UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TX 75202-2733

MAR - 3 2014

Ellen Carpenter
Chief, Water Division
Arkansas Department of Environmental Quality (ADEQ)
5301 Northshore Drive
North Little Rock, AR 72118-5317

RE: Site-specific Water Quality Criteria for an unnamed tributary of Willow Springs Branch (McGeorge Creek), Willow Springs Branch, and Little Fourche Creek, in Little Rock, Arkansas

Dear Ms. Carpenter:

Thank you for ADEQ's letter, dated February 17, 2011, requesting review and approval of site-specific water quality standards revisions to Regulation No. 2, *Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas* for McGeorge Creek, Willow Springs Branch, and Little Fourche Creek in the Gulf Coastal Plain ecoregion of Arkansas. These streams are receiving waters for a discharge from a mining facility operated by McGeorge Contracting Company, Inc., near Little Rock, Arkansas. Your letter included a request for U.S. Environmental Protection Agency (EPA) approval of revisions of site-specific criteria for sulfate and total dissolved solids (TDS) in the above mentioned streams.

We have completed our review of these site-specific water quality standards revisions. Based upon the initial and supplemental supporting documentation, the site-specific criteria identified in the table below have been demonstrated as appropriate to protect the designated uses in the receiving waterbodies. The table also indicates that existing ecoregion criteria for the downstream reach of Fourche Creek can be met and are not being revised.

Reach Description	Current Criteria (mg/L)		Proposed Criteria (mg/L)	
	Sulfate	TDS	Sulfate	TDS
McGeorge Creek to confluence with Willow Springs Branch	41.3	138	250	432
Willow Springs Branch between confluences with McGeorge Creek and Little Fourche Creek	41.3	138	112	247
Little Fourche Creek between confluences with Willow Springs Branch and Fourche Creek	41.3	138	No change	179
Fourche Creek below confluence with Little Fourche Creek	17.3	112.3	No change	No Change

The approval of these site-specific criteria are subject to the results of consultation under section 7(a)(2) of the Endangered Species Act (ESA). By approving the site-specific criteria "subject to the results of consultation under section 7(a)(2) of the Endangered Species Act," EPA retains the full range of options available under section 303(c) for ensuring that water quality standards are environmentally protective. EPA retains the discretion to revise its approval decision of these criteria if the consultation identifies deficiencies in the water quality standards that require remedial action

A detailed rationale for EPA's approval decision is provided in the enclosed technical support document. I would like to acknowledge ADEQ's efforts in the development of these site-specific criteria. If you have any questions or concerns, please contact me at (214) 665-7101, or have your staff contact Matt Hubner at (214) 665-9736.

Sincerely,

WK Honker

William K. Honker, P.E.
Director
Water Quality Protection Division

Enclosures

cc: Sarah Clem, Branch Manager, Water Division, ADEQ
Mary Barnett, Ecologist, Water Division, ADEQ

TECHNICAL SUPPORT DOCUMENT:
EPA APPROVAL OF SITE-SPECIFIC REVISIONS TO THE ARKANSAS WATER QUALITY STANDARDS FOR MCGEORGE CREEK, WILLOW SPRINGS BRANCH, AND LITTLE FOURCHE CREEK IN LITTLE ROCK, ARKANSAS

U.S. Environmental Protection Agency – Region 6

February 2014

TECHNICAL SUPPORT DOCUMENT: EPA APPROVAL OF SITE-SPECIFIC REVISIONS TO THE ARKANSAS WATER QUALITY STANDARDS FOR MCGEORGE CREEK, WILLOW SPRINGS BRANCH, AND LITTLE FOURCHE CREEK IN LITTLE ROCK, ARKANSAS

I. INTRODUCTION

Background

As described in §303(c) of the Clean Water Act (CWA) and in the standards regulation within the Code of Federal Regulations (CFR) at 40 CFR §131.20, states and authorized tribes have primary responsibility to develop and adopt water quality standards to protect their waters. State and tribal water quality standards consist of three primary components: beneficial uses, criteria to support those uses, and an antidegradation policy. In addition, CWA §303(c)(1) and 40 CFR §131.20 require states to hold public hearings at least once every three years to review and, as appropriate, modify and adopt standards. Under 40 CFR §131.21, EPA reviews new and revised surface water quality standards that have been adopted by states and authorized tribes. Authority to approve or disapprove new and/or revised standards submitted to EPA for review has been delegated to the Water Quality Protection Division Director in Region 6. Tribal or state water quality standards are not considered effective under the CWA until approved by EPA.[1]

The purpose of this technical support document is to provide the basis for the Environmental Protection Agency's (EPA) approval of water quality standards revisions to Regulation No. 2: *Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas* adopted by the Arkansas Pollution Control and Ecology Commission (APC&EC) in Minute Order 10-43 and further described in the subsection below titled "Summary of Revised Provisions."

Chronology of Events

August 25, 2009	A third party, McGeorge Contracting Co., Inc. (McGeorge), filed a petition with the APC&EC to amend Regulation No. 2.
September 1, 2009	McGeorge filed an amended petition to initiate a third party rulemaking after failing to meet the August APC&EC agenda deadline.

[1] "Alaska rule" [*Federal Register*: April 27, 2000 (Volume 65, Number 82)]

September 23, 2009	McGeorge filed an amendment to amend the third party petition based on comments from ADEQ.
October 23, 2009	The APC&EC initiated the rulemaking proceeding via Minute Order No. 09-20.
October 28 & 29, 2009	Public notice of the proposed rule-making was published.
December 14, 2009	Public hearing on the proposed rule-making was held in North Hot Springs, Arkansas.
December 30, 2009	Public comment period ended on the proposed changes to Regulation No. 2.
December 3, 2010	Teresa Marks, Director, Arkansas Department of Environmental Quality (ADEQ), signed Minute Order 10-43 adopting changes to Regulation No. 2.
February 22, 2011	Miguel I. Flores, Director, Water Quality Protection Division, EPA Region 6, received letter dated February 17, 2011 from Steve Drown, Water Division Chief, ADEQ, requesting EPA approval of the adopted revisions and transmitting the water quality standards submission package.
April 21, 2011	EPA took no action on the proposed revision, citing insufficient information to take action.
June 2012	EPA receives additional details and analytical information regarding toxicity component of study and ionic makeup of pit water.

