Draft Chloride Aquatic Life Water Quality Standards Technical Support Document for Chloride

Triennial Water Quality Standard Amendments to Minn. R. chs. 7050 and 7052

Minnesota Pollution Control Agency

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Authors

Phil Monson, M.S.

Contributors / acknowledgements *(if any)*

Angela Primesberger, M.S.

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Minnesota Pollution Control Agency

520 Lafayette Road North | Saint Paul, MN 55155-4194 | www.pca.state.mn.us | 651-296-6300
Toll free 800-657-3864 | TTY 651-282-5332

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Acronyms, abbreviations and commonly used terms

ACR	Acute to chronic ratio
Anion	Negatively charged ion
AWQC	Ambient Water Quality Criteria
CS	Chronic Standard
Cation	Positively charged ion
EPA	United State Environmental Protection Agency (USEPA)
FCV	Final Chronic Value
mg/L	milligrams per liter; equivalent to parts per million
MPCA	Minnesota Pollution Control Agency
MS	Maximum Standard
SO4	Sulfate
ug/L	micrograms per liter, equivalent to parts per billion
USGS	United States Geological Survey
Water hardness	Dissolved elements of primarily calcium, magnesium, sodium and potassium salts in water
WQS	Water quality standard

Executive Summary

The Minnesota Pollution Control Agency has developed a draft water quality standard for chloride for the protection of aquatic life. The draft water quality standard is based on information and efforts provided by the U.S. Environmental Protection Agency for the Iowa Department of Natural Resources, which promulgated this revised method for a chloride water quality standard in 2009. A primary change to this draft water quality standard compared to the existing Minnesota water quality standard is the inclusion of water hardness and sulfate concentrations, which affect chloride toxicity to aquatic organisms. A model of this relationship is used for calculating the acute and chronic numeric standards for chloride and provides the basis for the draft water quality standard.

Introduction

Chloride is one of the major anions commonly found in surface water and wastewater. It is a constituent of naturally occurring minerals, readily dissolves in water, and is important to living systems. As a solid, chloride is typically found as a salt bonded with a cation such as calcium, sodium, magnesium, or potassium. Effects on living organisms is exerted as ambient chloride concentration increases, causing an internal imbalance to osmoregulatory or salt-water balance functions. In 1988 the U.S. Environmental Protection Agency (EPA) published their Ambient Water Quality Criteria (AWQC) for chloride (EPA 1988), and in 1990 Minnesota promulgated these national criteria into the current water quality standard (WQS) for chloride. In 2005, the state of Iowa with the help of EPA Region 5 began an investigation into updating the existing chloride AWQC, which included a literature review and some additional toxicity testing (EPA 2010). The revised WQS was promulgated by Iowa in 2009. Efforts by EPA Office of Research and Development scientists served to link the relationship of chloride toxicity to aquatic organisms with water hardness and sulfate concentration. It is this relationship that provided the basis for the revised WQS promulgated in Iowa. This document provides the detailed technical support information considered in development of the draft WQS for chloride in Minnesota.

Chloride in the environment

Chloride enters the environment in small amounts through the dissolution of mineral salts, but human uses of chloride salts result in the greatest source to the environment. Of greatest importance are sources from municipal and industrial discharges containing salt wastes from water softening or process water, and stormwater sources associated with use of chlorides in road de-icing salts, agricultural runoff (livestock waste and fertilizer) and produced water from oil and gas wells.

U.S. EPA National Clean Water Act 304(a) Ambient Water Quality Criteria

The Minnesota Pollution Control Agency (MPCA) is required by federal law (Clean Water Act) to assess and revise its state rules that protect the designated, beneficial uses of state surface waters. Mandates under the Clean Water Act include a state's requirement to develop WQSs for the protection of aquatic life communities. The EPA is responsible for developing 304(a) *Ambient Water Quality Criteria* (AWQC) on a national basis following methodology outlined in the *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*, referred to as the 1985 Guidelines (USEPA 1985). States are directed to use or modify criteria based on local and scientifically defensible data that are still as protective as national criteria.

Minnesota water quality standards for chloride

Minnesota has existing water quality standards for chloride that protect aquatic life uses based on the EPA 304(a) AWQC (EPA 1988). In the criteria document, sodium chloride was the toxicant of choice as this is the most common source of chloride to the environment and has the greatest amount of toxicity data available. The authors noted that toxicity tests using the chloride salts of potassium, calcium, or magnesium tended to be more toxic to aquatic organisms compared to sodium chloride, but toxicity was predominately associated with the anion (chloride), and as a result chloride toxicity is based solely on the chloride concentration. Differences in acute toxicity of chloride were small among the set of test organisms considered, and invertebrates were generally more sensitive than vertebrates. The recommended national criteria and current Minnesota WQSs for chloride are established at a chronic value of 230 mg chloride/liter implemented as a four-day average concentration and acute (maximum concentration) of 860 mg chloride / liter implemented as a one-day average concentration.

Concerns for Human Health exposure to chloride in surface waters are minimal. Minnesota has a secondary drinking water standard (taste and odor) of 250 mg chloride/L. In addition, Minnesota Class 3 use designation (industrial consumption) includes chloride standards although these rules also are under consideration for revision in this current rulemaking.

The MPCA maintains a monitoring program that focuses on selected watersheds sampled on an annual and rotating basis. Monitoring parameters include measurements of chloride concentrations from surface water of lakes streams and wetlands. These ambient water quality data are used for assessing the condition of waterbodies based on the magnitude, duration, and frequency of concentrations of constituents to determine appropriate actions including listing as impaired water. This draft water quality standard for chloride will require not only chloride measurements but also water hardness and sulfate to calculate the effect concentration for a waterbody.

Current literature review/EPA research

Development of the draft Minnesota WQS for chloride is based on recent efforts by scientists at EPA, the Illinois Natural History Survey (Champaign. IL), the Great Lakes Environmental Center (GLEC; Columbus, OH), the Iowa Department of Natural Resources (IDNR) and others associated with the IDNR Technical Advisory Committee. The intent of this effort was to better inform decisions that led to the state of Iowa's revision of their chloride WQS. Iowa adopted the revised approach to chloride toxicity in 2009 (Iowa 2009) to address their needs to have water quality standards available for specific ions (chloride and sulfate) in preference to a WQS for Total Dissolved Solids. Their investigation included an updated literature review and additional toxicity tests completed in 2008 (EPA 2010). Much of the effort in these tests was placed in filling gaps of understanding regarding the role of hardness to mitigate chloride toxicity to aquatic organisms that served to establish the current toxicity model. The results of these efforts are presented in this document as the basis for the draft Minnesota chloride WQS. Details on the approach and rationale for acceptable toxicity tests and references, development of acute and chronic numeric criteria, and treatment of data can be found in EPA 2009a-f. These documents would best be considered notes of the interpretation completed by the EPA scientists using their insight on development of water quality criteria. These EPA documents are cited in this draft technical support document to highlight important decisions for development of this draft Minnesota chloride WQS. No additional literature search was performed since 2008 and the draft Minnesota chloride WQS is wholly a product of those efforts by the state of Iowa and the EPA. Recently, new literature is available that reports chloride toxicity to aquatic organisms (e.g., Elphick et al. 2011; Soucek et al. 2011), but it is anticipated that these will be included by the EPA in their future revision to national AWQC for chloride. The effort required to include these relatively few additional literature sources was not in the best interest to move ahead with this draft Minnesota chloride WQS.

The EPA published a number of documents that provide details of their efforts to revise the chloride water quality criteria, which are referenced in this document in support of the draft Minnesota chloride WQS. Details of the literature search conducted by EPA are found in EPA 2009b, and Table 3 (Appendix) lists the results of all literature considered and rationale for their acceptability for use in criteria development. In addition, the following is an excerpt describing the approach used for their literature search.

EPA searched the ECOTOX database and its extensive literature holdings compiled from monthly searches of online abstracting services (American Chemistry Society's STN-CAS and Cambridge Scientific Abstracts), manual searches of tables of contents from high-impact journals, and the bibliographies of review articles. The targets of these searches are documents containing information regarding lethal and sublethal adverse effects on, and bioaccumulation by, freshwater and/or saltwater aquatic plants and animals, as well as chronic feeding studies and long-term field studies using wildlife species that regularly consume aquatic organisms. To ensure comprehensive coverage of the literature, a chloride-specific search was also conducted using STN-CAS, Cambridge Scientific Abstract, Dissertation Abstracts, Science Direct, and Toxline. EPA also considered some information from other sources. The list of documents (Table 3, Appendix) contains data regarding the toxicity of chloride to aquatic animals. The table also contains various documents that were cited in various sources as possibly containing data regarding the toxicity of chloride to aquatic animals. In addition, some documents are cited because they might aid in the interpretation of a document that contains potentially useful results of toxicity tests on chloride. Many documents cited in "Unused Data" in the national ambient water quality criteria (EPA 1988) are not considered in this revision. A number in parentheses at the end of a citation is the ECOTOX reference number of the document.

This examination of new information compared to the previous national AWQC for chloride provided the rationale to integrate toxicity effects normalized to concentrations of water hardness and sulfate. EPA's findings concluded that water hardness (as calcium carbonate; $CaCO_3$) mitigates the effects of chloride toxicity similar to situations reported with other metals (e.g., zinc, lead, cadmium), where higher levels of hardness result in less toxicity. In addition, sulfate (SO_4) concentration exerts greater toxicity with chloride (probably through competition for bonding sites) in mixtures of the two ions. The final model developed by EPA integrated concentrations of both water hardness and sulfate in equations to calculate numeric values of chloride protective of aquatic life. The model formulae, matrix values, and graphic representation of toxicity are described in following sections of this document. Additional information on the approach used by EPA is found in U.S. EPA (2009c).

Technical Development of Draft Aquatic Life Criteria for Chloride

Development of draft acute chloride water quality criteria

Table 1 (Appendix) lists the results of acute toxicity information available from the literature that EPA (2009d) deemed acceptable for use to develop the chloride WQS by Iowa and others, such as planned for the draft Minnesota chloride WQS. Additional toxicity testing was completed by the EPA to fill information gaps and to further characterize the relationship of hardness and sulfate to chloride toxicity. Further discussion of these data can be found in EPA 2010.

A primary change included for this draft Minnesota chloride WQS, and a major revision to the existing Minnesota WQS and national AWQC (EPA 1988), is the role of hardness and sulfate as they affect toxicity to aquatic organisms. Mode of action of chloride toxicity is thought to be a disruption of

osmoregulatory function. Presence of hardness ions, primarily calcium and magnesium, are hypothesized to interact with chloride in a way that competes for bonding sites on the organism thereby reducing chloride uptake and resulting toxicity. Sulfate exerts its own toxicity in addition to chloride toxicity to aquatic organisms, and was accounted for in this model. In order to develop a species sensitivity distribution, acute toxicity values were normalized using the following equation Normalized Acute Value (NAV) = (AV) $(300/\text{Hardness})^{0.205797}$ $(65/\text{Sulfate})^{-0.07452}$.

Values of hardness (300) and sulfate (65) were selected arbitrarily fully recognizing that any value for these parameters could have been used. Further treatment of the normalized data followed the 1985 guidelines in calculating the Final Acute Value (FAV). Table 2a (Appendix) lists species FAVs and NAVs. The FAV is used to determine the Maximum Standard (MS), which is called the Continuous Maximum Concentration by EPA and is the FAV divided by two. To develop the equation that relates hardness and sulfate to chloride toxicity, acute toxicity tests endpoints for *Ceriodaphnia dubia* were analyzed based on a log-log regression of those test results incorporating the effects of hardness, sulfate and chloride toxicity to the organism. This regression provided the exponents used in the equation. The results of these tests are found in EPA 2010. The toxicity model developed using *C. dubia* endpoints was found to be reasonable as the organism's response was close to that of other organisms tested and toxicity tests from two different laboratories provided comparable results. Additional discussion of this approach can be found in EPA 2009c.

The Maximum Standard for this draft water quality standard for chloride is calculated using the equation: $MS = 287.8(\text{Hardness})^{0.205797}(\text{Sulfate})^{-0.07452}$

Table 1 shows MSs for chloride computed using selected values of hardness and sulfate based on the draft Minnesota chloride WQS. A plot of the trend generally shows chloride toxicity decreasing as water hardness increases while toxicity increases with increasing sulfate concentrations (Figure 1).

Table 1. Maximum Standard values calculated for select values of water hardness and sulfate using the equation: $MS = 287.8(\text{Hardness})^{0.205797}(\text{Sulfate})^{-0.07452}$.

