Version 1.1

Numeric Water Quality Criteria Recalculation for Several Toxicants Related to Central Valley Water Reclamation Facility Discharge into Mill Creek, Salt Lake County, UT

Part 1: Ammonia

Technical Report

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Submitted to:
Jordan River/ Farmington Bay Water Quality Council
Salt Lake City, UT, USA

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Summary

EPA regulations allow states to adopt water quality criteria that reflect site-specific conditions based on sound scientific rational. One EPA recommended site-specific method is the 'Recalculation Procedure' that best reflects the species that reside at a site and is used to edit the taxonomic composition of a toxicity dataset used for Species Sensitivity Distributions. The underlying premise of the Recalculation Procedure is, "taxonomy has value in predicting sensitivity".

It is well documented that ammonia (NH_3) can be highly toxic to aquatic organisms, particularly Unionoida mussels, non-pulmonate snails, and other sensitive species, and that ammonia criteria need to be developed by state water quality management agencies to protect these species. However, these taxa may be absent at a site and costs to treatment facilities and citizens to implement ammonia criteria based on taxa that are absent may be unnecessary, an economic burden, or misdirected from projects that could actually benefit the aquatic habitat of these sites.

The Jordan River/ Farmington Bay Water Quality Council contracted Dr. David C. Richards, OreoHelix Consulting to initiate an ammonia Recalculation Procedure and Deletion Process based on taxa that are 'resident' to the sections of Mill Creek and downstream sections of the Jordan River, UT that could potentially be affected by Central Valley Water Reclamation Facilities discharge using EPA recommended proceedures. For the purpose of this recalculation, the 'site' was designated as the degraded section of Mill Creek upstream of CVWRF to the bridge at Interstate -15 (UDWQ designated 'non game fishery') and downstream in the Jordan River to 2100 South, Salt Lake City (UDWQ designated 'warm water fishery').

The most relevant and usefull macroinvertebrate datasets available for the site were selected, as were amphibian and fish datasets. ITIS, the taxonomic system recommended by EPA was used for consistency. Taxa were determined to be 'resident' or 'not resident' based on EPA guidelines. This deletion and recalculation process adhered to EPAs guidelines including those for 'critical species'and acute values, species sensitivity distributions, and chronic values were calculated using EPA methods. Recalculation criteria were slightly lower but similar and consistent with EPA's recent ammonia criteria that were based on mussel and rainbow trout absence; further justification for recalculating NH_3 criteria for CVWRF's discharge into Mill Creek. Several problems need to be addressed to further improve recalculations and to evaluate EPAs reliance on these guidelines and methods. There is an urgent need to determine residency status of fish and amphibian taxa in the Mill Creek site. The reliance of surrogate taxa for invasive, ecosystem altering taxa that occur in Mill Creek is also very problematic and questionable and the determination of Unionoida residency continues to plague recalculation efforts. One major concern is the absence of error estimates in any of the EPA recommended steps in the process, which likely results in imprecise criteria values. Nevertheless, the

determination of resident taxa in the Mill Creek site and many of the calculations derived in this recalculation process can now be easily used for recalculation of any toxicant of concern by CVWRF, as long as there is ample sensitivity data in the national ECOTOX database. A thorough rechecking of the calculations to verify accuracy, particularly during the deletion process is recommended, as is verification of truly resident taxa. Further statistical analyses to test the supposition that there is use or value in presuming relationships between phylogeny and NH_3 sensitivty is highly recommended, as are future criteria recalculations that incorporate error estimates. Finally, laboratory ammonia toxicity tests are urgently needed on several species including *Anodonta* (native mussel), *Corbicula* (invasive clam), *Pisidium* sp., a native clam whose within- family surrogate is one of the most ammonia sensitive species which doesn't occur at the site, and *P. antipodarum* (New Zealand mudsnail), whose family level surrogate is the highly sensitive *Fluminicola* (pebblesnail), which also doesn't occur at the site.

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"A statement of a criterion as a number that is not to be exceeded any time or place is not acceptable because few, if any, people who use criteria would take it literally and few, if any, toxicologists would defend a literal interpretation." (USEPA 2010, page 4)

Introduction

Site Specific Water Quality Criteria and The Recalculation Procedure

EPA regulation at 40 CFR § 131.11(b)(l)(ii) "provides that states and tribes may adopt water quality criteria that "… reflect site-specific conditions." (USEPA 2013b, 2013c). "Site-specific criteria are intended to come closer than the national criteria recommendations to providing the intended level of protection to the aquatic life at the site, usually by taking into account the biological and/or chemical conditions (i.e., the species composition and/or water quality characteristics) at the site. Site-specific criteria, as with all water quality criteria, must be based on a sound scientific rationale and protect the designated use" (USEPA 2013c). Additionally, "EPA's decision to approve or disapprove site-specific criteria is not based on whether the resulting criteria are more or less stringent than EPA guidance" (USEPA 2013c).

One of the methods that EPA recommends for adoption of site specific water quality criteria is the 'Recalculation Procedure'; "intended to provide flexibility to States to derive site-specific criteria that best reflect the species that reside at a site" (USEPA 2013a). "The Recalculation Procedure is used to edit the taxonomic composition of the toxicity dataset used for the Species Sensitivity Distribution (SSD) upon which a site-specific criterion is based, in order to better match the assemblage that resides at the site (USEPA 2013c). The underlying premise of the Recalculation Procedure is that "taxonomy has value in predicting sensitivity[1]," (USEPA 2013a). A site-specific Species Sensitivity Distribution (SSD) can be adjusted to reflect the taxonomy of species that reside at a site. "The core of the procedure is the Deletion Process, which involves removing tested species from the SSD. The recommended procedure allows deletion of nonresident tested species if and only if they are not appropriate surrogates of resident untested species – based on taxonomy."

Justification

It is well documented that ammonia (NH_3) can be highly toxic to aquatic organisms, particularly Unionoida mussels, non-pulmonate snails, and other sensitive species, and that ammonia criteria need to be developed by state water quality management agencies to protect these species (USEPA 2013b). However, Unionoida, non-pulmonate snails, and other sensitive taxa that were

[1] This assumption has not been tested and is subject to much debate by ecologists and toxicologists. Richards (2016) Technical Memo suggests there is little or no evidence for this assumption based on NH_3 sensitivities using EPAs NH_3 national criteria dataset.

used to develop EPAs 2013 ammonia criteria may be absent at site specific locations and the cost to treatment facilities and citizens to implement ammonia criteria based on taxa that are absent may be unnecessary, an economic burden, or misdirected from projects that could actually benefit the aquatic habitat of these sites.

In response to the new EPA 2013 proposed NH_3 criteria and the need to potentially reevaluate the Central Valley Water Reclamation Facility (CVWRF) ammonia discharge limits into Mill Creek; the Jordan River Farmington Bay Water Quality Council, Salt Lake City, UT contracted Dr. David C. Richards, OreoHelix Consulting, Moab UT to initiate a Recalculation Procedure and Deletion Process based on taxa that are 'resident' to the sections of Mill Creek and downstream sections of the Jordan River that could potentially be affected by CVWRF discharge. These analyses are in addition and supplementation to the extensive mollusk survey that Richards (2016) and colleagues conducted in Mill Creek and nearby water bodies and which, based on these intensive surveys and other researchers, concluded that the status of Unionoida mussels in Mill Creek and the Jordan River is currently likely to be 'non-present'. If any isolated populations do exist, their survival is likely in severe jeopardy (Richards 2015). Being as Unionoida mussels are not considered residents of the Mill Creek site, Richards 2015 suggested that NH_3 recalculation values be based on those recommended in Appendix N in the USEPA 2013b document. The recalculations presented here that are based on resident taxa other than mussels can be used as further evidence that NH_3 criteria recalculations are justified.

Central Valley Water Reclamation Facility

The Central Valley Water Reclamation Facility (CVWRF) at 800 West Central Valley Road (3190 South) in Salt Lake City, UT is the largest treatment facility in the greater Salt Lake City area. The CVWRF was designed and built to treat 75 million gallons of wastewater/day and serves over half a million people in Salt Lake County. CVWRF discharges treated water directly into Mill Creek approximately 400 m upstream of its confluence with the Jordan River. CVWRF management and operators are required by law to protect Mill Creek and the Jordan River environment receiving waters under the Clean Water Act, whose goal is 'to maintain and improve the physical, chemical, and biological integrity' of these waters for present and future generations (http://www.cvwrf.org/brochure/page3.php). The CVWRF Mission Statement reflects this ethic and as stated is to "Improve the Utah environment by treating wastewater and recovering resources, safely, efficiently and sustainably". CVWRF has worked closely with UDWQ throughout its history meeting these goals (http://www.cvwrf.org).

Methods

Site Description and Designation of Site Area

In the USEPA (2013c) Technical Support document (EPA 800-R-13-003), EPA states that; "In the general context of site-specific criteria, a "site" may be a region, watershed, waterbody, or segment of a waterbody". Exactly how the site is defined is a mater of state discretion, for example a site may be designated as, "A segment of a stream, river, lake reservoir, or wetland" or "Some specified distance upstream and downstream of a point-source discharge." (EPA 800-R-13-003). Additionally, USEPA (2013a) states that, "Use of the Recalculation Procedure does not sidestep the need to protect downstream uses".

In a collaborative effort, CVWRF, the Jordan River Farmington Bay Water Quality Council and UDWQ, determined that for the purpose of this reevaluation of ammonia criteria, the 'site' would be designated as follows:

Upstream boundary: Upstream of CVWRF to Interstate 15 bridge.
Downstream boundary: Extent of CVWRF physical, chemical, and biological influence in Jordan River at 2100 South, Salt Lake City.

UDWQ Designated Beneficial Uses of Mill Creek and the Jordan River Downstream

Mill Creek from I-15 to its confluence with the Jordan River (UDWQ Assessment Unit: Mill Creek- 1) is designated by UDWQ as *3C*, "Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain." The section of the Jordan River from the confluence with Mill Creek downstream to 2100 South (UDWQ's Assessment Unit, Jordan-4) is designated as Use Class *3B* "warm water fishery and other aquatic life, including the necessary aquatic organisms in their food chain".

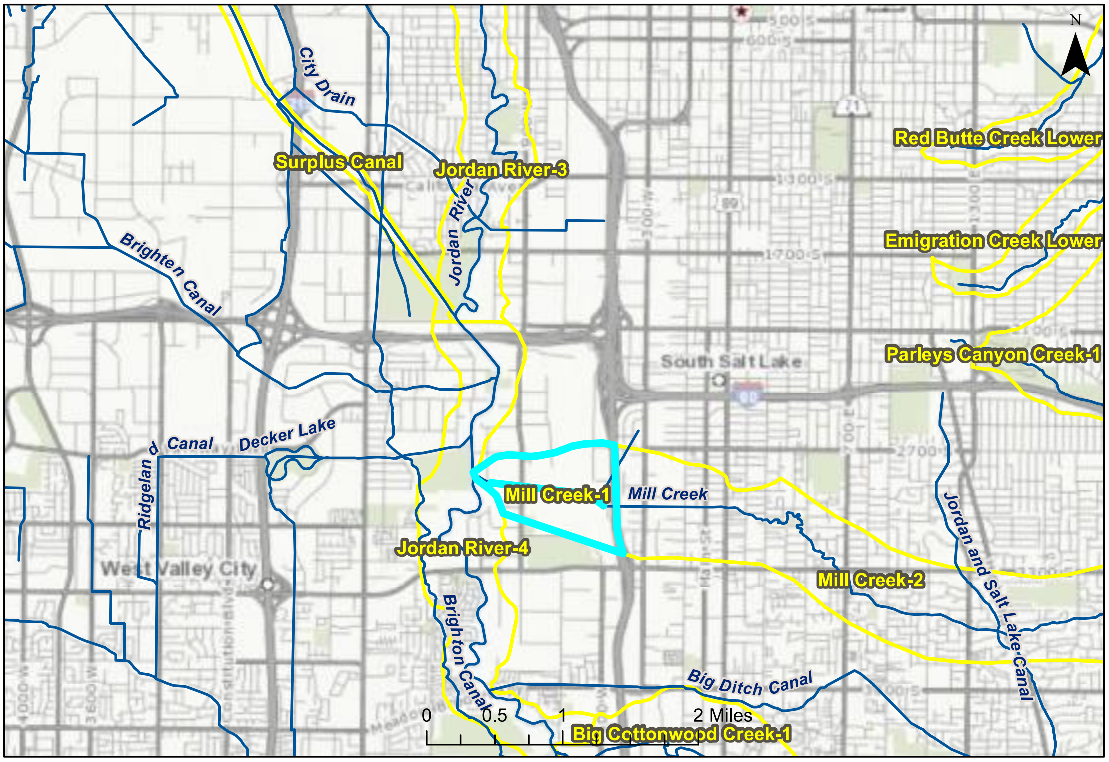
Table 1. Designated Beneficial Uses of Mill Creek and Jordan River at the recalculation site (Downloaded from Utah DEQ: DWQ: Beneficial Uses and Water Quality Assessment Map: HTTP://wq.deq.utah.gov.) Beneficial Use Classes: 2B = Infrequent primary contact recreation (e.g. wading, fishing); 3B = Warm water fishery/aquatic life; 3C = Protected for nongame fish and other aquatic life, included the necessary aquatic organisms in their food chain; 4 = Agricultural uses (crop irrigation and stock watering).