Summary of Revised Provisions

By letter dated February 17, 2011, from Steve Drown, ADEQ, to Miguel Flores, EPA Region 6, ADEQ requested EPA approval of site-specific water quality standards revisions to Regulation No. 2, *Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas* for several waterbodies in the Gulf Coastal Plain ecoregion of Arkansas. These are the receiving waterbodies for discharges from a kaolin clay mining operation operated by McGeorge Contracting Co., Inc, in Little Rock, Arkansas.

The letter included a request for EPA approval of site-specific criteria for sulfate and total dissolved solids (TDS) for the three waterbodies. A request for domestic water supply use removal was not included, as proposed values are at or below the drinking water criteria. This record of decision applies to the site-specific water quality criteria revisions for the waterbodies identified above, and are further outlined in Table 1 below.

II. REVISED PROVISIONS EPA IS APPROVING

In accordance with the requirements found in Regulation No. 2.306 of the Arkansas water quality standards, McGeorge contracted with FTN Associates, Ltd., to complete a use attainability analysis (UAA) of the receiving waterbodies. The purpose of the UAA was to provide scientific justification to support revised site-specific water quality criteria for sulfate and TDS for these waterbodies.

Table 1. Site-specific water quality criteria revisions for McGeorge Creek, Willow Springs Branch, and Little Fourche Creek submitted by ADEQ to EPA for review and approval.

Reach Description	Current Criteria (mg/L)		Proposed Criteria (mg/L)	
	Sulfate	TDS	Sulfate	TDS
McGeorge Creek to confluence with Willow Springs Branch	41.3	138	250	432
Willow Springs Branch between confluences with McGeorge Creek and Little Fourche Creek	41.3	138	112	247
Little Fourche Creek between confluences with Willow Springs Branch and Fourche Creek	41.3	138	No change	179
Fourche Creek below confluence with Little Fourche Creek*	17.3*	112.3*	No change	No Change

*Arkansas River Valley Ecoregion

Site-specific Water Quality Criteria for Sulfate and TDS

Criteria Derivation

Revised water quality criteria for sulfate and TDS were adopted in the waterbodies identified above by the APC&EC on December 3, 2010. The derivation of these site-specific criteria is summarized below. For specific details on the derivation of the criteria values, please refer to section *5.0 Mass Balance Model* in the study report.

McGeorge is not currently discharging water from the pit mines but is planning to release waters retained in the pits to continue operations at the site. Proposed criteria for sulfate and TDS resulting from this study were originally derived by calculating the 95th percentile of concentration data collected from the Herndon and Rauch pits, 2007 discharge monitoring data, and 2004 study data, and applying those values into mass balance models to determine downstream concentrations. Additional mass balance modeling was used to determine concentrations in downstream waterbodies based on flow and current in-stream concentrations of minerals. ADEQ requested that the proposed sulfate criteria be modified to protect the drinking water use in McGeorge Creek since it was not proposed for drinking water use removal. Therefore, the resulting calculated value of sulfate in McGeorge Creek was reduced from 257 mg/L to 250 mg/L (the state’s drinking water standard). Calculated concentrations of TDS in the receiving waterbodies remained below the drinking water use criteria of 500 mg/L for all waterbodies. Chloride was calculated to not exceed ecoregion criteria through the various models and flow rates.

Use Support Justification

The designated uses most sensitive to minerals are the Gulf Coastal Plain ecoregion and Arkansas River Valley ecoregion aquatic life uses for receiving and downstream waters. According to the Arkansas water quality standards, the fisheries use "provides for the protection and propagation of fish, shellfish and other forms of aquatic life."

The UAA study utilizes modeled loadings to predict downstream minerals concentrations in combination with a weight-of-evidence approach to provide scientific justification that the revised site-specific water quality criteria for sulfate and TDS will support the designated aquatic life use for McGeorge Creek, Willow Springs Branch and Little Fourche Creek. Specifically, the 2009 UAA study report[2] and subsequent revisions and addenda[3,4,5,6] present four primary lines of evidence to support the revised sulfate and TDS criteria.

First, the report provides instream sampling for physical parameters as outlined by the 2000 Arkansas Continuing Planning Process (CPP). Data collected in May and September 2008 at the sampling sites in Herndon and Rauch pits, McGeorge Creek, Willow Springs Branch, Little Fourche Creek, Fourche Creek, and Fountain Head Creek provide insight into the current levels of minerals in the waterbodies. The data indicates that waterbodies directly downstream of McGeorge have elevated sulfate and TDS concentrations, while the waterbodies further downstream have lower concentrations of minerals. The reference site at Fountain Head Creek showed minerals concentrations below ecoregion levels. As mentioned above, there was no discharge at the time of the sampling. These results indicate that, minus the McGeorge discharge, there are currently ambient minerals concentrations in the receiving waters in excess of the ecoregion criteria.

Second, analysis of physiochemical data was conducted using a salinity toxicity ratio (STR) model. The model predicts acute toxicity to test organisms based on the ratio of ions observed in the study. As discussed in Appendix A of this document, the specific ratios of ions can indicate potential toxicity that such a solution would have on sensitive species. In 2012, FTN, Associates, on behalf of McGeorge, submitted an evaluation of the ionic makeup of McGeorge's Herndon pit in response to specific concerns raised by

[2] FTN, Assoc. 2009. Use Attainability Analysis Report. Mine Site Discharge to an Unnamed Tributary of Willow Springs Branch. Little Rock, AR

[3] FTN, Assoc. 2011. Use Attainability Analysis Report. Mine Site Discharge to an Unnamed Tributary of Willow Springs Branch. Little Rock, AR (See Enclosure 2).

[4] American Interplex Co. 2008. Test Results of Third Quarter Chronic 7-Day Renewal Biomonitoring for Herndon (See Enclosure 3).

[5] American Interplex Co. 2008. Toxicity Identification Evaluation for Herndon Pit (See Enclosure 4).

[6] American Interplex Co. 2008. Suspended Material Analysis for Herndon Pit (See Enclosure 5).

