels above 500 µS/cm are likely to be associated with adverse impacts that may rise to the level of exceedances of narrative state water quality standards.
>
> ***
>
> For purposes of Section 230.10(c) of the Guidelines, the Regions should consider the [Benchmark Report] when examining whether a draft 404 permit is likely to result in significant degradation of waters of the U.S.
>
> ***
>
> Projects projected to increase conductivity levels above 300 µS/cm should include permit conditions requiring adaptive remedial action to prevent conductivity levels from rising….

April 1 Guidance at pp. 12 and 22.

UWAG has grave concerns about EPA circumventing the criteria-setting provisions of the Clean Water Act, deviating from its standard method, and then forcing federal and state permitting authorities to conform their permitting actions with EPA's views without regard to the process safeguards that form the core of the Clean Water Act, Administrative Procedures Act, and U.S. Constitution.

1. EPA's conductivity value has no legal effect and cannot be used to interpret state standards or assign permit limits.

Congress gave EPA two opportunities to establish water quality criteria. Under Section 303 of the Clean Water Act, EPA may adopt binding criteria when a state fails to meet its triennial review obligations or adopts a water quality standard that EPA believes to be inconsistent with the Act.[4] Alternatively, under Section 304 of the Act, EPA may adopt

[4] Earlier this year, EPA did so in connection with numeric nutrient criteria for lakes and flowing waters in the State of Florida. *See* 75 Fed. Reg. 4174 (January 26, 2010).

recommended criteria that reflect the "latest scientific knowledge" available to the Agency. Such recommended criteria are not binding on states and are not directly enforceable. Rather, states may consider them in setting their own binding criteria, and also may consider them when assigning water quality-based effluent limits to discharges deemed by a state to have reasonable potential to violate narrative water quality standards.[5]

EPA has not pursued either of these statutory opportunities here. Instead, EPA has derived a novel "benchmark value" that conforms with neither Section 303 nor Section 304 and, in turn, has no legal effect. The inherent problem with EPA's action is that the Agency ***expects*** its benchmark value to have legal effect, and, in fact, has instructed EPA regions and states to give it such effect.

In the April 1 Guidance, EPA advises regions and states to use the conductivity value to interpret state narrative water quality standards for the purpose of assigning water quality-based effluent limits necessary to protect those standards. But this usurps state authority in two fundamental ways. First, states have primary authority to interpret their own narrative standards. A state's interpretation trumps any competing federal interpretation, so long as the state's interpretation is supported by substantial evidence. *Am. Paper Inst., Inc. v. U.S. EPA*, 996 F.2d 346 (D.C. Cir. 1993).[6] Second, water quality-based limits are only necessary if a state first

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[5] *See* 40 CFR §131.11(b) ("In establishing criteria, States should: (1) Establish numerical values based on: (i) 304(a) Guidance; or (ii) 304(a) Guidance modified to reflect site-specific conditions; or (iii) Other scientifically defensible methods; (2) Establish narrative criteria or criteria based on biomonitoring methods where numerical criteria cannot be established to supplement numerical criteria."); *see also* 40 CFR §122.44(d)(1)(vi)(A), (B) and (C) (authorizing states to establish WQBELs to protect narrative standards using (1) a proposed State criterion or an explicit State policy or regulation; (2) EPA's 304(a) criteria, supplemented where necessary by other relevant information; or (3) an indicator parameter for the pollutant of concern).

[6] The only exception is where more than one state's standards are at issue. *See, e.g., Champion Int'l Corp. v. U.S. EPA*, 648 F. Supp. 1390 (W.D.N.C. 1986), *vacated and remanded on jurisdictional grounds at* 850 F.2d 182 (4th Cir. 1988) (upholding EPA's interpretation of North Carolina's narrative water quality standard for color to a discharge that impacted both North Carolina and Tennessee waters);

determines that a discharge has a reasonable potential to cause or contribute to an excursion of a water quality standard. Upon such a determination, EPA's conductivity value ***could*** serve as "other relevant information" for a state to consider in deriving a limit to protect a narrative standard. But until such a determination, EPA's conductivity value is irrelevant.

If EPA wants its conductivity value to have legal effect, then it must either promulgate the value as a water quality criterion (subject to all applicable process safeguards) or defer to a state to consider it (among other regulatory options) in permit proceedings involving discharges that a state determines, on a case-by-case basis, to have reasonable potential. EPA cannot circumvent the criteria-setting process, then usurp a state's authority to interpret its own standards, and then presume that an entire category of otherwise lawful discharges will violate the state's standards unless they receive limits based on EPA's otherwise unlawful conductivity value. To do so would be to turn the statute -- not to mention good government and common sense -- on its head.

2. EPA's Benchmark Report reflects a number of technical issues that must be resolved before the conductivity value is used or applied.

A. Ambiguous geographic applicability of conductivity benchmark

All of the field data that supported EPA's conductivity value were taken from field studies conducted in West Virginia (and then validated using data from Kentucky that were just recently released for public review). The Agency's final recommendation, however, is that the conductivity value be implemented at surface mining locations in Ecoregions 68, 69, and 70. While UWAG believes that the Agency's attempt to "parameterize" the conductivity value by major salt types (sulfate as dominant anion and bicarbonate as dominate cation) may be a

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see also Dioxin/Organochlorine Ctr. v. Rasmussen, No. C93-33D, 1993 WL 484888 (W.D.Wash. Aug. 10, 1993).

reasonable first step, the lack of similar field conductivity-biological response data in other geographic areas within the three ecoregions is a weakness to the benchmark's potential applicability.

One issue that states will likely need to address is the applicability of the conductivity value when the major anion and cation are not similar to the field studies used by EPA when deriving the benchmark. For example, in headwater streams affected by brine water having chloride as the dominant anion, is the proposed conductivity value of 300 µS/cm appropriate? What is the amount of departure from the sulfate and bicarbonate-dominated water quality (used to derive the benchmark) that is acceptable? In the Executive Summary of the Benchmark Report, the Agency states on page xiii that the 300 µS/cm value "… may not apply when the relative concentrations of dissolved ions are not dominated by salts of SO_4^{-2} and HCO_3^-." This statement is not satisfactory from either a technical or regulatory implementation standpoint.

B. Field-Based Methodology Issues

EPA's field-based approach represents a significant departure from the methodology the Agency currently uses to develop meaningful toxicological thresholds for specific chemicals or constituents. Before the methodology can be "finalized" by EPA, UWAG believes that outcomes of the methodology should be critically compared to other assessment tools. Toward that end, UWAG urges EPA to answer the following questions, all of which bear on whether EPA's approach is sufficiently robust to be used for use attainment decisions with a high degree of certainty:

1. How does the conductivity value compare with multimetric biological index scores that have been calibrated (and sometimes adopted) by states? What is the biological significance of the proposed conductivity value being exceeded in a particular

water body? Is it suggestive or indicative of a water body not meeting the "fishable" Clean Water Act goal? Does it implicitly or explicitly imply aquatic life use non-attainment? Is the conductivity benchmark still applicable when a state's own biological monitoring study shows the presence of conductivity-sensitive mayfly taxa (*e.g.*, genera having extirpation concentration - or EX_{95} - values of less than 1,000 µS/cm) at sites with measured conductivity values higher than 300 or 500 µS/cm?

2. How "cross-cutting" is the conductivity value across tiered aquatic life uses? Is it appropriate for states to implement the conductivity value indiscriminately across tiered aquatic life uses that range from "exceptional" to "water quality or habitat limited"? As an example, how would the Agency expect a state with multiple tiered aquatic life uses (*e.g.*, the State of Ohio) to implement the conductivity value? Would it be appropriate for the proposed benchmark to be implemented for water bodies that typically do not have mayfly taxa present?

3. How does the conductivity value compare with instream toxicity assessments? What is EPA's expectation when the conductivity value is maintained in a stream and samples are collected for toxicity testing using standard test organisms? Should the samples not be acutely and chronically toxic, or just acutely toxic? A key weakness of the methodology and resulting conductivity value is the lack of any cross-validation through the use of other, complimentary assessment tools that, in fact, EPA encourages states to implement to assess aquatic life use attainment.

4. What role does site-specific acclimation or adaptation have in the implementation of the conductivity benchmark? Does EPA acknowledge the fact that conductivity-sensitive mayfly genera may be present (and abundant) in stream settings where ambient

conductivity levels exceed 500 µS/cm on a long-term basis? Shouldn't an instream biological study be conducted to confirm or refute EPA's expectation that certain sensitive taxa should be extirpated at conductivity levels higher than 300 µS/cm?

C. Lack of toxicological validation

UWAG finds it very troubling that EPA makes no attempt to validate or "ground truth" the proposed benchmark by using independent laboratory exposure studies. The stringency of the field-based conductivity value (by itself) should have compelled the Agency to, at minimum, compare the proposed threshold with published laboratory studies where freshwater aquatic life were exposed to individual salts, salt mixtures, or surrogate measures (*e.g.*, total dissolved solids or specific conductivity). Very frequently, laboratory-derived toxicity thresholds for specific chemicals are found to be overly protective when the *in-situ* response of aquatic life to the same measured chemical is evaluated. This pattern, however, seems to be ***reversed*** regarding the conductivity value. UWAG can find no published studies indicating that sensitive invertebrate taxa exhibit acute or significant chronic toxicity at the proposed conductivity value.

If the proposed conductivity value does have toxicological significance, then there should be some evidence that mayflies - or other EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa - are relatively sensitive to dissolved salts (whether individually or in combination). Attached as Appendix 1 is a recent compilation of aquatic toxicity data (obtained from EPA) for freshwater organisms exposed to chloride. Table 3 lists the ranked sensitivity from most tolerant (the damselfly *Agria sp*.; Genus Mean Acute Value of 21,570 mg/L Cl) to most sensitive (fingernail clam, *Sphaerium sp*.; Genus Mean Acute Value of 1,089 mg/L Cl). The second most sensitive taxa regarding exposure to chloride is C*eriodaphnia dubia*. The Species Mean Acute Value for this species is 1,598 mg/L Cl. It should be noted that the toxicity test results listed for aquatic

insects in Table 3 (caddis flies, stoneflies) indicate that these taxa are considerably more tolerant to chloride exposure compared to many other species (Genus Mean Acute Values greater than 4,000 mg/L Cl).

Using all of the acute toxicity data (which was normalized to a hardness value of 300 mg/L $CaCO_3$), EPA calculates a Criterion Maximum Concentration value of 678 mg/L chloride. *See* page 6 of Table 3. While a direct chloride-to-conductivity comparison cannot be made in terms of chemical composition (though in some water bodies in Ecoregions 68, 69, and 70 chloride may be the predominant anion), the calculated CMC value is more than ***two times*** the Agency's conductivity benchmark of 300 µS/cm. We reiterate our point that EPA has provided no toxicological basis for the proposed conductivity value in terms of direct cause and effect.

UWAG has attached a summary of a study that was conducted by a UWAG member company, American Electric Power ("AEP"), regarding potential acute toxicity using actual effluent and artificially-mixed samples that were intended to "mock" anticipated effluent quality after installation of a flue gas desulfurization system at eight coal-fired power plants located in the Midwest. *See* Appendix 2. Standard acute toxicity tests with *Ceriodaphnia dubia* and fathead minnow were conducted on all treatment solutions, and a comprehensive analysis of individual salts, TDS, trace metals, and conductivity was conducted. Table 1 of the report indicates results of acute toxicity testing: percent mortality in the artificially mixed instream waste concentration water, percent mortality in the effluent or "mock" or "salt spike" effluent, and the resulting LC_{50} values for each test. Table 3 indicates concentrations of total hardness, alkalinity, pH, and conductivity measured at the beginning of each test.

The measured conductivity values in the various tests ranged from 430 to 11,850 µmhos/cm. All of the tests in which there was ***no mortality*** in the *Ceriodaphnia dubia* acute test

(*i.e.*, 100% survival) are circled in Table 3. Daphnids are known to be more sensitive to dissolved salts compared to fathead minnow, thus only the results for *Ceriodaphnia* were considered. A total of 22 tests resulted in 100% survival of *Ceriodaphnia*. The ***range*** of measured conductivity values in these tests was 430 to 4,450 µmhos/cm. The average and median conductivity value for all of the tests that resulted in 100% survival for *Ceriodaphnia* was 1,737 and 1,297 µmhos/cm, respectively. This case study provides compelling evidence that a sensitive freshwater aquatic species (likely to be more sensitive than any mayfly taxa regarded by EPA as conductivity-sensitive based on the West Virginia studies) is not adversely affected by conductivity values that approach or exceed 1,000 µmhos/cm.

In summary, the use of a limited number of taxa to elucidate a field-based "no effect" criterion value for conductivity is not only a significant departure from the Agency's methodology for deriving criteria for aquatic life (a process that requires incontrovertible cause and effect relationships based on controlled laboratory studies), but the proposed criterion is woefully lacking in any toxicological basis and/or underpinnings.