Unit Name	**Unit ID**	**Beneficial Use Class**	**Unit Description**
Mill Creek-1	UT16020204-026	2B, 3C, and 4	Mill Creek from confluence with Jordan River to Interstate 15 crossing
Jordan River-4	UT16020204-004	2B, 3B, and 4	Jordan River from 2100 South to the confluence with Little Cottonwood Creek

Beneficial Uses and Water Quality Assessment Map

utah automated geographic reference center

11/7/2014



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undefined: 414
Assessment Unit Name: Mill Creek-1
Unit ID: UT16020204-026
Unit Description: Mill Creek from confluence with Jordan River to Interstate 15 crossing
Beneficial Uses: Use Class 2B = Infrequent primary contact recreation (e.g. wading, fishing); Use Class 3C = Nongame fishery/aquatic life; Use Class 4 = Agricultural uses (crop irrigation and stock watering)
undefined: 1.032
Watershed Management Unit: Jordan River
undefined:
undefined:
2010 Assessment: Assessment Category 2 = Not impaired: assessed beneficial uses are supported, at least 1 use not assessed
Beneficial Use: Cause of Impairment:
TMDL Required: 303d Cause of Impairment: n/a
TMDL Approved: Cause of Impairment: n/a
Aquatic Habitat Impairment: n/a
undefined: 2
undefined:
undefined: 2
undefined:
undefined: 2

Figure 1. Beneficial use and water quality assessment map: UDWQ management unit, Mill Creek-1.

Beneficial Uses and Water Quality Assessment Map

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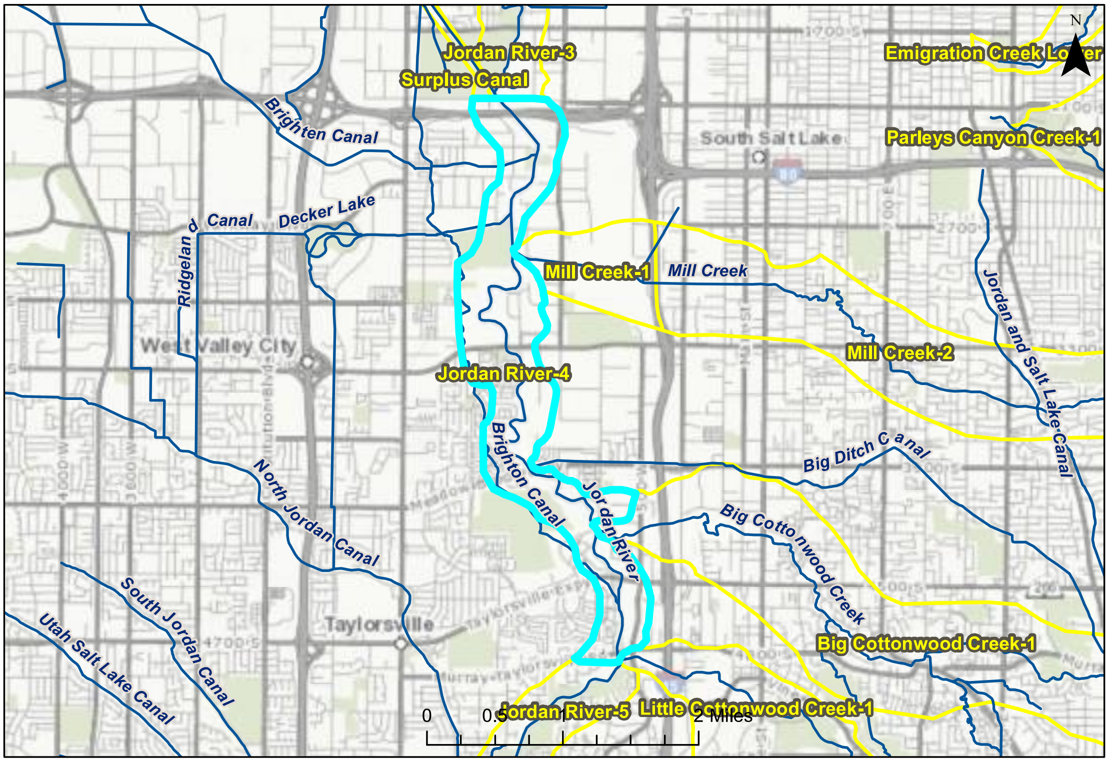

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undefined: 496
Assessment Unit Name: Jordan River-4
Unit ID: UT16020204-004
Unit Description: Jordan River from 2100 South to the confluence with Little Cottonwood Creek
Beneficial Uses: Use Class 2B = Infrequent primary contact recreation (e.g. wading, fishing); Use Class 3B = Warm water fishery/aquatic life; Use Class 4 = Agricultural uses (crop irrigation and stock watering)
undefined: 6.287
Watershed Management Unit: Jordan River
undefined:
undefined:
2010 Assessment: Assessment Category 5 = Impaired: TMDL required (303d list)
Beneficial Use: Cause of Impairment: Use Class 3B: Benthic-Macroinvertebrate Bioassessments; Use Class 4: Total Dissolved Solids
TMDL Required: 303d Cause of Impairment: poor Benthic Macro-invertebrate Community, Total Dissolved Solids
TMDL Approved: Cause of Impairment: n/a
Aquatic Habitat Impairment: n/a
undefined: 5
undefined:
undefined: 2
undefined:

Figure 2. Beneficial use and water quality assessment map: UDWQ management unit, Jordan-4.

Mill Creek

Mill Creek, Salt Lake County, UT originates in the Wasatch mountains and then flows through the City of Salt Lake where it joins the Jordan River, which then empties into Farmington Bay of the Great Salt Lake. After leaving the Wasatch mountains and USFS lands, where it is relatively unimpaired, most of Mill Creek waters are captured for culinary purposes for use by the citizens of Salt Lake City. Remaining waters in Mill Creek are then supplemented and often dominated by waters transported directly from Utah Lake via the Jordan and Salt Lake Canal. After the water quality in Mill Creek has been compromised by waters from hyper eutrophic Utah lake, it then flows through a heavily urbanized, residential, and industrial landscape before entering the Jordan River. For the most part, this heavily impacted downstream section of Mill Creek:

1) has been channelized,
2) has been vastly dewatered and lost its natural ability to create meanders and floodplains has been curtailed,
3) has degraded integrity (river continuum) as flows and habitat have been altered,
4) has numerous industrial point source discharges,
5) experiences large urban and industrial runoff events,
6) is dominated by highly invasive taxa (including carp, Asian clams, and New Zealand mudsnails, black rats are frequently encountered along its banks, etc.),
7) has substrates that are predominately embedded with fine organic matter often > 50 cm thick (Richards 2015)
8) has trash that often comprises a significant portion of the substrate (Richards 2015) and
9) is designated by UDWQ as water quality impaired.

By all standards the section of Mill Creek that flows through Salt Lake City is in poor condition and has been poorly managed in the past. The macroinvertebrate assemblages and fish taxa resident to Mill Creek clearly reflect these conditions (see the following section *Species Datasets and Taxonomic System Used* and the *Results* section).

Species Datasets and Taxonomic System Used

"Perhaps the most important condition in defining species residency is that the taxa that occur at the site cannot be determined merely by a one-time sampling downstream and/or upstream of the site" (USEPA 2013c, page 5).

The most pertinent datasets available were used in the deletion process. The most important and inclusive macroinvertebrate data sets available and examined included:

1. Four sampling events in Mill Creek between 2014 and 2016 using 1 m^2 500-micron mesh kick samples, 8-12 replicates/event, collected by Dr. Richards, OreoHelix Consulting, Moab, UT and processed and taxonomic identifications completed by Brett Marshall, Adjunct Senior Aquatic Entomologist with the National Academy of Sciences at his laboratory River Continuum Concepts, Manhattan, MT. The level of taxonomic resolution performed by this lab was much greater than other available datasets from all other sources and helped to improve the likelihood of including all 'resident' taxa need for the deletion process.

2. A one-time sampling event conducted by UDWQ, November 2009 with a single upstream of CVWRF discharge composite sample and a single downstream of discharge composite sample. Taxonomic resolution was at standard bioassessment levels.
3. All macroinvertebrate data available from the Western Center for Monitoring and Assessment of Freshwater Ecosystems, BLM/USU National Aquatic Monitoring Center "MAPIT-Mapping Application for Freshwater Invertebrate Taxa" database (http://wmc6.bluezone.usu.edu). Taxonomic resolution was typically only to standard bioassessment levels.

Summaries of amphibian and fish species known to occur (resident) at the site were compiled from the Jordan River Commission website: http://jordanrivercommission.com; (http://jordanrivercommission.com/wp-content/uploads/2011/04/Fish-Species-of-the-Jordan-River-2011.pdf) for fish and (http://jordanrivercommission.com/wp-content/uploads/2011/11/Amphibians-of-the-Jordan-River-2011.pdf) for amphibians. The Jordan River Commission is a clearinghouse for species that occur in the area. It appears that no formal fish or amphibian surveys have been conducted at the site in recent years. As additional fish and amphibian data becomes available the deletion process and NH_3 recalculations will be updated.

"Because the Deletion Process is taxonomy based, it is important that one taxonomic system be used consistently in the derivation of national and site-specific criteria. The system that U.S. EPA uses is the Integrated Taxonomic Information System (ITIS; www.itis.gov)." This system was used for the deletion process and recalculation procedure reported in this document.

The Process

Resident Species

Whether a taxon was considered resident or not in the site was based on EPAs (2013a) definitions:

"the equivalent terms "resident" or "occur at the site" includes life stages and species that:

a. are usually present at the site,

b. are present at the site only seasonally due to migration,

c. are present at the site intermittently because they periodically return to or extend their ranges into the site,

d. were present at the site in the past, are not currently present at the site due to degraded conditions, but are expected to return to the site when conditions improve, or

e. are present in nearby bodies of water, are not currently present at the site due to degraded conditions, but are expected to be present at the site when conditions improve.

The terms "resident" or "occur at the site" do not include life stages and species that:

a. were once present at the site but cannot exist at the site now due to permanent alterations of the habitat or other conditions that are not likely to change within reasonable planning horizons, or

b. are still-water life stages or species that are found in a flowing-water site solely and exclusively because they are washed through the site by stream flow from a still-water site" (USEPA 2013a).

Resident "critical species"

EPA defines a 'critical species' as on that is listed as threatened or endangered under section 4 of the Endangered Species Act and suggests that the Deletion Process should not be undertaken unless toxicity data are available for at least one species in each class of aquatic plants or animals that contains a critical species (2013a). This requirement was met.

Deletion process

"Based on taxonomy, U.S. EPA (1994) provided the Recalculation Procedure with a step-by-step protocol for deciding which nonresident tested species to retain or delete. For any particular nonresident tested species, the decision process begins at the genus level: the species is either

(a) deleted,

(b) retained as a surrogate for resident untested species in the genus, or

(c) a decision is postponed.

If the decision is postponed, then the next higher taxonomic level is considered. For a nonresident tested species, this hierarchical process stops once the decision to delete or retain is made – that is, the decision to delete or retain is not reconsidered or reversed at a higher taxonomic level." (USEPA 2013a). "The Deletion Process is designed to ensure that:

1. Each species, genus, family, order, class, and phylum that occurs both at the site and in the national toxicity dataset is retained in the site-specific toxicity dataset.
2. Each species, genus, family, order, class, and phylum that occurs at the site but not in the national toxicity dataset is represented in the site-specific dataset by at least one species most closely related to it from the national dataset" (USEPA 2013a).

EPAs underlying Deletion Process principle is as follows:

"1. Looking within a genus, are all of its resident species tested? (That is, are they in the national toxicity dataset?) If so, then delete the nonresident tested species in that genus. If not, retain them as surrogates.

2. Moving up to the family level, does every resident genus in a family contain at least one tested species? (That is, are all of its resident genera tested?) If so, then delete the tested species in the family's nonresident genera. If not, retain them. (Note that this is not asking whether every resident species in the family is tested. Rather it asks whether every resident genus in the family appears in the national toxicity dataset.)

3. Moving up each subsequent level, to order, class, and phylum, the concept remains parallel. Does every resident family in an order contain at least one tested species? Does

every resident order in a class contain at least one tested species? Does every resident class in a phylum contain at least one tested species? In each case, if so, delete the nonresident. If not, retain as surrogates" (USEPA 2013a).

The specific steps used in the deletion process for determining Genus Mean Acute Values (GMAV) followed *Appendix 2. Longer Statement of the Deletion Process* (USEPA 2013a). See Appendix 3 for explanation of the steps used.

Acute

The primary method for calculating acute values was first to use the GMAVs for genera retained in the deletion process (Appendices 5, 7, and 8). Then the Final Acute Value (FAV) was calculated using the formulas provided in *Section IV. Final Acute Value, parts J – O*, page 16 in the USEPA 2010 Guidelines. The steps are listed below:

J. For each genus for which one or more SMAVs are available, the Genus Mean Acute Value (GMAV) should be calculated as the geometric mean of the SMAVs available for the genus.

K. Order the GMAVs from high to low.

L. Assign ranks, R, to the GMAVs from "1" for the lowest to "N" for the highest. If two or more GMAVs are identical, arbitrarily assign them successive ranks.