	Hardness (mg/L CaCO3)								
Sulfate (mg/L)	50	100	150	200	250	300	350	400	450
5	571	659	716	760	795	826	852	876	897
10	542	625	680	721	755	784	809	832	852
25	506	584	635	674	705	732	756	777	796
50	481	555	603	640	670	695	718	738	756
100	457	527	573	608	636	660	682	701	718
150	443	511	556	589	617	641	661	680	697
200	434	500	544	577	604	627	647	665	682
250	427	492	535	567	594	617	637	654	671
300	421	485	528	560	586	609	628	646	661
350	416	480	522	553	579	602	621	638	654

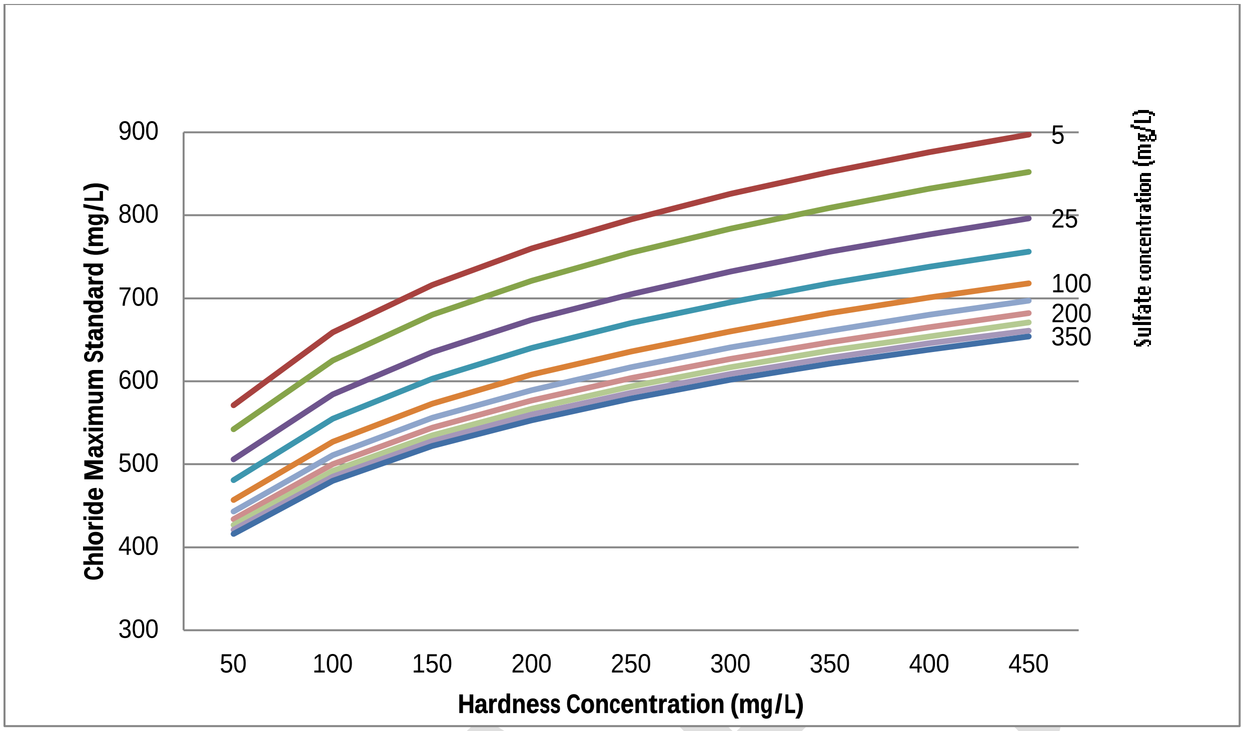

Figure 1. Values of acute water quality criteria (MS) for chloride based on selected values of water hardness and sulfate.

Development of draft chronic chloride water quality criteria

There was not enough information to fulfill the necessary eight taxonomic categories required by the 1985 guidelines (EPA 1985) for developing chronic chloride aquatic life criteria. This is not usual for most aquatic life criteria as chronic tests require more resources and so are performed less often. Therefore, chronic water quality criteria were determined using acceptable acute to chronic ratios (ACR). Table 2a (Appendix) shows the toxicity data with associated ACRs. Using a geometric mean of available ACR values is provided for in the 1985 guidelines and would be appropriate for use in this situation. However, observation of the toxicity literature concluded that differences between the ACR for invertebrates (ACR = 3.187) and an ACR for vertebrates (ACR = 7.308) were great enough to warrant a different approach to developing the final chronic value (FCV). To account for this, EPA scientists provided for an alternative approach to consider differences between the ACRs shown in Table 2b (Appendix). Details of this approach are found in EPA 2009e. Briefly, GMAVs were divided by their respective ACR for either invertebrates or vertebrates. These new values, termed predicted Genus Mean Chronic Values (pGMCV), were then used in a multiple regression with the test hardness and sulfate concentrations to develop the equation used for calculating the FCV:

$$\text{Chronic Standard} = 177.87(\text{Hardness})^{0.205797}(\text{Sulfate})^{-0.07452}$$

Table 2 shows FCVs for selected values of water hardness and sulfate based on the draft Minnesota chloride WQS. A plot of the trend generally shows chloride toxicity decreasing as water hardness increases while toxicity increases with increasing sulfate concentrations (Figure 2). Additional discussion about the chronic toxicity review is found in EPA 2009f.

Table 2. Final chronic values calculated for selected values of water hardness and sulfate using the equation: Chronic Standard = 177.87(Hardness)$^{0.205797}$(Sulfate)$^{-0.07452}$.

Sulfate (mg/L)	Hardness (mg/L CaCO3)								
	50	100	150	200	250	300	350	400	450
5	353	407	442	469	491	510	527	541	555
10	335	387	420	446	467	485	500	514	527
25	313	361	392	416	436	453	467	480	492
50	297	343	373	395	414	430	444	456	467
100	282	326	354	375	393	408	421	433	444
150	274	316	343	364	381	396	409	420	430
200	268	309	336	357	373	388	400	411	421
250	264	304	331	351	367	381	394	404	414
300	260	300	326	346	362	376	388	399	409
350	257	297	322	342	358	372	384	394	404

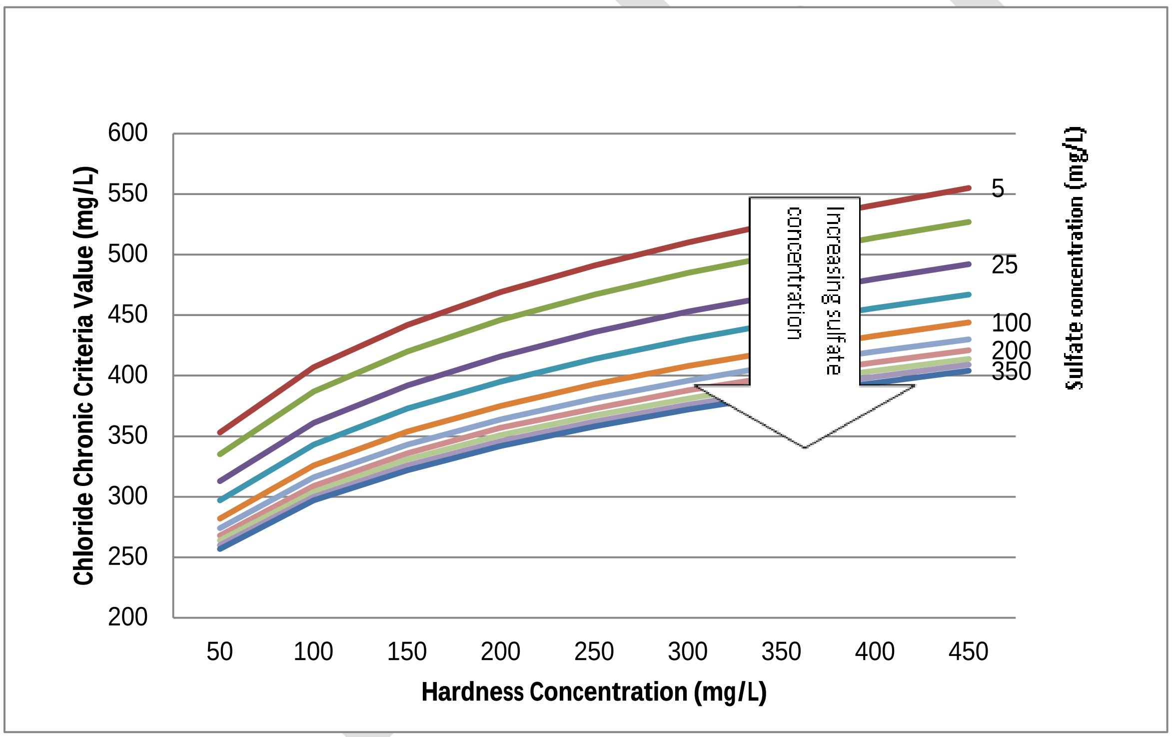

Figure 2. Values of chronic water quality criteria (CS) for chloride based on selected values of water hardness and sulfate.

Implementation

Draft Minnesota chloride WQS will be implemented using values of water hardness and sulfate to calculate acute and chronic criteria values. In ambient water, measured values of hardness and sulfate collected together with measured values of chloride is the most effective way to calculate final chloride WQS and for assessment of ambient conditions. To evaluate chloride toxicity in the absence of concurrent site-specific hardness and sulfate results it may be possible to use representative ambient hardness and sulfate data for the watershed. A summary of values of hardness and sulfate statewide are displayed in figures 3 and 4. Application in permitting would follow the procedures in Minn. R. ch. 7053 using the same approach as with other WQS that use hardness data (i.e., metals).

Conclusions and Future EPA Ambient Water Quality Criteria Direction

The development of revised methods and approach for aquatic toxicity-based WQSs for chloride stem from the efforts through 2009 by the EPA to help the IDNR develop WQSs for chloride. Considerable toxicity information has been published in the scientific literature since the (EPA) national ambient water quality criteria for chloride was published in 1988. Inspection of this broader data set served to provide a better understanding of chloride toxicity to aquatic organisms and the role of water hardness and sulfate in affecting toxicity endpoints. Based on this new toxicity information, scientists developed models to characterize this relationship between toxicity and ionic constituents using the standard guidance for developing aquatic life criteria. The future direction for a revised national AWQC for chloride are ongoing and anticipated within the next couple of years. Minnesota has taken the same approach as the State of Iowa for the draft Minnesota chloride WQS. Acute and chronic numeric standards are calculated using equations that include inputs of water hardness and sulfate concentrations. Using this information, the draft Minnesota chloride WQS calculate values that are somewhat more stringent for acute criteria and somewhat less stringent for chronic water quality criteria compared to their respective criteria values of the existing state standards. Implementation of this draft Minnesota chloride WQS will require values of water hardness and sulfate to be associated with measured values of chloride in ambient waters.

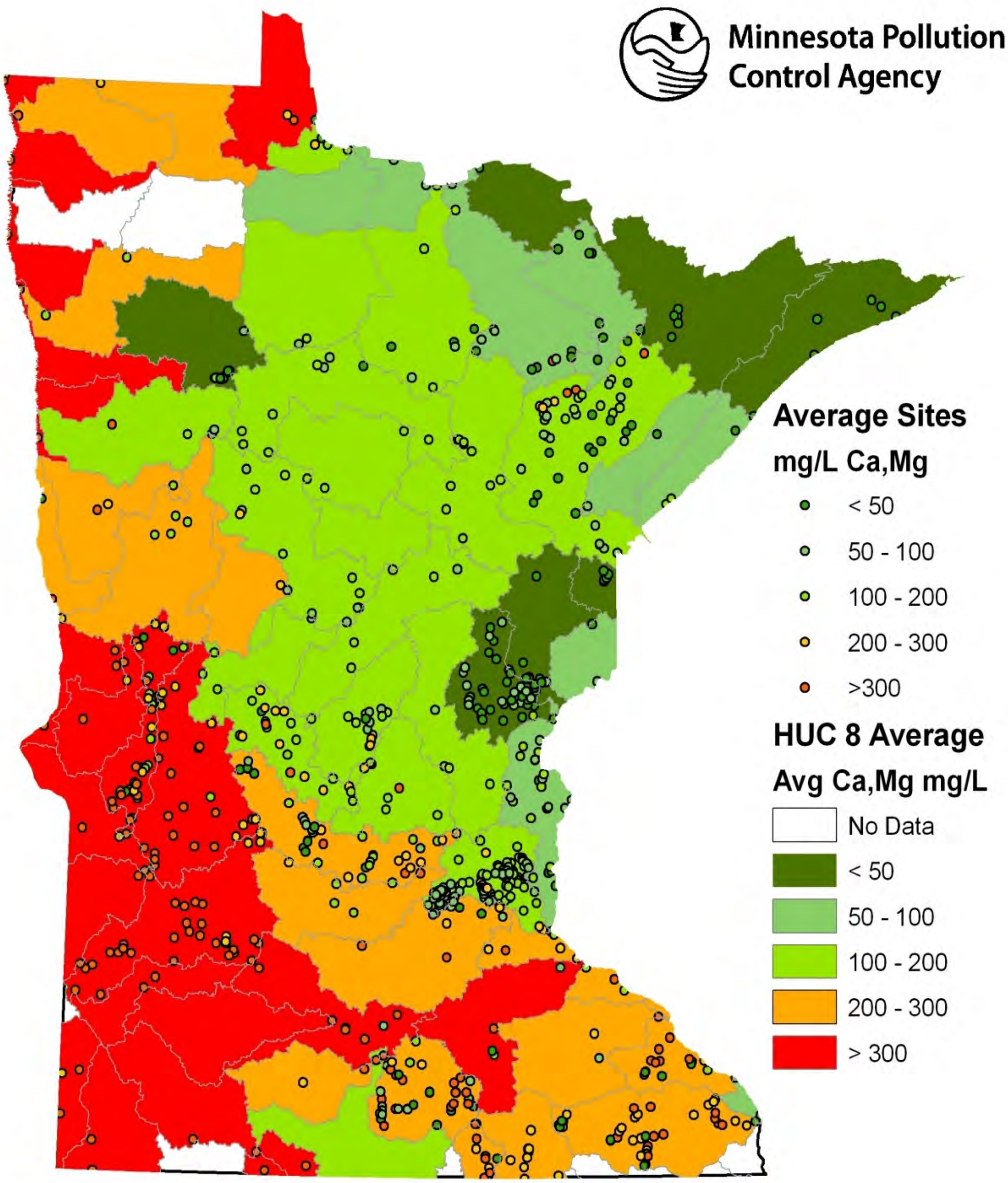

Figure 3. Map of mean hardness concentrations from ambient monitoring data of lakes and streams. Hardness calculated using calcium and magnesium concentrations.