EPA regarding the data to support the STR model findings (Enclosure 6). Though this data comprises only a single snapshot at one point in time, it does provide greater insight into the mineral constituents in McGeorge's pit mines and the results of the modeling. The presented information and model analysis predict that McGeorge's future discharge would not be likely to acutely affect sensitive aquatic species in McGeorge Creek and downstream receiving waterbodies.

Third, toxicity testing is beneficial to determine if the assumptions made by analyzing the ionic composition, as discussed above, are correct. Because the facility was not discharging during the study, McGeorge contractors extracted samples from the pit mines for toxic analysis. The results showed that the water in the Herndon pit was acutely toxic to the water flea and fathead minnow. The Rauch Pit exhibited sublethal toxicity to the water flea. McGeorge contended that the toxicity observations were not the result of minerals/ions. Its contractors performed a toxicity identification evaluation (TIE) that indicated an unknown organic constituent of the pit water was likely the cause of the toxicity. EPA requested further data on the toxicity and TIE to evaluate if the results matched the report's conclusions. Following receipt and review of those materials, EPA concurs that the source of the toxicity does not appear to be ionic in origin. The laboratory data indicates that the pit water samples treated (neutralized of the unknown toxicant) during the TIE process resulted in no acute toxicity to water fleas at ambient concentrations of minerals. The additional data presented by McGeorge is included in the attached appendices. The initial results of toxicity are of concern, and EPA recommends that McGeorge further investigate and address the toxicity. However, the facility and its contractors conducted appropriate analyses in the TIE to establish that minerals concentrations in the pit water were not the cause of toxicity.

Fourth, a comparison of the water quality monitoring data in combination with fish and benthic macroinvertebrate monitoring data indicate that elevated ambient chloride and TDS concentrations do not limit the benthic communities in downstream waterbodies. The upstream reference location, Fountain Head Creek, attains ambient levels of minerals at or below ecoregion concentrations. However, McGeorge Creek and Willow Springs Branch exhibit greater diversity of fish species (including key and indicator species) at current levels. In addition, McGeorge Creek and Willow Springs Branch exhibit similar numbers of macroinvertebrates in comparison to Fountain Head Creek, and the other downstream locations exhibit somewhat greater diversity, though the majority of species observed in the study indicate most sites contain more tolerant taxa. The contractor did conduct diel observations of dissolved oxygen (DO) at a few downstream locations. Though there was no comparison of DO levels in the reference stream to those downstream, it is apparent that DO levels dropped from September to May in the sites with comparative datasets, possibly indicating another biological limitation. From the information presented, it is clear that a combination of factors (including habitat) limit the biota in all sampled streams, including the reference location. This information is important to EPA's decision because it establishes that there is not a marked difference in biology between reference and downstream habitats; Fountain Head Creek consistently attains ecoregion minerals levels and the others do not, yet there is no major shift in biology.

The result of the information above culminates in the weight of evidence in support of the protectiveness of the proposed minerals criteria. Based upon the above supporting site-specific documentation and the summary of available toxicity information for acute and chronic lethality effects of chloride, sulfate, and TDS provided in Appendix A of this technical support document, EPA approves the site-specific sulfate and TDS criteria identified in Table 1 for McGeorge Creek, Willow Springs Branch and Little Fourche Creek.

Additional Concerns

In this matter, EPA was limited to review of the proposed site-specific criteria for the streams associated with McGeorge's discharge. Though EPA approves these site-specific criteria revisions, we remain concerned with the acute and chronic toxicity exhibited in the pit mines. The information presented by McGeorge and its contractors from the TIE indicates an organic toxicant of unknown origin. At the time of this approval, EPA understands that the toxicant has not yet been identified and the facility is not discharging. Per Arkansas Regulation No. 2.409 Toxic Substances:

"Discharges shall not be allowed into any waterbody which, after consideration of the zone of initial dilution, the mixing zone and critical flow conditions, will cause toxicity to human, animal, plant or aquatic life or interfere with normal propagation, growth, and survival of aquatic biota."

Additionally, Regulation 2.508 Toxic Substances states:

"Toxic substances shall not be present in receiving waters, after mixing, in such quantities as to be toxic to human, animal, plant or aquatic life or to interfere with the normal propagation, growth and survival of the indigenous aquatic biota. Acute toxicity standards may not be exceeded outside the zone of initial dilution. Within the ZID acute toxicity standards may be exceeded but acute toxicity may not occur. Chronic toxicity and chronic numeric toxicity standards shall not be exceeded at, or beyond, the edge of the mixing zone. Permitting of all toxic substances shall be in accordance with the toxic implementation strategy found in the Continuing Planning Process. For non permit issues and as a guideline for evaluating toxic substances not listed in the following tables, the Department may consider No Observed Effect Concentrations (NOECs) or other literature values as appropriate…"

EPA explicitly notes that approval of these site-specific minerals criteria do not imply approval of criteria or water quality standards for an unknown toxic agent. ADEQ should establish WET monitoring and controls when developing the permit for this facility to ensure that downstream impairments do not occur as a result of the discharge. Finally, when the facility does discharge, EPA strongly recommends that ADEQ adequately monitor the downstream segments to ensure that criteria and standards are being attained.

APPENDIX A:

SUMMARY OF AVAILABLE TOXICITY INFORMATION COMPILED BY REGION 6 FOR ACUTE AND CHRONIC LETHALITY EFFECTS OF CHLORIDE, SULFATE, AND TOTAL DISSOLVED SOLIDS (TDS)

BACKGROUND

EPA has published CWA §304(a) recommendations for chloride,[1] but has not developed aquatic life criteria for sulfate and TDS. The recommended chloride criteria for protection of aquatic life are 860 mg/L for acute toxicity and 230 mg/L for chronic toxicity. These values were derived following the Agency's procedures.[2] In total, EPA's criteria document for chloride includes acute data for twelve freshwater species. Data from numerous invertebrates were included in the calculation of EPA's recommended criteria including the following organisms: cladocerans, snail, isopod, midges, caddisfly, and mosquito larva. The most sensitive organism, based on species mean acute values, was *Daphnia magna*. The LC_{50} concentration (lethal concentration for 50% of the test organisms in a set period of time) associated with this ranking was 1470 mg/L of sodium chloride. EPA's criteria document also includes three chronic tests, in which *D. magna* was the most sensitive organism with a chronic LC_{50} of 372 mg/l for tests with sodium chloride.