M. Calculate the cumulative probability, P, for each GMAV as R/(N+1).

N. Select the four GMAVs which have cumulative probabilities closest to 0.05 (if there are less than 59 GMAVs, these will always be the four lowest GMAVs).

O. Using the selected GMAVs and Ps, calculate

$$S^2 = \frac{\sum((\ln GMAV)^2) - ((\sum \ln GMAV))^2 / 4}{\sum (F) - ((\sum(\sqrt{P}))^2 / 4)}$$

$$L = (\sum (\ln GMAV) - S(\sum(\sqrt{P}))) / 4$$

$$A = S(\sqrt{0.05}) + L$$

$$FAV = e^A$$

An alternative method was used to develop SSDs that included important error estimates. This method is recommended by USEPA CADDIS EcoTox Volume 4: Data analyses, Species Sensitivity Distributions (SSDs) (https://www3.epa.gov/caddis/da_advanced_2.html)(Updated 22Feb2016). The probit regression SSD_Generator_V1.xlt provided by CADDIS was used. Statistical steps used to generate SSDs and FAVs using this alternative method are as follows:

1) Calculated the geometric mean and $\log_{10}$ of the mean for each taxon.
2) Converted ranks to proportions: Proportion=(rank-0.5)/Number of taxa.

3) Transformed proportions to probit. The probit is the inverse cumulative distribution function of the normal distribution with a mean of 5 and a standard deviation of 1. A mean of 5 was chosen to ensure that all probit values are non-negative.
4) Calculated the slope and intercept for Log_{10}Mean (X axis) * Probit (Y axis).
5) Calculated the log_{10} central tendency (Pred) for the regression line:

log_{10} Central Tendency=(Probit-Intercept)/Slope.

Prediction intervals were calculated after Neter et al. 1990.

6) Calculated the Mean Squared Error (MSE): For each taxon, subtracted the observed log_{10} mean (Obs) from the log_{10} central tendency (Pred), square, added these values and divided by n-2.
7) Calculated the Corrected Sum of Squares (CSSQ): For each taxon, squared each probit value then sum (sum of squares). Next, summed the probit values for all taxa, squared this result and divided by the number of taxa (average sum squared). Subtracted the average sum squared from the total sum of squares to get the CSSQ.
8) Calculated the Grand Mean (average of all log_{10} exposure values).
9) Calculated the Point Error: $[(MSE/(Slope^2))*(1+(1/n)+((Pred\text{-}Grand\ Mean)^2)]/CSSQ)$
10) Calculated the prediction intervals (PI) using the critical t value:

logPI=logCentralTendency +/- tCrit*(SQRT(PointError)) and finally,

11) Back converted results from log value: 10^{value}

Chronic

According to USEPA (2010) *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection Of Aquatic Organisms and Their Uses* (page 19); "Depending on the data that are available concerning chronic toxicity to aquatic animals, the Final Chronic Value (*FCV*) might be calculated in the same manner as the Final Acute Value or by dividing the Final Acute Value by the Final Acute-Chronic Ratio (*ACR*)."

The later method was preferred therefore, the *FCV* was calculated by dividing the *FAV* by a Final-Acute-Chronic Ratio (*ACR*) developed using the deletion process and from Table F.1. Species, Genus and Taxon-specific *ACR*s for Freshwater Aquatic Animals Exposed to Ammonia (EPA 2013b). See Appendix 11 for the taxon specific ACRs for NH_3 used in the recalculation process. The *CMC* or Criterion Maximum Concentrations was calculated following EPA guidelines and was equal to one-half the Final Acute Value and the *CCC* or Criterion Continuous Concentration was set equal to the lowest of the Final Chronic Values" (USEPA 2010, page 29.)

Results

Acute

Final Acute Value (FAV)

Three Final Acute Values (*FAV*s) were calculated; the first with *Fluminicola* sp. resident, the second with *Fluminicola* sp. non- resident, and the third with three species that are considered rare in the Jordan River removed; Golden shiner (*Notemigonus crysoleucas*), Pebblesnail (*Fluminicola coloradensis*), and June sucker (*Chasmistes liorus*). The *FAV* with *Fluminicola* sp. resident was **66.89**, the *FAV* with *Fluminicola* not resident was **69.77**, and the *FAV* with three rare taxa removed was **75.28**. Tables 1 -3 contain the formulas, calculations and FAVs.

*Table 2. Methods and values used to calculate FAV with Fluminicola **resident** (N = total number of GMAVs in data set = 45)*

Rank	GMAV	ln(GMAV)	$\ln(GMAV)^2$	P=R/(n+1)	√P
1	62.15	4.129551	17.05319	0.0217391	0.147442
2	63.02	4.143452	17.1682	0.0434783	0.2085144
3	71.56	4.270536	18.23748	0.0652174	0.255377
4	72.55	4.284276	18.35502	0.0869565	0.2948839
Sum		**16.827815**	**70.81389**	**0.2173913**	**0.9062173**

$S^2 = [70.8138 - (16.8278)^2/4] / [0.2174 - (0.9062)^2/4] = 1.6593$

S = 1.2881

L = [16.8278 - (1.2881)(0.9062)]/4 = 3.9151

A = (1.2881)(√0.05) +3.9151 = 4.2032

FAV = $e^{4.2032}$ = 66.89

*Table 3. Methods and values used to calculate FAV with Fluminicola **not resident**. (N = total number of GMAVs in data set = 44)*

Rank	GMAV	ln(GMAV)	$\ln(GMAV)^2$	P=R/(n+1)	√P
1	63.02	4.143452	17.1682	0.0222222	0.1490712
2	71.56	4.270536	18.23748	0.0444444	0.2108185
3	72.55	4.284276	18.35502	0.0666667	0.2581989
4	74.25	4.307438	18.55402	0.0888889	0.2981424
Sum		**17.005702**	**72.31472**	**0.2222222**	**0.916231**

$S^2 = [72.31472 - (17.005702)^2/4] / [0.2222222 - (0.916231)^2/4] = 1.3151$

S = 1.1468

L = [17.005702- (1.2454)(0.916231)]/4 = 3.9887

A = (1.1468)(√0.05) + 3.9887= 4.2452

FAV = $e^{4.2452}$ = 69.77

Table 4. Methods and values used to calculate FAV with three rare or not resident taxa removed. (N = total number of GMAVs in data set = 43)

Rank	GMAV	ln(GMAV)	$\ln(GMAV)^2$	P=R/(n+1)	√P
1	71.56	4.2705	18.2374	0.0232	0.1524
2	72.55	4.2842	18.3550	0.0465	0.2156

3	74.25	4.3074	18.5540	0.0697	0.2641
4	89.06	4.4893	20.1539	0.0930	0.3049
Sum		**17.3515**	**75.3004**	**0.2325**	**0.9372**

S^2 = [75.3004- (17.3515)^2/4] / [0.2326– (0.9373)^2/4] = 2.4191

S = 1.5553

L = [17.3515- (1.5553)(0.9373)]/4 = 3.9734

A = (1.5553)(√0.05) + 3.9734= 4.321

FAV = $e^{4.321}$ = 75.28

Critical Species

The federally listed June sucker (*Chasmistes liorus*) is an unlikely but possible resident of the site. The surrogate for the June sucker included in the National Toxicity Dataset, *Chasmistes brevirostris* was therefore, included in the calculations at the genus level for the analyses that included *Flumincola* sp. as a resident and as not resident but not for analyses with the three rare or absent taxon deleted.

Alternative Species Sensitivity Distributions (SSDs)

The alternative probit regresssion *FAV*s had lower predicted mean values than those that were calculated and presented in Tables 1 -3 but were well within the prediction intervals (Table 5). There was no statistically significant difference between values using probit regression. Complete SSD results using probit regression are in Appendices 9, 10, and 11.

Table 5. Mean and lower and upper 95% prediction intervals for FAVs developed using probit regression species sensitivity distribution methods used by EPAs CADDIS EcoTox program (https://www3.epa.gov/caddis/da_advanced_2.html). Mean and prediction intervals are for the 5th percentile GMAVs.

	Mean	Lower 95% PI	Upper 95% PI
Fluminicola "resident"	46.247	28.256	75.693
Fluminicola "not resident"	47.792	28.825	79.238
Three rare or absent taxa removed	49.00	28.99	82.82

The *FAV* developed using EPA Appendix N. Table N.2 with mussels absent/RBT present was **48.21**, whereas with mussels absent/RBT absent the FAV was **76**. Therefore, the deletion and recalculation process resulted in similar but consistently lower *FAV* values than those reported by EPA based on mussels and RBT absent. These lower FAV values were likely a result of the most sensitive taxa and their surrogates (e.g *Fluminicola* (Pebblesnail), *Notemigonus* (Golden shiner), *Pseudacris* (Spring peeper), and *Hybognathus* sp. (Rio Grande silvery minnow)) having disproportionally more weight on the Mill Creek/Jordan River dataset with fewer taxa than with the more robust EPA dataset, which included a greater number of taxa. The number of taxa in a dataset affects EPA FAV calculations.

Chronic

The Acute Chronic Ratio (*ACR*) was calculated using taxa that had *ACR* values reported in USEPA 2013b (see Appendix 11, Table 6). Geometric means of the *ACR*s and 95% confidence intervals were 12.4556 (7.6054, 20.3989). The estimated Final Chronic Value (*FCV*) was 5.319 (3.248, 8.712); and the Criterion Continuous Concentration (*CCC*) was 5.319 (3.248, 8.712)(Table 6). The Chronic Maximum Concentrations (*CMC*s) were 33.45 with *Fluminicola* resident, 34.89 with *Fluminicola* not resident, and 37.64 for three rare or absent taxa removed.

Table 6. Taxa whose Acute Chronic Ratios were used to calculate chronic values.

Fluminicola sp.	7.94
Musculium transversum	42.5
Pimephales promelas	19.24
Ictalurus punctatus	4.8
Cyprinus carpio	8.1
Hyalella azteca	15.81
Lepomis cyanellus	6.468
Lepomis macrochirus	28.51
Micropterus dolomieui	13.61
Actinopterygii	8.973

Geometric mean = **12.4556 (7.6054, 20.3989)**
Final Chronic Value (*FCV*)= **5.319 (3.248, 8.712)**
Criterion Continuous Concentration (CCC) = *FCV* = **5.319 (3.248, 8.712)**
Criterion Maximum Concentration (CMC):

With *Fluminicola* sp. *CMC* = 0.5*66.89 = **33.45**
Without *Fluminicola* sp. *CMC* = 0.5*69.77 = **34.89**
Without three rare or absent taxa *CMC* = 0.5*75.28 = **37.64**
EPA (2013b) *CMC* excluding mussels and RBT = **38**.

Discussion

Results of this deletion and recalculation process were similar to and somewhat consistent with EPAs NH_3 criteria based solely on mussel and RBT presence/absence (USEPA 2013b). These results also bolster the decision to recalculate NH_3 criteria for CVWRFs discharge into Mill Creek. Several problems need to be addressed to further improve these calculations and to justify EPAs reliance on these methods. There is an urgent need to determine residency status of fish taxa in the Mill Creek site and particularly to determine if the June sucker (*Chasmistes liorus*) should be considered a resident, as well as Golden shiner (*Notemigonus)*. Amphibian surveys are also needed. The use of *Fluminicola* sp. (pebblesnail) as a surrogate for other taxa particularly the highly invasive New Zealand mudsnails (*Potamopyrgus antipodarum*) and Asian clams (*Corbicula* sp.) is problematic. *Fluminicola* sp. (i.e. *F. coloradensis*) likely do not occur in the site (they are more of a cold water species) and their use as surrogates to protect highly invasive, ecosystem-altering species such as *P. antipodarum* and *Corbicula* sp. is highly questionable and the continued use of these surrogates by EPA is possibly quite detrimental to critically evaluating the biological integrity of the Mill Creek site. The determination of Unionoida residency at the site is still in effect for any recalculation procedure until regulators can acknowledge or confirm that these taxa are no longer residents. For all practical purposes, Unionoida were assumed to be 'not resident' in the Mill Creek site because; 1) none of the macroinvertebrate datasets used in the analyses contained Unionoida species eventhough other bivalves were collected, 2) Richards (2015) intensive surveys did not find any individuals, and 3) there are no other recent reports of their residency.

One of the most important deficiencies exposed during this EPAs deletion and recalculation process was the absence of error estimates in any of the EPA recommended steps: starting from the untested premise that taxonomy (or more correctly phylogeny) has value in determining sensitivy to NH_3; to the highly variable within- species NH_3 sensitivies; and continuing through each succesive step to the derivations of final criteria values. Unfortunately, these systematic errors were likely multiplicative throughout each step of the process. In a brief technical memo to JR/FBWQC, Richards (2016) analyzed taxa from EPA's NH_3 criteria development report (USEPA 2013b) and showed that phylogeny had little or no ammonia sensivity predictive value, even between different phyla. In addition, the probit regression species sensitivity distributions (SSD) developed in this report and recommended by the EPA CADDIS program included prediction interval estimates. These model estimates suggested that any single point estimates, although potentionally accurate, likely were imprecise and unless addressed and accounted for could have costly consequences to citizens and to the aquatic environments of Utah, if enforced. As an additional example, by incorporating a basic understanding of the importance of model error, the geometric means of Acute Chronic Ratios (ACRs) calculated for chronic criteria in this report included error estimates (e.g. confidence intervals). For example, the *Criterion Continuous Concentration (CCC)* estimate based on geometric means of ACRs had a mean of 5.319 and 95% CIs between 3.248 to 8.712, quite a wide range when considering potential costs to society and environmental protection. In contrast, no error estimates were possible using point estimate formulas provided by and recommended by EPA. Hence, the precision of these estimates remains unknown, as is their ecological relevance. There also was also a paucity of chronic ammonia data, even at the national level on which to base criteria, which likely added to imprecise final values.