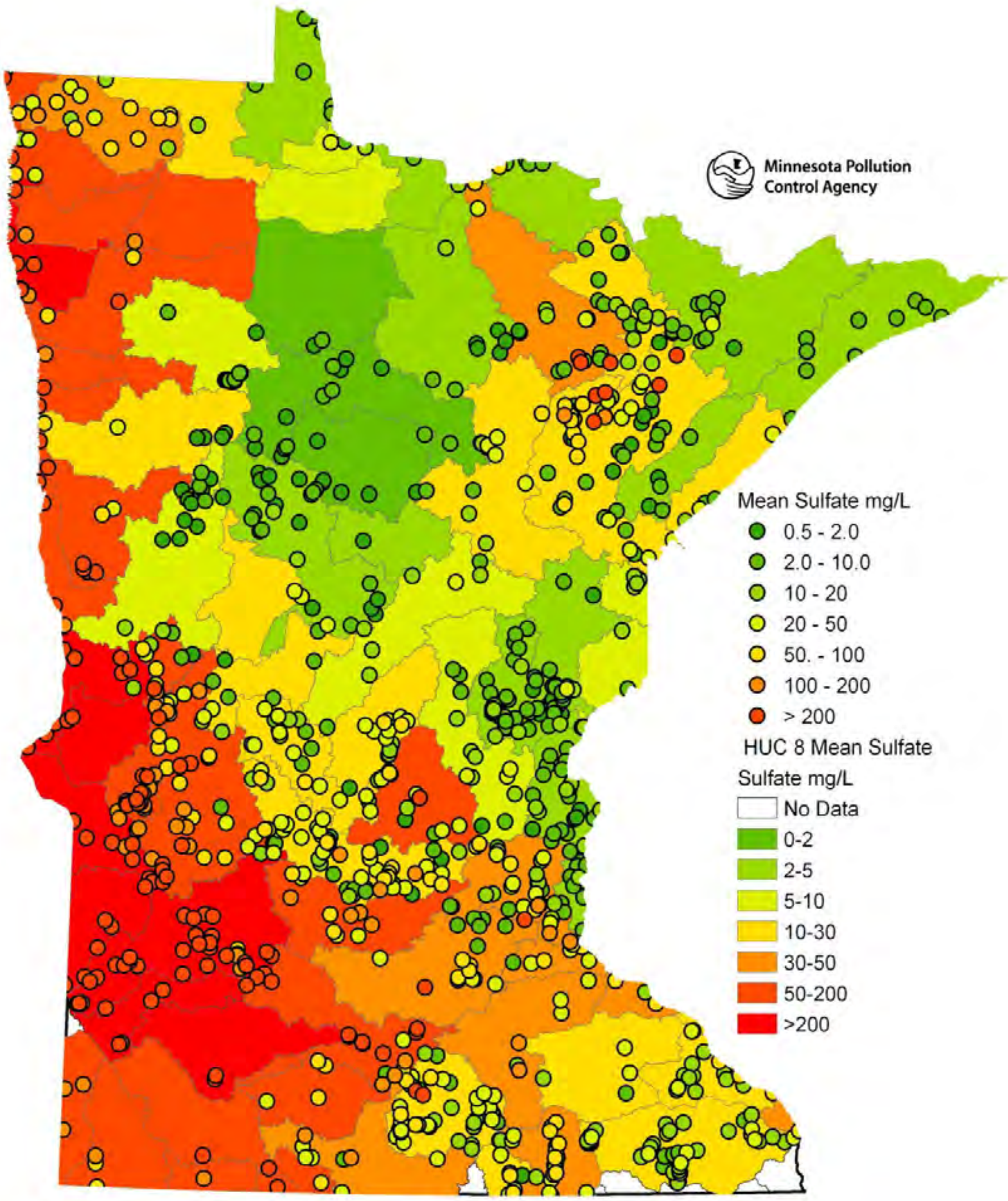

Figure 4. Map of mean sulfate concentrations from ambient monitoring data of lakes and streams statewide.

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Appendix

Table 1. Acute Toxicity of Sodium Chloride to Aquatic Animals; Excerpted from "Summary of Data concerning the Acute Toxicity of Sodium Chloride to Aquatic Animals"; 09MayChlorideAcute.doc. Information displayed below was compiled from original correspondence file: 09MayChlorideAcute.pdf. Normalized Acute Values (NAV) were calculated by normalizing the Acute Values (AV) to hardness = 300 mg/L and sulfate = 65 mg/L using the following equation: NAV = (AV) $(300/\text{Hardness})^{0.205797}$ $(65/\text{Sulfate})^{-0.07452}$. This equation is based on the equation presented in "Multiple Regression Equation for Chloride" dated 5-21-09. The hardness of 300 mg/L and the sulfate concentration of 65 mg/L are arbitrary; any other values for hardness and sulfate would have worked equally well. NAVs could not be calculated for all AVs because assumed values were not used for hardness or sulfate. Some of the values of hardness and sulfate are nominal, not measured, values. Supplemental comments are available in the original file.

Species	Method	Test	Hardness (mg/L)	Sulfate (mg/L)	Acute Value (mg chloride/L)	Normalized Acute Value (mg chloride/L)	Reference Material
Tubificid worm, Limnodrilus hoffmeisteri	S,U	Sodium chloride	100	----	3761	------	Wurtz and Bridges 1961
Tubificid worm, Tubifex tubifex	S,M	Sodium chloride	52 220	57.9 58.9	4278 6008	6083.2 6357.1	GLEC and INHS 2008
Aquatic worm, Lumbriculus variegatus	R,M	Sodium chloride	296	68.5	5408	5444	Environ 2009
Leech, Erpobdella punctata	S,U	Sodium chloride	100	----	4550	------	Wurtz and Bridges 1961
Leech, Nephelopsis obscura	R,M	Sodium chloride	290	71	4310	4369	Environ 2009
Mussel, Villosa delumbis juvenile	S,M	Sodium chloride	169.5	162.7	3173	3821.1	Bringolf et al. 2007
Mussel, juvenile *Villosa iris*	R,M	Sodium chloride	169.5	162.7	2069	2491.6	Wang 2007
Mussel, juvenile Lampsilis fasciola	S,M	Sodium chloride	169.5	162.7	2414	2907.1	Bringolf et al. 2007
Mussel, juvenile Lampsilis siliquoidea	R,M	Sodium chloride	169.5	162.7	1905	2294.1	Wang 2007
Mussel, juvenile Lampsilis siliquoidea	S,M	Sodium chloride	169.5	162.7	2766	3331.0	Bringolf et al. 2007

Species	Method	Test	Hardness (mg/L)	Sulfate (mg/L)	Acute Value (mg chloride/L)	Normalized Acute Value (mg chloride/L)	Reference Material
Fingernail clam, *Sphaerium simile*	S,M	Sodium chloride	51 192	59.9 61.7	740 1100	1059.2 1201.1	GLEC and INHS 2008
Fingernail clam, *Sphaerium tenue*	S,U	Sodium chloride	100 20	------	667 698	-----------	Wurtz and Bridges 1961
Snail, Physa gyrina	F,M	Sodium chloride	84.8	81.4	2540	3350.0	Birge et al. 1985
Snail, Physa heterostropha	S,U	Sodium chloride	100 100 100 20	--------	2123 3094 3761 2487	----------	Wurtz and Bridges 1961
Snail, *Physa* sp.	S,M	Sodium chloride	22	15	3247hp	4983.6	Clemens and Jones 1954
Snail, *Physa* sp.	S,U	Sodium chloride	---	---	>3000p	-----	Williams et al. 2000
Snail, Gyraulus circumstriatus	S,U	Sodium chloride	100	---	1941	------	Wurtz and Bridges 1961
Snail, Gyraulus parvus	S,M	Sodium chloride	56 212	60.9 59.7	3078 3009	4326.9 3211.4	GLEC and INHS 2008
Snail, Helisoma campanulata	S,U	Sodium chloride	100	---	3731	------	Wurtz and Bridges 1961
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8	81.4	1189brt 1042brt	1568.2 1374.3	Mount et al. 1997
Cladoceran, Ceriodaphnia dubia	R,U	Sodium chloride	74.1	---	1395	------	Cowgill and Milazzo 1990
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	39.2	4.6	507 447	632.7 557.8	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	1740.8 2044.1 1589.8 1740.8 1867.0	USEPA 1991
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8 169.5	81.4 162.7	1677c 1499c	2211.8 1805.2	WISLOH 2007
Cladoceran, Ceriodaphnia dubia	S,U	Sodium chloride	84.8	81.4	1413e	1863.6	Valenti et al. 2007

Species	Method	Test	Hardness (mg/L)	Sulfate (mg/L)	Acute Value (mg chloride/L)	Normalized Acute Value (mg chloride/L)	Reference Material
Cladoceran, Ceriodaphnia dubia	S,M	Sodium chloride	67.1	64.4q	964	1311.1	Harmon et al. 2003
Cladoceran, Ceriodaphnia dubia	S,M	Sodium chloride				1542.9	GLEC and INHS 2008
						1434.1	
						1442.1	
						1792.8	
						1425.5	
						1690.9	
						1457.7	
			30	78.7	947	1688.4	
			44	75.9	955	1117.1	
			96	73.7	1130	1744.7	
			180	67.7	1609	1314.3	
			400	78.7	1491	1618.3	
			570	76.2	1907	1458.2	
			800	75.5	1764	1573.5	
			25	69.9	1007	1334.0	
			49	67.8	767	1733.4	
			95	70.3	1369	1477.2	
			194	69.9	1195		
			375	68.9	1687		
			560	68.3	1652		
			792	70.9	1909		
			280	28.1	1400		
			280	59.6	1720		
			280	117	1394		
			280	239	1500	1676.5	
			280	482	1109	1306.0	
			280	729	1206	1464.7	
			279	22.9	1311	1231.2	
			276	49.7	1258	1254.4	
			283	107	1240	1302.5	
			281	229	1214	1351.5	
			290	461	1199	1397.2	
			278	694	1179	1428.8	
Cladoceran, Daphnia ambigua	S,M	Sodium chloride	67.1	64.4q	1213	1649.7	Harmon et al. 2003.
Cladoceran, Daphnia magna	S,U	Sodium chloride	84.8	81.4	2893brs	3815.5	Mount et al. 1997

Species	Method	Test	Hardness (mg/L)	Sulfate (mg/L)	Acute Value (mg chloride/L)	Normalized Acute Value (mg chloride/L)	Reference Material
Cladoceran, Daphnia magna	S,U	Sodium chloride	240	---	621	------	Khangarot and Ray 1989
Cladoceran, Daphnia magna	S,U	Sodium chloride	39.2 39.2 39.2	4.6 4.6 4.6	3038 2726 2053	3791.1 3401.8 2561.9	Hoke et al. 1992
Cladoceran, Daphnia magna	-,	Sodium chloride	---	---	1008k 3319m	-----------	Cowgill 1987
Cladoceran, Daphnia magna	S,U	Sodium chloride	108.7	13	<2548	<2785.1	Anderson 1946
Cladoceran, Daphnia magna	S,U	Sodium chloride	108.7	13	2232i	2439.7	Anderson 1948
Cladoceran, Daphnia magna	S,U	Sodium chloride	41.5	31.2	3563	5068.2	Dowden and Bennett 1965
Cladoceran, Daphnia magna	S,M	Sodium chloride	45.3	3.9v	2529a,f 2806b,f	3025.9 3357.4	Biesinger and Christensen 1972
Cladoceran, Daphnia magna	S,U	Sodium chloride	169.5	162.7	>2669 <3943d	>3214.2 <4748.4	Seymour et al. 1997
Cladoceran, Daphnia magna	S,U	Sodium chloride	46	3.9v	1880	2242.3	USEPA 1991
Cladoceran, Daphnia magna	S,U	Sodium chloride	169.5	162.7	3944c	4749.6	WISLOH 2007
Cladoceran, Daphnia magna	S,U	Sodium chloride	84.8	81.4	3009e	3968.5	Valenti et al. 2007
Cladoceran, Daphnia magna	S,U	Sodium chloride	106	102	3136 3222 3137	4017.4 4127.5 4018.6	Davies and Hall 2007
Cladoceran, Daphnia pulex	S,M	Sodium chloride	84.8	81.4	1470	1938.8	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	1528.6 2341.0 2380.6 2956.9	Palmer et al. 2004
Copepod, Diaptomus clavipes	S,M	Sodium chloride	22	15	2571h	3946.1	Clemens and Jones 1954
Isopod, Asellus communis	S,U	Sodium chloride	100 20	------	5004 3094	-----------	Wurtz and Bridges 1961
Isopod, Lirceus fontinalis	F,M	Sodium chloride	84.8	81.4	2950	3890.7	Birge et al. 1985

Species	Method	Test	Hardness (mg/L)	Sulfate (mg/L)	Acute Value (mg chloride/L)	Normalized Acute Value (mg chloride/L)	Reference Material
Amphipod, Hyalella azteca	S,U	Sodium chloride	102.5	98.4	3947	5077.7	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	16203.2	Clemens and Jones 1954
Dragonfly, Libellulidae	S,M	Sodium chloride	22	15	9671h	14843.4	Clemens and Jones 1954
Damselfly, *Agria* sp.	S,U	Sodium chloride	100 20	------	14558 13952	-----------	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
Midge, Chironomus dilutus	R,M	Sodium chloride	296	68.5	6032	6072	Environ 2009
American eel, Anquilla rostrata	S,U	Sodium chloride	42.4	40.7	10846	15667.3	Hinton and Eversole 1978
American eel, Anquilla rostrata	S,U	Sodium chloride	42.4	40.7	13012	18796.2	Hinton and Eversole 1979
Goldfish, Carassius auratus	S,M	Sodium chloride	148.8	---	9465	-----	Threader and Houston 1983
Bannerfin shiner, *Cyprinella leedsi*	R,M	Sodium chloride	296	68.5	6070	6111	Environ 2009
Red shiner, Notropis lutrensis	S,M	Sodium chloride	22	15	5771g 5920g	8857.5 9086.2	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	3481.7 2649.3 2467.3	USEPA 1991
Fathead minnow, Pimephales promelas	F,M	Sodium chloride	84.8	81.4	6570	8665.1	Birge et al. 1985