For the purposes of this summary, EPA also considered available toxicity information for chloride, sulfate and TDS. As discussed above, the Agency has published an aquatic life criteria document for chloride, which includes some toxicity data. A study funded by the Gas Research Institute (GRI) evaluated toxicity of saline waters to freshwater organisms.[3] This study evaluated toxicity of four major cations (Ca^{++}, Mg^{++}, Na^{+} and K^{+}) and three major anions (HCO_3^-, SO_4^- and Cl^-) to the fathead minnow (*Pimphales promelas*) and two invertebrates (*Ceriodaphnia dubia* and *D. magna*). The relative toxicity to the fathead minnow and *C. dubia*, in order of decreasing toxicity was:

$$K^+ > HCO_3^- > Mg^{++} > Cl^- > SO_4^-$$

The toxicity to *D. magna* followed a similar pattern, with bicarbonate and magnesium reversed. Sodium and calcium were not found to be toxic to the test species at the concentrations tested (range of 14 mg/L to 3960 mg/L).

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[1] U.S. Environmental Protection Agency. 1988. *Ambient Water Quality Criteria for Chloride*. Office of Water - Regulations and Standards, Washington D.C.

[2] U.S. Environmental Protection Agency. 1985b. *Guidelines for Deriving National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses.* Office of Water Regulations and Standards, Washington, DC. 45 F.R. 79341, November 28, 1980, as amended at 50 F.R. 30784, July 29, 1985.

[3] Gas Research Institute. 1992. *Development of a Salinity/Toxicity Relationship to Predict Acute Toxicity of Saline Waters to Freshwater Organisms*. Prepared by David R. Mount, ENSR Consulting and Engineering and David D. Gully, University of Wyoming.

The GRI study developed equations to predict the survival of the test organisms at concentrations of the major ions. The results of these equations indicate that mortality for the fathead minnow and the two invertebrate species does not occur until chloride concentrations are over 1000 mg/L. Tests used in the GRI study indicate that sulfate is less toxic than chloride and that mortality does not occur until concentrations are over 2000 mg/L.

CHLORIDE

In addition to the above information, a search of EPA's ECOTOX database[4] was conducted for toxicity of sodium chloride and calcium chloride to fish species. The ECOTOX database included 153 freshwater acute (test duration less than or equal to 96 hours) LC_{50} results and two freshwater chronic (test duration greater than 96 hours) LC_{50} results for sodium chloride and calcium chloride for the following eleven freshwater species: American eel, goldfish, Crucian carp, western mosquitofish, eastern mosquitofish, bluegill, striped bass, rainbow trout, medaka-high eyes, fathead minnow, and sailfin mollies (see Tables 1 and 2 below). Sodium chloride and calcium chloride acute LC_{50} results for these freshwater fish species ranged from 1000 mg/L to 21,450 mg/L. The two chronic LC_{50} concentrations were for the goldfish and blue gill and were equal to 4324 mg/L and 10,650 mg/L, respectively.

EPA also conducted a search of EPA's ECOTOX database for effects of sodium chloride and calcium chloride to invertebrate species. The ECOTOX database included 111 freshwater acute (test duration less than or equal to 96 hours) LC_{50} results and 27 freshwater chronic (test duration greater than 96 hours) LC_{50} results for sodium chloride and calcium chloride for several species included within the following general groups: insects, crustaceans, worms, and molluscs (see Tables 3 and 4 below). Sodium chloride and calcium chloride acute LC_{50} results ranged from 649 mg/L to 44,425 mg/L. With the exception of two sodium chloride chronic LC_{50} concentrations for *C. dubia* of 280 mg/L and 330 mg/L, chronic LC_{50} concentrations for sodium chloride ranged from 910 mg/L to 7500 mg/L. While the two chronic LC_{50} concentrations for *C. dubia* were relatively low, fourteen additional sodium chloride chronic LC_{50} concentrations for *C. dubia* ranged from 910 mg/L to 2000 mg/L.

Table 1. Acute freshwater LC_{50} values for sodium chloride and calcium chloride for fish species from EPA's ECOTOX database.

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
Sodium chloride (NaCl)	*Anguilla rostrata*	American eel	17880	593
Sodium chloride (NaCl)	*Anguilla rostrata*	American eel	21450	592
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	6170	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	6180	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	6800	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	6800	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	6800	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	6950	2145

[4] U.S. Environmental Protection Agency. 2002. ECOTOX User Guide: ECOTOXicology Database System. Version 2.0. Available: http:/www.epa.gov/ecotox/.

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	6950	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7000	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7000	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7050	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7050	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7150	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7200	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7200	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7200	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7300	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7341	5230
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7350	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7388	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7400	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7400	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7550	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7600	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7650	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7850	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7900	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7900	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7900	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7950	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7950	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	7950	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	8050	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	8200	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	8350	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	8400	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	8500	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	8530	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	8800	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	8800	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	9270	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	9600	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	9750	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	9800	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	9850	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	9900	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	9950	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	9980	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	10000	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	10100	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	10200	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	10270	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	10400	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	10450	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	11050	2145
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	11050	2145