D. Lack of conductivity effects in other field studies

The response of pollution-intolerant aquatic insects to measured conductivity (and other pollutant) levels in field studies has been reported in several publications. Here, UWAG discusses a case study concerning the response of mayflies to conductivity in a long-term biological monitoring study conducted by AEP. Blaine Creek is a 5th order tributary of the Big Sandy River in eastern Kentucky. The Blaine Creek watershed is in the Western Allegheny Plateau Ecoregion (Ecoregion 70) while most of the Big Sandy drainage system falls in the Central Appalachians Ecoregion (Ecoregion 69). The upper (headwater) portion of Blaine Creek was impacted historically by brine contamination, as a result of oil and gas drilling operations.

These effects were mitigated in the 1980s and 1990s through Kentucky agency enforcement action. AEP operates a coal-fired power plant on the Big Sandy River. Fly ash produced during coal combustion at this plant is routed to a large settling impoundment. The treated fly ash water is discharged to Blaine Creek at a location approximately 3 miles upstream of the Big Sandy River confluence. AEP biologists conducted chemical and biological monitoring (fish and benthic macroinvertebrates) in Blaine Creek from the early 1970s to 2000. Three sampling sites were located for long-term monitoring: a headwater site, a site just upstream of the fly ash pond discharge, and a site just downstream of the fly ash pond discharge. The primary goal of the monitoring study was to evaluate potential adverse effects of the treated fly ash discharge.

A summary of the long-term chemical and biological studies conducted in the stream was provided in Van Hassel et al. (1988). This is attached as Appendix 3. Mean measured conductivity values at the three locations during 1981 – 1985 were 1,869 µmhos/cm at the headwater site, 991 µmhos/cm at the site just upstream of the fly ash discharge, and 1,055 µmhos/cm at the site downstream of the discharge (*see* Table 2 of publication). A total of nine mayfly genera were collected from the three sites: *Baetis, Pseudocloeon, Heptagenia, Stenonema, Ephemerella, Tricorythodes, Caenis, Baetisca, and Ephemera*. In the CB technical guidance document, EPA lists the conductivity extirpation concentration for all of these taxa except for *Pseudocloeon*:

Mayfly Genus	**U.S. EPA Conductivity Extirpation concentration (µmhos/cm)**
Baetis	1,383
Heptagenia	313
Stenonema	729
Ephemerella	302
Tricorythodes	2,006
Caenis	3,884
Baetisca	918
Ephemera	736

For five of the eight mayfly genera listed above, EPA's calculated extirpation concentration is considerably lower than measured conductivity values at Blaine Creek sites ***where these taxa were found, often on a frequent temporal basis.*** These taxa include *Heptagenia, Stenonema, Ephemerella, Baetisca, and Ephemera*. Thus, for a stream within the geographic range that EPA believes the conductivity value of 300 µS/cm could be implemented, UWAG provides evidence that the sensitivity of certain mayfly genera to conductivity exposure is markedly ***overestimated*** by EPA compared to field studies in an eastern Kentucky stream.

An updated analysis of the Blaine Creek chemical and biological monitoring data is provided. For sample years 1986 - 1999, Table 1 indicates measured conductivity values at the time of sampling, number of mayfly taxa per sample, total number of mayflies (all genera) per sample, total taxa richness, and the number of mayfly genera that have extirpation concentration values of less than 1,000 µmhos/cm (as reported by U.S. EPA, EPA/600/R-10/023A). Each of these parameters is given for the sampling site upstream of the fly ash pond discharge, and the site located downstream of the discharge. [NOTE: all of the data up to 1990 were submitted to the Kentucky Department of Environmental Protection, Division of Water, in a document entitled "Request and Justification for Copper and Selenite Site-Specific Water Quality Criteria for Blaine Creek, Under KAR 5:031(9)," submitted by AEP on May 19, 1992. The conductivity and mayfly data from 1992 to 1999 are from in-house reports compiled by AEP].

In Table 1, measured conductivity values ranged from 135 - 1,430 µhmos/cm. Conductivity values were uniformly higher at the downstream site, indicating the influence of the fly ash pond discharge. The total number of mayfly genera collected in each sample was no greater than four. While total mayfly richness is not exemplary in any way, it should be noted that the predominant substrate in Blaine Creek consists of shifting sand.

Figure 1 indicates a plot of measured conductivity values versus the number of mayfly genera collected (both upstream and downstream sites combined). The very weak correlation coefficient (r = -0.19) indicates no suggestion of correlation between conductivity and mayfly richness. The graph suggests that mayfly richness decreases at conductivity concentrations equal to or greater than about 1,000 µmhos/cm. Figure 2 shows the same plot for the downstream site only. Again, the relationship between the variables shows a very weak correlation coefficient (r = -0.03), and a suggestion that mayfly richness at the downstream site decreases at conductivity levels at or about 1,000 µhmos/cm. Thus, in Blaine Creek, mayfly richness is insensitive to conductivity concentrations less than about 1,000 µhmos/cm.

Figure 3 indicates a plot of measured conductivity versus total macroinvertebrate richness. Total taxa richness is a community parameter often used to assess potential adverse water quality effects. There is virtually no statistical relationship between the two variables (correlation coefficient value = -0.15). Even at conductivity measurements greater than 1,000 µhmos/cm, total taxa richness is relatively unaffected. This provides some evidence that, at least in Blaine Creek, there would be no expected effects on macroinvertebrate community composition at a conductivity concentration between 300 - 500 µhmos/cm.

Figure 4 shows a plot of measured conductivity versus the total number of mayflies counted in a sample (all general combined). There is a suggestion that total mayfly abundance may be lowered at conductivity levels greater than 900 µhmos/cm. It should be noted, however, that the total number of mayflies often reflects one, or sometimes two, particular abundant genera present at the time of sampling (asymmetrical abundance among taxa). Lastly, Figure 5 indicates a plot between measured conductivity values and the number of mayfly genera collected that have, according to EPA, a conductivity extirpation concentration value (95th percentile) less than 1,000

µhmos/cm. A total of five mayfly genera have been collected in Blaine Creek that have extirpation concentration values of less than 1,000 µhmos/cm. Four of these taxa have extirpation levels of less than 800 µhmos/cm. Figure 5 indicates that, for any given sample, the number of mayfly genera collected that are conductivity-sensitive ranges from zero to two. Like the other figures, there is no apparent decrease in the biological parameter response at conductivity levels less than 1,000 µhmos/cm. In summary, in contrast to EPA's finding that biological impairment would be expected to occur at stream conductivity concentrations that exceed 300 µhmos/cm, studies in Blaine Creek, Kentucky clearly indicate that both mayfly richness and total macroinvertebrate richness are unaffected at measured instream conductivity concentrations less than, or equal to, 1,000 µhmos/cm.

In summary, UWAG believes that there are significant technical and scientific deficiencies in: 1) the process used by EPA to derive the conductivity value; and 2) the lack of any demonstrated toxicological basis, which ***is an explicit requirement*** in the Agency's guidelines for deriving water quality criteria for aquatic life. UWAG encourages the Agency to conduct further studies and analyses in order to address these technical issues.

Table 1.

Blaine Creek, Kentucky Conductivity and Mayfly Data for Biological Studies Conducted During 1986 - 1999. Source: American Electric Power, Columbus, OH

note: benthic macroinvertebrates collected using circular depletion sampler (1991 - 1995; Van Hassel et al., 1988); Hester-Dendy samplers used for 1995 sample.

note: site "UP FAP" is location just upstream of fly ash pond discharge (dominant anion is chloride). Site "Down FAP" is downstream of fly ash pond discharge (chloride and sulfate anion concentrations relatively equal)

Sample date	Sample location	Conductivity level (uhmos/cm)	No. mayfly Species	Total mayfly abundance	No. mayfly genera w/ EX95 value < 1,000 umhos/cm
Jun 21 1995	UP FAP	168	2	13	1
Sep 6 1995	UP FAP	145	2	85	1
Jul 28 1994	UP FAP	144	2	104	1
Sep 20 1994	UP FAP	150	3	258	1
Aug 26 1993	UP FAP	186	3	41	2
Oct 6 1993	UP FAP	182	2	109	2
Jun 9 1999	UP FAP	172	4	101	1
Jun 11 1992	UP FAP	135	2	13	1
Aug 10 1992	UP FAP		2	69	1
April 18 1986	UP FAP	780	0	0	1
Aug 15 1986	UP FAP	661	0	0	0
Oct 23 1986	UP FAP	655	4	18	0
Oct 15 1987	UP FAP	458	3	30	1
Oct 13 1988	UP FAP	950	0	0	1
Nov 15 1989	UP FAP	200	4	11	0
June 22 1990	UP FAP	257	2	44	2
Oct 4 1990	UP FAP	307	4	197	2
July 24 1991	UP FAP	212	4	57	1
Jun 21 1995	Down FAP	403	2	8	
Sep 6 1995	Down FAP	913	3	394	1
Jul 28 1994	Down FAP	735	4	229	1
Sep 20 994	Down FAP	465	4	113	2
Aug 26 1993	Down FAP	810	3	4	2
Oct 6 1993	Down FAP	814	3	11	1
Jun 9 1999	Down FAP	811	6	52	1
Jun 11 1992	Down FAP	300	2	11	1
Aug 10 1992	Down FAP	935	3	15	0
April 18 1986	Down FAP	788	2	48	2
Aug 15 1986	Down FAP	1083	2	2	1
Oct 23 1986	Down FAP	932	0	0	0
Oct 15 1987	Down FAP	969	3	33	0
Oct 13 1988	Down FAP	1,430	1	2	1
Nov 15 1989	Down FAP	255	1	3	0
June 22 1990	Down FAP	327	2	27	1
Oct 4 1990	Down FAP	884	2	51	1
July 24 1991	Down FAP	628	2	30	1

Figure 1

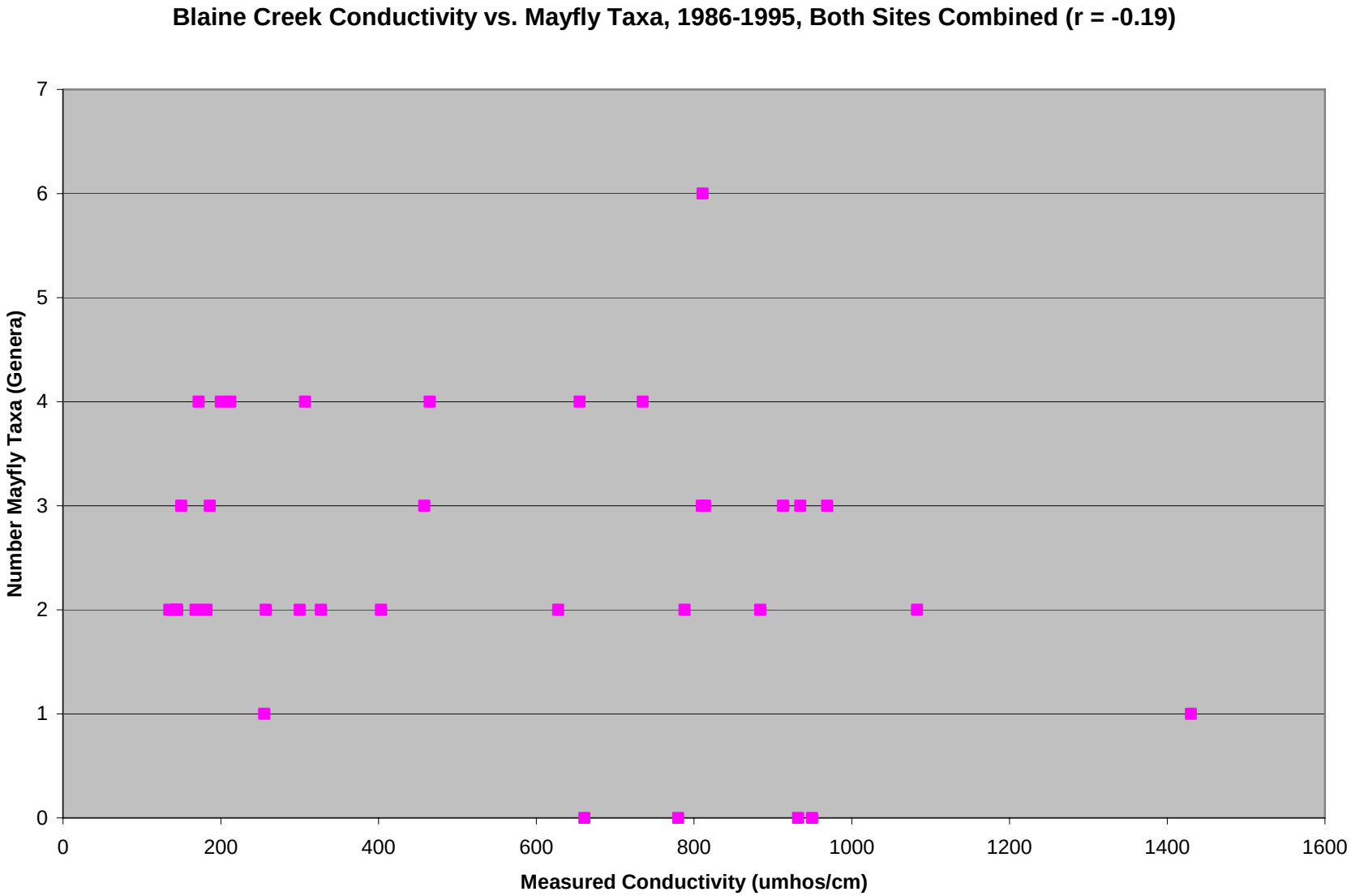

Blaine Creek Conductivity vs. Mayfly Taxa, 1986-1995, Both Sites Combined (r = -0.19)
Number Mayfly Taxa (Genera)
0
1
2
3
4
5
6
7
0
200
400
600
800
1000
1200
1400
1600
Measured Conductivity (umhos/cm)