Species	Method	Test	Hardness (mg/L)	Sulfate (mg/L)	Acute Value (mg chloride/L)	Normalized Acute Value (mg chloride/L)	Reference Material
Fathead minnow, Pimephales promelas	S,M	Sodium chloride	22	15	5288g 5431g	8116.2 8335.7	Clemens and Jones 1954
Fathead minnow, Pimephales promelas	S,U	Sodium chloride	84.8	81.4	3876br	5112.0	Mount et al. 1997
Fathead minnow, Pimephales promelas	S,U	Sodium chloride	84.8 169.5	81.4 162.7	4167c 4127c	5495.8 4970.0	WISLOH 2007
Black bullhead, *Ameiurus melas*	S,M	Sodium chloride	22	15	4849g	7442.4	Clemens and Jones 1954
Rainbow trout, Oncorhynchus mykiss	S,U	Sodium chloride	22.4	---	>485j	------	Camargo and Tarazona 1991
Rainbow trout, Oncorhynchus mykiss	F,M	Sodium chloride	46	3.9v	6743	8042.6	Spehar 1986,1987
Rainbow trout, Oncorhynchus mykiss	R,U	Sodium chloride	284	---	12363	------	Vosyliene et al. 2006
Brown trout, *Salmo trutta*	S,U	Sodium chloride	22.4	---	>607j	------	Camargo and Tarazona 1991
Plains killifish, *Fundulus kansae*	S,M	Sodium chloride	22	15	9706g	14897.1	Clemens and Jones 1954
Mosquitofish, Gambusia affinis	S,M	Sodium chloride	22	15	6472g	9933.4	Clemens and Jones 1954
Mosquitofish, Gambusia affinis	S,U	Sodium chloride	---	14.9	9099	-----	Al-Daham and Bhatti 1977
Guppy, Poecilia reticulata	R,M	Sodium chloride	290	71	>11700	>11860	Environ 2009
Threespine stickleback, *Gasterosteus aculeatus*	R,M	Sodium chloride	84.8	81.4	10200b	13452.6	Garibay and Hall 2004
Green sunfish, Lepomis cyanellus	S,M	Sodium chloride	22	15	6499g	9974.9	Clemens and Jones 1954
Bluegill, Lepomis macrochirus	F,M	Sodium chloride	84.8	81.4	5840	7702.3	Birge et al. 1985

Species	Method	Test	Hardness (mg/L)	Sulfate (mg/L)	Acute Value (mg chloride/L)	Normalized Acute Value (mg chloride/L)	Reference Material
Bluegill (3.7 g), Lepomis macrochirus	S,U	Sodium chloride	44.3	15.5	7853	10461.6	Academy of Natural Sciences 1960; Patrick et al. 1968; Trama 1954
Bullfrog (tadpole), *Rana catesbeiana*	R,M	Sodium chloride	300	73	5846	5897	Environ 2009
Chorus frog, *Pseudacris* sp.	R,M	Sodium chloride	84.8	81.4	3553	4686.0	Garibay and Hall 2004

a = not fed. (All tests not marked “a” or “b” were unfed tests.)
b = fed
= 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.

Table 2a. Calculation of Aquatic Life Criteria for Chloride; excerpted from "Calculation of Aquatic Life Criteria for Chloride"; 09MayChlorideCriteria.doc.

These calculations are based on information and discussion found in the following supplemental files: 09MayChlorideAcute.pdf titled "Summary of Data concerning the Acute Toxicity of Sodium Chloride to Aquatic Animals" and 09MayChlorideChronic.pdf titled "Summary of Data concerning the Chronic Toxicity of Sodium Chloride to Aquatic Animals". Additional discussion and guidelines for calculating criteria values can be found in the U.S. EPA 1985 (EPA 1985) Guidelines and in the following documents: 09MayChlorideAcute.pdf titled "Summary of Data concerning the Acute Toxicity of Sodium Chloride to Aquatic Animals" and 09MayChlorideChronic.pdf titled, 09MayChlorideChronic.pdf titled "Summary of Data concerning the Chronic Toxicity of Sodium Chloride to Aquatic Animals", 09MayChlorideEq.pdf titled " Multiple Regression Equations for Chloride".

Except as noted (for example, see footnote a), these calculations are consistent with the 1985 Guidelines. GMAVs and SMAVs are normalized to hardness = 300 mg/L and sulfate = 65 mg/L. GMAVs and SMAVs are expressed as mg chloride/L.

Rank*	GMAV	Genus	Species	SMAV	SMACR
	-----	Agria	Damselfly, *Agria* sp.	----	
29	17161	Anquilla	American eel, Anquilla rostrata	17160.6	
	16203	Cambarus	Crayfish, *Cambarus* sp.	16203.2	
	14897	Fundulus	Plains killifish, *Fundulus kansae*	14897.1	
	14843	Libellulidae**	Dragonfly, Libellulidae	14843.4	
	13453	Gasterosteus	Threespine stickleback, *Gasterosteus aculeatus*	13452.6	
	>11860	Poecilia	Guppy, Poecilia reticulata	>11860	
	-----	Carassius	Goldfish, Carassius auratus	----	
	9933	Gambusia	Mosquitofish, Gambusia affinis	9933.4	
	9157	Lepomis	Green sunfish, Lepomis cyanellus	9974.9	
			Bluegill, Lepomis macrochirus	8406.5b	
	8971	Notropis	Red shiner, Notropis lutrensis	8971.1	
	8043	Oncorhynchus	Rainbow trout, Oncorhynchus mykiss	8042.6	7.308
	7442	Ameiurus	Black bullhead, *Ameiurus melas*	7442.4	
	-----	Erpobdella	Leech, Erpobdella punctata	---	
	6515	Pimephales	Fathead minnow, Pimephales promelas	6515.3c	15.17d
	6219	Tubifex	Tubificid worm, *Tubifex tubifex*	6218.6	
	6111	Cyprinella	Bannerfin shiner, *Cyprinella leedsi*	6111	
	6072	Chironomus	Midge, Chironomus attenuatus	----	
			Midge, Chironomus dilutus	6072	
	5897	Rana	Bullfrog (tadpole), *Rana catesbeiana*	5897	
	5444	Lumbriculus	Aquatic worm, Lumbriculus variegatus	5444	
	5078	Hyalella	Amphipod, Hyalella azteca	5077.7	
	-----	Asellus	Isopod, Asellus communis	-----	
	----	Limnodrilus	Tubificid worm, Limnodrilus hoffmeisteri	-----	
	----	Helisoma	Snail, Helisoma campanulata	----	

Rank*	GMAV	Genus	Species	SMAV	SMACR
	4686	Pseudacris	Chorus frog, *Pseudacris* sp.	4686.0	
	-----	Gammarus	Amphipod, Gammarus pseudolimnaeus	----	
	-----	Crangonyx	Amphipod, *Crangonyx* sp.	----	
	-----	Nemoura	Stonefly, Nemoura trispinosa	----	
	-----	Lepidostoma	Caddisfly, *Lepidostoma* sp.	----	
	-----	Parapsyche	Caddisfly, *Parapsyche* sp.	----	
	4369	Nephelopsis	Leech, Nephelopsis obscura	4369	
	3946	Diaptomus	Copepod, Diaptomus clavipes	3946.1	
	3891	Lirceus	Isopod, Lirceus fontinalis	3890.7	
	3728	Gyraulus	Snail, Gyraulus circumstriatus	----	
			Snail, Gyraulus parvus	3727.7	
	3350	Physa	Snail, Physa gyrina	3350.0	
			Snail, Physa heterostropha	----	
	3086	Villosa	Mussel, Villosa delumbis	3821.1	
			Mussel, Villosa iris	2491.6	
4	2835	Lampsilis	Mussel, Lampsilis fasciola	2907.1	
			Mussel, Lampsilis siliquoidea	2764.4	
3	2326	Daphnia	Cladoceran, Daphnia ambigua	1649.7	4.148
			Cladoceran, Daphnia magna	3773.1e	1.974
			Cladoceran, Daphnia pulex	2020.5f	3.952
2	1542	Ceriodaphnia	Cladoceran, Ceriodaphnia dubia	1542.3g	>2.470h
1	1128	Sphaerium	Fingernail clam, *Sphaerium simile*	1127.9	
			Fingernail clam, *Sphaerium tenue*	-----	

* 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.
** 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.

b. Bluegill: SMAV = antilog ([2.5(log 7702.3) + log 10461.6]/3.5) = 8406.5.

c. Fathead minnow: SMAV = antilog([log 2833.9 + 2.5(log 8665.1) + 2.5(log 8225.2) + log 5112.0 + log 5226.3]/8) = 6515.3.

d. 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.

e. For Daphnia magna, the values of 3815.5 (Mount et al. 1997), <2785.1, (Anderson 1946), 2439.7 (Anderson 1948), and 3025.9 and 3357.4 (Biesinger and Christensen 1972) were not used. A geometric mean of 3906.7 was calculated from the limits given by Seymour et al. (1997). The geometric mean is 3208.8 for Hoke et al. (1992) and is 4054.2 for Davies and Hall (2007). The SMAV is 3773.1, which is the geometric mean of 3208.8, 5068.2, 3906.7, 2242.3, 4749.6, 3968.5, and 4054.2.

f. Daphnia pulex: SMAV = antilog([2.5(log 1938.8) + log 2240.3]/3.5) = 2020.5.

g. For Ceriodaphnia dubia, the acute values from Hoke et al. (1992) are considered outliers. The geometric mean is 1468.1 for Mount et al. (1997), 1790.2 for U.S. EPA (1991), 1998.2 for WISLOH (2007), and 1457.3 for GLEC and INHS (2008). SMAV = antilog ([log 1468.1 + log 1790.2 + log 1998.2 + log 1863.6 + 2.5(log 1311.1) + 2.5(log 1457.3)]/9) = 1542.3.

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

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.

FAV = 1364 mg chloride/L CMC = FAV/2 = 682.0 mg chloride/L

CCC = FCV = 428.0 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 = (1364 mg chloride/L)/4.826 = 282.6 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 = (1364 mg chloride/L)/3.187 = 428.0 mg chloride/L.

The CMC and CCC given above are for hardness = 300 mg/L and sulfate = 65 mg/L. The equation that was used to normalize the acute values can be used to make the CMC and CCC dependent on hardness and sulfate. The resulting equations for the CMC and CCC are:

CMC = (682.0 mg chloride/L) $(\text{hardness}/300)^{0.205797}$ $(\text{sulfate}/65)^{-0.07452}$ = (287.8 mg chloride/L) $(\text{hardness})^{0.205797}$ $(\text{sulfate})^{-0.07452}$

At hardness = 300 mg/L and sulfate = 65 mg/L, CMC = 682.0 mg chloride/L.

CCC = (428.0 mg chloride/L) $(\text{hardness}/300)^{0.205797}$ $(\text{sulfate}/65)^{-0.07452}$ = (180.6 mg chloride/L) $(\text{hardness})^{0.205797}$ $(\text{sulfate})^{-0.07452}$

At hardness = 300 mg/L and sulfate = 65 mg/L, CCC = 428.0 mg chloride/L.

Table 2b. Derivation of an Alternative Final Chronic Values; excerpted from "Calculation of Aquatic Life Criteria for Chloride"; 09MayChlorideCriteria.doc.

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

Rank	GMAV	Genus	Species	pGMCV
	-----	Agria	Damselfly, *Agria* sp.	----
29	16203	Cambarus	Crayfish, *Cambarus* sp.	5084
	14843	Libellulidae*	Dragonfly, Libellulidae	4657
	17161	Anquilla	American eel, Anquilla rostrata	2348
	14897	Fundulus	Plains killifish, *Fundulus kansae*	2038
	6219	Tubifex	Tubificid worm, Tubifex tubifex	1951
	6072	Chironomus	Midge, Chironomus attenuatus	1905
			Midge, Chironomus dilutus	
	-----	Erpobdella	Leech, Erpobdella punctata	-----
	13453	Gasterosteus	Threespine stickleback, Gasterosteus aculeatus	1841
	-----	Carassius	Goldfish, Carassius auratus	-----
	5444	Lumbriculus	Aquatic worm, Lumbriculus variegatus	1708
	>11860	Poecilia	Guppy, Poecilia reticulata	>1663
	5078	Hyalella	Amphipod, Hyalella azteca	1593
	----	Asellus	Isopod, Asellus communis	-----
	-----	Limnodrilus	Tubificid worm, Limnodrilus hoffmeisteri	-----
	-----	Helisoma	Snail, Helisoma campanulata	----
	4369	Nephelopsis	Leech, Nephelopsis obscura	1371
	9933	Gambusia	Mosquitofish, Gambusia affinis	1359
	-----	Gammarus	Amphipod, Gammarus pseudolimnaeus	----
	-----	Crangonyx	Amphipod, *Crangonyx* sp.	----
	-----	Nemoura	Stonefly, Nemoura trispinosa	----
	-----	Lepidostoma	Caddisfly, *Lepidostoma* sp.	----
	-----	Parapsyche	Caddisfly, *Parapsyche* sp.	----
	9157	Lepomis	Green sunfish, Lepomis cyanellus	1253
			Bluegill, Lepomis macrochirus	

Rank	GMAV	Genus	Species	pGMCV
	3946	Diaptomus	Copepod, Diaptomus clavipes	1238
	8971	Notropis	Red shiner, Notropis lutrensis	1228
	3891	Lirceus	Isopod, Lirceus fontinalis	1221
	3728	Gyraulus	Snail, Gyraulus circumstriatus	1170
			Snail, Guraulus parvus	
	8043	Oncorhynchus	Rainbow trout, Oncorhynchus mykiss	1101
	3350	Physa	Snail, Physa heterostropha	1051
			Snail, Physa gyrina	
	7442	Ameiurus	Black bullhead, *Ameiurus melas*	1018
	3086	Villosa	Mussel, Villosa delumbis	968.3
			Mussel, Villosa iris	
	6515	Pimephales	Fathead minnow, Pimephales promelas	891.5
	2835	Lampsilis	Mussel, Lampsilis fasciola	889.6
			Mussel, Lampsilis siliquoidea	
	6111	Cyprinella	Bannerfin shiner, *Cyprinella leedsi*	836.2
	5897	Rana	Bullfrog (tadpole), *Rana catesbeiana*	806.9
4	2326	Daphnia	Cladoceran, Daphnia ambigua	729.8
			Cladoceran, Daphnia magna	
			Cladoceran, Daphnia pulex	
3	4686	Pseudacris	Chorus frog, *Pseudacris* sp.	641.2
2	1542	Ceriodaphnia	Cladoceran, Ceriodaphnia dubia	483.8
1	1128	Sphaerium	Fingernail clam, *Sphaerium simile*	353.9
			Fingernail clam, *Sphaerium tenue*	

* Name of family, not name of genus.
FCV based on predicted GMCVs = 421.5 mg chloride/L at hardness = 300 mg/L and sulfate = 65 mg/L.
CCC = (421.5 mg chloride/L) (hardness/300)0.205797 (sulfate/65)-0.07452 = (177.87 mg chloride/L) (hardness)0.205797 (sulfate)-0.07452
At hardness = 300 mg/L and sulfate = 65 mg/L, CCC = 421.5 mg chloride/L.