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
Sodium chloride (NaCl)	*Carassius carassius*	Crucian carp	13750	915
Sodium chloride (NaCl)	*Gambusia affinis*	Western mosquitofish	17550	508
Sodium chloride (NaCl)	*Gambusia affinis*	Western mosquitofish	18100	508
Sodium chloride (NaCl)	*Gambusia affinis*	Western mosquitofish	18100	508
Calcium chloride	*Gambusia affinis*	Western mosquitofish	13400	508
Calcium chloride	*Gambusia affinis*	Western mosquitofish	13400	508
Calcium chloride	*Gambusia affinis*	Western mosquitofish	13400	508
Sodium chloride (NaCl)	*Gambusia holbrooki*	Eastern mosquitofish	11540	6176
Sodium chloride (NaCl)	*Lepomis macrochirus*	Bluegill	1294.6	8037
Sodium chloride (NaCl)	*Lepomis macrochirus*	Bluegill	5840	45826
Sodium chloride (NaCl)	*Lepomis macrochirus*	Bluegill	12946	5683
Sodium chloride (NaCl)	*Lepomis macrochirus*	Bluegill	12946	949
Sodium chloride (NaCl)	*Lepomis macrochirus*	Bluegill	14125	915
Calcium chloride	*Lepomis macrochirus*	Bluegill	8350	915
Calcium chloride	*Lepomis macrochirus*	Bluegill	9500	930
Calcium chloride	*Lepomis macrochirus*	Bluegill	9500	930
Calcium chloride	*Lepomis macrochirus*	Bluegill	10650	8037
Calcium chloride	*Lepomis macrochirus*	Bluegill	10650	5683
Calcium chloride	*Lepomis macrochirus*	Bluegill	11300	930
Sodium chloride (NaCl)	*Morone saxatilis*	Striped bass	1000	2012
Sodium chloride (NaCl)	*Morone saxatilis*	Striped bass	1000	2012
Sodium chloride (NaCl)	*Morone saxatilis*	Striped bass	1500	2012
Sodium chloride (NaCl)	*Morone saxatilis*	Striped bass	3000	2012
Sodium chloride (NaCl)	*Morone saxatilis*	Striped bass	5000	2012
Sodium chloride (NaCl)	*Morone saxatilis*	Striped bass	5000	2012
Sodium chloride (NaCl)	*Morone saxatilis*	Striped bass	5000	2012
Sodium chloride (NaCl)	*Morone saxatilis*	Striped bass	7000	2012
Sodium chloride (NaCl)	*Oncorhynchus mykiss*	Rainbow trout,donaldson trout	6094	56474
Sodium chloride (NaCl)	*Oncorhynchus mykiss*	Rainbow trout,donaldson trout	6094	58703
Sodium chloride (NaCl)	*Oncorhynchus mykiss*	Rainbow trout,donaldson trout	7461	56474
Sodium chloride (NaCl)	*Oncorhynchus mykiss*	Rainbow trout,donaldson trout	7461	58703
Calcium chloride	*Oryzias latipes*	Medaka, high-eyes	1000	12497
Calcium chloride	*Oryzias latipes*	Medaka, high-eyes	1000	12497
Calcium chloride	*Oryzias latipes*	Medaka, high-eyes	1000	12497
Calcium chloride	*Oryzias latipes*	Medaka, high-eyes	1000	12497
Calcium chloride	*Oryzias latipes*	Medaka, high-eyes	1000	12497
Calcium chloride	*Oryzias latipes*	Medaka, high-eyes	1000	12497
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	6390	18272
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	6510	18272
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	6570	45826
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7050	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7050	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7050	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7100	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7100	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7100	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7200	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7200	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7200	2145

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7200	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7300	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7400	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7400	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7400	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7400	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7400	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7450	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7500	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7500	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7500	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7500	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7550	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7600	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7650	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7650	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7650	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7650	5230
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7650	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7650	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7700	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7750	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7750	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7800	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7800	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7950	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	7950	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8100	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8150	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8150	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8200	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8200	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8280	18272
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8300	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8300	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8300	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8300	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8400	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8700	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8800	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	8800	2145
Sodium chloride (NaCl)	*Pimephales promelas*	Fathead minnow	9000	2145
Calcium chloride	*Pimephales promelas*	Fathead minnow	4630	18272
Calcium chloride	*Pimephales promelas*	Fathead minnow	6560	18272
Calcium chloride	*Pimephales promelas*	Fathead minnow	6660	18272
Sodium chloride (NaCl)	*Poecilia latipinna*	Sailfin molly	16595	915
Sodium chloride (NaCl)	*Poecilia latipinna*	Sailfin molly	18735	915

Table 2. Chronic freshwater LC_{50} values for sodium chloride and calcium chloride for fish species from EPA's ECOTOX database.

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
Sodium chloride (NaCl)	*Carassius auratus*	Goldfish	4324	10487
Calcium chloride	*Lepomis macrochirus*	Bluegill	10650	949

Table 3. Acute freshwater LC_{50} values for sodium chloride and calcium chloride for invertebrate species from EPA's ECOTOX database.

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
Sodium chloride (NaCl)	*Argia sp.*	Damselfly	32000	2050
Sodium chloride (NaCl)	*Argia sp.*	Damselfly	32000	2050
Sodium chloride (NaCl)	*Argia sp.*	Damselfly	26000	2050
Sodium chloride (NaCl)	*Argia sp.*	Damselfly	32000	2050
Sodium chloride (NaCl)	*Argia sp.*	Damselfly	23000	2050
Sodium chloride (NaCl)	*Argia sp.*	Damselfly	24000	2050
Sodium chloride (NaCl)	*Argia sp.*	Damselfly	26000	2050
Sodium chloride (NaCl)	*Argia sp.*	Damselfly	24000	2050
Sodium chloride (NaCl)	*Asellus communis*	Aquatic sowbug	5600	2050
Sodium chloride (NaCl)	*Asellus communis*	Aquatic sowbug	10000	2050
Sodium chloride (NaCl)	*Asellus communis*	Aquatic sowbug	5600	2050
Sodium chloride (NaCl)	*Asellus communis*	Aquatic sowbug	10000	2050
Sodium chloride (NaCl)	*Asellus communis*	Aquatic sowbug	5100	2050
Sodium chloride (NaCl)	*Asellus communis*	Aquatic sowbug	8250	2050
Sodium chloride (NaCl)	*Asellus communis*	Aquatic sowbug	5100	2050
Sodium chloride (NaCl)	*Asellus communis*	Aquatic sowbug	8250	2050
Sodium chloride (NaCl)	*Caenorhabditis elegans*	Nematode	16439	19999
Sodium chloride (NaCl)	*Caenorhabditis elegans*	Nematode	17008	19999
Sodium chloride (NaCl)	*Caenorhabditis elegans*	Nematode	23817	19999
Sodium chloride (NaCl)	*Caenorhabditis elegans*	Nematode	25064	19999
Sodium chloride (NaCl)	*Caenorhabditis elegans*	Nematode	25190	19999
Sodium chloride (NaCl)	*Caenorhabditis elegans*	Nematode	25786	19999
Sodium chloride (NaCl)	*Caenorhabditis elegans*	Nematode	14899	19999
Sodium chloride (NaCl)	*Caenorhabditis elegans*	Nematode	22457	19999
Sodium chloride (NaCl)	*Caenorhabditis elegans*	Nematode	24829	19999
Calcium chloride	*Caenorhabditis elegans*	Nematode	44425	18605
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	3380	18272
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1960	18272
Calcium chloride	*Ceriodaphnia dubia*	Water flea	1830	18272
Calcium chloride	*Ceriodaphnia dubia*	Water flea	2260	18272
Sodium chloride (NaCl)	*Cricotopus trifasciatus*	Midge	6221	6244
Sodium chloride (NaCl)	*Culex sp.*	Mosquito	10500	915
Sodium chloride (NaCl)	*Culex sp.*	Mosquito	10200	915