Conclusion and Recommendations

Results of this 'draft' Deletion and Recalculation Procedure for NH_3 in the Mill Creek site are strong evidence to support CVWRF ammonia recalculations. The determination of 'resident' taxa in the Mill Creek site completed in this report and many of the calculations derived therein can subsequently be used to recalculate any toxicant of concern by CVWRF, as long as there is ample sensitivity data in the national EcoTox database. A thorough rechecking of the calculations provided in this draft is recommended to verify accuracy, particularly the deletion process and determination of truly resident taxa. Further statistical analyses are needed to test the supposition that there is value in using phylogenic relationships for evaluating NH_3 sensitivty, as is the informed choice of requiring future criteria recalculations to include error estimates. Amphibian and fish surveys at the site in the near future to determine residency are highly recommended. Annual macroinvertebrate collections including mollusk surveys to monitor changes should also be considered. Finally, laboratory ammonia toxicity tests are urgently needed to be conducted on several species, particularly *Anodonta* (native mussel), *Corbicula* (invasive clam), *Pisidium* sp. a native clam whose within- family surrogate is one of the most NH_3 sensitive species and doesn't occur at the site, and for *P. antipodarum* (New Zealand mudsnail), whose family level surrogate is the highly sensitive *Fluminicola* (pebblesnail), which also doesn't occur at the site.

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Appendices

Appendix 1 Acute toxicity of ammonia to aquatic animals including SMAV (mg TAN/L). Ammended from Appendix A, EPA 822-R-13-001.

Phylum	Class	Order	Family	Genus	Species	SMAV (mg TAN/L)
Annelida	Citellata	Haplotaxida	Tubificidae	*Limnodrilus*	*Limnodrilus hoffmeisteri*	170.2
Annelida	Citellata	Lumbriculida	Lumbriculidae	*Lumbriculus*	*Lumbriculus variegatus*	218.7
Annelida	Clitellata	Oligochaeta	Naididae	*Tubifex*	*Tubifex tubifex*	216.5
Arthropoda	Branchiopoda	Cladocera	Chydoridae	*Chydorus*	*Chydorus sphaericus*	162.6
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Ceriodaphnia*	*Catostomus platyrhynchus*	136.2
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Ceriodaphnia*	*Ceriodaphnia acanthina*	154.3
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Ceriodaphnia*	*Ceriodaphnia dubia*	134.2
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Daphnia*	*Daphnia magna*	**157.7**
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Daphnia*	*Daphnia pulicaria*	**99.0**
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Simocephalus*	*Simocephalus vetulus*	142.9
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	*Stenelmis sexlineata*	735.9
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	*Chironomus riparius*	1029.0
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	*Chironomus tentans*	451.8
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Callibaetis*	*Callibaetis skokianus*	364.6
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Callibaetis*	*Callibaetis* sp.	166.7
Arthropoda	Insecta	Ephemeroptera	Ephemereliidae	*Drunella*	*Drunella grandis*	442.4
Arthropoda	Insecta	Odonata	Coenagrionidae	*Enallagma*	*Enallagma* sp.	164.0
Arthropoda	Insecta	Odonata	Coenagrionidae	*Erythromma*	*Erythromma najas*	2515.0
Arthropoda	Insecta	Odonata	Libellulidae	*Pachydiplax*	*Pachydiplax longipennis*	233.0
Arthropoda	Insecta	Plecoptera	Perlodidae	*Skwala*	*Skwala americana*	192.4
Arthropoda	Insecta	Trichoptera	Limnephilidae	*Philarctus*	*Philarctus quaeris*	994.5

Arthropoda	Malacostraca	Amphipoda	Crangonyctidae	*Crangonyx*	*Crangonyx pseudogracilis*	270.5
Arthropoda	Malacostraca	Amphipoda	Crangonyctidae	*Crangonyx*	*Crangonyx* sp.	122.2
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	*Hyalella*	*Hyalella azteca*	192.6
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes*	*Orconectes immunis*	1550.0
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes*	*Orconectes nais*	303.8
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Procambarus*	*Procambarus clarkii*	138.0
Arthropoda	Malacostraca	Isopoda	Asellidae	*Asellus*	*Asellus aquaticus*	378.2
Arthropoda	Malacostraca	Isopoda	Asellidae	*Caecidotea*	*Caecidotea racovitzai*	387.0
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	*Acipenser*	*Acipenser brevirostrum*	156.7
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Catostomus*	*Catostomus commersonii*	157.5
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Chasmistes*	*Chasmistes brevirostris*	69.4
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Deltistes*	*Deltistes luxatus*	56.6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Campostoma*	*Campostoma anomalum*	115.9
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinella*	*Cyprinella lutrensis*	196.1
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinella*	*Cyprinella spiloptera*	83.8
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinella*	*Cyprinella whipplei*	80.9
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinus*	*Cyprinus carpio*	106.3
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Hybognathus*	*Hybognathus amarus*	72.6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Notemigonus*	*Notemigonus crysoleucas*	63.0
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Notropis*	*Notropis topeka*	96.7
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Pimephales*	*Pimephales promelas*	159.2
Chordata	Actinopterygii	Cyprinodontiformes	Poeciliidae	*Gambusia*	*Gambusia affinis*	219.3
Chordata	Actinopterygii	Cyprinodontiformes	Poeciliidae	*Poecilia*	*Poecilia reticulata*	74.7
Chordata	Actinopterygii	Gasterosteiformes	Gasterosteidae	*Gasterosteus*	*Gasterosteus aculeatus*	281.5
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	*Lepomis cyanellus*	150.8
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	*Lepomis gibbosus*	77.5
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	*Lepomis macrochirus*	104.5
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	Micropterus dolomieu	150.6
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	*Micropterus salmoides*	86.0

Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	*Micropterus treculii*	54.5
Chordata	Actinopterygii	Perciformes	Cichlidae	*Oreochromis*	*Oreochromis mossambicus*	185.2
Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	*Morone chrysops*	144.0
Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	*Morone saxatilis*	246.2
Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	*Morone saxatilis x chrysops*	70.2
Chordata	Actinopterygii	Perciformes	Percidae	*Etheostoma*	*Etheostoma nigrum*	71.5
Chordata	Actinopterygii	Perciformes	Percidae	*Etheostoma*	*Etheostoma spectabile*	77.2
Chordata	Actinopterygii	Perciformes	Percidae	*Sander*	*Sander vitreus*	117.1
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*Oncorhynchus aguabonita*	112.1
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*Oncorhynchus clarkii*	78.9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*Oncorhynchus gorbuscha*	180.7
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*Oncorhynchus kisutch*	87.1
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*Oncorhynchus mykiss*	82.9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Prosopium*	*Prosopium williamsoni*	51.9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Salmo*	*Salmo salar*	183.3
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Salvelinus*	*Salvelinus fontinalis*	156.3
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Salvelinus*	*Salvelinus namaycush*	159.3
Chordata	Actinopterygii	Scorpaeniformes	Cottidae	*Cottus*	*Cottus bairdii*	222.2
Chordata	Actinopterygii	Siluriformes	Ictaluridae	*Ictalurus*	*Ictalurus punctatus*	142.4
Chordata	Amphibia	Anura	Hylidae	*Pseudacris*	*Pseudacris crucifer*	61.2
Chordata	Amphibia	Anura	Hylidae	*Pseudacris*	*Pseudacris regilla*	83.7
Chordata	Amphibia	Anura	Pipidae	*Xenopus*	*Xenopus laevis*	122.5
Chordata	Amphibia	Anura	Ranidae	*Rana*	*Rana pipiens*	96.4
Mollusca	Bivalvia	Unionoida	Unionidae	*Actinonaias*	*Actinonaias ligamentina*	63.9
Mollusca	Bivalvia	Unionoida	Unionidae	*Actinonaias*	*Actinonaias pectorosa*	79.5
Mollusca	Bivalvia	Unionoida	Unionidae	*Alasmidonta*	*Alasmidonta heterodon*	>109.0
Mollusca	Bivalvia	Unionoida	Unionidae	*Epioblasma*	*Epioblasma capsaeformis*	31.1
Mollusca	Bivalvia	Unionoida	Unionidae	*Fusconaia*	*Fusconaia masoni*	47.4
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*Lampsilis abrupta*	26.0

Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*Lampsilis cardium*	50.5
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*Lampsilis fasciola*	48.1
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*Lampsilis higginsii*	41.9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*Lampsilis rafinesqueana*	70.0
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*Lampsilis siliquoidea*	55.4
Mollusca	Bivalvia	Unionoida	Unionidae	*Lasmigona*	*Lasmigona subviridis*	23.4
Mollusca	Bivalvia	Unionoida	Unionidae	*Potamilus*	*Potamilus ohiensis*	>109.0
Mollusca	Bivalvia	Unionoida	Unionidae	*Pyganodon*	*Pyganodon grandis*	70.7
Mollusca	Bivalvia	Unionoida	Unionidae	*Utterbackia*	*Utterbackia imbecillis*	46.9
Mollusca	Bivalvia	Unionoida	Unionidae	*Venustaconcha*	*Venustaconcha ellipsiformis*	23.1
Mollusca	Bivalvia	Unionoida	Unionidae	*Villosa*	*Villosa iris*	34.2
Mollusca	Bivalvia	Verenoida	Sphaeriidae	*Musculium*	*Musculium transversum*	89.4
Mollusca	Gastropoda	Hygrophila	Lymnaeidae	*Lymnaea*	*Lymnaea stagnalis*	88.6
Mollusca	Gastropoda	Hygrophila	Physidae	*Physa*	*Physa gyrina*	164.5
Mollusca	Gastropoda	Hygrophila	Planorbidae	*Planorbella*	*Planorbella*	211.6
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*Fluminicola*	*Fluminicola* sp.	> 62.15
Mollusca	Gastropoda	Sorbeocncha	Pleuroceridae	*Pleurocera*	*Pleurocera uncialis*	68.5
Platyhelminthes	Trepaxonemata	Tricladida	Dendrocoelidae	*Dendrocoelum*	*Dendrocoelum lacteum*	119.5

Appendix 2. Mill Creek/Jordan River 'resident' taxa including common names and status for several species.

Phylum	**Class**	**Order**	**Family**	**Genus**	**Species**	**Common Name**	**Status**
Annelida	Clitellata	Arhynchobdellida	Erpobdellidae	*unidentified*	*unidentified*	leech	
Annelida	Clitellata	Oligochaeta	unidentified	*unidentified*	*unidentified*	aquatic worm	
Annelida	Clitellata	Oligochaeta	Naididae	*unidentified*	*unidentified*	aquatic worm	
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	*Helobdella*	stagnalis	leech	
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Glossiphonia*	*complanata*	leech	

Arthropoda	Arachnida	Trombidiformes	Lebertiidae	*Lebertia*	*sp.*	mite	
Arthropoda	Entognatha	Collembola	unidentified	*unidentified*	*unidentified*	springtail	
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	*sp.*	riffle beetle	
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Palpomyia/Bezzia*	*sp.*	Biting midge	
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Probezzia*	*sp.*	Biting midge	
Arthropoda	Insecta	Diptera	Chironomidae	*unidentified*	*unidentified*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*unidentified*	*unidentified*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Cryptochironomus*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Glptotendipes*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Parachironomus*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Paratanytarsus*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Paratendipes*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Phaenopsectra*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Procladius*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Prodiamesa*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Rheocricotopus*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Chironomidae	*Tvetenia*	*sp.*	midge	
Arthropoda	Insecta	Diptera	Psychodidae	*Pericoma*	*sp.*	sewer fly	
Arthropoda	Insecta	Diptera	Psychodidae	*Psychoda*	*sp.*	sewer fly	
Arthropoda	Insecta	Diptera	Simuliidae	*Simulium*	*sp.*	black fly	
Arthropoda	Insecta	Diptera	Simuliidae	*Simulium*	*vittatum*	black fly	
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	*sp.*	mayfly	
Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	*sp.*	mayfly	
Arthropoda	Insecta	Hemiptera	Corixidae	*Corisella*	*sp.*	water boatman	
Arthropoda	Insecta	Hemiptera	Corixidae	*Hesperocorixa*	*sp.*	water boatman	