Table 3 References for sources reporting chloride toxicity to aquatic organisms; Excerpted from "Results of Literature Search concerning the Toxicity of Chloride to Aquatic Animals"; 09MayChlorideRefs.pdf.

Comments are intended to be consistent with "Description of the Review of Results of Toxicity Tests on Chloride" dated 5-21-09.The only test materials that are addressed in the following table are calcium chloride, magnesium chloride, potassium chloride, and sodium chloride. Interpreting results obtained with these four test materials might not be straightforward, however, because, for example, potassium and magnesium ions might be sufficiently toxic to impact the results of tests on their chloride salts.

	Comments
Academy of Natural Sciences. 1960. The Sensitivity of Aquatic Life to Certain Chemicals Commonly Found in Industrial Wastes. Final Report No. RG-3965(C2R1). Academy of Natural Sciences, Philadelphia, PA. (A: 5683)	Results of acute tests on chloride are acceptable. (7-9 mg Cl/L in dilution water)
Adelman, I.R., and L.L. Smith, Jr. 1976a. Standard Test Fish Development. Part I. Fathead Minnows (*Pimephales promelas*) and Goldfish (*Carassius auratus*) as Standard Fish in Bioassays and Their Reaction to Potential Reference Toxicants. EPA-600/3-76/061a.	Results are not acceptable because potassium phosphate was used to buffer pH; the goldfish had tapeworms. (Fish were fed during tests.)
Adelman, I.R., and L.L. Smith, Jr. 1976b. Fathead Minnows (*Pimephales promelas*) and Goldfish (*Carassius auratus*) as Standard Fish in Bioassays and Their Reaction to Potential Reference Toxicants. J. Fish. Res. Bd. Can. 33:209-214.	Same data as Adelman and Smith 1976a.
Adelman, I.R., L.L. Smith, Jr., and G.D. Siesennop. 1976. Acute Toxicity of Sodium Chloride, Pentachlorophenol, Guthion, and Hexavalent Chromium to Fathead Minnows (*Pimephales promelas*) and Goldfish (*Carassius auratus*). J. Fish. Res. Bd. Can. 33:203-208.	Same data as Adelman and Smith 1976a.
Al-Daham, N.K., and M.N. Bhatti. 1977. Salinity Tolerance of *Gambusia affinis* (Baird & Girard) and *Heteropneustes fossilis* (Bloch). J. Fish Biol. 11:309-313.	Results of acute tests on chloride using *G. affinis* are acceptable. *H. fossilis* is not resident.
Almeida, A.M., et al. 2005. Transformation of Tobacco with an *Arabidopsis thaliana* gene involved in Trehalose Biosynthesis Increases Tolerance to Several Abiotic Stresses. Euphyutica 146:165-176.	Results are not acceptable because they concern tolerance of tobacco to osmotic stress.
Anderson, B.G. 1944. The Toxicity Thresholds of Various Substances Found in Industrial Wastes As Determined by the Use of *Daphnia magna*. Sewage Works J. 16(6):1156-1165. (A: 2171)	Results are not acceptable because the duration was too short.
Anderson, B.G. 1946. The Toxicity Thresholds of Various Sodium Salts Determined by the Use of *Daphnia magna*. Sewage Works J. 18(1):82-87. (A: 2130)	Results of acute tests on chloride are acceptable.

	Comments
Anderson, B.G. 1948. The Apparent Thresholds of Toxicity of *Daphnia magna* for Chlorides of Various Metals When Added to Lake Erie Water. Trans. Amer. Fish. Soc. 78:96-113.	Results of acute tests on chloride are acceptable, but must be footnoted as 64hr tests.
Anderson, K.B. 1977. *Musculium Transversum* in the Illinois River and an Acute Potassium Bioassay Method for the Species. PB-288088. National Technical Information Service, Springfield, VA.	Results of acute and chronic tests on KCl.
Anderson, K.B., et al. 1978. Rapid Assessment of Water Quality, Using the Fingernail Clam, *Musculium transversum*. UILU-WRC-780133. University of Illinois at Urbana-Champaign, Water Resources Center.	Results of acute and chronic tests on KCl.
Anonymous. Toxicity Studies in Fish Using Thirteen Chemicals in Sewer Effluent. EPA/OTS. Doc #86-870000533; Microfische number: NTIS/OTS0513611.	Results are not acceptable because the test was on hydrochloric acid in sewer effluent.
Aragao, M.A., and E.V. Pereira. 2003. Sensitivity of *Ceriodaphnia dubia* of Different Ages to Sodium Chloride. Bull. Environ. Contam. Toxicol. 70:1247-1250.	These are chronic tests.
Arambasic, M.B., S. Bjelic, and G. Subakov. 1995. Acute Toxicity of Heavy Metals (Copper, Lead, Zinc), Phenol and Sodium on Allium cepa L., *Lepidium sativum* L. and *Daphnia magna* St.: Comparative Investigations and the Practical Applications. Water Res. 29(2):497503. (A: 13712)	Results are not acceptable because an unusual dilution water was used.
Baillieul, M., et al. 1993. Assessment of the Toxicity of an Industrial Effluent with a Two-generation Reproduction Test using *Daphnia magna*. Sci. Total Environ. Supplement:1159-1164.	Results are not acceptable because tests were on an effluent and cadmium chloride.
Baudouin, M.F., and P. Scoppa. 1974. Acute Toxicity of Various Metals to Freshwater Zooplankton. Bull. Environ. Contam. Toxicol. 12:745-751.	Results are not acceptable because the test species are not resident.

	Comments
Beak International Inc. 1999. Ecotoxicity Test Results. Unpublished report for M.S. Evans.	Evans and Frick (2001) say that this contains results of 7-day tests with fathead minnows and 7-and 27-day tests with rainbow trout. Evans has not replied to requests for this document. It appears that no results would be acceptable.
Benbow, M.E., and R.W. Merritt. 2004. Road-salt Toxicity of Select Michigan Wetland Macroinvertebrates under Different Testing Conditions. Wetlands 24:68-76.	Results are not acceptable because the test material was road salt.
Bernot, R.J., M.A. Brueseke, M.A. Evans-White, and G.A. Lamberti. 2005. Acute and Chronic Toxicity of Imidazolium-based Ionic Liquids on *Daphnia magna*. Environ. Toxicol. Chem. 24:87-92 (A: 80861)	Results of acute tests on KCl.
BHP Billiton Diamonds. 2008. Site-specific Water Quality Objective for Chloride.	Results are not acceptable because too little information is given concerning methodology.
Biesinger, K.E., and G.M. Christensen. 1972. Effects of Various Metals on Survival, Growth, Reproduction, and Metabolism of *Daphnia magna*. J. Fish. Res. Bd. Canada 29:1691-1700 (A: 2022)	Results of acute tests on chloride are acceptable. Contains comparisons of fed and unfed acute tests. Also contains chronic tests.
Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson. 1980. Aquatic Toxicity Tests on Inorganic Elements Occurring in Oil Shale. IN: Oil Shale Symposium, C. Gale (ed.), USEPA. PB80-221435. pp. 519-534.	Chronic test on magnesium chloride.
Birge, W.J., J.A. Black, A.G. Westerman, T.M Short, S.B. Taylor, D.M. Bruser, and E.D. Wallingford. 1985. Recommendations on Numerical Values for Regulating Iron and Chloride Concentrations for the Purpose of Protecting Warmwater Species of Aquatic Life in the Commonwealth of Kentucky.	Results of acute tests on chloride are acceptable, except when chloride was a component of an effluent. Also contains chronic tests.

	Comments
Black, H.H. 1950. Federal Industrial Pollution Studies. Sew. Indus. Wastes 22:1049-1053.	No results of toxicity tests.
Blasius, B.J., and R.W. Merritt. 2002. Field and Laboratory Investigations on the Effects of Road Salt (NaCl) on Stream Macroinvertebrate Communities. Environ. Pollut. 120:219-231.	Results are not acceptable because the test material was road salt.
Borgmann, U. 1996. Systematic Analysis of Aqueous Ion Requirements of *Hyalella azteca*: A Standard Artificial Medium Including the Essential Bromide Ion. Arch. Environ. Contam. Toxicol. 30:356-363.	No results of toxicity tests.
Boutet, C., and C. Chaisemartin. 1973. Specific Toxic Properties of Metal Salts of *Austropotamobius pallipes pallipes* and *Orconectes limosus*. C.R. Soc. Biol 167:1933-1938. (English translation used)	Results of acute, but not chronic, tests on MgCl2 and KCl using *O. limosus* are acceptable. *A. pallipes* is not resident.
Bright, D.A., and J. Addison. 2002. Derivation of Matrix Soil Standards for Salt under the British Columbia Contaminated Sites Regulation. Royal Roads University, British Columbia, Canada.	Results are not acceptable because they are secondary information.
Bringoff, R.B., et al. 2007. Acute and Chronic Toxicity of Technical-grade Pesticides to Glochidia and Juveniles of Freshwater Mussels (Unionidae). Environ. Toxicol. Chem. 26:2086-2093.	Results of tests on NaCl using juveniles are acceptable, but results of tests using glochidia are not acceptable.
Buckley, J.A., K.P. Rustagi, and J.D. Laughlin. 1996. Response of *Lemna minor* to Sodium Chloride and a Statistical Analysis of Continuous Measurements for EC50 and 95% Confidence Limits Calculation. Bull. Environ. Contam. Toxicol. 57:1003-1008.	Results are not acceptable because the test organisms were plants.
Burton, G.A., Jr., et al. 1996. Interlaboratory Study of Precision: *Hyalella azteca* and *Chironomus tentans* Freshwater Sediment Toxicity Assays. Environ. Toxicol. Chem. 15:1335-1343.	Results of acute tests on KCl.
Cairns, J., and A. Scheier. 1959. The Relationship of Bluegill Sunfish Body Size to its Tolerance for Some Common Chemicals. Proc.13th Ind. Waste Conf., Purdue Univ, Eng. Bull 43:243-252. (A: 930)	Results of acute tests on calcium chloride.
Calleja, M.C., G. Persoone, and P. Geladi. 1994. Comparative Acute Toxicity of the First 50 Multicentre Evaluation of In Vitro Cytotoxicity Chemicals to Aquatic Non-vertebrates. Arch. Environ. Contam. Toxicol. 26:69-78.	Results are not acceptable because the duration was too short.
Camargo, J.A., and J.V. Tarazona. 1991. Short-term Toxicity of Fluoride Ion (F □) Soft Water to Rainbow Trout and Brown Trout. Chemosphere 22:605-611.	Results of acute tests on chloride are acceptable.
Cant, B., K. James, and T. Ryan. 2003. Salt Impact Model.	No results of toxicity tests.

	Comments
Chadwick, M.A., and J.W. Feminella. 2001. Influence of Salinity and Temperature on the Growth and Production of a Freshwater Mayfly in the Lower Mobile River, Alabama. Limnol. Oceanogr. 46:532-542.	Results are not acceptable because too few test organisms were used and the test material was an aquarium salt.
Chervinski, J. 1983. Salinity Tolerance of the Mosquito Fish, *Gambusia affinis* (Baird and Girard). J. Fish Biol. 22:9-11.	Results are not acceptable because all treatments were mixtures of fresh water and seawater.
Clemens, H.P., and W.H. Jones. 1954. Toxicity of Brine Water from Oil Wells. Trans. Amer. Fish. Soc. 84:97-109.	Results of acute tests on chloride are acceptable.
Clunie, P., T. Ryan, K. James, and B. Cant. 2002. Implications for Rivers from Salinity Hazards: Scoping Study.	Results are not acceptable because they are secondary information. Ranges within fishes and within invertebrates are wide.
Cooney, J.D., et al. 1992. Effects of Environmental and Experimental Design Factors on Culturing and Toxicity Testing on *Ceriodaphnia dubia*. Environ. Toxicol. Chem. 11:839-850.	Chronic tests on NaCl using *Ceriodaphnia dubia*.
Cowgill, U.M. 1987. Critical Analysis of Factors Affecting the Sensitivity of Zooplankton and the Reproducibility of Toxicity Test Results. Wat. Res. 21:1453-1462.	Some results are acceptable.
Cowgill, U.M., and D.P. Milazzo. 1990. The Sensitivity of Two Cladocerans to Water Quality Variables: Salinity and Hardness. Arch. Hydrobiol. 120:185-196.	Results of *C. dubia* acute tests on NaCl are acceptable. Results of other acute tests are not acceptable because the calcium chloride is from a brine well. Also contains chronic tests.
Cowgill, U.M., and D.P. Milazzo. 1991a. The Response of the Three Brood *Ceriodaphnia* Test to Fifteen Formulations and Pure Compounds in Common Use. Arch. Environ. Contam. Toxicol. 21:35-40.	No toxicity tests on chlorides.
Cowgill, U.M., and D.P. Milazzo. 1991b. The Sensitivity of Two Cladocerans to Water Quality Variables: Salinity <467 mg NaCl/L and Hardness <200 mg CaCO3/L. Arch. Environ. Contam. Toxicol. 21:218223.	These are chronic tests.