Figure 2

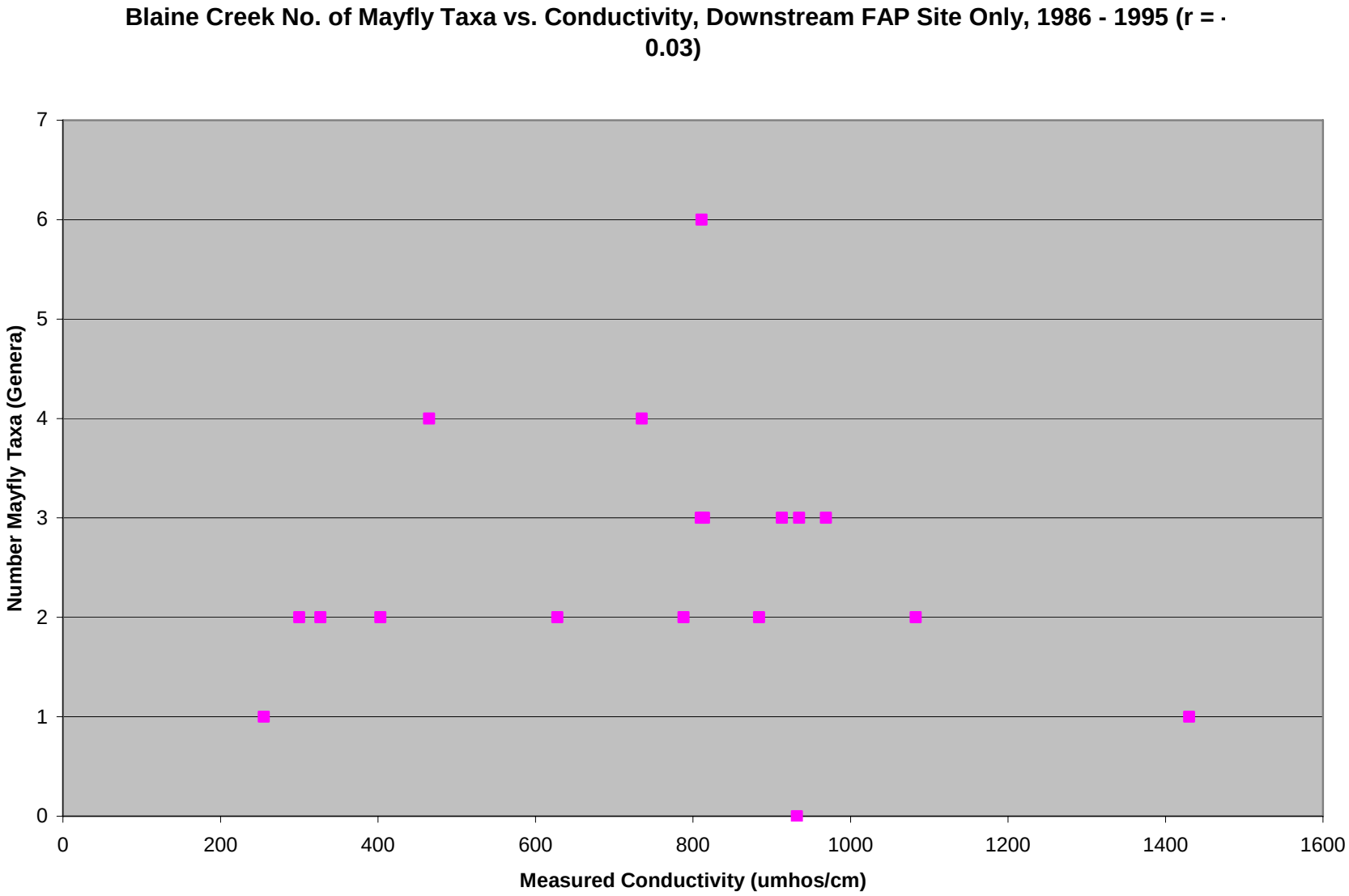

Blaine Creek No. of Mayfly Taxa vs. Conductivity, Downstream FAP Site Only, 1986 - 1995 (r = -0.03)
Number Mayfly Taxa (Genera)
0
1
2
3
4
5
6
7
0
200
400
600
800
1000
1200
1400
1600
Measured Conductivity (umhos/cm)

Figure 3

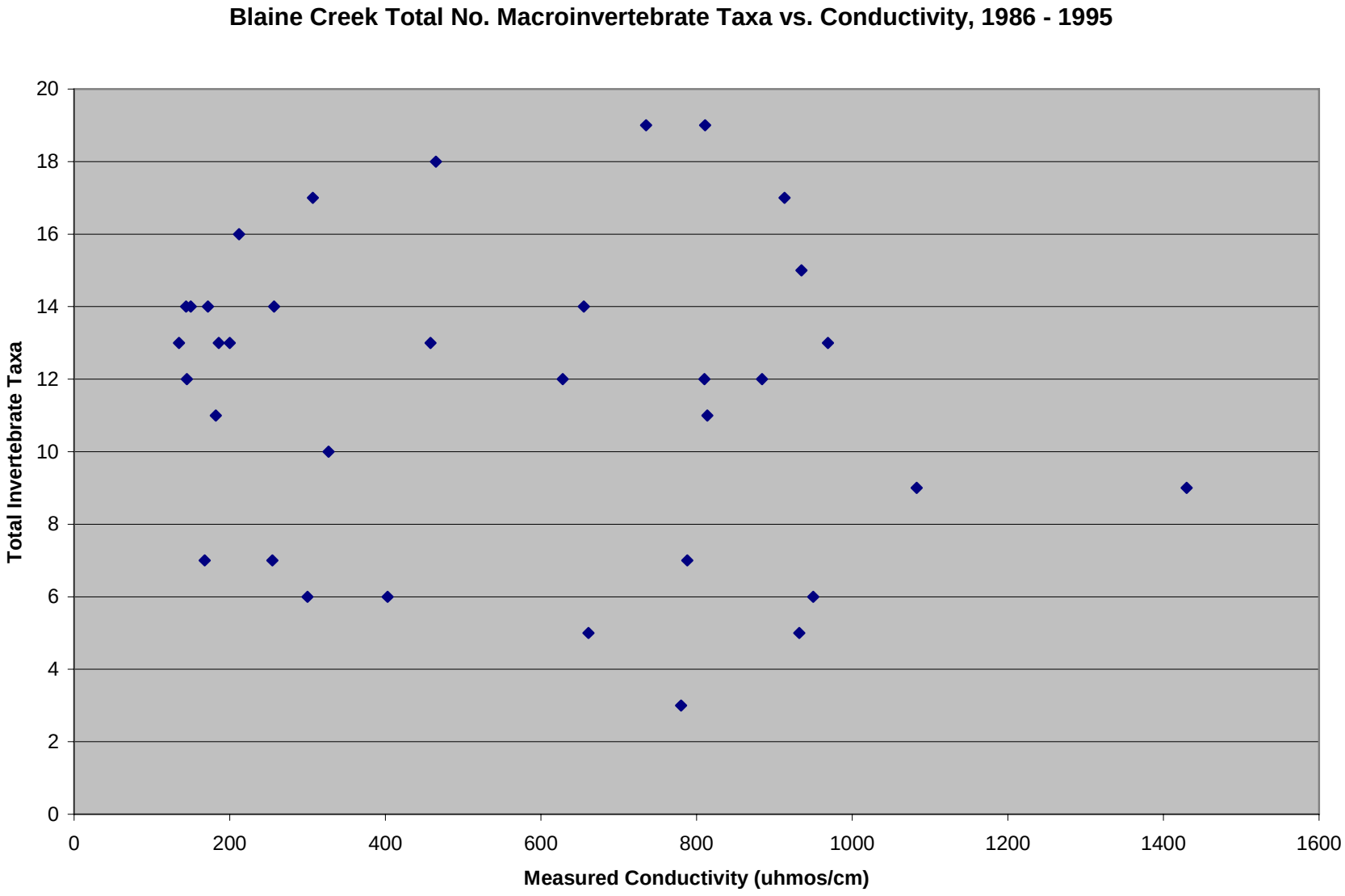

Blaine Creek Total No. Macroinvertebrate Taxa vs. Conductivity, 1986 - 1995
Total Invertebrate Taxa
0
2
4
6
8
10
12
14
16
18
20
0
200
400
600
800
1000
1200
1400
1600
Measured Conductivity (uhmos/cm)