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
Calcium chloride	*Daphnia hyalina*	Water flea	3000	5339
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	3412	915
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	3412	2465
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	6380	18272
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	6447	915
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	3310	915
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	3318	2465
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	4745	13712
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	4770	18272
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	5020	14713
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	5600	14713
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	5600	14713
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	6027	14713
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	6027	14713
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	5874	915
Sodium chloride (NaCl)	*Daphnia magna*	Water flea	3114	915
Calcium chloride	*Daphnia magna*	Water flea	649	915
Calcium chloride	*Daphnia magna*	Water flea	759	915
Calcium chloride	*Daphnia magna*	Water flea	759	2465
Calcium chloride	*Daphnia magna*	Water flea	759	915
Calcium chloride	*Daphnia magna*	Water flea	1838	915
Calcium chloride	*Daphnia magna*	Water flea	1838	2465
Calcium chloride	*Daphnia magna*	Water flea	2770	18272
Calcium chloride	*Daphnia magna*	Water flea	3005	915
Calcium chloride	*Daphnia magna*	Water flea	3250	18272
Calcium chloride	*Daphnia magna*	Water flea	3526	915
Sodium chloride (NaCl)	*Daphnia pulex*	Water flea	1470	45826
Sodium chloride (NaCl)	*Daphnia pulex*	Water flea	3050	45826
Sodium chloride (NaCl)	*Erpobdella punctata*	Red leech	10000	2050
Sodium chloride (NaCl)	*Erpobdella punctata*	Red leech	7500	2050
Sodium chloride (NaCl)	*Erpobdella punctata*	Red leech	7500	2050
Sodium chloride (NaCl)	*Erpobdella punctata*	Red leech	7500	2050
Sodium chloride (NaCl)	*Gyraulus circumstriatus*	Flatly coiled gyraulus	10000	2050
Sodium chloride (NaCl)	*Gyraulus circumstriatus*	Flatly coiled gyraulus	10000	2050
Sodium chloride (NaCl)	*Gyraulus circumstriatus*	Flatly coiled gyraulus	3700	2050
Sodium chloride (NaCl)	*Gyraulus circumstriatus*	Flatly coiled gyraulus	3200	2050
Sodium chloride (NaCl)	*Helisoma campanulatum*	Ramshorn snail	10000	2050
Sodium chloride (NaCl)	*Helisoma campanulatum*	Ramshorn snail	7500	2050
Sodium chloride (NaCl)	*Helisoma campanulatum*	Ramshorn snail	6150	2050
Sodium chloride (NaCl)	*Helisoma campanulatum*	Ramshorn snail	6150	2050
Sodium chloride (NaCl)	*Hydroptila angusta*	Caddisfly	6621	6244
Sodium chloride (NaCl)	*Limnodrilus hoffmeisteri*	Tubificid worm, Oligochaete	7500	2050
Sodium chloride (NaCl)	*Limnodrilus hoffmeisteri*	Tubificid worm, Oligochaete	6950	2050
Sodium chloride (NaCl)	*Limnodrilus hoffmeisteri*	Tubificid worm, Oligochaete	6800	2050

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
Sodium chloride (NaCl)	*Limnodrilus hoffmeisteri*	Tubificid worm, Oligochaete	6200	2050
Sodium chloride (NaCl)	*Lirceus fontinalis*	Aquatic sowbug	2970	45826
Sodium chloride (NaCl)	*Lymnaea sp.*	Pond snail	3412	915
Sodium chloride (NaCl)	*Lymnaea sp.*	Pond snail	3388	915
Calcium chloride	*Lymnaea sp.*	Pond snail	2573	915
Calcium chloride	*Lymnaea sp.*	Pond snail	3094	915
Calcium chloride	*Lymnaea sp.*	Pond snail	3308	915
Calcium chloride	*Lymnaea sp.*	Pond snail	4485	915
Sodium chloride (NaCl)	*Nais variabilis*	Oligochaete	2569	6244
Sodium chloride (NaCl)	*Physa gyrina*	Pouch snail	2540	45826
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	4200	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	4800	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	5600	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	7500	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	3700	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	4250	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	5600	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	6950	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	3500	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	4250	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	5600	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	6200	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	3500	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	4100	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	5100	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	6200	2050
Sodium chloride (NaCl)	*Sphaerium sp.*	Orb cockle, fingernail clam	2250	2050
Sodium chloride (NaCl)	*Sphaerium sp.*	Orb cockle, fingernail clam	2400	2050
Sodium chloride (NaCl)	*Sphaerium sp.*	Orb cockle, fingernail clam	1550	2050
Sodium chloride (NaCl)	*Sphaerium sp.*	Orb cockle, fingernail clam	1950	2050
Sodium chloride (NaCl)	*Sphaerium sp.*	Orb cockle, fingernail clam	1250	2050
Sodium chloride (NaCl)	*Sphaerium sp.*	Orb cockle, fingernail clam	1250	2050
Sodium chloride (NaCl)	*Sphaerium sp.*	Orb cockle, fingernail clam	1100	2050
Sodium chloride (NaCl)	*Sphaerium sp.*	Orb cockle, fingernail clam	1150	2050

Table 4. Chronic freshwater LC_{50} values for sodium chloride for invertebrate species from EPA's ECOTOX database.