	Comments
Cressman, C.P. III, and P.L. Williams. 1997. Reference Toxicants for Toxicity Testing Using *Caenorhabditis elegans* in Aquatic Media. IN: Environmental Toxicology and Risk Assessment: Modeling and Risk Assessment (Sixth Volume), Dwyer, F.J., T.R. Doane, and M.L. Hinman (eds), ASTM.	Results are not acceptable because the tests used a non-aquatic nematode and the dilution water was a broth.
Crisinel, A., et al. 1994. Cyst-based Ecotoxicological Tests Using Anostracans: Comparison of Two Species of *Streptocephalus*. Environ. Toxicol. Water Qual. 9:317-326.	Results are not acceptable because duration was too short.
Cronkite, D.L., A.N. Gustafson, and B.F. Bauer. 1985. Role of Protein Synthesis and Ninhydrin-Positive Substances in Acclimation of *Paramecium tetraurelia* to High NaCl. J. Exp. Zool. 233:21-28 (A: 19928)	Results are not acceptable because these studies concerned acclimation.
Crowther, R.A., and H.B.N. Hynes. 1977. The Effect of Road Deicing Salt on the Drift of Stream Benthos. Environ. Pollut. 14:113-126.	Results are not acceptable because these studies concerned drift.
Cruikshank, D.R. 1991. Whole Lake Additions in the Experimental Lakes Area, 1986-1989. Can. Data Rept. Fish. Aquat. Sci. No. 816.	Results are not acceptable because hydrochloric acid was added to a lake.
Davies, T.D., and K.J. Hall. 2007. Importance of Calcium in Modifying the Acute Toxicity of Sodium Sulphate to *Hyalella azteca* and *Daphnia magna*. Environ. Toxicol. Chem. 26:1243-1247.	Results of acute tests on chloride are acceptable. KCl is much more toxic than NaCl to *D. magna*.
DeGraeve, G.M., J.D. Cooney, B.H. Marsh, T.L. Pollock, and N.G. Reichenbach. 1992. Variability in the Performance of the 7-d *Ceriodaphnia dubia* Survival and Reproduction Test: an Intra-and Interlaboratory Study. Environ. Toxicol. Chem. 11:851-866.	Chronic tests on sodium chloride using *C. dubia*.
De Jong, L.E. 1965. Tolerance of *Chlorella vulgaris* for Metallic and Non-metallic ions. Antonie Leeuwenhoek 31:301-313.	Results are not acceptable because the test organisms were plants.
Diamond, J.M, E.L. Winchester, D.G. Mackler, and D. Gruber. 1992. Use of the Mayfly *Stenonema modestum* (Heptageniidae) in Subacute Toxicity Assessments. Environ. Toxicol. Chem. 11:415-425.	Chronic tests on chloride using a mayfly, the fathead minnow, and *Ceriodaphnia dubia*.

	Comments
Diamond, J., et al. 2005. Effects of Pulsed Contaminant Exposures on Early Life Stages of the Fathead Minnow. Arch. Environ. Contam. Toxicol. 49:511-519.	Results are not acceptable because they concern the effect of pulsed exposures on the 7-d subchronic test.
Dodson, S.I., and D.G. Frey. 2001. Cladocera and Other Branchiopoda. IN: Ecology and Classification of North American Freshwater Invertebrates. 2nd ed. J.H. Thorp and A.P Covich, ed.	Results are not acceptable because they are secondary information.
Dowden, B.F. 1960. Cumulative Toxicities of Some Inorganic Salts to *Daphnia magna* as Determined by Median Tolerance Limits. Proc. La. Acad. Sci. 23:77-85. (A: 2465) [This was mistakenly cited in USEPA 1988 as "Dowden 1961".]	Results are not acceptable because the dilution water was from a drainpipe-fed lake on the LSU campus.
Dowden, B.F. 1962. A Simple Solution for the Support of Aquatic Test Animals. La. Acad. Sci. 25:80-85.	No results of toxicity tests.
Dowden, B.F., and H.J. Bennett. 1965. Toxicity of Selected Chemicals to Certain Animals. J. Water Pollut. Control Fed. 37(9):1308-1316. (A: 915)	Some results are acceptable, but other results are not acceptable because duration was too long or too short or the dilution water was from a drainpipe-fed lake on the LSU campus.
Dunlop, J., G. McGregor, and N. Horrigan. 2005. Potential Impacts of Salinity and Turbidity in Riverine Ecosystems.	No results of toxicity tests.
Dunlop, J.E., et al. 2007. Effect of Spatial Variation on Salinity Tolerance of Macroinvertebrates in Eastern Australia and Implications for Ecosystem Protection Trigger Values. Environ. Pollut. (In press).	Results are not acceptable because the treatments were prepared by dissolving a synthetic sea salt in distilled water.
Dvorak, M., J. Kouiril, and I. Prikryl. 1985. The Tolerance of Early Wels Fry to Preventive Baths in NaCl and Formalin Solutions. Prace Vurh Vodnany 14:36-42.	Results are not acceptable because duration was too short.

	Comments
Edmister, J.O., and J.W. Gray. 1948. The Toxicity Thresholds for Three Chlorides and Three Acids to the Fry of Whitefish (*Coregonus clupeaformis*) and Yellow Pickerel (*Stizostedion v. vitreum*). Prog. Fish-Cult. 10:105-106	Results are not acceptable because no information is given concerning methodology.
Environ International Corp. 2009. Chloride Toxicity Test Results.	Results of acute tests on chloride are acceptable.
Environment Canada. 1994. The Comparative Toxicity of Crude and Refined Oils to Daphnia magna. Report No. EE-152.	Results are not acceptable because they are secondary information.
Evans, M., and C. Frick. 2001. The Effects of Road Salts on Aquatic Ecosystems. Environment Canada, National Water Research Institute, Burlington/Saskatoon, Canada.	Results are not acceptable because they are secondary information.
Fairchild, E.J. 1955. Low Dissolved Oxygen: Effect Upon the Toxicity of Certain Inorganic Salts to the Aquatic Invertebrate *Daphnia magna*. Louisiana State University Engineering Experiment Station Bulletin 51:95-102.	Results are not acceptable because duration was too long.
Fairchild, E.J. 1954. Effects of Lowered Oxygen Tension on the Susceptibility of *Daphnia magna* to Certain Inorganic Salts. Thesis. Louisiana State University, Baton Rouge, LA.	Results are not acceptable because duration was too long.
Fisher, S.W., P. Stromberg, K.A. Bruner, and L.D. Boulet. 1991. Molluscicidal Activity of Potassium to the Zebra Mussel, *Dreissena polymorphia*: Toxicity and Mode of Action. Aquat. Toxicol. 20:219234.	Results are not acceptable because duration was too short.
Fisher, S.W., et al. 1992. The Toxicity of Potassium Chloride to Zebra Mussel Veligers and Select Nontarget Organisms. J. Shellfish Res. 11(1):225.	Non-standard tests were performed with zebra mussels; no results were given for other species.
Galat, D.L., and R. Robinson. 1983. Predicted Effects of Increasing Salinity on the Crustacean Zooplankton Community of Pyramid Lake, Nevada. Hydrobiologia 105:115-131.	Results are not acceptable because the treatments were prepared by concentrating lake water.
Garibay, R., and S. Hall. 2004. Chloride Threshold Recommendations for the Protection of Aquatic Life in the Upper Santa Clara River. The Advent Group, Brentwood, TN. Attachment 8: NaCl Testing with Three-Spined Stickleback Attachment 9: NaCl Testing with Chorus Frog Tadpoles	Results of acute tests on chloride are acceptable.

	Comments
Garrey, W.E. 1916. The Resistance of Fresh Water Fish to Changes in Osmotic and Chemical Conditions. Am. J. Physiol. 39:313-329.	Results are not acceptable because these were non-standard tests in distilled water.
Geddes, M.C. 1979. Salinity Tolerance and Osmotic Behaviour of European Carp (*Cyprinus carpio* L.) from the River Murray, Australia. Royal Society of South Australia 103:185-189.	Results are not acceptable because the treatments were prepared by adding seawater to dechlorinated tap water.
Geilenkirchen,W.L.M. 1964. The Action and Interaction of Calcium and Alkali Chlorides on Eggs of *Lymnaea stagnalis* and Their Chemical Interpretation. Exp. Cell Res. 34:463-487.	Results are not acceptable because these were non-standard tests in distilled water.
Ghosh, A.K., and R.N. Pal. 1969. Toxicity of Four Therapeutic Compounds to Fry of Indian Major Carps. Fish. Technol. 6:120-123.	Results are not acceptable because the test species are not resident.
GLEC and INHS. 2008. Acute Toxicity of Chloride to Select Freshwater Invertebrates. Final Draft Report to USEPA. 9-26-08.	Results of acute tests on chloride are acceptable.
Goetsch, P.A., and C.G. Palmer. 1997. Salinity Tolerances of Selected Macroinvertebrates of the Sabie River, Kruger National Park, South Africa. Arch. Environ. Contam. Toxicol. 32(1):32-41. (A: 17845)	Results are not acceptable because industrial-grade NaCl was used, organisms were not identified to species and not obtained in North America, some control mortalities were >10%, and the field-collected organisms were not adequately acclimated.
Gonzalez-Moreno, S., J. Gomez-Barrera, H. Perales, and R. Moreno-Sanchez. 1997. Multiple Effects of Salinity on Photosynthesis of the Protist *Euglena gracilis*. Physiologia Plantarum 101:777-786.	Results are not acceptable because the test species is a plant.

	Comments
Grizzle, J.M., and A.C. Mauldin II. 1995. Effect of Calcium on Acute Toxicity of Sodium Chloride to Larval and Newly Transformed Juvenile Striped Bass. J. Aqua. Animal Health 7:298-303.	Results are not acceptable because duration is too short. Calcium reduced the toxicity of NaCl.
Grundy, J.E., and K.B. Storey. 1994. Urea and Salt Effects on Enzymes from Estivating and Non-estivating Amphibians. Molecular Cellular Biochem. 131:9-17.	Results are not acceptable because these tests concerned effects of NaCl and KCl on enzymes.
Hamilton, R.W., J.K. Buttner, and R.G. Brunetti. 1975. Lethal Levels of Sodium Chloride and Potassium Chloride for an Oligochaete, a Chironomid Midge, and a Caddisfly of Lake Michigan. Environ. Entomol. 4:1003-1006.	Results are not acceptable because the midges were not adequately acclimated; tests using the other two species were too short.
Harmon, S.M., et al. 2003. A Comparison of the Daphnids *Ceriodaphnia dubia* and *Daphnia ambigua* for Their Utilization in Routine Toxicity Testing in the Southeastern United States. Arch. Environ. Contam. Toxicol. 45:79-85.	Results of acute tests on chloride are acceptable. Also contains chronic tests.
Hart, B.T., et al. 1991. A Review of the Salt Sensitivity of the Australian Freshwater Biota. Hydrobiologia 210:105-144.	Result are not acceptable because they are secondary information.
Health Canada. 2006. Sodium chloride.	Results are not acceptable because they are secondary information.
Hinton, M.J., and A.G. Eversole. 1978. Toxicity of Ten Commonly Used Chemicals to American Eels. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 32:599-604.	Results of acute tests on chloride are acceptable.
Hinton, M.J., and A.G. Eversole. 1979. Toxicity of Ten Chemicals Commonly Used in Aquaculture to the Black Eel Stage of the American Eel. Proc. World Maricul. Soc. 10:554-560.	Results of acute tests on chloride are acceptable.
Hodgson, E.S. 1951. Reaction Thresholds of an Aquatic Beetle, *Laccophilus maculosus* Germ., to Salts and Alcohols. Physiol. Zool. 24:131-140.	Results are not acceptable because these were non-standard tests.
Hoke, R.A., W.R. Gala, J.B. Drake, J.P. Giesy, and S. Flegler. 1992. Bicarbonate as a Potential Confounding Factor in Cladoceran Toxicity Assessments on Pore Water from Contaminated Sediments. Can. J. Fish. Aquat. Sci. 49:1633-1640.	Results of acute tests on chloride are acceptable.

	Comments
Horrigan, N., J.E. Dunlop, B.J. Kefford, and F. Zavahir. 2007. Acute Toxicity Largely Reflects the Salinity Sensitivity of Stream Macroinvertebrates Derived using Field Distributions. Marine and Freshwater Res. 58:178-186.	Results are not acceptable because they are secondary information.
Hosiaisluoma, V. 1976. Effect of HCl and NaCl on the Growth of *Netrium digitus* (Desmidiales). Ann. Bot. Fennici. 13:107-113.	Results are not acceptable because the test species was an alga.
Hruska, K.A., and M.G. Dube. 2004. Using Artificial Streams to Assess the Effects of Metal Mining Effluent on the Life Cycle of the Freshwater Midge (*Chironomus tentans*) in situ. Environ. Toxicol. Chem. 23:2709-2718.	Results are not acceptable because the test was on an effluent that contained metals, etc.
Hughes, J.S. 1969. Toxicity of Some Chemicals to Striped Bass (*Roccus saxatilis*). Proceedings of the Twenty-second Annual Conference of the Southeastern Association. (A: 5990) The methodology is also described in Hughes (1971).	Results are not acceptable because the fish were not adequately acclimated.
Hughes, J.S. 1971. Tolerance of Striped Bass, *Morone saxatilis* (Walbaum), Larvae and Fingerlings to Nine Chemicals Used in Pond Culture. Proc. Ann. Conf. S.E. Assoc. Game Fish. Comm. 24:431-438 (A: 2724).	No results concerning chloride.
Hughes, J.S. 1973. Acute Toxicity of Thirty Chemicals to Striped Bass (*Morone saxatilis*). Louisiana Wild Life and Fisheries Commission. (A: 2012)	Same data as Hughes (1969).
James, K.R., B. Cant, and T. Ryan. 2003. Responses of Freshwater Biota to Rising Salinity Levels and Implications for Saline Water Management: A Review. Australian J. Botany 51:703-713.	Results are not acceptable because they are secondary information.
Jasim, B.M. 1988. Tolerance and Adaptation of Goldfish *Carassius auratus* (L.) to Salinity. J. Biol. Sci. Res. 19:149-154.	Results are not acceptable because they are expressed in terms of conductivity.
Jones, J.R.E. 1941. A Study of the Relative Toxicity of Anions, with *Polycelis nigra* as Test Animal. J. Exp. Biol. 18:170-181. (A: 40155)	Results are not acceptable because the dilution water was distilled water.
Jop, K.M., and A.M. Askew. 1994. Toxicity Identification Evaluation Using a Short-term Chronic Test with *Ceriodaphnia dubia*. Bull. Environ. Contam. Toxicol. 53:91-97.	Results are not acceptable because unusual dilution water and salts were used.
Judd, K.E., et al. 2005. A Case History: Effects of Mixing Regime on Nutrient Dynamics and Community Structure in Third Sister Lake, Michigan, During Late Winter and Early Spring 2003. Lake Reserv. Manage. 21:316-329.	No results of toxicity tests.