Figure 4

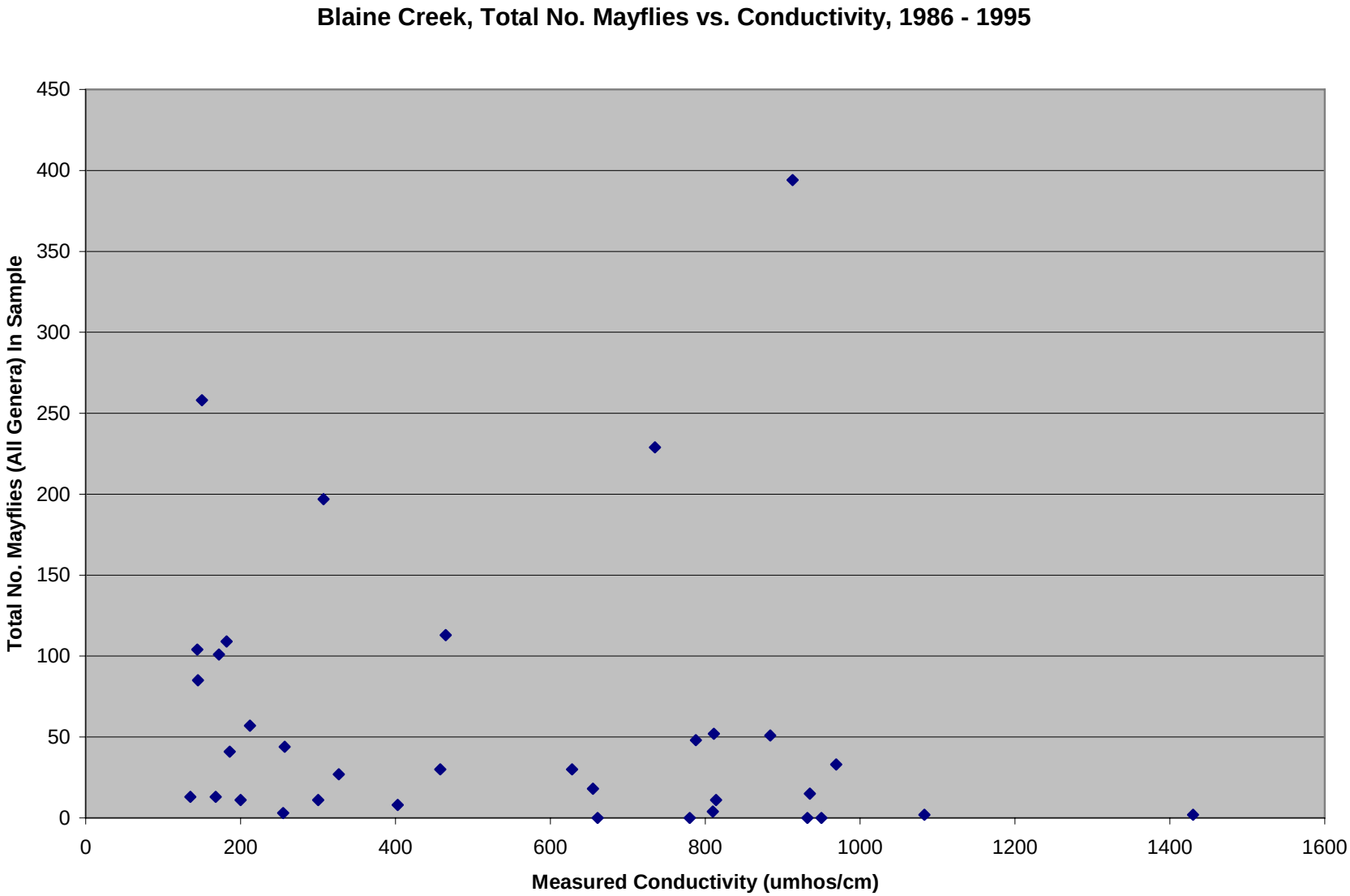
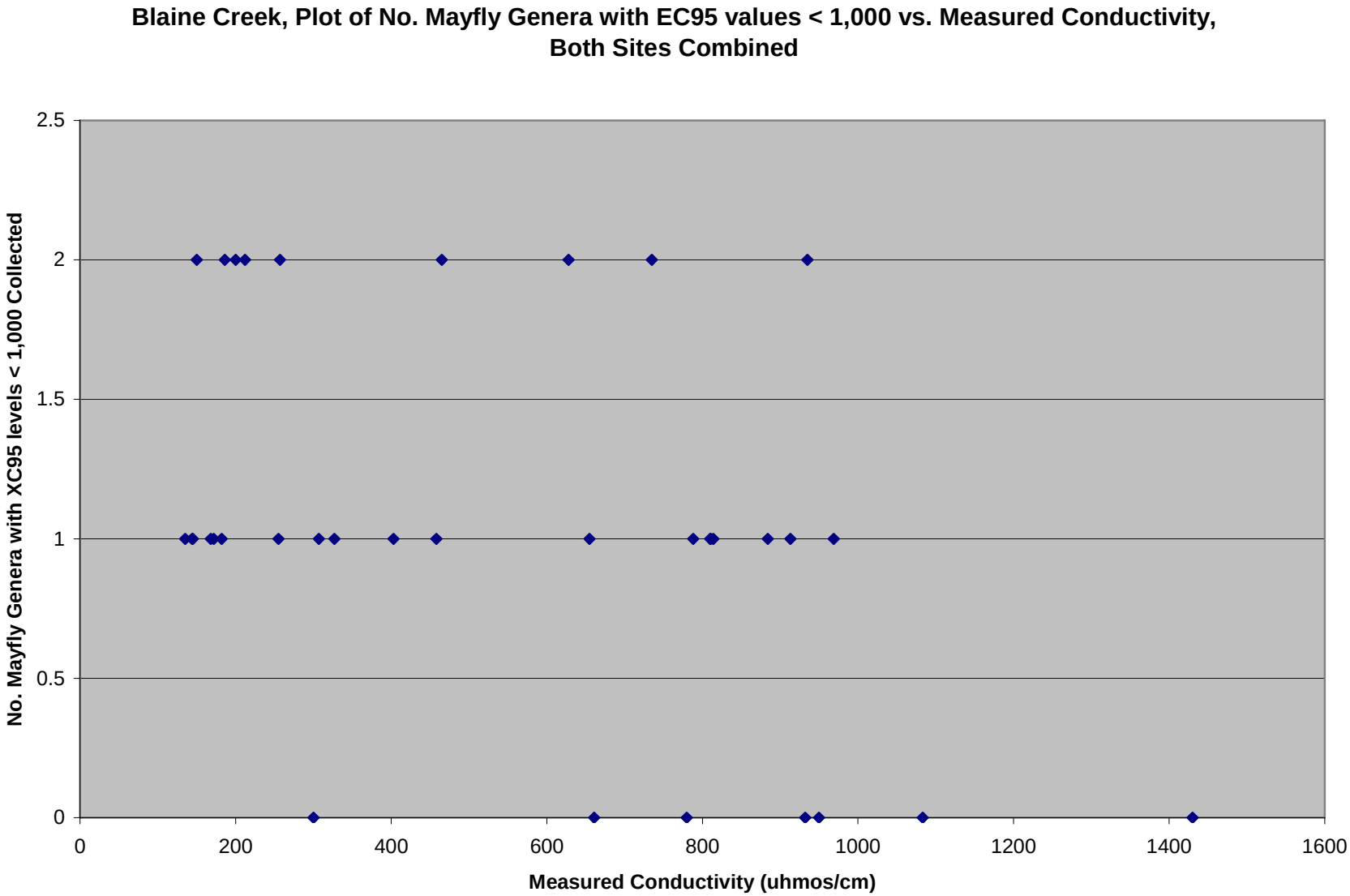

Blaine Creek, Total No. Mayflies vs. Conductivity, 1986 - 1995
Total No. Mayflies (All Genera) In Sample
450
400
350
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
1600
Measured Conductivity (umhos/cm)

Figure 5


Blaine Creek, Plot of No. Mayfly Genera with EC95 values < 1,000 vs. Measured Conductivity, Both Sites Combined
No. Mayfly Genera with XC95 levels < 1,000 Collected
2.5
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
Measured Conductivity (uhmos/cm)

08ChloridePrD-T3.wpd

DRAFT

10-15-08
C. Stephan

Procedure D for Chloride

Table 3

(based on toxicity tests on sodium chloride)
(GMAVs and SMAVs are normalized to hardness = 300 mg/L)
(GMAVs and SMAVs are expressed as mg chloride/L)
(see footnotes a and b)

Rank	GMAV	Genus	Species	SMAV	SMACR
29	21570	Agria	Damselfly, Agria sp.	21570	
	18647	Cambarus	Crayfish, Cambarus sp.	18647	
	18190	Anquilla	American eel, Anquilla rostrata	18190	
	17144	Fundulus	Plains killifish, Fundulus kansae	17144	
	17082	Libellulidae*	Dragonfly, Libellulidae	17082	
	13430	Gasterosteus	Threespine stickleback, Gasterosteus aculeatus	13430	
	11432	Gambusia	Mosquitofish,	11432	

		Gambusia affinis		
11026	Carassius	Goldfish, Carassius auratus	11026	
10770	Oncorhynchus	Rainbow trout, Oncorhynchus mykiss	10770h	7.308
10324	Notropis	Red shiner, Notropis lutrensis	10324	
10001	Lepomis	Green sunfish, Lepomis cyanellus	11479	
		Bluegill, Lepomis macrochirus	8713e	
-----	Chironomus	Midge, Chironomus attenuatus	-----	
8565	Ameiurus	Black bullhead, Ameiurus melas	8565	
6868	Pimephales	Fathead minnow, Pimephales promelas	6868f	15.17i
6346	Tubifex	Tubificid worm, Tubifex tubifex	6346	
5955	Asellus	Isopod, Asellus communis	5955	
5780	Erpobdella	Leech,	5780	

		Erpobdella punctata	
4987	Hyalella	Amphipod, Hyalella azteca	4987
4777	Limnodrilus	Tubificid worm, Limnodrilus hoffmeisteri	4777
4739	Helisoma	Snail, Helisoma campanulata	4739
4678	Pseudacris	Chorus frog, Pseudacris sp.	4678
-----	Gammarus	Amphipod, Gammarus pseudolimnaeus	-----
-----	Crangonyx	Amphipod, Crangonyx sp.	-----
-----	Nemoura	Stonefly, Nemoura trispinosa	-----
-----	Lepidostoma	Caddisfly, Lepidostoma sp.	-----
-----	Parapsyche	Caddisfly, Parapsyche sp.	-----
4541	Diaptomus	Copepod, Diaptomus clavipes	4541
3884	Lirceus	Isopod,	3884

			Lirceus fontinalis		
	3603	Physa	Snail, Physa gyrina	3344	
			Snail, Physa heterostropha	3882	
	3059	Gyraulus	Snail, Gyraulus circumstriatus	2466	
			Snail, Gyraulus parvus	3794	
	2901	Villosa	Mussel, Villosa delumbis	3593	
			Mussel, Villosa iris	2343	
4	2666	Lampsilis	Mussel, Lampsilis fasciola	2734	
			Mussel, Lampsilis siliquoidea	2599	
3	2343	Daphnia	Cladoceran, Daphnia ambigua	1681	4.148
			Cladoceran, Daphnia magna	3987d	1.974

			Cladoceran, Daphnia pulex	2018g	3.952
2	1598	Ceriodaphnia	Cladoceran, Ceriodaphnia dubia	1598c	>2.470j
1	1089	Sphaerium	Fingernail clam, Sphaerium simile	1148	
			Fingernail clam, Sphaerium tenue	1033	

* Name of family, not name of genus.

a. Section IV.I of the 1985 Guidelines says: "For each species for which at least one acute value is available, the Species Mean Acute Value should be calculated as the geometric mean of the results of all flow-through tests in which the concentrations of test material were measured. For a species for which no such result is available, the SMAV should be calculated as the geometric mean of all available acute values, i.e., results of flow-through tests in which the concentrations were not measured and results of static and renewal tests based on initial concentrations (nominal concentrations are acceptable for most test materials if measured concentrations are not available) of test material." The guidance presented in section IV.I of the 1985 Guidelines seems inappropriate for chloride because chloride is different from most pollutants for which aquatic life criteria are derived. Chloride is very soluble in water, does not oxidize or reduce, is not volatile, does not degrade, does not sorb to test chambers, test organisms, food, or waste products, is not complexed by materials that commonly occur in water, is not involved in a pH-dependent equilibrium in water, and does not precipitate in waters in which aquatic organisms commonly occur.
   i. For chloride, as long as the concentration of dissolved oxygen is sufficiently high, it seems appropriate to give static and renewal acute tests the same weight as flow-through acute tests in the derivation of the SMAV for a species.
   ii. For chloride, it seems inappropriate to give measured acute tests a weight of 1 and unmeasured acute tests a weight of 0 when both are available for the derivation of the SMAV for a species. For example, if there is a choice between one measured acute test on chloride and three unmeasured acute tests in three different laboratories, the three tests are probably preferable to the one test, but if the choice is between one measured acute test and two unmeasured acute tests in two different laboratories, the one test is probably preferable. Thus, for a species for which both measured and unmeasured acute tests are available for chloride, it seems appropriate to give measured acute tests a weight of 2.5 and unmeasured acute tests a weight of 1 when the SMAV is calculated.

The conclusions described above concerning chloride were developed during discussions among Charles Delos, Charles Stephan, and Glen Thursby. For other pollutants, different conclusions concerning the relative merits of static, renewal, and flow-through acute toxicity tests and the relative merits of measured and unmeasured acute toxicity tests are likely to be more appropriate.

b. A "greater than" acute value for the brown trout (Salmo trutta) is not in this table because it is too low to be a useful "greater than" value.

c. For Ceriodaphnia dubia, the acute values from Hoke et al. (1992) are considered outliers. The geometric mean is 1466 for Mount et al. (1997), 2086 for U.S. EPA (1991), 1936 for WISLOH (2007), and 1419 for GLEC and INHS (2008).
SMAV = antilog ([log 1466 + log 1891 + log 2086 + log 1936 + log 1960 + 2.5(log 1336) + 2.5(log 1419)]/10) = 1598.

d. For Daphnia magna, the acute value from Khangarot and Ray (1989) was considered an outlier. The values of 3809 (Mount et al. 1997), <3178, (Anderson 1946), 2784 (Anderson 1948), and 3817 and 4235 (Biesinger and Christensen 1972) were not used. A geometric mean of 3673 was calculated from the limits given by Seymour et al. (1997). The geometric mean is 4005 for Hoke et al. (1992) and 3969 for Davies and Hall (2007). The SMAV is 3987, which is the geometric mean of 4005, 5481, 3673, 2828, 4466, 3962, and 3969.

e. Bluegill: SMAV = antilog ([2.5(log 7689) + log 11910]/3.5) = 8713.

f. Fathead minnow: SMAV = antilog ([log 3155 + 2.5(log 8651) + 2.5(log 9466) + log 5103 + log 5064]/8) = 6868.

g. Daphnia pulex: SMAV = antilog ([2.5(log 1936) + log 2237]/3.5) = 2018.

h. Rainbow trout: SMAV = antilog ([2.5(log 10143) + log 12511]/3.5) = 10770.

i. Not used in calculations because, even though the acute and chronic tests were in the same document, different dilution waters were used in the tests.

j. The SMACR for Ceriodaphnia dubia is the geometric mean of 1.508, >3.841, and 2.601.

FAV = 1355 mg chloride/L

CMC = FAV/2 = 677.5 mg chloride/L

The five SMACRs (7.308, 4.148, 1.974, 3.952, and >2.438) that are available for use in calculations result in three GMACRs:

7.308	Oncorhynchus
3.187	Daphnia
>2.470	Ceriodaphnia

The 1985 Guidelines require ACRs for species in three different families, but Daphnia and Ceriodaphnia are in the same family. However, even though the ACR for the fathead minnow should not be used in calculations because the acute and chronic tests using the fathead minnow were performed in different dilution waters, the fathead minnow ACR can be considered a qualitative ACR and used to satisfy the MDRs because chloride is not likely to be complexed or sorbed or detoxified by organic or inorganic constituents of the dilution water.

The GMACRs for Oncorhynchus and Daphnia are consistent with the "greater than" GMACR for Ceriodaphnia and the GMACRs are within a factor of ten. Therefore, the Final ACR = 4.826, which is the geometric mean of the GMARCs for Oncorhynchus and Daphnia. This would give FCV = FAV/FACR = (1355 mg chloride/L)/4.826 = 280.8 mg chloride/L. However, this approach is contraindicated because the GMACRs (including the unused GMACR for Pimephales) indicate that the GMACR increases as the GMAV increases.