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
Sodium chloride (NaCl)	*Asellus communis*	Aquatic sowbug	7200	2050
Sodium chloride (NaCl)	*Asellus communis*	Aquatic sowbug	6800	2050
Sodium chloride (NaCl)	*Asellus communis*	Aquatic sowbug	6150	2050
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	280	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	330	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	910	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1170	11152

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1430	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1640	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1710	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1740	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1830	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1830	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1830	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1940	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1940	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1940	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	1940	11152
Sodium chloride (NaCl)	*Ceriodaphnia dubia*	Water flea	2000	45168
Sodium chloride (NaCl)	*Erpobdella punctata*	Red leech	7500	2050
Sodium chloride (NaCl)	*Gyraulus circumstriatus*	Flatly coiled gyraulus	3200	2050
Sodium chloride (NaCl)	*Helisoma campanulatum*	Ramshorn snail	6150	2050
Sodium chloride (NaCl)	*Limnodrilus hoffmeisteri*	Tubificid worm, Oligochaete	6200	2050
Sodium chloride (NaCl)	*Limnodrilus hoffmeisteri*	Tubificid worm, Oligochaete	5800	2050
Sodium chloride (NaCl)	*Limnodrilus hoffmeisteri*	Tubificid worm, Oligochaete	5800	2050
Sodium chloride (NaCl)	*Limnodrilus hoffmeisteri*	Tubificid worm, Oligochaete	5800	2050
Sodium chloride (NaCl)	*Physa heterostropha*	Pond snail, pneumonate snail	5100	2050

SULFATE

A search of EPA's ECOTOX database was also conducted for toxicity of sodium sulfate and calcium sulfate to fish species. The ECOTOX database included 27 freshwater acute (test duration less than or equal to 96 hours) LC_{50} results and two freshwater chronic (test duration greater than 96 hours) LC_{50} results for sodium sulfate and calcium sulfate for the following four freshwater species: bluegill, fathead minnow, sailfin mollies, and western mosquitofish (see Tables 5 and 6 below). Sodium sulfate and calcium sulfate acute LC_{50} results for these freshwater fish species ranged from 1970 mg/L to 56,000 mg/L. The two chronic LC_{50} concentrations were for the western mosquitofish and were equal to 2200 and 3200 mg/L.

EPA also conducted a search of EPA's ECOTOX database for effects of sodium sulfate and calcium sulfate to invertebrate species. The ECOTOX database included 29 freshwater acute (test duration less than or equal to 96 hours) LC_{50} results and two freshwater EC_{50} results (one acute and one chronic (test duration greater than 96 hours)) for sodium sulfate and calcium sulfate for the following invertebrate species: scud (Amphipoda), water fleas (*C. dubia* and *D. magna*), mosquitos (*Culex sp.*), mayflies (*Tricorythus sp.*), and the pond snail (egg life stage) (*Lymnaea sp.*) (see Tables 7 and 8 below). Sodium sulfate and calcium sulfate acute LC_{50} results for invertebrate species other than the pond snail ranged from 630 mg/L to 13,350 mg/L. For the pond snail (egg life stage), two out of four acute LC_{50} values fell below 480 mg/L, with a range in LC_{50} values from 3.55 mg/L to 5401 mg/L. One of the two EC_{50} concentrations was for the water flea *C. dubia* which had a 48-hour acute EC_{50} value of 3150.21 mg/L. The other EC_{50} concentration was for the water flea *D. magna*, which had a 100.8-hour chronic EC_{50} value of 4547 mg/L.

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
sodium sulfate	*Gambusia affinis*	western mosquitofish	3710	508
sodium sulfate	*Gambusia affinis*	western mosquitofish	3940	508
sodium sulfate	*Gambusia affinis*	western mosquitofish	5350	508
sodium sulfate	*Gambusia affinis*	western mosquitofish	5400	508
sodium sulfate	*Gambusia affinis*	western mosquitofish	5670	508
sodium sulfate	*Gambusia affinis*	western mosquitofish	7800	508
calcium sulfate	*Gambusia affinis*	western mosquitofish	56000	508
calcium sulfate	*Gambusia affinis*	western mosquitofish	56000	508
calcium sulfate	*Gambusia affinis*	western mosquitofish	56000	508
calcium sulfate	*Lepomis macrochirus*	bluegill	2980	5683
calcium sulfate	*Lepomis macrochirus*	bluegill	2980	949
sodium sulfate	*Lepomis macrochirus*	bluegill	3040	8037
sodium sulfate	*Lepomis macrochirus*	bluegill	4380	8037
sodium sulfate	*Lepomis macrochirus*	bluegill	12500	930
sodium sulfate	*Lepomis macrochirus*	bluegill	12750	930
sodium sulfate	*Lepomis macrochirus*	bluegill	13000	930
sodium sulfate	*Lepomis macrochirus*	bluegill	13500	5683
sodium sulfate	*Lepomis macrochirus*	bluegill	13500	949
sodium sulfate	*Lepomis macrochirus*	bluegill	17500	915
calcium sulfate	*Pimephales promelas*	fathead minnow	1970	18272
calcium sulfate	*Pimephales promelas*	fathead minnow	1970	18272
calcium sulfate	*Pimephales promelas*	fathead minnow	1970	18272
sodium sulfate	*Pimephales promelas*	fathead minnow	7960	18272
sodium sulfate	*Pimephales promelas*	fathead minnow	7960	18272
sodium sulfate	*Pimephales promelas*	fathead minnow	8080	18272
sodium sulfate	*Poecilia latipinna*	sailfin molly	15996	915
sodium sulfate	*Poecilia latipinna*	sailfin molly	20040	915

Table 5. Acute freshwater LC_{50} values for sodium sulfate and calcium sulfate for four fish species from EPA's ECOTOX database.

Table 6. Chronic freshwater LC_{50} values for sodium sulfate for the western mosquitofish (*Gambusia affinis*) from EPA's ECOTOX database.

Chemical Name	Scientific Name	Common Name	Cocentration (mg/L)	Ecotox Ref #
sodium sulfate	*Gambusia affinis*	western mosquitofish	2200	508
sodium sulfate	*Gambusia affinis*	western mosquitofish	3200	508

Table 7. Acute freshwater LC_{50} values for sodium sulfate and calcium sulfate for invertebrate species from EPA's ECOTOX database.