	Comments
Kapoor, N.N. 1979. Osmotic Regulation and Salinity Tolerance of the Stonefly Nymph, *Paragnetina media*. J. Insect Physiol. 25:17-20.	Results are not acceptable because the dilution water was distilled water.
Karraker, N.E. 2007. Are Embryonic and Larval Green Frogs (*Rana clamitans*) Insensitive to Road Deicing Salt? Herpt. Conser. Biol. 2:3541.	Results are not acceptable because they were tests on road salt.
Keating, K.I., and B.C. Dagbusan. 1986. Diatoms in Daphnid Culture and Bioassay. Environ. Toxicol. Chem. 5:299-307.	Results are not acceptable because these were 72-h unfed tests with *D. pulex.*
Kefford, B.J., P.J. Papas, and D. Nugegoda. 2003. Relative Salinity Tolerance of Macroinvertebrates from the Barwon River, Victoria, Australia. Marine and Freshwater Res. 54:755-765.	Results are not acceptable because the treatments were prepared by dissolving a synthetic sea salt in tap water.
Kefford, B.J., P.J. Papas, and D. Nugegoda. 2003. Lethal Salinity Tolerance and Selected Field Distributions of Freshwater Macroinvertebrate Taxa Tested in the Present Study. Accessory publication to Kefford et al. (2003).	Results are not acceptable because they are secondary information.
Kefford, B.J., P.J. Papas, L. Metzeling, and D. Nugegoda. 2004. Do Laboratory Salinity Tolerances of Freshwater Animals Correspond with Their Field Salinity? Environ. Pollut. 129:355-362.	Results are not acceptable because they are secondary information. Discusses ways of measuring tolerance to salinity.
Kefford, B.J., C.G. Palmer, L. Pakhomova, and D. Nugegoda. 2004. Comparing Test Systems to Measure the Salinity Tolerance of Freshwater Invertebrates. Water SA 30:499-506.	Results are not acceptable because they are given in terms of salinity.
Kefford, B.J., and D. Nugegoda. 2005. No Evidence for a Critical Salinity Threshold for Growth and Reproduction in the Freshwater Snail *Physa acuta*. Environ. Pollut. 134:377-383.	Results are not acceptable because the tested treatments were prepared by dissolving a synthetic sea salt in distilled water.

	Comments
Keller, A.E. 2000. Water Quality and Toxicity Data for Unpublished Unionid Mussel Tests. Memorandum to R. Pepin. September 1.	Results of acute tests on KCl.
Khangarot, B.S. 1991. Toxicity of Metals to a Freshwater Tubificid Worm, *Tubifex tubifex* (Muller). Bull. Environ. Contam. Toxicol. 46:906-912. (A: 2918)	Results are not acceptable because test temperature was high and results of tests with *D. magna* (Khangarot and Ray 1989) in same water were unusually low.
Khangarot, B.S., and P.K. Ray. 1989. Investigation of Correlation Between Physicochemical Properties of Metals and Their Toxicity to the Water Flea *Daphnia magna* Straus. Ecotoxicol. Environ. Saf. 18(2):109-120. (A: 6631)	Results of acute tests on chloride are acceptable. (7 mg Cl/L in the dilution water.)
Khanna, N., C.P. Cressman III, C.P. Tatara, and P.L. Williams. 1997. Tolerance of the Nematode *Caenorhabditis elegans* to pH, Salinity, and Hardness in Aquatic Media. Arch. Environ. Contam. Toxicol. 32:110114.	Results are not acceptable because the test species was a non-aquatic nematode.
Kostecki, P.T., and J.J. Jones. 1983. The Effect of Osmotic and Ion-osmotic Stresses on the Mortality of Rainbow Trout (*Salmo gairdneri*). Comp. Biochem. Physiol. 74A:773-775.	Results are not acceptable because duration was too short and an unusual dilution water was used.
Kszos, L.A., J.D. Winter, and T.A. Storch. 1990. Toxicity of Chautauqua Lake Bridge Runoff to Young-of-the-Year Sunfish (*Lepomis macrochirus*). Bull. Environ. Contam. Toxicol. 45:923-930.	Results are not acceptable because there were only 6 fish per treatment and no results for 96 hr.
Lange, M., W. Gebauer, J. Marki, and R. Nagel. 1995. Comparison of Testing Acute Toxicity on Embryos of Zebrafish, *Brachydania rerio* and RTG-2 Cytotoxicity as Possible Alternatives to the Acute Fish Test. Chemosphere 30:2087-2102.	Results are not acceptable because the zebrafish is not resident and tests using cells are not acceptable.
Lasier, P.J., P.V. Winger, and R.E. Reinert. 1997. Toxicity of Alkalinity to *Hyalella azteca*. Bull. Environ. Contam. Toxicol. 59:807-814.	Results of acute tests on chloride are acceptable.
Lasier, P.J., P.V. Winger, W.S. Perkins, and G.L. Baughman. 2004. Effects of Anions and Anion Mixtures on the Reproduction of *Ceriodaphnia dubia*. Poster at SETAC.	These are chronic tests.

	Comments
Lasier, P.J., P.V. Winger, and I.R. Hardin. 2006. Effects of Hardness and Alkalinity in Culture and Test Waters on Reproduction of *Ceriodaphnia dubia*. Environ. Toxicol. Chem. 25:2781-2786.	These are chronic tests.
Leblanc, G.A., and D.C. Surprenant. 1984. The Influence of Mineral Salts on Fecundity of the Water Flea (*Daphnia magna*) and the Implications on Toxicity Testing of Industrial Wastewater. Hydrobiol. 108:25-31.	These are chronic tests.
Lilius, H., B. Isomaa, and T. Holmstrom. 1994. A Comparison of the Toxicity of 50 Reference Chemicals to Freshly Isolated Rainbow Trout Hepatocytes and *Daphnia magna*. Aquat. Toxicol. 30:47-60.	Results are not acceptable because tests using *D. magna* were too short and tests using hepatocytes are not acceptable.
Lilius, H., T. Hastbacka, and B. Isomaa. 1995. A Comparison of the Toxicity of 30 Reference Chemicals to *Daphnia magna* and *Daphnia pulex*. Environ. Toxicol. Chem. 14:2085-2088.	Results are not acceptable because the duration was too short.
Lowell, R.B., J.M. Culp, and F.J. Wrona. 1995. Toxicity Testing with Artificial Streams: Effects of Differences in Current Velocity. Environ. Toxicol. Chem. 14:1209-1217.	Results are not acceptable because the duration was too short.
MacGregor, R., et al. 1986. The Effects of Total Hardness on Potassium Dichromate and Sodium Dichloride Acute Toxicity to *Daphnia pulex* and *Ceriodaphnia reticulata*. EPA/OTS. Doc. #4084421610; NTIS microfische number: NTIS/OTS0519382.	Results are not acceptable because very little information is given concerning methodology. Toxicity of NaCl was not significantly affected by hardness.
Mackie, G.L. 1978. Effects of Pollutants on Natality of *Musculium securis* (Bivalvia: Pisidiidae). Nautilis 92:25-33.	These are chronic tests.
Madsen, H. 1990. The Effect of Sodium Chloride Concentration on Growth and Egg Laying of *Helisoma duryi*, *Biomphalaria alexandrina* and *Bulinus truncatus* (Gastropoda: Planorbidae). J. Moll. Stud. 56:181-187.	Results are not acceptable because an unusual reconstituted water was used.
Mahajan, C.L., S.D. Sharma, and S.P. Sharma. 1979. Tolerance of Aquatic Organisms to Chloride Salts. Indian J. Exp. Biol. 17:12441245.	Results are not acceptable because the dilution water was deionized water.

	Comments
Mazik, P.M., et al. 1991. Influence of Nitrite and Chloride on Survival and Hematological Profiles of Striped Bass. Trans. Amer. Fish. Soc. 120:247-254.	Results are not acceptable because they concern the effect of NaCl and CaCl2 on the toxicity of nitrite.
McCulloch, W.L., W.L. Goodfellow, Jr., and J.A. Black. 1993. Characterization, Identification, and Confirmation of Total Dissolved Solids as Effluent Toxicants. Environ. Toxicol. Risk Assess. 2:213-227.	Results are not acceptable because they are secondary information.
McNulty, E.W., et al. 1999. Evaluation of Ability of Reference Toxicity Tests to Identify Stress in Laboratory Populations of the Amphipod *Hyalella azteca*. Environ. Toxicol. Chem. 18:544-548.	Studied toxicity of KCl to stressed and unstressed *H. azteca*.
Miklovic, A., and S.M. Galatowitsch. 2005. Effect of NaCl and *Typha angustifolia* L. on Marsh Community Establishment: A Greenhouse Study. Wetlands 25:420-429.	No results of toxicity tests on aquatic animals.
Mosslacher, F. 2000. Sensitivity of Groundwater and Surface Water Crustaceans to Chemical Pollutants and Hypoxia: Implications for Pollution Management. Arch. Hydrobiol. 149:51-66.	Results of tests on KCl.
Mount, D.R., D.D. Gulley, J.R. Hockett, T.D. Garrison, and J.M. Evans. 1997. Statistical Models to Predict the Toxicity of Major Ions to *Ceriodaphnia dubia*, *Daphnia magna* and *Pimephales promelas* (Fathead Minnows). Environ. Toxicol. Chem. 16(10):2009-2019. (A: 18272)	Although the organisms were fed during the tests, results of acute tests on chloride are acceptable. Comparisons of fed and unfed acute tests are reported.
Muschal, M. 2006. Assessment of Risk to Aquatic Biota from Elevated Salinity -A Case Study from the Hunter River, Australia. J. Environ. Manage. 79:266-278.	Results are not acceptable because they are secondary information and the species are not resident in North America.
Nagpal, N.K., D.A. Levy, and D.D. MacDonald. 2003. Ambient Water Quality Guidelines for Chloride. Environmental Protection Division, Ministry of Environment, British Columbia, Canada.	Results are not acceptable because they are secondary information.
Newman, M., and M.S. Aplin. 1992. Enhancing Toxicity Data Interpretation and Prediction of Ecological Risk with Survival Time Modeling: An Illustration Using Sodium Chloride Toxicity to Mosquitofish (*Gambusia holbrooki*). Aquat. Toxicol. 23:85-96.	Results are not acceptable because pH < 6.5.
Nielson, D.L., M.A. Brock, G.N. Rees, and D.S. Baldwin. 2003. Effects of Increasing Salinity on Freshwater Ecosystems in Australia. Australian J. Botany 51:655-665.	No results of toxicity tests.

	Comments
Nordlie, F.G., and A. Mirandi. 1996. Salinity Relationships in a Freshwater Population of Eastern Mosquitofish. J. Fish. Biol. 49:12261232.	Results are not acceptable because the treatments were ocean water diluted with deionized water.
Osterhout, J.V. 1906. Extreme Toxicity of Sodium Chloride and Its Prevention by Other Salts. J. Biol. Chem. 1:363-369.	Results are not acceptable because the test species were plants.
Padhye, A.D., and H.V. Ghate. 1992. Sodium Chloride and Potassium Chloride Tolerance of Different Stages of the Frog, *Microhyla ornata*. Herpetol. 2:18-23.	Results are not acceptable because the test species is not resident.
Palladini, G., V. Margotta, A. Carolei, and M.C. Hernandez. 1980. Dopamine Agonist Performance in Planaria after Manganese Treatment. Experientia 36:449-450.	Results are not acceptable because the dilution water was distilled water.
Palmer, C.G., et al. 2004. The Development of a Toxicity Database Using Freshwater Macroinvertebrates, and Its Application to the Protection of South African Water Resources. South African J. of Sci. 100:643-650 (with attached Table 1).	Some tests with the only resident species, *Daphnia pulex*, are acceptable.
Patrick, R., J. Cairns Jr., and A. Scheier. 1968. The Relative Sensitivity of Diatoms, Snails, and Fish to Twenty Common Constituents of Industrial Wastes. Prog. Fish-Cult. 30(3):137-140. (A: 949)	Results of acute tests on chloride are acceptable.
Phillips, A.M., Jr. 1944. The Physiological Effect of Sodium Chloride upon Brook Trout. Trans. Amer. Fish. Soc. 74:297-309.	Results are not acceptable because the exposures were via ingested salt and salt baths for up to 24 hr.
Pickering, Q.H., J.M. Lazorchak, and K.L. Winks. 1996. Subchronic Sensitivity of One-, Four-, and Seven-day-old Fathead Minnow (*Pimephales promelas*) Larvae to Five Toxicants. Environ. Toxicol. Chem. 15:353-359.	These are 7-day subchronic tests.
Pillard, D.A., J.R. Hockett, and D.R. DiBona. 1999. The Toxicity of Common Ions to Freshwater and Marine Organisms. American Petroleum Institute, Washington, DC.	Results are not acceptable because they are secondary information.
Pillard, D.A., P. Odenbeck, C. Archer, A. Hawkins, B.J. David, D.A. Anders, and J.A. Bleiler. 2006. Toxicity of Chloride Salts to Larval Amphibians. Poster at SETAC annual meeting.	Results are not acceptable because the durations and effects are non-standard.