The GMACR for Daphnia is consistent with the "greater than" GMACR for Ceriodaphnia, so the GMACR for Daphnia can be used as the FACR. Therefore, FACR = 3.187 and FCV = FAV/FACR = (1355 mg chloride/L)/3.187 = 425.2 mg chloride/L.

CCC = FCV = 425.2 mg chloride/L.

The CMC and CCC given above are for hardness = 300 mg/L. The equation that was used to normalize the acute values can be used to make the CMC and CCC dependent on hardness. The resulting equations for the CMC and CCC are:

$$\text{CMC} = (677.5 \text{ mg chloride/L})\ (\text{hardness}/300)^{0.217736}$$
$$= (195.7 \text{ mg chloride/L})\ (\text{hardness})^{0.217736}$$

At hardness = 300 mg/L, CMC = 677.5 mg chloride/L.

$$\text{CCC} = (425.2 \text{ mg chloride/L})\ (\text{hardness}/300)^{0.217736}$$
$$= (122.8 \text{ mg chloride/L})\ (\text{hardness})^{0.217736}$$

At hardness = 300 mg/L, CCC = 425.2 mg chloride/L.

Derivation of an Alternative FCV

Even though the above derivation of FCV = 378.1 mg chloride /L follows the procedure described in the 1985 Guidelines, there is an alternative approach that is justified on the basis of the "good science" clause in section XII.B of the 1985 Guidelines. This approach is based on the fact that the four low SMACRs for chloride were obtained with invertebrates, whereas the high SMACR was obtained with a vertebrate. This can be interpreted to mean that vertebrates have a higher ACR, on the average, than invertebrates, especially because the qualitative ACR for the fathead minnow is 15.17. Therefore, a vertebrate ACR and an invertebrate ACR can be used with the GMAVs to calculate a predicted Genus Mean Chronic Value for each genus, and then a FCV can be calculated directly from the predicted GMCVs. This approach calculates and uses a predicted chronic value for each genus for which an acute value is available and probably does a better job of taking into account the chronic sensitivities of both vertebrates and invertebrates to chloride. The relevant data and calculations are presented on the next few pages.

The FACR of 3.187 derived above was derived from all of the acceptable ACRs for invertebrates. The only acceptable ACR for a vertebrate is 7.308. A predicted GMCV can be calculated from each GMAV by using 3.187 as the invertebrate ACR and using 7.308 as the vertebrate ACR.

Table of predicted GMCVs for Chloride

(GMAVs and pGMCVs are expressed as mg chloride/L)
(ranked according to predicted GMCVs)

Rank	GMAV	Genus	Species	pGMCV
29	21570	Agria	Damselfly, Agria sp.	6768
	18647	Cambarus	Crayfish, Cambarus sp.	5851
	17082	Libellulidae*	Dragonfly, Libellulidae	5360

18190	Anquilla	American eel, Anquilla rostrata	2489
6346	Tubifex	Tubificid worm, Tubifex tubifex	1991
------	Chironomus	Midge, Chironomus attenuatus	-----
5780	Erpobdella	Leech, Erpobdella punctata	1814
13430	Gasterosteus	Threespine stickleback, Gasterosteus aculeatus	1838
17144	Fundulus	Plains killifish, Fundulus kansae	2346
11026	Carassius	Goldfish, Carassius auratus	3460
4987	Hyalella	Amphipod, Hyalella azteca	1565
5955	Asellus	Isopod, Asellus communis	1869
4777	Limnodrilus	Tubificid worm, Limnodrilus hoffmeisteri	1499
4739	Helisoma	Snail, Helisoma campanulata	1487

10770	Oncorhynchus	Rainbow trout, Oncorhynchus mykiss	1474
11432	Gambusia	Mosquitofish, Gambusia affinis	1564
-----	Gammarus	Amphipod, Gammarus pseudolimnaeus	-----
-----	Crangonyx	Amphipod, Crangonyx sp.	-----
-----	Nemoura	Stonefly, Nemoura trispinosa	-----
-----	Lepidostoma	Caddisfly, Lepidostoma sp.	-----
-----	Parapsyche	Caddisfly, Parapsyche sp.	-----
3884	Lirceus	Isopod, Lirceus fontinalis	1219
10001	Lepomis	Green sunfish, Lepomis cyanellus	1368
		Bluegill, Lepomis macrochirus	
3603	Physa	Snail, Physa heterostropha	1131

		Snail, Physa gyrina	
4541	Diaptomus	Copepod, Diaptomus clavipes	1425
2901	Villosa	Mussel, Villosa delumbis	910.3
		Mussel, Villosa iris	
10324	Notropis	Red shiner, Notropis lutrensis	1413
3059	Gyraulus	Snail, Gyraulus circumstriatus	959.8
		Snail, Gyraulus parvus	
2666	Lampsilis	Mussel, Lampsilis fasciola	836.5
		Mussel, Lampsilis siliquoidea	
8565	Ameiurus	Black bullhead, Ameiurus melas	1172
6868	Pimephales	Fathead minnow, Pimephales promelas	939.8

4	2343	Daphnia	Cladoceran, Daphnia ambigua Cladoceran, Daphnia magna Cladoceran, Daphnia pulex	735.2
3	4678	Pseudacris	Chorus frog, Pseudacris sp.	640.1
2	1598	Ceriodaphnia	Cladoceran, Ceriodaphnia dubia	501.4
1	1089	Sphaerium	Fingernail clam, Sphaerium simile Fingernail clam, Sphaerium tenue	341.7

* Name of family, not name of genus.

FCV based on predicted GMCVs = 417.8 mg chloride/L at hardness = 300 mg/L.

$$\text{CCC} = (417.8 \text{ mg chloride/L})\ (\text{hardness}/300)^{0.217736}$$
$$= (120.7 \text{ mg chloride/L})\ (\text{hardness})^{0.217736}$$

At hardness = 300 mg/L, CCC = 417.8 mg chloride/L.

Procedure D for Chloride

Table 1

(based on toxicity tests on sodium chloride)
(Acute Values and Normalized Acute Values are expressed as mg chloride/L)

Normalized Acute Values were calculated by normalizing the Acute Values to hardness = 300 mg/L using the following equation:

$$NAV = (AV)\ (300/Hardness)^{0.217736}$$

This equation is based on regression analysis of results of toxicity tests concerning the effect of hardness on the acute toxicity of chloride to C. dubia. The hardness of 300 mg/L is arbitrary; any other hardness would have worked equally well. NAVs could not be calculated for all AVs because assumed hardnesses were not used. Some of the hardnesses are nominal, not measured.

Species	Method	Chemical	Hardness (mg/L)	Sulfate (mg/L)	Acute Value	Normalized Acute Value	Reference
Tubificid worm, Limnodrilus hoffmeisteri	S,U	Sodium chloride	100	----	3761	4777	Wurtz and Bridges 1961
Tubificid worm, Tubifex tubifex	S,M	Sodium chloride	52 220	57.9 58.9	4278 6008	6266 6428	GLEC and INHS 2008
Leech, Erpobdella punctata	S,U	Sodium chloride	100	----	4550	5780	Wurtz and Bridges 1961
Mussel, juvenile Villosa delumbis	S,M	Sodium chloride	169.5	162.7	3173	3593	Bringolf et al. 2007

Mussel, juvenile Villosa iris	R,M	Sodium chloride	169.5	162.7	2069	2343	Wang 2007
Mussel, juvenile Lampsilis fasciola	S,M	Sodium chloride	169.5	162.7	2414	2734	Bringolf et al. 2007
Mussel, juvenile Lampsilis siliquoidea	R,M	Sodium chloride	169.5	162.7	1905	2157	Wang 2007
Mussel, juvenile Lampsilis siliquoidea	S,M	Sodium chloride	169.5	162.7	2766	3132	Bringolf et al. 2007
Fingernail clam, Sphaerium simile	S,M	Sodium chloride	51 192	59.9 61.7	740 1100	1088 1212	GLEC and INHS 2008
Fingernail clam, Sphaerium tenue	S,U	Sodium chloride	100 20	---- ----	667 698	847.3 1259	Wurtz and Bridges 1961
Snail, Physa gyrina	F,M	Sodium chloride	84.8	81.4	2540	3344	Birge et al. 1985
Snail, Physa heterostropha	S,U	Sodium chloride	100 100 100 20	---- ---- ---- ----	2123 3094 3761 2487	2697 3930 4777 4485	Wurtz and Bridges 1961
Snail, Physa sp.	S,M	Sodium chloride	22	15	3247hp	5735	Clemens and Jones 1954
Snail, Physa sp.	S,U	Sodium chloride	----	----	>3000p	-----	Williams et al. 2000
Snail,	S,U	Sodium	100	----	1941	2466	Wurtz and Bridges 1961

Gyraulus circumstriatus		chloride					
Snail, Gyraulus parvus	S,M	Sodium chloride	56 212	60.9 59.7	3078 3009	4436 3245	GLEC and INHS 2008
Snail, Helisoma campanulata	S,U	Sodium chloride	100	----	3731	4739	Wurtz and Bridges 1961
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8	81.4	1189brt 1042brt	1566 1372	Mount et al. 1997
Cladoceran, Ceriodaphnia dubia	R,U	Sodium chloride	74.1	----	1395	1891	Cowgill and Milazzo 1990
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	39.2	4.6	507 447	789.7 696.2	Hoke et al. 1992
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	39.2 39.2 39.2 39.2 339.0	4.6 4.6 4.6 4.6 325.4	1395 1638 1274 1395 1698	2173 2551 1984 2173 1653	USEPA 1991
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8 169.5	81.4 162.7	1677c 1499c	2208 1697	WISLOH 2007
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8	81.4	1413e	1860	Valenti et al. 2007
Cladoceran, Ceriodaphnia dubia	S,M	Sodium chloride	67.1	64.4q	964	1336	Harmon et al. 2003
Cladoceran,	S,M	Sodium	30	78.7	947	1563	GLEC and INHS 2008

Ceriodaphnia dubia		chloride	44	75.9	955	1451	
			96	73.7	1130	1448	
			180	67.7	1609	1798	
			400	78.7	1491	1400	
			570	76.2	1907	1658	
			800	75.5	1764	1425	
			25	69.9	1007	1730	
			49	67.8	767	1138	
			95	70.3	1369	1758	
			194	69.9	1195	1314	
			375	68.9	1687	1607	
			560	68.3	1652	1442	
			792	70.9	1909	1545	
			280	28.1	1400	1421	
			280	59.6	1720	1746	
			280	117	1394	1415	
			280	239	1500	1523	
			280	482	1109	1126	
			280	729	1206	1224	
			279	22.9	1311	1332	
			276	49.7	1258	1281	
			283	107	1240	1256	
			281	229	1214	1231	
			290	461	1199	1208	
			278	694	1179	1199	
Cladoceran, Daphnia ambigua	S,M	Sodium chloride	67.1	64.4q	1213	1681	Harmon et al. 2003.
Cladoceran, Daphnia magna	S,U	Sodium chloride	84.8	81.4	2893brs	3809	Mount et al. 1997
Cladoceran,	S,U	Sodium	240	-----	621	651.9	Khangarot and Ray 1989

Daphnia magna		chloride					
Cladoceran, Daphnia magna	S,U	Sodium chloride	39.2 39.2 39.2	4.6 4.6 4.6	3038 2726 2053	4732 4246 3198	Hoke et al. 1992
Cladoceran, Daphnia magna	-,-	Sodium chloride	----	----	1008k 3319m	------ ------	Cowgill 1987
Cladoceran, Daphnia magna	S,U	Sodium chloride	108.7	13	<2548	<3178	Anderson 1946
Cladoceran, Daphnia magna	S,U	Sodium chloride	108.7	13	2232i	2784	Anderson 1948
Cladoceran, Daphnia magna	S,U	Sodium chloride	41.5	31.2	3563	5481	Dowden and Bennett 1965
Cladoceran, Daphnia magna	S,M	Sodium chloride	45.3	3.9v	2529a,f 2806b,f	3817 4235	Biesinger and Christensen 1972
Cladoceran, Daphnia magna	S,U	Sodium chloride	169.5	162.7	>2669 <3943d	>3022 <4465	Seymour et al. 1997
Cladoceran, Daphnia magna	S,U	Sodium chloride	46	3.9v	1880	2828	USEPA 1991
Cladoceran, Daphnia magna	S,U	Sodium chloride	169.5	162.7	3944c	4466	WISLOH 2007
Cladoceran, Daphnia magna	S,U	Sodium chloride	84.8	81.4	3009e	3962	Valenti et al. 2007