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
sodium sulfate	Amphipoda	scud order	880	915

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
sodium sulfate	Amphipoda	scud order	880	915
sodium sulfate	Amphipoda	scud order	1110	915
sodium sulfate	Amphipoda	scud order	2380	915
calcium sulfate	*Ceriodaphnia dubia*	water flea	1910	18272
calcium sulfate	*Ceriodaphnia dubia*	water flea	1940	18272
calcium sulfate	*Ceriodaphnia dubia*	water flea	1970	18272
sodium sulfate	*Ceriodaphnia dubia*	water flea	3080	18272
sodium sulfate	*Ceriodaphnia dubia*	water flea	3590	18272
sodium sulfate	*Culex sp.*	mosquito	11430	915
sodium sulfate	*Culex sp.*	mosquito	13350	915
sodium sulfate	*Daphnia magna*	water flea	630	915
sodium sulfate	*Daphnia magna*	water flea	725	915
calcium sulfate	*Daphnia magna*	water flea	1970	18272
sodium sulfate	*Daphnia magna*	water flea	2564	915
sodium sulfate	*Daphnia magna*	water flea	2564	2465
sodium sulfate	*Daphnia magna*	water flea	4547	915
sodium sulfate	*Daphnia magna*	water flea	4580	18272
sodium sulfate	*Daphnia magna*	water flea	6100	915
sodium sulfate	*Daphnia magna*	water flea	6290	18272
sodium sulfate	*Daphnia magna*	water flea	6800	915
sodium sulfate	*Daphnia magna*	water flea	7616	13712
sodium sulfate	*Daphnia magna*	water flea	8384	915
sodium sulfate	*Daphnia magna*	water flea	8384	2465
sodium sulfate	*Lymnaea sp.*	pond snail	3.553	915
sodium sulfate	*Lymnaea sp.*	pond snail	5.4	915
sodium sulfate	*Lymnaea sp.*	pond snail	5400	915
sodium sulfate	*Lymnaea sp.*	pond snail	5401	915
sodium sulfate	*Tricorythus sp.*	mayfly	660	17845

Table 8. Acute and chronic freshwater EC_{50} values for sodium sulfate for water fleas from EPA's ECOTOX database.

Chemical Name	Scientific Name	Common Name	Concentration (mg/L)	Ecotox Ref #
sodium sulfate	*Ceriodaphnia dubia*	water flea	3150.21	20672
sodium sulfate	*Daphnia magna*	water flea	4547	2462

There is a general lack of data available as to the toxicity of dissolved minerals on freshwater mussel species. However, a previous use attainability analysis (UAA) study report associated with site-specific revisions for Ditch No. 27, Ditch No. 6, and the Tyronza River in the delta ecoregion of Arkansas (prepared by FTN & Associates, Ltd.) presented some unpublished data on acute sulfate toxicity for juvenile fatmucket mussels (*Lampsilis siliquoidea*) at various levels of hardness and chloride. This data was obtained from Dr. David Soucek (Illinois Natural History Survey; 607 East Peabody Drive; Champaign, IL 61820) and is summarized in Table 9 below.

Table 9. Acute toxicity (96 h LC_{50}) of sulfate to juvenile fatmucket mussels (*Lampsilis siliquoidea*), at various levels of hardness and chloride.

Hardness (mg/L)	Chloride (mg/L)	96h LC_{50} (Sulfate, mg/L)
100	25	3377
300	25	3525
500	25	3729
100	5	1727
100	33	1822

In addition, another study was conducted by Soucek and Kennedy (2005)[5] which provides acute and chronic sulfate toxicity data for the fingernail clam (*Sphaerium simile*). The study included three rounds of 96-hour toxicity tests (each with three to five *S. simile* juveniles per treatment). A mean acute LC_{50} value of 2078 mg/L was calculated for *S. simile*, as well as a chronic LC_{10} value of 1502 mg/L.

TOTAL DISSOLVED SOLIDS (TDS)

Information on toxicity of TDS to aquatic life is limited. The ECOTOX database does not include tests using TDS. EPA's "Red Book" reports that freshwater fish have survived in waters with TDS concentrations of 10,000 mg/L.[6] TDS levels may have physical toxicity effects by altering the osmotic pressure. The State of Pennsylvania recently incorporated an aquatic life criterion for osmotic pressure in its water quality standards to replace a TDS criterion of 1500 mg/L, on the basis that the two criteria provide the same level of protection to aquatic life. TDS concentrations of less than 1200 mg/L are not likely to affect invertebrate species such as cladocerans.

EPA uses two screening levels equal to 1000 mg/L and 2000 mg/L for evaluation of TDS criteria. The value of 1000 mg/L is based on EPA's Technical Support Document[7] which recommends that freshwater toxicity testing organisms be used when the receiving water salinity is less than 1000 mg/L and that marine organisms be used when salinity equals or exceeds 1000 mg/L. The TDS screening level of 2000 mg/L was obtained from the 1994 EPA Region 6 "Strategy for Evaluating and Addressing Impacts of Total Dissolved Solids in Freshwater

[5] Soucek, David, and Alan Kennedy. 2005. "Effects of hardness, chloride, and acclimation on the acute toxicity of sulfate to freshwater invertebrates." *Environmental Toxicology and Chemistry*. Volume 24, No. 5, pages 1204-1210.
[6] U.S. Environmental Protection Agency. 1976. Quality Criteria for Water ("Red Book"). U.S. Environmental Protection Agency, Washington, D.C. PB-263 943.
[7] U.S. Environmental Protection Agency. 1991. *Technical Support Document For Water Quality-based Toxics Control*. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA/505/2-90-001.

Invertebrate Species Toxicity Testing."[8] The strategy states that TDS concentrations greater than 2000 mg/L are needed in order to conclude that TDS is the source of toxicity in a toxicity identification evaluation.

ENCLOSURES 2-6 INCLUDED ELECTRONICALLY (CD)

[8] Ferguson, Jack. "Strategy for Evaluating and Addressing Impacts of Total Dissolved Solids in Freshwater Invertebrate Species Toxicity Testing." Memo to various internal EPA Region 6 staff and to State water quality contacts. U.S. Environmental Protection Agency, Region 6, Dallas, Texas. 20 Jan. 1994.