Arthropoda	Insecta	Hemiptera	Corixidae	*Sigara*	*sp.*	water boatman	
Arthropoda	Insecta	Odonata	Calopterygidae	*Hetaerina*	*sp.*	Damselfly	
Arthropoda	Insecta	Odonata	Coenagrionidae	*unidentified*	*unidentified*	Damselfly	
Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	*sp.*	Damselfly	
Arthropoda	Insecta	Odonata	Coenagrionidae	*Ischnura*	*sp.*	Damselfly	
Arthropoda	Insecta	Odonata	Corduliidae	*unidentified*	*unidentified*	Dragonfly	
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	*sp.*	caddis fly	
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche*	*sp.*	caddis fly	
Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Hydroptila*	*sp.*	caddis fly	
Arthropoda	Insecta	Trichoptera	Leptoceridae	*unidentified*	*unidentified*	caddis fly	
Arthropoda	Malacostraca	Amphipoda	Gammaridae	*Gammarus*	*sp.*	scud	
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	*Hyalella*	*sp.*	scud	
Arthropoda	Malacostraca	Copepoda	unidentified	*unidentified*	*unidentified*	copepod	
Arthropoda	Malacostraca	Isopoda	Asellidae	*Asellus*	*sp.*	sow bug	
Arthropoda	Malacostraca	Isopoda	Asellidae	*Caecidotea*	*sp.*	sow bug	
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Catostomus*	*ardens*	Utah sucker	common
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Catostomus*	*platyrhynchus*	Mountain sucker	uncommon
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Chasmistes*	*liorus*	June sucker	rare
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinus*	*carpio*	Common carp	common
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Gila*	*atraria*	Utah chub	uncommon
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Notemigonus*	*crysoleucas*	Golden shiner	rare
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Pimephales*	*promelas*	Fathead minnow	rare
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Rhinichthys*	*osculus*	speckled dace	locally common
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Richardsonius*	*balteatus*	redside shiner	locally common
Chordata	Actinopterygii	Cyprinodontiformes	Poeciliidae	*Gambusia*	*affinis*	Mosquito fish	common
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	*cyanellus*	Green sunfish	common
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	*macrochirus*	Bluegill	uncommon
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	*salmoides*	Largemouth bass	uncommon
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Pomoxis*	*nigromaculatus*	Black crappie	uncommon

Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	*chrysops*	White bass	common
Chordata	Actinopterygii	Perciformes	Percidae	*Perca*	*flavescens*	Yellow perch	uncommon
Chordata	Actinopterygii	Perciformes	Percidae	*Stiozostedion*	*vitreum*	Walleye	uncommon
Chordata	Actinopterygii	Siluriformes	Ictaluridae	*Ameiurus*	*melas*	Black bullhead	common
Chordata	Actinopterygii	Siluriformes	Ictaluridae	*Ictalurus*	*punctatus*	Channel catfish	common
Chordata	Amphibia	Anura	Hylidae	*Pseudacris*	*triseriatea maculata*	Boreal chorus frog	common
Chordata	Amphibia	Anura	Ranidae	*Rana*	*catesbeiana*	American bullfrog	common
Chordata	Amphibia	Anura	Ranidae	*Rana*	*luteiventris (pretiosa)*	Northern spotted frog	rare
Chordata	Amphibia	Anura	Ranidae	*Lithobates*	*pipiens*	Northern leopard frog	rare
Mollusca	Bivalvia	Verenoida	Cyrenidae	*Corbicula*	*sp.*	Asian clam	
Mollusca	Bivalvia	Verenoida	Sphaeriidae	*Pisidium*	*sp.*	fingernail clam	
Mollusca	Gastropoda	Hygrophila	Physidae	*Physa*	*sp.*	Physa snail	
Mollusca	Gastropoda	Hygrophila	Planorbidae	*unidentified*	*unidentified*	Planorbid snail	
Mollusca	Gastropoda	Hygrophila	Planorbidae	*unidentified*	*unidentified*	Planorbid snail	
Mollusca	Gastropoda	Hygrophila	Planorbidae	*Gyraulus*	*sp.*	Planorbid snail	
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*unidentified*	*unidentified*	Hydrobiid snail	
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*Potamopyrgus*	*antipodarum*	New Zealand mudsnail	common
Nemotoda	unidentified	unidentified	unidentified	*unidentified*	*unidentified*	Nemotode	
Platyhelminthes	Trepaxonemata	Tricladida	unidentified	*unidentified*	*unidentified*	Flatworm	
Platyhelminthes	Turbellaria	unidentified	unidentified	*unidentified*	*unidentified*	Flatworm	

Appendix 3. Deletion process method used for determining GMAVs (USEPA RDPSSRPALC EPA-823-R-13-001)

Appendix 2. Longer Statement of the Deletion Process

In contrast to the Appendix 1 version, which operates on the list of tested species, comparing it to the list of resident species, this version operates on a single combined list. Use of a single list was found to have certain advantages, which furthered the development of an automated spreadsheet for determining retention or deletion of tested species. Appendices 1 and 2 are intended to yield identical results.

Steps A through J are performed sequentially so that the appropriate entry is made in the site- specific toxicity dataset column for each species; the entry indicates whether the species is or is not included in the site-specific toxicity dataset. This version of the Deletion Process is organized so that, beginning with Step D, each species that does not have an entry in the site- specific toxicity dataset column is addressed at the genus level before any species is addressed at the family level. Then, the order, class, and phylum taxonomic levels are addressed sequentially. The number of species that need to be addressed decreases as higher and higher taxonomic levels are addressed.

Step A: Make a table that lists all of the species in the (possibly modified) national toxicity dataset, all of the species that occur at the site, and all surrogates that are used for critical species at the site in taxonomic order by species, genus, family, order, class, and

phylum using the current version of ITIS. If a surrogate species is listed in the table, the species that it is a surrogate for should not be listed in the table. Fill in each column for each species, except do not put anything in the last column on the right, which is titled "In site-specific toxicity dataset?"

Step B: For each species that has a "No" in the national toxicity dataset column, enter "N-1" in the site-specific toxicity dataset column.

1. N = "No" and means that the species is not in the site-specific toxicity database.

Step C: For each species that has a "Yes" in the "Occur at the site?" column and a "Yes" in the national toxicity dataset column, enter "Y-2" in the site-specific toxicity dataset column.

Each species that does not yet have an entry in the site-specific toxicity dataset column has a "No" in the "Occur at the site?" column and a "Yes" in the national toxicity dataset column.

Step D: Look down the column titled "Genus" and every time a genus name appears more than once, draw a circle around all of the multiple entries for that one genus. The species in the circled genera are the only species that will be addressed in this Step D. For each species that is in a circled genus and does not already have an entry in the site-specific toxicity dataset column, look at the circled genus that that species is in and do one of the following regarding the site-specific toxicity dataset column:

1. Enter "N-3" if all of the species in that genus that occur at the site are already in the site-specific toxicity dataset.
2. Enter "Y-4" if one or more of the species in that genus that occur at the site are not in the site-specific toxicity dataset species occurring at the site.

Step E: Look down the column titled "Family" and every time a family name appears more than once, draw a circle around all of the multiple entries for that one family. The species in the circled families are the only species that will be addressed in this Step E. For each species that is in a circled family and does not already have an entry in the site-specific toxicity dataset column, look at the circled family that that species is in and do one of the following regarding the site-specific toxicity dataset column:

1. Enter "N-5" if all of the genera in that family that occur at the site are already represented in the site-specific toxicity dataset.
2. Enter "Y-6" if one or more of the genera in that family that occur at the site are not represented in the site-specific toxicity dataset.

This step will not result in an entry for tested species in families having no species occurring at the site.

Step F: Look down the column titled "Order" and every time an order name appears more than once, draw a circle around all of the multiple entries for that one order. The species in the circled orders are the only species that will be addressed in this Step F. For each species that is in a circled order and does not already have an entry in the site-specific toxicity dataset column, look at the circled order that that species is in and do one of the following regarding the site-specific toxicity dataset column:

1. Enter "N-7" if all of the families in that order that occur at the site are already represented in the site-specific toxicity dataset.
2. Enter "Y-8" if one or more of the families in that order that occur at the site are not represented in the site-specific toxicity dataset.

This step will not result in an entry for tested species in orders having no species occurring at the site.

Step G: Look down the column titled "Class" and every time a class name appears more than once, draw a circle around all of the multiple entries for that one class. The species in the circled classes are the only species that will be addressed in this Step G. For each species that is in a circled class and does not already have an entry in the site-specific toxicity dataset column, look at the circled class that that species is in and do one of the following regarding the site-specific toxicity dataset column:

1. Enter "N-9" if all of the orders in that class that occur at the site are already represented in the site-specific toxicity dataset.
2. Enter "Y-10" if one or more of the orders in that class that occur at the site are not represented in the site-specific toxicity dataset.

This step will not result in an entry for tested species in classes having no species occurring at the site.

Step H: Look down the column titled "Phylum" and every time a phylum name appears more than once, draw a circle around all of the multiple entries for that one phylum. The species in the circled phyla are the only species that will be addressed in this Step H. For each species that is in a circled phylum and does not already have an entry in the following regarding the site-specific toxicity dataset column:

1. Enter "N-11" if all of the classes in that phylum that occur at the site are already represented in the site-specific toxicity dataset.
2. Enter "Y-12" if one or more of the classes in that phylum that occur at the site are not represented in the site-specific toxicity dataset.

Step I: For each species for which no entry has been made in the site-specific toxicity dataset column, enter "N-13" because the phylum does not occur at the site.

Aspects of a completed table that are easy to review. a. Every "N" should have an odd number after it.

b. Every "Y" should have an even number after it.
c. Every species that has "No" in the national toxicity database column should have "N-1" in the site-specific database column.
d. Every species that has "Y-2" in the site-specific toxicity database column should have "Yes" in the "Occur at the site?" column and in the national toxicity dataset column.

Appendix 4. The deletion process. Taxa occurrence in Mill Creek/Jordan River site, taxa in national toxicity dataset, and determination for inclusion in site toxicity dataset with Fluminicola sp, resident (see Appendix 3 for description of deletion methods and N and Y values in the "Include in Site Toxicity Dataset?" column. Taxa are color coded to help interpret deletion methods used in Appendix 3)

Phylum	**Class**	**Order**	**Family**	**Genus**	**Species**	**Occurs at site?**	**In National Toxicity Dataset?**	**Include in Site Toxicity Dataset?**
Annelida	Clitellata	Arhynchobdellida	Erpobdellidae	*?*	*?*	Yes	No	N-1
Annelida	Clitellata	Lumbriculida	Lumbriculidae	*Lumbriculus*	*variegatus*	?	Yes	Y-10
Annelida	Clitellata	Oligochaeta	?	*?*	*?*	Yes	?	Y-8
Annelida	Clitellata	Oligochaeta	Naididae	*?*	*?*	Yes	?	Y-6
Annelida	Clitellata	Oligochaeta	Naididae	*Limnodrilus*	*hoffmeisteri*	?	Yes	Y-6
Annelida	Clitellata	Oligochaeta	Naididae	*Tubifex*	*tubifex*	?	Yes	Y-6
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Helobdella	stagnalis	Yes	No	N-1
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Glossiphonia	*complanata*	Yes	No	N-1
Arthropoda	Arachnida	Trombidiformes	Lebertiidae	Lebertia	*?*	Yes	No	N-1
Arthropoda	Branchiopoda	Cladocera	Chydoridae	*Chydorus*	*sphaericus*	No	Yes	Y-12
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Ceriodaphnia*	*acanthina*	No	Yes	Y-12
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Ceriodaphnia*	*dubia*	No	Yes	Y-12
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Daphnia*	*magna*	No	Yes	Y-12
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Daphnia*	*pulicaria*	No	Yes	Y-12
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Simocephalus*	*vetulus*	No	Yes	Y-12
Arthropoda	Entognatha	Collembola	?	?	*?*	Yes	No	N-1
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	*?*	Yes	?	Y-4

Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	*sexlineata*	?	Yes	Y-4
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Palpomyia/Bezzia*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Probezzia*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	?	?	Yes	?	Y-6
Arthropoda	Insecta	Diptera	Chironomidae	?	?	Yes	?	Y-6
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	*riparius*	?	Yes	Y-4
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	?	Yes	?	Y-4
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	*tentans*	?	Yes	Y-4
Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus*	*sp*	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Cryptochironomus*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Glptotendipes*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Parachironomus*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Paratanytarsus*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Paratendipes*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Phaenopsectra*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Procladius*		Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Prodiamesa*		Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Rheocricotopus*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Tvetenia*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Psychodidae	*Pericoma*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Psychodidae	Psychoda	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	?	Yes	No	N-1

Arthropoda	Insecta	Diptera	Simuliidae	Simulium	*vittatum*	Yes	No	N-1
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	*?*	Yes	No	N-1
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Callibaetis*	*skokianus*	No	Yes	Y-6
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Callibaetis*	sp.	No	Yes	Y-6
Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	*?*	Yes	No	N-1
Arthropoda	Insecta	Ephemeroptera	Ephemereliidae	*Drunella*	*grandis*	No	Yes	Y-8
Arthropoda	Insecta	Hemiptera	Corixidae	*Corisella*	*?*	Yes	No	N-1
Arthropoda	Insecta	Hemiptera	Corixidae	*Hesperocorixa*	*?*	Yes	No	N-1
Arthropoda	Insecta	Hemiptera	Corixidae	*Sigara*	*?*	Yes	No	N-1
Arthropoda	Insecta	Odonata	Calopterygidae	*Hetaerina*	*?*	Yes	No	N-1
Arthropoda	Insecta	Odonata	Coenagrionidae	*?*	*?*	Yes	?	Y-6
Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	*?*	Yes	No	N-1
Arthropoda	Insecta	Odonata	Coenagrionidae	*Enallagma*	sp.	?	Yes	Y-6
Arthropoda	Insecta	Odonata	Coenagrionidae	*Erythromma*	*najas*	?	Yes	Y-6
Arthropoda	Insecta	Odonata	Coenagrionidae	*Ischnura*	*?*	Yes	No	N-1
Arthropoda	Insecta	Odonata	Corduliidae	*?*	*?*	Yes	No	N-1
Arthropoda	Insecta	Odonata	Libellulidae	*Pachydiplax*	*longipennis*	No	Yes	Y-8
Arthropoda	Insecta	Plecoptera	Perlodidae	*Skwala*	*americana*	No	Yes	Y-10
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	*?*	Yes	No	N-1
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche*	*?*	Yes	No	N-1
Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Hydroptila*	*?*	Yes	No	N-1
Arthropoda	Insecta	Trichoptera	Leptoceridae	*?*	*?*	Yes	No	N-1
Arthropoda	Insecta	Trichoptera	Limnephilidae	*Philarctus*	*quaeris*	No	Yes	Y-8
Arthropoda	Malacostraca	Amphipoda	Crangonyctidae	*Crangonyx*	*pseudogracilis*	?	Yes	Y-2