Cladoceran, Daphnia magna	S,U	Sodium chloride	106	102	3136 3222 3137	3933 4041 3935	Davies and Hall 2007
Cladoceran, Daphnia pulex	S,M	Sodium chloride	84.8	81.4	1470	1936	Birge et al. 1985
Cladoceran, Daphnia pulex	S,U	Sodium chloride	84.8 84.8 84.8 84.8	81.4 81.4 81.4 81.4	1159 1775 1805 2242	1526 2337 2377 2952	Palmer et al. 2004
Copepod, Diaptomus clavipes	S,M	Sodium chloride	22	15	2571h	4541	Clemens and Jones 1954
Isopod, Asellus communis	S,U	Sodium chloride	100 20	---- ----	5004 3094	6356 5580	Wurtz and Bridges 1961
Isopod, Lirceus fontinalis	F,M	Sodium chloride	84.8	81.4	2950	3884	Birge et al. 1985
Amphipod, Hyalella azteca	S,U	Sodium chloride	102.5	98.4	3947	4987	Lasier et al. 1997
Amphipod, Gammarus pseudolimnaeus	S,U	Sodium chloride	----	---	>3000	------	Williams et al. 2000
Amphipod, Crangonyx sp.	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Crayfish, Cambarus sp.	S,M	Sodium chloride	22	15	10557h	18647	Clemens and Jones 1954

Dragonfly, Libellulidae	S,M	Sodium chloride	22	15	9671h	17082	Clemens and Jones 1954
Damselfly, Agria sp.	S,U	Sodium chloride	100 20	---- ----	14558 13952	18492 25160	Wurtz and Bridges 1961
Stonefly, Nemoura trispinosa	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Caddisfly, Lepidostoma sp.	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Caddisfly, Parapsyche sp.	S,U	Sodium chloride	----	----	>3000	------	Williams et al. 2000
Midge, Chironomus attenuatus	S,U	Sodium chloride	----	----	4850	------	Thornton and Sauer 1972
American eel, Anquilla rostrata	S,U	Sodium chloride	42.4	40.7	10846	16607	Hinton and Eversole 1978
American eel, Anquilla rostrata	S,U	Sodium chloride	42.4	40.7	13012	19924	Hinton and Eversole 1979
Goldfish, Carassius auratus	S,M	Sodium chloride	148.8	----	9465	11026	Threader and Houston 1983
Red shiner, Notropis lutrensis	S,M	Sodium chloride	22	15	5771g 5920g	10193 10456	Clemens and Jones 1954
Fathead minnow, Pimephales promelas	S,U	Sodium chloride	39.2 39.2 339.0	4.6 4.6 325.4	2790 2123 2244	4346 3307 2185	USEPA 1991

Fathead minnow, Pimephales promelas	F,M	Sodium chloride	84.8	81.4	6570	8651	Birge et al. 1985
Fathead minnow, Pimephales promelas	S,M	Sodium chloride	22	15	5288g 5431g	9340 9593	Clemens and Jones 1954
Fathead minnow, Pimephales promelas	S,U	Sodium chloride	84.8	81.4	3876br	5103	Mount et al. 1997
Fathead minnow, Pimephales promelas	S,U	Sodium chloride	84.8 169.5	81.4 162.7	4167c 4127c	5487 4673	WISLOH 2007
Black bullhead, Ameiurus melas	S,M	Sodium chloride	22	15	4849g	8565	Clemens and Jones 1954
Rainbow trout, Oncorhynchus mykiss	S,U	Sodium chloride	22.4	----	>485j	>853.3j	Camargo and Tarazona 1991
Rainbow trout, Oncorhynchus mykiss	F,M	Sodium chloride	46	3.9v	6743	10143	Spehar 1986,1987
Rainbow trout, Oncorhynchus mykiss	R,U	Sodium chloride	284	----	12363	12511	Vosyliene et al. 2006
Brown trout, Salmo trutta	S,U	Sodium chloride	22.4	----	>607j	>1068j	Camargo and Tarazona 1991
Plains killifish, Fundulus kansae	S,M	Sodium chloride	22	15	9706g	17144	Clemens and Jones 1954
Mosquitofish, Gambusia affinis	S,M	Sodium chloride	22	15	6472g	11432	Clemens and Jones 1954

Mosquitofish, Gambusia affinis	S,U	Sodium chloride	----	14.9	9099	------	Al-Daham and Bhatti 1977
Threespine stickleback, Gasterosteus aculeatus	R,M	Sodium chloride	84.8	81.4	10200b	13430	Garibay and Hall 2004
Green sunfish, Lepomis cyanellus	S,M	Sodium chloride	22	15	6499g	11479	Clemens and Jones 1954
Bluegill, Lepomis macrochirus	F,M	Sodium chloride	84.8	81.4	5840	7689	Birge et al. 1985
Bluegill (3.7 g), Lepomis macrochirus	S,U	Sodium chloride	44.3	15.5	7853	11910	Academy of Natural Sciences 1960; Patrick et al. 1968; Trama 1954
Chorus frog, Pseudacris sp.	R,M	Sodium chloride	84.8	81.4	3553	4678	Garibay and Hall 2004

a = not fed. (All tests not marked "a" or "b" were unfed tests.)
b = fed.
c = mean of at least 15 LC50s.
d = range of several toxicity tests.
e = mean of 32 tests.
f = not used because there is reason to suspect that the daphnids might have been unhealthy.
g = tables 4, 7, and 9, except for tests at 28C in table 4.
h = tables 8 and 11; Daphnia pulex tests were not used because test duration was 96 hr.
i = test duration was 64 hr.
j = no deaths in 196 hr.
k = selenium deficient.
m = selenium sufficient
p = not used in calculation of GMAV because the species is unknown and so it is not known how to combine this acute value with the acute values for which the species are known.

q = calculated using the formula for reconstituted water and the reported average measured hardness.
r = concentrations were measured in stock solutions.
s = not acclimated to the dilution water.
t = might not have been acclimated to the dilution water.
v = based on analyses of samples of Lake Superior water taken in the spring and fall of 2008.

Supplementary information concerning the results of toxicity tests on chloride

1. The atomic weights used are those given on the website of the National Institute of Standards and Technology:
   Calcium = 40.078
   Carbon = 12.011
   Chlorine = 35.453
   Hydrogen = 1.008
   Iron = 55.845
   Magnesium = 24.305
   Nitrogen = 14.007
   Oxygen = 15.999
   Potassium = 39.098
   Sodium = 22.990
   Sulfur = 32.065

2. The molecular weights used are:
   $CaCl_2$ = 110.984 (63.89 % chloride) (36.11 % calcium) (Cl/Ca = 1.769)
   $CaCl_2 \cdot 2H_2O$ = 147.014 (27.26 % calcium) (48.23 % chloride)
   $CaCO_3$ = 100.086 (40.04 % calcium)
   CaO = 56.077 (71.47 % calcium)
   $Ca(NO_3)_2$ = 164.086 (24.42 % calcium)
   $Ca(NO_3)_2 \cdot 4H_2O$ = 236.146 (16.97 % calcium)
   $CaSO_4$ = 136.139 (70.56 % sulfate)
   $CaSO_4 \cdot 2H_2O$ = 172.169 (55.79 % sulfate) (23.28 % calcium) (20.93 % water)
   $FeCl_3 \cdot 6H_2O$ = 270.294 (39.35 % chloride)
   H_2O = 18.015
   KCl = 74.551 (47.56 % chloride) (52.44 % potassium) (Cl/K = 0.9068)
   K_2SO_4 = 174.257 (55.13 % sulfate)
   $MgCl_2$ = 95.211 (74.47 % chloride) (25.53 % magnesium) (Cl/Mg = 2.917)
   $MgSO_4$ = 120.366 (79.81 % sulfate) (20.19 % magnesium)
   $MgSO_4 \cdot 7H_20$ = 246.471 (38.97 % sulfate) (9.86 % magnesium)
   NaCl = 58.443 (60.66 % chloride) (39.34 % sodium) (Cl/Na = 1.542)
   Na_2SO_4 = 142.041 (67.63 % sulfate)

$Na_2SO_4 \cdot 10H_2O$ = 322.191 (29.81 % sulfate)
SO_4 = 96.061

3. Hardness (as $CaCO_3$) = (100.086/40.078)(Ca) + (100.086/24.305)(Mg) = 2.497(Ca) + 4.118(Mg)

4. Trama (1954), Cairns and Scheier (1959), Academy of Natural Sciences (1960), and Patrick et al. (1968) all reported results of toxicity tests that were performed at the Academy of Natural Sciences of Philadelphia with the bluegill in dilution waters that were very similar:

	mg/L
KCl	20
Na_2SiO_3	20
$NaHCO_3$	40
$MgSO_4 \cdot 7H_2O$	40
$Ca(NO_3)_2$	30*
$CaCO_3$	10
K_2HPO_4	10 or 2
Fe^{+++} (as ferric citrate)	4 or 0.4

Ca = 11.3 mg/L
Mg = 3.9 mg/L
Hardness = 44.3 mg/L as $CaCO_3$
Chloride = 9.5 mg/L
Sulfate = 15.5 mg/L

*Long after the tests of concern were performed, this was reported to be 40 mg/L of $Ca(NO_3)_2 \cdot 4H_20$.

5. Freeman (1953), Freeman and Fowler (1953), Fairchild (1955), Dowden (1960), Dowden (1962), and Dowden and Bennett (1965) all contained information regarding toxicity tests performed at Louisiana State University in Baton Rouge, but several different dilution waters were used. Dowden and Bennett (1965) tried to clarify the most important dilution waters used, but the citations given for the waters on page 1310 need to be clarified. Reference 4 is the correct citation for "Standard Reference Water" (SRW), but the correct citation for "Reference Dilution Water" (RDW) is reference 6 (not reference 3) and reference 3 should be cited for "glass-wool filtered University Lake Water (ULW). ULW is considered an unacceptable dilution water because it is from "a small drainpipe-fed lake on the campus of Louisiana State University" (Dowden 1960). The compositions of SRW and RDW are:

SRW	mg/L
$MgSO_4 \cdot 7H_2O$	71.

K_2SO_4	6.5
$MnSO_4 \cdot 4H_2O$	0.2
$CaCl_2 \cdot 2H_2O$	18.6
$NaHCO_3$	25.
NH_4NO_3	3.
$K_2HPO_4 \cdot 3H_2O$	1.1
CaO	32.2
$Na_2SiO_3 \cdot 9H_2O$	62.6
$FeCl_3 \cdot 6H_2O$	1.2

Ca = 23.0 mg/L
Mg = 7.0 mg/L
Hardness = 86.2 mg/L as $CaCO_3$
Chloride = 9.4 mg/L
Sulfate = 31.2 mg/L

RDW	mg/L
$CaCl_2$	110
$NaHCO_3$	110
NaCl	100
$MgSO_4 \cdot 7H_2O$	60
KCl	20

Ca = 39.7 mg/L
Mg = 5.9 mg/L
Hardness = 123.4 mg/L as $CaCO_3$
Chloride = 140.4 mg/L
Sulfate = 23.4 mg/L

6. When known, the concentration of chloride in dilution water was negligible in tests on chloride.

7. Karraker (2007) says that "road salt" contains sodium chloride, sodium ferrocyanide, heavy metals, and often sand or cinder. Results of toxicity tests on "road salt" were not used.

8. If tests in a document using some species had acceptable control mortalities but other tests in the same document using other species had unacceptable control mortalities, the tests using species with unacceptable control mortalities were not used. The general policy is that tests in a document using different species should be evaluated on a species-by-species basis, not on a document-by-document basis.

9. Hyalella azteca appears to be especially sensitive to some pollutants when the concentration of chloride is low, e.g., lower than 25 mg/L. This should not affect the sensitivity of this species to chloride.

10. Grizzle and Mauldin (1995; 24-hr tests using striped bass) and Lasier et al. (2006; 7-day survival tests using Ceriodaphnia dubia) reported that calcium and/or magnesium reduced the toxicity of chloride, but sufficient data are not available to make a chloride criterion dependent on hardness or on the concentration of calcium and/or magnesium. In contrast, McGregor et al. (1986) reported that the toxicity of NaCl was not significantly affected by hardness. Davies and Hall (2007) reported that the Ca-Mg ratio did not affect the toxicity of either NaCl or KCl to D. magna.

11. Mount et al. (1997) reported that the toxicities of sodium and calcium salts to C. dubia, D. magna, and the fathead minnow are primarily attributable to the corresponding anion.

12. Results of 96-hr toxicity tests using juvenile freshwater mussels were used if the methodology, etc., were acceptable, but results of tests using glochidia of freshwater mussels were not used. Acute (e.g., 96-h) toxicity tests using juvenile freshwater mussels are rather standard acute toxicity tests and can be evaluated using, for example, ASTM Standard E729. In contrast, acute toxicity tests using glochidia of freshwater mussels require special consideration because free-living glochidia must attach to a host in order to survive, and they typically attach within seconds to days. In addition, for a specific species and a specific toxicant, the glochidia 6-h EC50 might be substantially higher than the 24-h EC50. It is known that free-living glochidia of several species can remain viable for up to about ten days, depending on the species and on the percent viability that is considered acceptable. However, it is not known how fast glochidia of individual species usually attach to a host, and this is important because the glochidia EC50 for some toxicants and species is quite dependent on the duration of the toxicity test. Thus, a very important question is "What species-specific toxicity-test duration is ecologically relevant for glochidia?"