	Comments
Rasowo, J., et al. 2007. Effects of Formaldehyde, Sodium Chloride, Potassium Permanganate, and Hydrogen Peroxide on Hatch Rate of African Catfish *Clarias gariepinus* eggs. Aquaculture 269:271-277.	Results are not acceptable because the test species is not resident.
Reed, P., and R. Evans. 1981. Acute toxicity of chlorides, sulfates, and total dissolved solids to some fishes in Illinois. Illinois Department of Energy and Natural Resources, State Water Survey Division. SWS Contract Report 283. (A: 60643)	Results are not acceptable because the sodium chloride was technical grade. (The test organisms were fed during the tests.)
Roback, S.S. 1965. Environmental Requirements of Trichoptera. IN: Biological Problems in Water Pollution, C.M. Tarzwell (ed.), USPHS Tech Rept. 999-WP25, Cincinnati, OH. pp. 118-126.	Results are not acceptable because these are field data relating chloride and caddisflies.
Rosicky, P., J. Kouril, and I. Prikryl. 1987. The Effect of the Length of Short-term Exposure to NaCl on the Tolerance of Early Common Carp and Silver Carp Fry to NaCl Baths. Bul. Vurh. Vodnany 23:8-13.	Results are not acceptable because duration was too short.
Rozman, K.K. 2000. The Role of Time in Toxicology or Haber's c x t Product. Toxicology 149:35-42.	Results are not acceptable because they are secondary information.
Salman, N.A., and F.B. Eddy. 1988. Effect of Dietary Sodium Chloride on Growth, Food Intake and Conversion Efficiency in Rainbow Trout (*Salmo gairdneri* Richardson). Aquaculture 70:131-144.	Results are not acceptable because they concern the effect of NaCl in food.
Sanzo, D., and S.J. Hecnar. 2006. Effects of Road De-Icing Salt (NaCl) on Larval Wood Frogs (*Rana sylvatica*). Environ. Pollut. 140:247-256.	Results are not acceptable because the sodium chloride was technical grade. (The test organisms were fed during the tests.) Also contains chronic tests.
Sarma, S.S.S. et al. 2006. Effects on NaCl Salinity on the Population Dynamics of Freshwater Zooplankton (Rotifers and Cladocerans). Aquat. Ecol. 40:349-360.	Results of unusual chronic tests on NaCl using ten species.

	Comments
Schreier, T.M., et al. 1996. Efficacy of Formalin, Hydrogen Peroxide, and Sodium Chloride on Fungal-infected Rainbow Trout Eggs. Aquatculture 140:323-331.	Results are not acceptable because they concern the effects of short pulses of NaCl on infected and uninfected eggs.
Seals, C., C.J. Kempton, J.R. Tomasso, Jr., and T.I.J. Smith. 1994. Environmental Calcium Does Not Affect Production or Selected Blood Characteristics of Sunshine Bass Reared under Normal Culture Conditions. Prog. Fish-Cult. 56:269-272.	No data pertaining to the toxicity of chloride.
Seymour, D.T., A.G. Verbeek, S.E. Hrudey, and P.M. Fedorak. 1997. Acute Toxicity and Aqueous Solubility of Some Condensed Thiophenes and Their Microbial Metabolites. Environ. Toxicol. Chem. 16:658-665.	Results of acute tests on chloride are acceptable.
Short, T.M., et al. 1991. Ecology of a Saline Stream: Community Responses to Spatial Gradients on Environmental Conditions. Hydrobiologia 226:167-178.	Results are not acceptable because they concern effects of oil-field brines on a stream.
Slaughter, A.R., C.G. Palmer, and W.J. Muller. 2007. An Assessment of Two-Step Linear Regression and Multifactor Probit Analysis as Alternatives to Acute to Chronic Ratios in the Estimation of Chronic Responses from Acute Toxicity Data to Derive Water Quality Guidelines. Integ. Environ. Assess. Manage. 3:193-202.	Results are not acceptable because the test species are not resident.
Sparks, R.E., and K.B. Anderson. 1977. Acute Toxicity of Potassium to the Fingernail Clam, *Musculium transversum*. Trans. Ill. State Acad. Sci. 69:229.	Same data as Anderson et al. 1978.
Spehar, R.L. 1986. Criteria Document Data. Memorandum to D.J. Call. September 16.	Results of acute tests on chloride are acceptable. Also contains a chronic test.
Spehar, R.L. 1987. Criteria Document Data. Memorandum to C. Stephan. June 24.	Results of acute tests on chloride are acceptable. Also contains a chronic test.
Stanley, R.A. 1974. Toxicity of Heavy Metals and Salts to Eurasian Watermilfoil. Arch. Environ. Contam. Toxicol. 2:331-341.	Results are not acceptable because the test organisms were plants.

	Comments
Stom, D.I., and L.D. Zubareva. 1994. Comparative Resistance of *Daphnia* and *Epischura* to Toxic Substances in Acute Exposure. Hydrobiol. J. 30:35-38. (A: 17048)	Results are not acceptable because the tests with *D. magna* were too short, there were too few test organisms, and *E. baicalensis* is not resident.
Sutcliffe, D.W. 1961. Studies on Salt and Water Balance in Caddis Larvae (Trichoptera). II. Osmotic and Ionic Regulation of Body Fluids in *Limnephilus stigma* Curtis and *Anabolia nervosa* Leach. J. Exp. Biol. 38:521-530.	Results are not acceptable because the tests were non-standard. *L. stigma* is resident. *A. nervosa* probably is not resident.
Tatara, C.P., M.C. Newman, J.T. McCloskey, and P.L. Williams. 1997. Predicting Relative Metal Toxicity with Ion Characteristics: *Caenorhabditis elegans* LC50. Aquat. Toxicol. 39:279-290.	Results are not acceptable because the test species is a free-living soil nematode.
Teschner, M. 1995. Effects of Salinity on the Life History and Fitness of *Daphnia magna*: Variability within and between Populations. Hydrobiologia 307:33-41.	Results are not acceptable because the treatment was prepared by adding sea salt to lake water.
Thornton, K.W., and J.R. Sauer. 1972. Physiological Effects of NaCl on *Chironomus attenuatus* (Diptera: Chironomidae). Ann. Entomol. Soc. Amer. 65:872-875.	Results of acute tests on chloride are acceptable.
Thornton, K.W., and H.L. Wilhm. 1975. The Use of Life Tables in Demonstrating the Effects of pH, Phenol, and NaCl on Chironomus attenuatus Populations. Environ. Entomol. 4:325-328.	Results are not acceptable because the treatments also contained penicillin, methylene blue, etc.
Threader, R.W., and A.H. Houston. 1983. Use of NaCl as a Reference Toxicant for Goldfish, *Carassius auratus*. Can. J. Fish. Aquatic Sci. 40:89-92.	The 96-hr results are acceptable.
Trama, F.B. 1954. The Acute Toxicity of Some Common Salts of Sodium, Potassium and Calcium to the Common Bluegill (*Lepomis macrochirus* Rafinesque). Proc. Acad. Nat. Sci. Philadelphia 106:185205. (A: 8037)	Results of acute tests on chloride are acceptable.
U.S. EPA. 1988. Ambient Water Quality Criteria for Chloride -1988. EPA 440/5-88-001. Washington, DC. Web site: internewater.epa.gov/scitech/swguidance/standards/criteria/upload/chloride1988.pdf)	Results are not acceptable because they are secondary information.

	Comments
U.S. EPA. 1991. Methods for Aquatic Toxicity Identification Evaluations. Phase I Toxicity Characterization Procedures. Second Edition. EPA/600/6-91/003.	Results of acute tests on chloride are acceptable, except those that are secondary information.
Utz, L.R.P., and M.B.C. Bohrer. 2001. Acute and Chronic Toxicity of Potassium Chloride (KCl) and Potassium Acetate (KC2H3O2) to *Daphnia similis* and *Ceriodaphnia dubia* (Crustacea; Cladocera). Bull. Environ. Contam. Toxicol. 66:379-385.	Results of tests on KCl.
Valenti, T.W., D.S. Cherry, R.J. Neves, B.A. Locke, and J.J. Schmerfeld. 2007. Case Study: Sensitivity of Mussel Glochidia and Regulatory Test Organisms to Mercury and a Reference Toxicant. IN: Freshwater Bivalve Ecotoxicology. Farris, J.L., and J.H. Van Hassel (eds). CRC Press. pp. 351-367.	Results of tests on NaCl using *Ceriodaphnia dubia* or *Daphnia magna* are acceptable, but not results of tests using fathead minnows or glochidia of freshwater mussels.
Van Horn, W.M., J.B. Anderson, and M. Katz. 1949. The Effect of Kraft Pulp Mill Wastes on Some Aquatic Organisms. Trans. Amer. Fish. Soc. 79:55-63. (A: 663)	Results are not acceptable because these were non-standard tests.
Van Horn, W.M., J.B. Anderson, and M. Katz. 1950. The Effect of Kraft Pulp Mill Wastes on Fish Life. TAPPI 33:209-212.	Results are not acceptable because these were non-standard tests.
Vosyliene, M.Z., et al. 2006. Toxicity of Road Maintenance Salts to Rainbow Trout *Oncorhynchus mykiss*. Ekologija 2:15-20.	Test on NaCl is acceptable; test on road maintenance salt is not acceptable.
Wadhia, K., et al. 2007. Intra-laboratory Evaluation of Microbial Assay for Risk Assessment (MARA) for Potential Application in the Implementation of the Water Framework Directive WFD). J. Environ. Monit. 9:953-958.	Results are not acceptable because the test duration was 24 h.
Wallace, R.L., and T.W. Snell. 2001. Phylum Rotifera. IN: Ecology and Classification of North American Freshwater Invertebrates. 2nd ed. J.H. Thorp and A.P Covich, ed.	Results are not acceptable because they are secondary information.

	Comments
Wallen, I.E., W.C. Greer, and R. Lasater. 1957. Toxicity to *Gambusia affinis* of Certain Pure Chemicals in Turbid Waters. Sewage Ind. Wastes 29(6):695-711. (A: 508)	Results are not acceptable because the dilution water was from a turbid farm pond and the fish were treated for disease during holding.
Waller, D.L., et al. 1993. Toxicity of Candidate Molluscicides to Zebra Mussels (*Dreissena polymorpha*) and Selected Nontarget Organisms. J. Great Lakes Res. 19:695-702.	Results are not acceptable because duration was too short.
Waller, D.L., S.W. Fisher, and H. Dabrowska. 1996. Prevention of Zebra Mussel Infestation and Dispersal during Aquaculture Operations. Prog. Fish-Cult. 58:77-84 (A: 76054)	Results are not acceptable because duration was too short.
Wang, N. 2007. Email to C. Stephan. September 11.	Results of 96-hr tests are acceptable.
Warne, M.S.T., and A.D. Schifko. 1999. Toxicity of Laundry Detergent Components to a Freshwater Cladoceran and Their Contribution to Detergent Toxicity. Ecotoxicol. Environ. Saf. 44(2):196-206. (A: 20672)	Results are not acceptable because the dilution water was tap water to which seawater was added.
Warren, E. 1900. On the Reaction of Daphnia magna (Straus) to Certain Changes in its Environment. Quart. J. Microsc. Sci. 43:199224.	Results are not acceptable because too little information is available concerning methodology.
Weider, L.J., and P.D.N. Hebert. 1987. Ecological and Physiological Differentiation among Low-arctic Clones of *Daphnia pulex*. Ecology 68:188-198.	Results not acceptable because the treatments were prepared by adding sea salt to synthetic pond water.
Williams, D.D., N.E. Williams, and Y. Cao. 2000. Road Salt Contamination of Groundwater in a Major Metropolitan Area and Development of a Biological Index to Monitor its Impact. Wat. Res. 34:127-138.	Results of acute tests on chloride are acceptable. Also contains chronic tests.
Williams, J.E. 1948. The Toxicity of Some Inorganic Salts to Game Fish. MS Thesis, Louisiana State University, Baton Rouge, LA.	Results are not acceptable because duration was too short.

	Comments
Williams, M.D., and W.D. Williams. 1991. Salinity Tolerances of Four Species of Fish from the Murray-Darling River System. Hydrobiologia 210:145-150.	Results are not acceptable because the test organisms are not resident.
Wisconsin State Laboratory of Hygiene. 2007. Tables of Data.	Results of acute tests on chloride are acceptable. Also contains chronic tests.
Wurtz, C.B. 1968. A Review of Recent Literature Relative to Waste Components Associated with the Petroleum Industry. American Petroleum Institute.	Results are not acceptable because they are secondary information.
Wurtz, C.B., and C.H. Bridges. 1961. Preliminary Results from Macroinvertebrate Bioassays. Proc. Pennsyl. Acad. Sci. 35:51-56.	Results of acute tests on chloride are acceptable. (6 mg Cl/L in the dilution water.)
Yarzhombek, A.A., A.Y. Mikulin, and A.N. Zhdanova. 1991. Toxicity of Substances in Relation to Form of Exposure. J. Ichthyol. 31:99-106. (A: 7367)	Some results are not acceptable because the test organisms were exposed via oral administration or injection. Other results are not acceptable because duration was too short and very little info is available concerning methodology, water quality, etc.
Zalizniak, L., B.J. Kefford, and D. Nugegoda. 2006. Is All Salinity the Same? I. The Effect on Ionic Compositions on the Salinity Tolerance of Five Species of Freshwater Invertebrates. Marine Freshwater Res. 57:75-82.	No toxicity tests on chloride.