Arthropoda	Malacostraca	Amphipoda	Crangonyctidae	*Crangonyx*	sp.	Yes	Yes	Y-2
Arthropoda	Malacostraca	Amphipoda	Gammaridae	*Gammarus*	*?*	Yes	No	N-1
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	*Hyalella*	*azteca*	Yes	Yes	Y-2
Arthropoda	Malacostraca	Copepoda	?	*?*	*?*	Yes	?	Y-10
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes*	*nais*	No	Yes	Y-10
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes*	*immunis*	No	Yes	Y-10
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Procambarus*	*clarkii*	No	Yes	Y-10
Arthropoda	Malacostraca	Isopoda	Asellidae	*Asellus*	*?*	Yes	?	Y-4
Arthropoda	Malacostraca	Isopoda	Asellidae	*Asellus*	*aquaticus*	?	Yes	Y-4
Arthropoda	Malacostraca	Isopoda	Asellidae	*Caecidotea*	*?*	Yes	?	Y-4
Arthropoda	Malacostraca	Isopoda	Asellidae	*Caecidotea*	*racovitzai*	?	Yes	Y-4
Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	*Acipenser*	*brevirostrum*	No	Yes	N-9
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Catostomus*	*ardens*	Yes	No	N-1
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Catostomus*	*commersonii*	No	Yes	Y-4
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Catostomus*	*platyrhynchus*	Yes	Yes	Y-2
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Chasmistes*	*brevirostris*	No	Yes	Y-4
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Chasmistes*	*liorus*	Yes	No	N-1
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Deltistes*	*luxatus*	No	Yes	N-5
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Campostoma*	*anomalum*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinella*	*lutrensis*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinella*	*spiloptera*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinella*	*whipplei*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinus*	*carpio*	Yes	Yes	Y-2
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Gila*	*atraria*	Yes	No	N-1

Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Hybognathus*	*amarus*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Notemigonus*	*crysoleucas*	Yes	Yes	Y-2
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Notropis*	*topeka*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Pimephales*	*promelas*	Yes	Yes	Y-2
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Rhinichthys*	*osculus*	Yes	No	N-1
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Richardsonius*	*balteatus*	Yes	No	N-1
Chordata	Actinopterygii	Cyprinodontiformes	Poeciliidae	*Gambusia*	*affinis*	Yes	Yes	Y-2
Chordata	Actinopterygii	Cyprinodontiformes	Poeciliidae	*Poecilia*	*reticulata*	No	Yes	N-5
Chordata	Actinopterygii	Gasterosteiformes	Gasterosteidae	*Gasterosteus*	*aculeatus*	No	Yes	N-9
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	*cyanellus*	Yes	Yes	Y-2
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	*gibbosus*	No	Yes	N-3
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	*macrochirus*	Yes	Yes	Y-2
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	*salmoides*	Yes	Yes	Y-2
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	*treculii*	No	Yes	N-3
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	dolomieu	No	Yes	N-3
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Pomoxis*	*nigromaculatus*	Yes	No	N-1
Chordata	Actinopterygii	Perciformes	Cichlidae	*Oreochromis*	*mossambicus*	No	Yes	N-7
Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	*chrysops*	Yes	Yes	Y-2
Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	*saxatilis*	No	Yes	N-3
Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	*saxatilis x chrysops*	No	Yes	N-3
Chordata	Actinopterygii	Perciformes	Percidae	*Etheostoma*	*nigrum*	No	Yes	Y-6
Chordata	Actinopterygii	Perciformes	Percidae	*Etheostoma*	*spectabile*	No	Yes	Y-6
Chordata	Actinopterygii	Perciformes	Percidae	*Perca*	*flavescens*	Yes	No	N-1
Chordata	Actinopterygii	Perciformes	Percidae	*Sander*	*vitreus*	No	Yes	Y-6

Chordata	Actinopterygii	Perciformes	Percidae	*Stiostedion*	*vitreum*	Yes	No	N-1
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*kisutch*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*aguabonita*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*clarkii*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*gorbuscha*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*mykiss*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Prosopium*	*williamsoni*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Salmo*	*salar*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Salvelinus*	*fontinalis*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Salvelinus*	*namaycush*	No	Yes	N-9
Chordata	Actinopterygii	Scorpaeniformes	Cottidae	*Cottus*	*bairdii*	No	Yes	N-9
Chordata	Actinopterygii	Siluriformes	Ictaluridae	*Ameiurus*	*melas*	Yes	No	N-1
Chordata	Actinopterygii	Siluriformes	Ictaluridae	*Ictalurus*	*punctatus*	Yes	Yes	Y-2
Chordata	Amphibia	Anura	Hylidae	*Pseudacris*	*crucifer*	No	Yes	Y-4
Chordata	Amphibia	Anura	Hylidae	*Pseudacris*	*regilla*	No	Yes	Y-4
Chordata	Amphibia	Anura	Hylidae	*Pseudacris*	*triseriatea maculata*	Yes	No	N-1
Chordata	Amphibia	Anura	Pipidae	*Xenopus*	*laevis*	No	Yes	N-7
Chordata	Amphibia	Anura	Ranidae	*Rana*	*cateseiana*	Yes	No	N-1
Chordata	Amphibia	Anura	Ranidae	*Rana*	*luteiventris*	Yes	No	N-1
Chordata	Amphibia	Anura	Ranidae	*Rana*	*pipiens*	Yes	Yes	Y-2
Mollusca	Bivalvia	Unionoida	Unionidae	*Actinonaias*	*ligamentina*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Actinonaias*	*pectorosa*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Alasmidonta*	*heterodon*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Epioblasma*	*capsaeformis*	No	Yes	N-9

Mollusca	Bivalvia	Unionoida	Unionidae	*Fusconaia*	*masoni*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*abrupta*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*cardium*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*fasciola*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*higginsii*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*rafinesqueana*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*siliquoidea*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lasmigona*	*subviridis*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Potamilus*	*ohiensis*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Pyganodon*	*grandis*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Utterbackia*	*imbecillis*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Venustaconcha*	*ellipsiformis*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Villosa*	*iris*	No	Yes	N-9
Mollusca	Bivalvia	Verenoida	Cyrenidae	*Corbicula*	*?*	Yes	No	N-1
Mollusca	Bivalvia	Verenoida	Sphaeriidae	*Musculium*	*transversum*	No	Yes	Y-6
Mollusca	Bivalvia	Verenoida	Sphaeriidae	*Pisidium*	*?*	Yes	No	N-1
Mollusca	Gastropoda	Hygrophila	Lymnaeidae	*Lymnaea*	*stagnalis*	?	Yes	N-7
Mollusca	Gastropoda	Hygrophila	Physidae	*Physa*	*?*	Yes	?	Y-4
Mollusca	Gastropoda	Hygrophila	Physidae	*Physa*	*gyrina*	?	Yes	Y-4
Mollusca	Gastropoda	Hygrophila	Planorbidae	*?*	*?*	Yes	?	Y-6
Mollusca	Gastropoda	Hygrophila	Planorbidae	*?*	*?*	Yes	?	Y-6
Mollusca	Gastropoda	Hygrophila	Planorbidae	*Gyraulus*	*?*	Yes	No	N-1
Mollusca	Gastropoda	Hygrophila	Planorbidae	*Planorbella*	*trivolvis*	?	Yes	Y-6
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*?*	*?*	Yes	?	Y-6

Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*Fluminicola*	sp.	No	Yes	Y-6
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*Potamopyrgus*	*antipodarum*	Yes	No	N-1
Mollusca	Gastropoda	Sorbeocncha	Pleuroceridae	*Pleurocera*	*uncialis*	No	Yes	N-9
Nemotoda	?	?	?	?	?	Yes	No	N-1
Platyhelminthes	Trepaxonemata	Tricladida	?	?	?	Yes	?	Y-8
Platyhelminthes	Trepaxonemata	Tricladida	Dendrocoelidae	*Dendrocoelum*	*lacteum*	?	Yes	Y-8
Platyhelminthes	Turbellaria	?	?	?	?	Yes	No	N-1

Phylum	**Class**	**Order**	**Family**	**Genus**	GMAV (mg TAN/L)
Annelida	Clitellata	Lumbriculida	Lumbriculidae	*Lumbriculus*	218.7
Annelida	Clitellata	Oligochaeta	Naididae	*Limnodrilus*	170.2
Annelida	Clitellata	Oligochaeta	Naididae	*Tubifex*	216.5
Arthropoda	Branchiopoda	Cladocera	Chydoridae	*Chydorus*	162.6
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Ceriodaphnia*	143.9
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Daphnia*	125
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Simocephalus*	142.9
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	735.9
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	681.8
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Callibaetis*	246.5
Arthropoda	Insecta	Ephemeroptera	Ephemereliidae	*Drunella*	442.4
Arthropoda	Insecta	Odonata	Coenagrionidae	*Enallagma*	164
Arthropoda	Insecta	Odonata	Coenagrionidae	*Erythromma*	2515
Arthropoda	Insecta	Odonata	Libellulidae	*Pachydiplax*	233
Arthropoda	Insecta	Plecoptera	Perlodidae	*Skwala*	192.4
Arthropoda	Insecta	Trichoptera	Limnephilidae	*Philarctus*	994.5

Arthropoda	Malacostraca	Amphipoda	Crangonyctidae	*Crangonyx*	181.8
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	*Hyalella*	192.6
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes*	686.2
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Procambarus*	138
Arthropoda	Malacostraca	Isopoda	Asellidae	*Asellus*	378.2
Arthropoda	Malacostraca	Isopoda	Asellidae	*Caecidotea*	387
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Catostomus*	146.5
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Campostoma*	115.9
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinella*	110
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinus*	106.3
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Hybognathus*	72.55
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Notropis*	96.72
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Pimephales*	159.2
Chordata	Actinopterygii	Cyprinodontiformes	Poeciliidae	*Gambusia*	219.3
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	106.9
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	89.06
Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	134.8
Chordata	Actinopterygii	Perciformes	Percidae	*Etheostoma*	74.25
Chordata	Actinopterygii	Perciformes	Percidae	*Sander*	117.1
Chordata	Actinopterygii	Siluriformes	Ictaluridae	*Ictalurus*	142.4
Chordata	Amphibia	Anura	Hylidae	*Pseudacris*	71.56
Chordata	Amphibia	Anura	Ranidae	*Rana*	96.38
Mollusca	Bivalvia	Verenoida	Sphaeriidae	*Musculium*	89.36
Mollusca	Gastropoda	Hygrophila	Physidae	*Physa*	164.5
Mollusca	Gastropoda	Hygrophila	Planorbidae	*Planorbella*	211.6
Platyhelminthes	Trepaxonemata	Tricladida	Dendrocoelidae	*Dendrocoelum*	119.5

Appendix 5. Taxa used for Acute Recalculation and genus level GMAVs including Fluminicola sp.

Phylum	Class	Order	Family	Genus	GMAV (mg TAN/L)
Annelida	Clitellata	Lumbriculida	Lumbriculidae	*Lumbriculus*	218.7
Annelida	Clitellata	Oligochaeta	Naididae	*Limnodrilus*	170.2
Annelida	Clitellata	Oligochaeta	Naididae	*Tubifex*	216.5
Arthropoda	Branchiopoda	Cladocera	Chydoridae	*Chydorus*	162.6
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Ceriodaphnia*	143.9
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Daphnia*	125
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Simocephalus*	142.9
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	735.9
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	681.8
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Callibaetis*	246.5
Arthropoda	Insecta	Ephemeroptera	Ephemereliidae	*Drunella*	442.4
Arthropoda	Insecta	Odonata	Coenagrionidae	*Enallagma*	164
Arthropoda	Insecta	Odonata	Coenagrionidae	*Erythromma*	2515
Arthropoda	Insecta	Odonata	Libellulidae	*Pachydiplax*	233
Arthropoda	Insecta	Plecoptera	Perlodidae	*Skwala*	192.4
Arthropoda	Insecta	Trichoptera	Limnephilidae	*Philarctus*	994.5
Arthropoda	Malacostraca	Amphipoda	Crangonyctidae	*Crangonyx*	181.8
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	*Hyalella*	192.6
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes*	686.2
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Procambarus*	138
Arthropoda	Malacostraca	Isopoda	Asellidae	*Asellus*	378.2
Arthropoda	Malacostraca	Isopoda	Asellidae	*Caecidotea*	387
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Catostomus*	146.5
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Chasmistes*	146.5

Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Campostoma*	115.9
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinella*	110
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinus*	106.3
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Hybognathus*	72.55
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Notemigonus*	63.02
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Notropis*	96.72
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Pimephales*	159.2
Chordata	Actinopterygii	Cyprinodontiformes	Poeciliidae	*Gambusia*	219.3
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	106.9
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	89.06
Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	134.8
Chordata	Actinopterygii	Perciformes	Percidae	*Etheostoma*	74.25
Chordata	Actinopterygii	Perciformes	Percidae	*Sander*	117.1
Chordata	Actinopterygii	Siluriformes	Ictaluridae	*Ictalurus*	142.4
Chordata	Amphibia	Anura	Hylidae	*Pseudacris*	71.56
Chordata	Amphibia	Anura	Ranidae	*Rana*	96.38
Mollusca	Bivalvia	Verenoida	Sphaeriidae	*Musculium*	89.36
Mollusca	Gastropoda	Hygrophila	Physidae	*Physa*	164.5
Mollusca	Gastropoda	Hygrophila	Planorbidae	*Planorbella*	211.6
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*Fluminicola*	>62.15
Platyhelminthes	Trepaxonemata	Tricladida	Dendrocoelidae	*Dendrocoelum*	119.5

Appendix 6. Some common names for species used in Acute recalculation and their SMAVs. Some common names are not ITIS recognized.