13. Section IV.C of the 1985 Guidelines says: "Except for tests with saltwater annelids and mysids, results of acute tests during which the test organisms were fed should not be used, unless data indicate that the food did not affect the toxicity of the test material." Section XII.B of the 1985 Guidelines says: "On the basis of all available pertinent laboratory and field information, determine if the criterion is consistent with sound scientific evidence. If it is not, another criterion, either higher or lower, should be derived using appropriate modifications of these Guidelines." Appendix 1 demonstrates that results of fed acute tests on chloride should be used and should be given preference over unfed tests when the test organisms are cladocerans.

14. Some data presented in Table 1 of USEPA (1988) have been changed:
    a. Several values differ because of roundoff differences.
    b. USEPA (1988) used results of short acute tests for the reasons given on pages 2 and 3 (see also Lowell et al. 1995), but results of short tests are not used here because short acute tests sometimes give higher LC50s than standard tests.
    c. Data from Dowden (1961, which should be 1960) and Kostecki and Jones (1983) are not used here because of the dilution water used in the tests.
    d. The test results from Trama (1954) are also given in Academy of Natural Sciences (1960) and Patrick et al. (1968).
    e. Hamilton et al. (1975) did not adequately acclimate the midges.
    f. Fed acute tests were not used in USEPA (1988), but fed tests are used here and are given preference over unfed tests when the test organisms are cladocerans.

(Acute values are expressed as mg chloride/L; quotients of acute values do not have units)

	Acute Values				Ratios of Acute Values				
	NaCl	CaCl2	MgCl2	KCl	Ca/Na	Mg/Na	K/Na	K/Mg	Mg/Ca
C. dubia Mount fed	1189	1169	655	300	0.98	0.55	0.25	0.46	0.56
D. magna Mount fed	2893	1770	990	314	0.61	0.34	0.11	0.32	0.56
D. magna B&C fed	2806	821	939	150	0.29	0.33	0.05	0.16	1.14
D. magna B&C unfed	2529	92	408	84	0.04	0.16	0.03	0.21	4.43
D. magna K&R unfed	621	679		128	1.09		0.21		
D. magna Anderson unfed (64 hr tests)	2232	588	551	205	0.26	0.25	0.09	0.37	0.94
D. magna D&B unfed	3563	1920	2755		0.54	0.77			1.43
T. tubifex Khangarot	1204	497		737	0.41		0.61		
Fathead minnow Mount fed	3876	2958	1579	418	0.76	0.41	0.11	0.26	0.53

Mosquitofish A&B unfed	9099	5196	<2378	0.57	<0.26
Bluegill Trama unfed	7853	6804	956	0.87	0.12

Appendix 2

ADVENT ENVIRON

WHOLE EFFLUENT TOXICITY STUDY OF FLUE GAS DESULPHURIZATION EFFLUENTS

Prepared for

AEP OHIO
A unit of American Electric Power

AMERICAN ELECTRIC POWER
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April 2007

FLUE GAS DESULPHURIZATION PROJECT TOXICITY TESTING

1.0 INTRODUCTION AND BACKGROUND

Acute Whole Effluent Toxicity (WET) testing was conducted to assess potential effluent toxicity if a new high-salinity Flue Gas Desulphurization (FGD) process waste stream is routed to wastewater treatment ponds at several AEP facilities. The FGD waste stream (chloride purge stream, or CPS) is produced when excess chlorides (in addition to other dissolved salts and trace metals) is "purged" from the FGD absorber vessel. FGD-simulated wastewater samples from the following plants were tested: Cardinal (Brilliant, OH), Mitchell (Moundsville, WV), Mountaineer (New Haven, WV), Clifty Creek (Madison, IN), Kyger Creek (Addison, OH), Amos (St. Albans, WV), Muskingum River (Beverly, OH), and Conesville (Coshocton, OH).

Effluent samples were collected and shipped overnight to the ADVENT-ENVIRON Ecotoxicology Laboratory. Tests were conducted with effluent, mock effluent, and salt-spiked effluent.

2.0 TOXICITY TESTING PROCEDURES

Whole effluent toxicity (WET) tests consisted of 48 hour and 96 hour acute tests with *C. dubia* and fathead minnow (*Pimephales promelas*), respectively. Test methods followed US Environmental Protection Agency (USEPA) protocols (USEPA, 2002). The primary control for each test was river water, with a secondary control of moderately hard laboratory water. Effluents, whether actual, mock, or salt-spiked, were tested at their In-stream Waste Concentration (IWC) and at 100% effluent using each site's river water for dilution and control water.

Mock effluents (i.e., laboratory control water to which salts, or salts and metals were added) were prepared based on available background analytical data for each effluent and the projected water chemistry with FGD process water. There were two types of mock effluent tests: Tier 1 (projected FGD salt, or salt and metal additions) and Tier 2 (1.5 to 2 times the Tier 1 additions). Salt-spiking tests (i.e., salt, or salt and metals added to effluents) were based on the background analytical data and projected water

chemistry for each facility. The metals added to effluents were arsenate and selanite. The other proposed additions (aluminum and copper) were not added since the projected levels were below concentrations known to cause acute toxicity. Most of the background water chemistry data were not available to ADVENT-ENVIRON until the testing had begun or was completed. Estimates were used in many cases when determining the salt, or salt and metal additions for each effluent. Some of the choices of salts selected to make mock effluents were dependent on the solubility of the salt, especially when high projected sulfate concentrations precluded the use of calcium sulfate due to its poor solubility. Salt-spiking tests were also evaluated for Tier 1 and Tier 2 salt addition levels.

3.0 RESULTS

Tables 1, 2, and 3 list LC50 values, mortality values in selected exposures, and analytical results for all tests. A brief summary of each facility's result follows. For brevity, the Tier 1 and Tier 2 salt, or salt and metal additions are indicated as "1" or "2" following each test designation. Unless otherwise noted, all control organisms met test acceptability criteria. For all sites, the calculated LC50 values were above the IWC values when LC50 values were greater than 100% effluent. Attachment 1 presents the raw data and statistics for each test. Attachment 2 presents chain-of-custody forms for each facility and recent laboratory reference toxicant data. Attachment 3 consists of the chemical data supplied by Dolan Laboratory for each facility.

AMOS

Fathead Minnow Test Results: The Amos Plant effluent (Outfall 003), Mock 1, and Salt-spike 1 toxicity tests indicated LC50 values greater than 100% effluent for fathead minnows. The Mock 2 and Salt-spike 2 toxicity tests indicated LC50 values of 71.5% and 80.3%, respectively; lower than 100% effluent, but much higher than the IWC of 20% effluent (i.e. would not cause toxicity following dilution to the IWC). These data indicate that the current effluent is not acutely toxic to the fathead minnow at 100% effluent, and only Tier 2 level FGD conditions would cause acute toxicity in 100% effluent. However, the additional toxicity is not sufficient to cause toxicity at the 20% IWC

of the Amos discharge. The IWC represents a mixture of Outfall 003 and Kanawha River water using default mixing assumptions.

***C. dubia* Test Results**: The Amos effluent indicated a *C. dubia* LC50 value of greater than 100% effluent. Although the Mock 1 and 2 LC50 values (44.7% and 38.8%, respectively) and the Salt-spike 1 and 2 LC50 values (42.9% and 44.7%, respectively) were below 100%, they were still above the IWC of 20% effluent. These data indicate that while FGD additions would increase final effluent toxicity to *C. dubia*, it is not sufficient to cause toxicity at the IWC under either the Tier 1 or Tier 2 scenarios.

Comparison of the fathead minnow and *C. dubia* data for the Tier 1 and Tier 2 additions (mock effluent and salt-spiking tests) indicates higher sensitivity of *C. dubia*. (i.e., the Tier 1 and 2 additions resulted in fathead minnow LC50 values above those of *C. dubia* for both tier conditions). This is consistent with the known higher sensitivity of *C. dubia* to salts relative to the fathead minnow.

CARDINAL

Fathead Minnow Test Results: Tests conducted with the Cardinal Plant effluent indicated possible pathogen interference in the river water diluent. The pathogen effects were present throughout the test, infecting the river water controls and the secondary moderately hard water controls. No other moderately hard laboratory water controls tested on the same date indicated these effects, and the laboratory water effects are apparently a result of cross-contamination in this test only. More than the acceptable 10% mortality was observed in the river water and moderately hard water controls. Regardless, the fathead minnow tests with the Cardinal effluent and all mock and salt-spiked effluents indicated no acute toxicity at the 100% effluent levels. These data indicate that FGD additions to the effluent should not result in non-compliance with acute WET limits for this site.

***C. dubia* Test Results**: The *C. dubia* tests with the Cardinal effluent and all mock and salt-spiked effluents indicated no acute toxicity (LC50 values greater than 100% effluent) and thus it is expected that meeting acute WET limits for this discharge (if applicable)

would not be problematic. Comparison of the Amos and Cardinal Tier 1 and Tier 2 additions' toxicity to *C. dubia* also indicates higher toxicity under projected Amos FGD conditions.

CLIFTY CREEK

Fathead Minnow Test Results: Tests conducted with the Clifty Creek plant effluent and all mock and spiked effluents indicated LC50 values greater than 100% effluent. There was some mortality observed in the test concentrations, but mortality was less than 50 percent. Once again, the control organisms indicated pathogen interference, but test results indicate likely compliance with projected IWC-based WET limits of 20% effluent.

***C. dubia* Test Results:** There was no acute mortality in the effluent, mock, or spiked effluent tests with *C. dubia*. The LC50 values were all greater than 100% effluent, and also indicate likely compliance at projected IWC-based WET limits. The amount of toxicity was insufficient to generate LC50 values below 100% effluent to either species with Tier 1 or Tier 2 salt additions.

CONESVILLE

Fathead Minnow Test Results: Tests with Conesville effluent indicated an LC50 value of greater than 100% effluent. The river water control organisms met test acceptability criteria, and did not exhibit the mortality that was observed in other river water controls. The mock effluents and salt-spiked effluents indicated some acute mortality less than 40%, but not enough to generate an LC50 value in any exposures. The mock effluents and Tier 1 salt-spiked test indicated 25 percent or less mortality, and only the Tier 2 salt-spiked test indicated 40% mortality.

***C. dubia* Test Results:** The *C. dubia* tests with effluent, mock 1, and spiked-effluent indicated LC50 values of greater than 100% effluent. Testing with the mock Tier 2 effluent produced an LC50 value of 86.4% effluent. All LC50 values were greater than the IWC of 20% effluent.

KYGER CREEK

Fathead Minnow Test Results: The fathead minnow toxicity test results indicated pathogen interference with all control and effluent-exposed organisms. Although toxicity was observed in all test concentrations and controls, LC50 values were greater than 100% effluent for all tests except the Tier 2 mock effluent (LC50 value 93.3%) The mortality in all other tests ranged from 15 to 40 percent. All LC50 values were greater than the IWC of 50% effluent.

***C. dubia* Test Results:** No mortality was observed for any of the *C. dubia* toxicity tests except for the Tier 2 mock and Tier 2 salt-spiked test (resulting LC50 values approximately 71% effluent). Regardless, all LC50 values were above the 50% IWC value, indicating compliance with projected WET limits.

MITCHELL

Fathead Minnow Test Results: The fathead minnow toxicity tests with Mitchell plant effluent and mock effluents indicated LC50 values of greater than 100% effluent. The salt-spiked effluent tests indicated an LC50 value of greater than 100% effluent for the Tier 1 test, but an LC50 value of 44.7% for the Tier 2 salt-spiked effluent. All LC50 values were above the IWC of 20% effluent.

***C. dubia* Test Results:** The LC50 value for the *C. dubia* test with Mitchell plant effluent was greater than 100% effluent. No mortality was observed in the effluent at either the 100% or IWC concentration of 20% effluent. However, the mock effluents indicated LC50 values of 44.7% and less than 20% at respective Tier 1 and Tier 2 levels. An LC50 value of 44.7% effluent was observed for Tier 1 and Tier 2 salt-spiking tests (the reason for this is unknown). With the exception of the Tier 2 mock effluent test, all LC50 values were greater than the IWC of 20% effluent.

MOUNTAINEER

Fathead Minnow Test Results: The toxicity test with Mountaineer Plant effluent indicated an LC50 value of greater than 100% effluent. The mock effluent indicated similar LC50 values of approximately 85% effluent at the Tier 1 and Tier 2 spiking levels. This may be an artifact of the pathogen interference in these tests. The Tier 1 salt-spiked effluent tests indicated LC50 values of greater than 100% effluent, but an LC50 value of less than 20% effluent for the Tier 2 salt-spiked test. All tests except the Tier 2 salt-spiked test indicate projected compliance at the IWC of 20% effluent. These effects may be due to the combined effects of the salt addition and pathogens noted in the test.

***C. dubia* Test Results:** The LC50 value for the *C. dubia* test was greater than 100% effluent. No mortality was observed in the effluent at either the 100% exposure or the 20% IWC concentration. However, the mock effluents indicated LC50 values of less than the IWC of 20% effluent. Mortality of *C. dubia* in the test concentration of 20% of Mock 1 and 2 effluents reached 60% and 100% mortality, respectively. The salt-spiked effluent tests indicated LC50 values of 44.7% (Tier 1) and 36.6% (Tier 2). Although the salt-spiked effluent tests indicate toxicity near the IWC of 20% effluent, only the mock effluent tests indicate potential non-compliance at the IWC. This effluent received the highest levels of spiked fluoride. The projected fluoride concentrations (210 mg/L and higher) are similar to a previously reported acute toxicity value of 250 mg/L to *Daphnia magna*. (Fieser, A.H. et al, 1986 and LeBlanc, G.A., 1980)

MUSKINGUM RIVER

Fathead Minnow Test Results: The fathead minnow tests with Muskingum River Plant effluent indicated LC50 values of greater than 100% effluent for all tests conducted. However, the control organisms appeared to be infected by a pathogen that caused mortality in the river water controls and some of the test concentrations. The toxicity data indicate compliance with projected WET limits at the IWC of 10% effluent.

***C. dubia* Test Results:** The Muskingum effluent was not acutely toxic to *C. dubia* at 100% effluent. The Tier 1 mock and salt-spiked effluents were also not acutely toxic to

C. dubia at 100% effluent. However, the Tier 2 mock and salt-spiked effluents had LC50 values of 31.6% effluent, but still greater than the IWC of 10% effluent.

SUMMARY

In summary, none of the existing coal ash pond effluents induced acute toxicity to the fathead minnow or *C. dubia* sufficient to result in LC50 values of less than 100% effluent. Projected FGD chemical additions did not increase WET to either test organism (Tier 1 or Tier 2 levels) for effluent samples from Cardinal and Clifty Creek plants.

Acute toxicity to fathead minnow increased mainly at the Tier 2 level additions, except for the Mountaineer Plant test where the Tier 1 level addition in mock effluent indicated an LC50 value of 85.1% effluent. This test also had pathogen interference, which may have contributed to the observed toxicity. The Mountaineer Tier 2 level salt-spike test indicated a fathead minnow LC50 value lower than the site's corresponding IWC (20% effluent). The relatively high toxicity observed in the Mountaineer Plant salt-spiking tests may be anomalous given the pathogen interference. Re-running these tests may resolve this discrepancy. Ultimately, WET tests using full scale FGD-influenced wastewater would be necessary to confirm projected results.

Acute toxicity to *C. dubia* increased in three of the eight Tier 1 level mock and salt spiked effluent additions (Amos, Mitchell, and Mountaineer), in five of the eight Tier 2 salt-spiked effluents, and in six of the eight Tier 2 level mock effluents. Taken with the fathead minnow data, these data reflect the higher sensitivity of *C. dubia* to salts and metals. The *C. dubia* data also indicated fairly good agreement between the mock and salt-spiked effluent test results. The Mitchell and Mountaineer tests indicated the highest toxicity to *C. dubia* due to FGD additions, and were the only sites with toxicity sufficient to be potentially non-compliant with projected IWC-based WET limits. The projected concentrations of fluoride may be of concern in these effluents. At the time of sampling and testing, the measured fluoride values for current Mitchell and Mountaineer effluents indicated 0.25 mg/L and 0.77 mg/L of fluoride, respectively.

All other plant effluents, mock effluents, and salt-spiked effluents indicated some degree of toxicity, but not enough to generate LC50 values of less than the IWC for each facility. There were cases of fathead minnow mortality due to pathogen interference, and this could have caused or contributed to some mortality in effluent exposures. However, even with pathogen infections to fish, most of the plant effluents did not indicate increased toxicity at the additional salt or salt and metals concentrations that would cause LC50 values to be less than the IWC for each plant. As expected, *C. dubia* were more sensitive to the salt additions. Additional *C. dubia* testing of the Mitchell effluent may also be warranted as it and the Mountaineer Plant are the only sites where FGD additions exceeded IWC-based WET limits, albeit only under Tier 2 conditions.

REFERENCES

USEPA, 2002. *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms* (Fifth Ed.). EPA-821-R-02-012. US Environmental Protection Agency, Office of Water. Washington, DC.

Fieser, A.H., J.L. Sykora, M.S. Kostalos 1986. *Effect of fluorides on survival and reproduction of Daphnia magna.* J. Water Pollution Control Federation 58(1):82:86.

LeBlanc, G.A. 1980. *Acute toxicity of priority pollutants to water flea (Daphnia magna).* Bulliten of Environmental Contamination and Toxicology. 24(5): 684:691.

Table 2. Major Ion Analysis for AEP Power Plants

Plant Name	Water Source	Cations (mg/L) Calcuim	Magnesium	Sodium	Potassium	Anions (mg/L) Chloride	Sulfate	Alkalinity	Sum Major Ions	Measured TDS
Amos	Intake	19	8	20	3	18	38	59	164	131
	003 CP discharge	42	17	41	6	38	140	78	361	326
	Tier 1	122	854	53	5	2497	293	140	3964	
	Tier 2	183	1283	53	5	3746	438	140	5847	
Clifty Creek	intake	35	11	19	3	27	46	64	204	190
	002	45	13	22	5	30	98	78	291	269
	Tier 1	307	107	22	0	311	737	59	1542	
	Tier 2	461	160	22	0	466	1105	59	2272	
Mountaineer	intake	30	8	20	3	29	54	40	184	182
	001	137	36	101	14	108	366	108	870	925
	Tier 1	292	549	47	0	1600	700	123	3311	
	Tier 2	438	823	70	0	2400	1050	185	4966	
Conesville	upstream	54	17	?	6	41	82	105	305	410
	001	56	28	18	9	30	127	60	327	335
	Tier 1	366	72	53	7	218	878	140	1735	
	Tier 2	915	181	53	7	534	2194	140	4025	
Kyger	upstream	139	19	37	13	58	332	36	635	644
	005 FA pond	114	57	27	7	31	264	42	542	502
	Tier 1	248	263	8	5	772	594	22	1913	
	Tier 2	620	658	8	5	1924	1485	22	4722	
Cardinal	upstream	29	8	16	3	28	47	43	173	190
	001	32	9	18	3	27	48	43	180	180
	Tier 1	54	34	7	0	98	130	18	340	
	Tier 2	135	84	7	0	244	325	18	813	
Muskingum	upstream	46	14	15	6	24	49	84	238	223
	002 Unit 5 AP discharge	171	30	58	16	75	418	59	827	835
	Tier 1	473	242	65	15	735	1113	172	2815	
	Tier 2	1169	620	65	15	1836	2783	172	6659	
Mitchell	river water	24	6	16	6	21	37	40	149	162
	001 Bottom AP discharge	39	10	66	10	95	96	40	356	372
	Tier 1	405	492	26	5	1441	970	69	3408	
	Tier 2	607	738	26	5	2159	1455	69	5059	

Ca:Mg ratio 1:1 or less.

Table 3. Water Chemistry Comparison

Water Type	A-E Hardness mg/L	Dolan Hardness mg/L	A-E Alkalinity mg/L	Dolan Alkalinity mg/L	A-E pH s.u.	Dolan pH s.u.	A-E Conductivity umhos/cm
Amos Effluent	84	172	162.4	78	7.8	7.40	554
Amos Mock 1	3000		125		8.59		8510
Amos Salt Spike 1	4000		100		7.73		7940
Amos Mock 2	6000		125		8.55		12650
Amos Salt Spike 2	2600		85		7.66		11850
Cardinal Effluent	168	114	44	43	7.68		449
Cardinal Mock 1	2664		30		7.47		574
Cardinal Salt Spike 1	336		33		7.58		729
Cardinal Mock 2	608		30		7.47		1297
Cardinal Salt Spike 2	520		40		7.45		1164
Clifty Creek Effluent	152	165	121	78	8.17	7.90	430
Clifty Creek Mock 1	3000		55		8.65		2160
Clifty Creek Salt Spike 1	3900		55		8.03		2300
Clifty Creek Mock 2	4500		50		8.55		3230
Clifty Creek Salt Spike 2	4500		55		8.01		3110
Conesville Effluent	256	255	75	60	7.72	7.00	533
Conesville Mock 1	1220		120		8.22		2340
Conesville Salt Spike 1	1392		200		8.03		2740
Conesville Mock 2	2500		135		8.14		4330
Conesville Salt Spike 2	2920		380		7.85		5640
Kyger Effluent	300	350	43	42	8.54	6.80	772
Kyger Mock 1	1640		28		7.68		3320
Kyger Salt Spike 1	1400		51		8.03		3030
Kyger Mock 2	4140		15		7.47		7740
Kyger Salt Spike 2	3248		44		7.99		6480
Mitchell Effluent	136	138	48	40	7.74	6.80	568
Mitchell Mock 1	3000		55		9.06		5870
Mitchell Salt Spike 1	3900		55		7.74		6520
Mitchell Mock 2	4500		50		8.52		8810
Mitchell Salt Spike 2	4500		55		7.71		8990
Muskingum Effluent	488	549	85	59	8.37	7.90	1265
Muskingum Mock 1	3800		155		8.20		4450
Muskingum Salt Spike 1	4000		80		8.12		4250
Muskingum Mock 2	5600		155		8.17		9410
Muskingum Salt Spike 2	8500		90		8.01		8530
Mountaineer Effluent	492	488	125	108	8.26	7.70	1468
Mountaineer Mock 1	3300		85		7.99		6250
Mountaineer Salt Spike 1	2300		115		7.79		6380
Mountaineer Mock 2	4000		110		8.26		9030
Mountaineer Salt Spike 2	3300		120		7.73		8760

Table 1. LC50 Values for FGD Study Effluents

Sample ID	Test Date	Effluent						Tier 1 Mock Effluent						Tier 2 Mock Effluent						Tier 1 Salt Solvad Effluent						Tier 2 Salt Solvad Effluent					
		FM			CD			FM			CD			FM			CD			FM			CD			FM			CD		
		IWC Percent Mortality	100% Percent Mortality	LC50 Value (%)	IWC Percent Mortality	100% Percent Mortality	LC50 Value (%)	IWC Percent Mortality	100% Percent Mortality	LC50 Value (%)	IWC Percent Mortality	100% Percent Mortality	LC50 Value (%)	IWC Percent Mortality	100% Percent Mortality	LC50 Value (%)	IWC Percent Mortality	100% Percent Mortality	LC50 Value (%)	IWC Percent Mortality	100% Percent Mortality	LC50 Value (%)	IWC Percent Mortality	100% Percent Mortality	LC50 Value (%)	IWC Percent Mortality	100% Percent Mortality	LC50 Value (%)	IWC Percent Mortality	100% Percent Mortality	LC50 Value (%)
Ames (IWC = 20%)	8/8/2006	15	70	> 100	5	0	>100	5	10	>100	0	100	<44.7	10	65	71.5	15	100	38.8	25	20	>100	5	100	42.9	5	60	60.3	0	100	<44.7
Cardinal (IWC = 5%)	7/28/2006	30	30	>100*	5	5	>100	20	30	>100*	0	0	>100	25	10	>100*	0	0	>100	35	15	>100*	0	0	>100	45	30	>100*	0	0	>100
Gilby Creek (IWC = 20%)	8/9/2006	30	20	>100*	0	0	>100	20	20	>100*	5	5	>100	15	35	>100*	0	10	>100	30	30	>100*	0	0	>100	30	40	>100*	0	0	>100
Conesville (IWC = 20%)	7/13/2006	5	0	>100	0	0	>100	5	15	>100	5	0	>100	25	25	>100	0	55	89.4	10	0	>100	0	5	>100	10	40	>100	0	15	>100
Kyger (IWC = 50%)	7/25/2006	30	40	>100*	0	0	>100	40	25	>100*	0	0	>100	30	55	85.3*	0	100	70.7	20	35	>100*	0	0	>100	15	25	>100*	0	95	72
Mitchell (IWC = 20%)	8/9/2006	35	25	>100	0	0	>100	30	25	>100	0	100	<44.7	15	15	>100	65	100	<20	20	10	>100	0	100	44.7	45	65	<44.7	0	100	<44.7
Mountaineer (IWC = 20%)	8/23/2006	10	15	>100*	0	0	>100	5	55	85.4*	80	100	<20	0	55	85.4*	100	100	<20	10	45	>100*	0	100	44.7	85	85	<20*	20	100	36.4
Muskingum (IWC = 10%)	7/19/2006	10	30	>100*	0	0	>100	15	30	>100*	0	75	>100	15	35	>100*	0	100	31.6	10	20	>100*	0	15	>100	0	35	>100*	0	100	31.6

*Control failure due to a natural pathogen in river water
BOLD - LC50 Values greater than 100 percent effluent
Blue - LC50 Value less than 100 percent effluent
Red - LC50 Values less than the IWC