Common Name	**Species**	**SMAV (mg TAN/L)**
Spring peeper	*Pseudacris crucifer*	61.18

Pebblesnail	*Fluminicola sp.*	62.15
Golden shiner	*Notemigonus crysoleucas*	63.02
Shortnose sucker	*Chasmistes brevirostris*	69.36
Johnny darter	*Etheostoma nigrum*	71.45
Rio Grande silvery minnow	*Hybognathus amarus*	72.55
Orangethroat darter	*Etheostoma spectabile*	77.17
Steelcolor shiner	*Cyprinella whipplei*	80.94
Pacific tree frog	*Pseudacris regilla*	83.71
Spotfin shiner	*Cyprinella spiloptera*	83.80
Largemouth bass	*Micropterus salmoides*	86.02
Great pond snail	*Lymnaea stagnalis*	88.62
Long fingernail clam	*Musculium transversum*	89.36
Lithobates pipiens	*Rana pipiens*	96.38
Topeka shiner	*Notropis topeka*	96.72
Bluegill	*Lepomis macrochirus*	104.50
Carp	*Cyprinus carpio*	106.30
Central stoneroller	*Campostoma anomalum*	115.90
Walleye	*Sander vitreus*	117.10
Flatworm species	*Dendrocoelum lacteum*	119.50
Amphipod sp.	*Crangonyx sp.*	122.20
Mountain sucker	*Catostomus platyrhynchus*	136.20
Red swamp crayfish	*Procambarus clarkii*	138.00
Channel catfish	*Ictalurus punctatus*	142.40
White bass	*Morone chrysops*	144.00
Green sunfish	*Lepomis cyanellus*	150.80
White sucker	*Catostomus commersonii*	157.50
Fathead minnow	*Pimephales promelas*	159.20

Damselfly sp.	*Enallagma sp.*	164.00
Physa snail	*Physa gyrina*	164.50
Mayfly species	*Callibaetis sp.*	166.70
Aquatic oligochaete worm	*Limnodrilus hoffmeisteri*	170.20
Perlodid stonefly	*Skwala americana*	192.40
Amphipod sp.	*Hyalella azteca*	192.60
Red shiner	*Cyprinella lutrensis*	196.10
Marsh ramshorn	*Planorbella trivolvis*	211.60
Aquatic oligochaete worm	*Tubifex tubifex*	216.50
Aquatic oligochaete worm	*Lumbriculus variegatus*	218.70
Mosquito fish	*Gambusia affinis*	219.30
Blue dasher dragonfly	*Pachydiplax longipennis*	233.00
Northern river crangonyctid	*Crangonyx pseudogracilis*	270.50
Water nymph crayfish	*Orconectes nais*	303.80
Mayfly species	*Callibaetis skokianus*	364.60
Aquatic sowbug (not ITIS)	*Asellus aquaticus*	378.20
Aquatic sowbug (not ITIS)	*Caecidotea acovitzai*	387.00
Mayfly species	*Drunella grandis*	442.40
Midge species	*Chironomus tentans*	451.80
Riffle beetle	*Stenelmis sexlineata*	735.90
Caddisfly species	*Philarctus quaeris*	994.50
Midge species	*Chironomus riparius*	1029.00
Calico crayfish(not ITIS)	*Orconectes immunis*	1550.00
Red eyed damselfly (not ITIS)	*Erythromma najas*	2515.00

Appendix 7. Genera used for Acute Recalculation

Genus	GMAV (mg TAN/L)
Fluminicola	62.15

Notemigonus	63.02
Pseudacris	71.56
Hybognathus	72.55
Etheostoma	74.25
Micropterus	89.06
Musculium	89.36
Rana	96.38
Notropis	96.72
Cyprinus	106.3
Lepomis	106.9
Cyprinella	110
Campostoma	115.9
Sander	117.1
Dendrocoelum	119.5
Daphnia	125
Morone	134.8
Procambarus	138
Ictalurus	142.4
Simocephalus	142.9
Ceriodaphnia	143.9
Catostomus	146.5
Chasmistes	146.5
Pimephales	159.2
Chydorus	162.6
Enallagma	164
Physa	164.5
Limnodrilus	170.2
Crangonyx	181.8

Skwala	192.4
Hyalella	192.6
Planorbella	211.6
Tubifex	216.5
Lumbriculus	218.7
Gambusia	219.3
Pachydiplax	233
Callibaetis	246.5
Asellus	378.2
Caecidotea	387
Drunella	442.4
Chironomus	681.8
Orconectes	686.2
Stenelmis	735.9
Philarctus	994.5
Erythromma	2515

Appendix 8. The deletion process. Taxa occurrence in Mill Creek/Jordan River site, taxa in national toxicity dataset, and determination for inclusion in site toxicity dataset with three rare or absent taxa removed (see Appendix 3 for description of deletion methods and N and Y values in the "Include in Site Toxicity Dataset?" column. Taxa are color coded to help interpret deletion methods used in Appendix 3)

Phylum	Class	Order	Family	Genus	Species	Occurs at site?	In National Toxicity Dataset?	Include in Site Toxicity Dataset?
Annelida	Clitellata	Arhynchobdellida	Erpobdellidae	?	?	Yes	No	N-1
Annelida	Clitellata	Lumbriculida	Lumbriculidae	*Lumbriculus*	*variegatus*	?	Yes	Y-10
Annelida	Clitellata	Oligochaeta	?	?	?	Yes	?	Y-8
Annelida	Clitellata	Oligochaeta	Naididae	?	?	Yes	?	Y-6

Annelida	Clitellata	Oligochaeta	Naididae	*Limnodrilus*	*hoffmeisteri*	?	Yes	Y-6
Annelida	Clitellata	Oligochaeta	Naididae	*Tubifex*	*tubifex*	?	Yes	Y-6
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Helobdella	stagnalis	Yes	No	N-1
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Glossiphonia	*complanata*	Yes	No	N-1
Arthropoda	Arachnida	Trombidiformes	Lebertiidae	Lebertia	?	Yes	No	N-1
Arthropoda	Branchiopoda	Cladocera	Chydoridae	*Chydorus*	*sphaericus*	No	Yes	Y-12
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Ceriodaphnia*	*acanthina*	No	Yes	Y-12
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Ceriodaphnia*	*dubia*	No	Yes	Y-12
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Daphnia*	*magna*	No	Yes	Y-12
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Daphnia*	*pulicaria*	No	Yes	Y-12
Arthropoda	Branchiopoda	Cladocera	Daphnidae	*Simocephalus*	*vetulus*	No	Yes	Y-12
Arthropoda	Entognatha	Collembola	?	?	?	Yes	No	N-1
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	?	Yes	?	Y-4
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	*sexlineata*	?	Yes	Y-4
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Palpomyia/Bezzia*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Probezzia*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	?	?	Yes	?	Y-6
Arthropoda	Insecta	Diptera	Chironomidae	?	?	Yes	?	Y-6
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	*riparius*	?	Yes	Y-4
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	?	Yes	?	Y-4
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	*tentans*	?	Yes	Y-4
Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus*	*sp*	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Cryptochironomus*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	?	Yes	No	N-1

Arthropoda	Insecta	Diptera	Chironomidae	*Glptotendipes*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Parachironomus*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Paratanytarsus*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Paratendipes*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Phaenopsectra*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Procladius*		Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Prodiamesa*		Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Rheocricotopus*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Chironomidae	*Tvetenia*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Psychodidae	*Pericoma*	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Psychodidae	Psychoda	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	?	Yes	No	N-1
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	*vittatum*	Yes	No	N-1
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	?	Yes	No	N-1
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Callibaetis*	*skokianus*	No	Yes	Y-6
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Callibaetis*	sp.	No	Yes	Y-6
Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	?	Yes	No	N-1
Arthropoda	Insecta	Ephemeroptera	Ephemereliidae	*Drunella*	*grandis*	No	Yes	Y-8
Arthropoda	Insecta	Hemiptera	Corixidae	*Corisella*	?	Yes	No	N-1
Arthropoda	Insecta	Hemiptera	Corixidae	*Hesperocorixa*	?	Yes	No	N-1
Arthropoda	Insecta	Hemiptera	Corixidae	*Sigara*	?	Yes	No	N-1
Arthropoda	Insecta	Odonata	Calopterygidae	*Hetaerina*	?	Yes	No	N-1
Arthropoda	Insecta	Odonata	Coenagrionidae	?	?	Yes	?	Y-6

Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	*?*	Yes	No	N-1
Arthropoda	Insecta	Odonata	Coenagrionidae	*Enallagma*	sp.	?	Yes	Y-6
Arthropoda	Insecta	Odonata	Coenagrionidae	*Erythromma*	*najas*	?	Yes	Y-6
Arthropoda	Insecta	Odonata	Coenagrionidae	*Ischnura*	*?*	Yes	No	N-1
Arthropoda	Insecta	Odonata	Corduliidae	*?*	*?*	Yes	No	N-1
Arthropoda	Insecta	Odonata	Libellulidae	*Pachydiplax*	*longipennis*	No	Yes	Y-8
Arthropoda	Insecta	Plecoptera	Perlodidae	*Skwala*	*americana*	No	Yes	Y-10
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	*?*	Yes	No	N-1
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche*	*?*	Yes	No	N-1
Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Hydroptila*	*?*	Yes	No	N-1
Arthropoda	Insecta	Trichoptera	Leptoceridae	*?*	*?*	Yes	No	N-1
Arthropoda	Insecta	Trichoptera	Limnephilidae	*Philarctus*	*quaeris*	No	Yes	Y-8
Arthropoda	Malacostraca	Amphipoda	Crangonyctidae	*Crangonyx*	*pseudogracilis*	?	Yes	N-3
Arthropoda	Malacostraca	Amphipoda	Crangonyctidae	*Crangonyx*	sp.	Yes	Yes	Y-2
Arthropoda	Malacostraca	Amphipoda	Gammaridae	*Gammarus*	*?*	Yes	No	N-1
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	*Hyalella*	*azteca*	Yes	Yes	Y-2
Arthropoda	Malacostraca	Copepoda	?	*?*	*?*	Yes	No	Y-10
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes*	*nais*	No	Yes	Y-10
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes*	*immunis*	No	Yes	Y-10
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Procambarus*	*clarkii*	No	Yes	Y-10
Arthropoda	Malacostraca	Isopoda	Asellidae	*Asellus*	*?*	Yes	?	Y-4
Arthropoda	Malacostraca	Isopoda	Asellidae	*Asellus*	*aquaticus*	?	Yes	Y-4
Arthropoda	Malacostraca	Isopoda	Asellidae	*Caecidotea*	*?*	Yes	?	Y-4
Arthropoda	Malacostraca	Isopoda	Asellidae	*Caecidotea*	*racovitzai*	?	Yes	Y-4

Chordata	Actinopterygii	Acipenseriformes	Acipenseridae	*Acipenser*	*brevirostrum*	No	Yes	Y-12
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Catostomus*	*ardens*	Yes	No	N-1
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Catostomus*	*commersonii*	No	Yes	Y-4
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Catostomus*	*platyrhynchus*	Yes	Yes	Y-2
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Chasmistes*	*brevirostris*	No	Yes	N-5
Chordata	Actinopterygii	Cypriniformes	Catostomidae	*Deltistes*	*luxatus*	No	Yes	N-5
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Campostoma*	*anomalum*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinella*	*lutrensis*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinella*	*spiloptera*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinella*	*whipplei*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Cyprinus*	*carpio*	Yes	Yes	Y-2
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Gila*	*atraria*	Yes	No	N-1
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Hybognathus*	*amarus*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Notropis*	*topeka*	No	Yes	Y-6
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Pimephales*	*promelas*	Yes	Yes	Y-2
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Rhinichthys*	*osculus*	Yes	No	N-1
Chordata	Actinopterygii	Cypriniformes	Cyprinidae	*Richardsonius*	*balteatus*	Yes	No	N-1
Chordata	Actinopterygii	Cyprinodontiformes	Poeciliidae	*Gambusia*	*affinis*	Yes	Yes	Y-2
Chordata	Actinopterygii	Cyprinodontiformes	Poeciliidae	*Poecilia*	*reticulata*	No	Yes	N-3
Chordata	Actinopterygii	Gasterosteiformes	Gasterosteidae	*Gasterosteus*	*aculeatus*	No	Yes	N-9
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	*cyanellus*	Yes	Yes	Y-2
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	*gibbosus*	No	Yes	Y-6
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Lepomis*	*macrochirus*	Yes	Yes	Y-2
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	*salmoides*	Yes	Yes	Y-2

Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	*treculii*	No	Yes	Y-6
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Micropterus*	dolomieu	No	Yes	Y-6
Chordata	Actinopterygii	Perciformes	Centrarchidae	*Pomoxis*	*nigromaculatus*	Yes	No	N-1
Chordata	Actinopterygii	Perciformes	Cichlidae	*Oreochromis*	*mossambicus*	No	Yes	N-7
Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	*chrysops*	Yes	Yes	Y-2
Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	*saxatilis*	No	Yes	N-3
Chordata	Actinopterygii	Perciformes	Moronidae	*Morone*	*saxatilis x chrysops*	No	Yes	N-3
Chordata	Actinopterygii	Perciformes	Percidae	*Etheostoma*	*nigrum*	No	Yes	Y-6
Chordata	Actinopterygii	Perciformes	Percidae	*Etheostoma*	*spectabile*	No	Yes	Y-6
Chordata	Actinopterygii	Perciformes	Percidae	*Perca*	*flavescens*	Yes	No	N-1
Chordata	Actinopterygii	Perciformes	Percidae	*Sander*	*vitreus*	No	Yes	Y6
Chordata	Actinopterygii	Perciformes	Percidae	*Stiostedion*	*vitreum*	Yes	No	N-1
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*kisutch*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*aguabonita*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*clarkii*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*gorbuscha*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus*	*mykiss*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Prosopium*	*williamsoni*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Salmo*	*salar*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Salvelinus*	*fontinalis*	No	Yes	N-9
Chordata	Actinopterygii	Salmoniformes	Salmonidae	*Salvelinus*	*namaycush*	No	Yes	N-9
Chordata	Actinopterygii	Scorpaeniformes	Cottidae	*Cottus*	*bairdii*	No	Yes	N-9
Chordata	Actinopterygii	Siluriformes	Ictaluridae	*Ameiurus*	*melas*	Yes	No	N-1
Chordata	Actinopterygii	Siluriformes	Ictaluridae	*Ictalurus*	*punctatus*	Yes	Yes	Y-2

Chordata	Amphibia	Anura	Hylidae	*Pseudacris*	*crucifer*	No	Yes	Y-6
Chordata	Amphibia	Anura	Hylidae	*Pseudacris*	*regilla*	No	Yes	Y-6
Chordata	Amphibia	Anura	Hylidae	*Pseudacris*	*triseriatea maculata*	Yes	No	N-1
Chordata	Amphibia	Anura	Pipidae	*Xenopus*	*laevis*	No	Yes	N-7
Chordata	Amphibia	Anura	Ranidae	*Rana*	*cateseiana*	Yes	No	N-1
Chordata	Amphibia	Anura	Ranidae	*Rana*	*luteiventris*	Yes	No	N-1
Chordata	Amphibia	Anura	Ranidae	*Rana*	*pipiens*	Yes	Yes	Y-2
Mollusca	Bivalvia	Unionoida	Unionidae	*Actinonaias*	*ligamentina*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Actinonaias*	*pectorosa*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Alasmidonta*	*heterodon*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Epioblasma*	*capsaeformis*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Fusconaia*	*masoni*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*abrupta*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*cardium*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*fasciola*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*higginsii*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*rafinesqueana*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*	*siliquoidea*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Lasmigona*	*subviridis*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Potamilus*	*ohiensis*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Pyganodon*	*grandis*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Utterbackia*	*imbecillis*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Venustaconcha*	*ellipsiformis*	No	Yes	N-9
Mollusca	Bivalvia	Unionoida	Unionidae	*Villosa*	*iris*	No	Yes	N-9

Mollusca	Bivalvia	Verenoida	Cyrenidae	*Corbicula*	*?*	Yes	No	N-1
Mollusca	Bivalvia	Verenoida	Sphaeriidae	*Musculium*	*transversum*	No	Yes	Y-6
Mollusca	Bivalvia	Verenoida	Sphaeriidae	*Pisidium*	*?*	Yes	No	N-1
Mollusca	Gastropoda	Hygrophila	Lymnaeidae	*Lymnaea*	*stagnalis*	?	Yes	N-7
Mollusca	Gastropoda	Hygrophila	Physidae	*Physa*	*?*	Yes	?	Y-2
Mollusca	Gastropoda	Hygrophila	Physidae	*Physa*	*gyrina*	?	Yes	Y-2
Mollusca	Gastropoda	Hygrophila	Planorbidae	*?*	*?*	Yes	?	Y-6
Mollusca	Gastropoda	Hygrophila	Planorbidae	*?*	*?*	Yes	?	Y-6
Mollusca	Gastropoda	Hygrophila	Planorbidae	*Gyraulus*	*?*	Yes	No	N-1
Mollusca	Gastropoda	Hygrophila	Planorbidae	*Planorbella*	*trivolvis*	?	Yes	Y-6
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*Fluminicola*	sp.	No	Yes	N-9
Mollusca	Gastropoda	Sorbeocncha	Pleuroceridae	*Pleurocera*	*uncialis*	No	Yes	N-9
Nemotoda	?	?	?	*?*	*?*	Yes	No	N-1
Platyhelminthes	Trepaxonemata	Tricladida	?	*?*	*?*	Yes	?	Y-8
Platyhelminthes	Trepaxonemata	Tricladida	Dendrocoelidae	*Dendrocoelum*	*lacteum*	?	Yes	Y-8
Platyhelminthes	Turbellaria	?	?	*?*	*?*	Yes	No	N-1

Appendix 9. EPA (2013b) Appendix N. Table N.5 and N. 7 site specific criteria based on mussel present/absent and RBT present/absent.

Table N.5. 2013 Acute Criterion Recalculations for Site-specific Criteria.

Acute Criterion Duration (1 hr average) at pH 7 and 20°C (mg TAN/L)	**Acute Criterion Magnitude (CMC) Oncorhynchus spp. (Rainbow Trout) Present**	**Acute Criterion Magnitude (CMC) Oncorhynchus spp. (Rainbow Trout) Absent**
Mussels Present	17	17
Mussels Absent	24	38
Frequency: Criteria values not to be exceeded more than once in three years.		

Table N.7. Chronic Criterion Recalculations for Site-Specific Criteria.

Chronic Criterion Duration (30-day average) at pH 7 and 20°C (mg TAN/L)	**Chronic Criterion Magnitude (CCC) Fish ELS Present**	**Chronic Criterion Magnitude (CCC) Fish ELS Absent**
Mussels Present	1.9	1.9
Mussels Absent	6.5	7.1
Not to exceed 2.5 times the CCC as a 4-day average within the 30-day averaging period.		
Frequency: Criteria values not to be exceeded more than once in three years.		

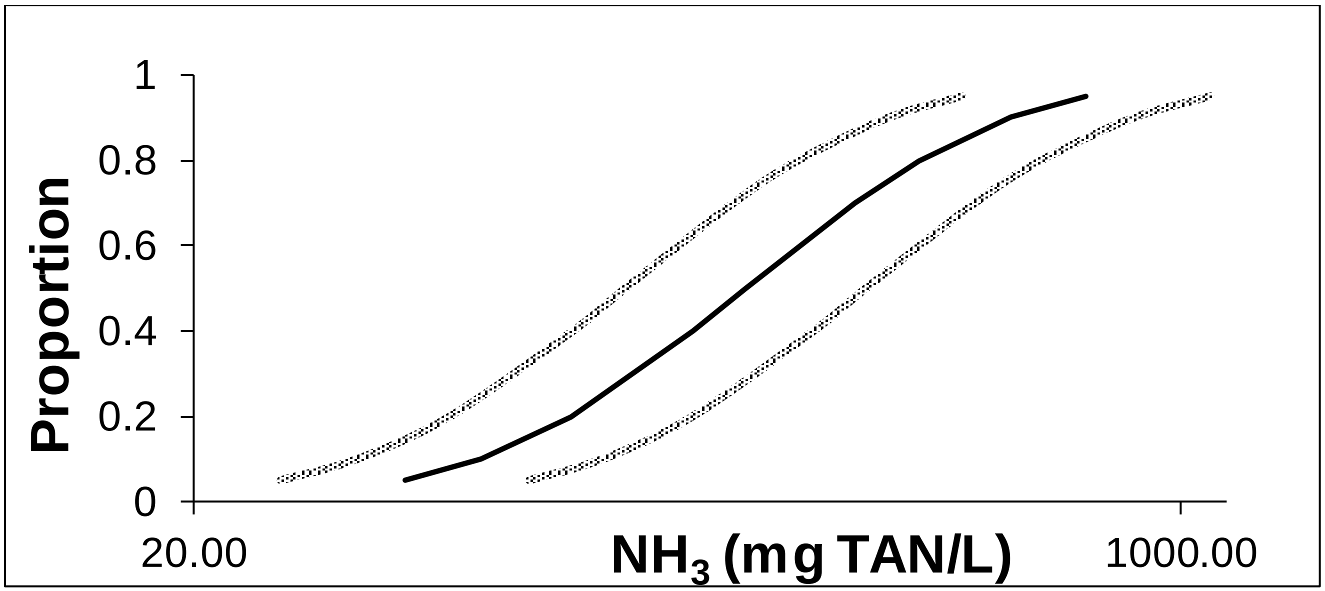
Appendix 10 Results of Species Sensitivity Distributions probit regressions using EPA CADDIS Volume 4: Data Analysis SSD_Generator_V1.xlt ***Fluminicola resident*** *(https://www3.epa.gov/caddis/da_software_ssdmacro.html)*

Genus	GMAV NH_3 (mg TAN/L)	Taxon Log Exposure Geometric Mean	Proportion	Rank	Probit	Probit Predicted	Difference
Fluminicola	62.15	1.7934	1%	1	2.7135	3.7155	1.0042
Notemigonus	63.02	1.7995	3%	2	3.1661	3.7325	0.3208
Pseudacris	71.56	1.8547	6%	3	3.4068	3.8874	0.2310
Hybognathus	72.55	1.8606	8%	4	3.5798	3.9042	0.1052
Etheostoma	74.25	1.8707	10%	5	3.7184	3.9324	0.0458
Micropterus	89.06	1.9497	12%	6	3.8361	4.1542	0.1012
Musculium	89.36	1.9511	14%	7	3.9394	4.1583	0.0479
Rana	96.38	1.9840	17%	8	4.0326	4.2505	0.0475
Notropis	96.72	1.9855	19%	9	4.1180	4.2548	0.0187
Cyprinus	106.3	2.0265	21%	10	4.1974	4.3700	0.0298
Lepomis	106.9	2.0290	23%	11	4.2721	4.3768	0.0110
Cyprinella	110	2.0414	26%	12	4.3429	4.4117	0.0047
Campostoma	115.9	2.0641	28%	13	4.4105	4.4754	0.0042
Sander	117.1	2.0686	30%	14	4.4756	4.4880	0.0002
Dendrocoelum	119.5	2.0774	32%	15	4.5385	4.5127	0.0007
Daphnia	125	2.0969	34%	16	4.5996	4.5676	0.0010
Morone	134.8	2.1297	37%	17	4.6593	4.6596	0.0000
Procambarus	138	2.1399	39%	18	4.7178	4.6882	0.0009
Ictalurus	142.4	2.1535	41%	19	4.7753	4.7265	0.0024
Simocephalus	142.9	2.1550	43%	20	4.8321	4.7308	0.0103
Ceriodaphnia	143.9	2.1581	46%	21	4.8884	4.7393	0.0222
Catostomus	146.5	2.1658	48%	22	4.9443	4.7611	0.0335
Chasmistes	146.5	2.1658	48%	22	4.9443	4.7611	0.0335
Pimephales	159.2	2.2019	52%	24	5.0557	4.8625	0.0373
Chydorus	162.6	2.2111	54%	25	5.1116	4.8882	0.0499
Enallagma	164	2.2148	57%	26	5.1679	4.8987	0.0725
Physa	164.5	2.2162	59%	27	5.2247	4.9024	0.1039

Limnodrilus	170.2	2.2310	61%	28	5.2822	4.9439	0.1144
Crangonyx	181.8	2.2596	63%	29	5.3407	5.0243	0.1001
Skwala	192.4	2.2842	66%	30	5.4004	5.0934	0.0942
Hyalella	192.6	2.2847	68%	31	5.4615	5.0947	0.1345
Planorbella	211.6	2.3255	70%	32	5.5244	5.2094	0.0992
Tubifex	216.5	2.3355	72%	33	5.5895	5.2373	0.1240
Lumbriculus	218.7	2.3398	74%	34	5.6571	5.2497	0.1660
Gambusia	219.3	2.3410	77%	35	5.7279	5.2530	0.2255
Pachydiplax	233	2.3674	79%	36	5.8026	5.3269	0.2263
Callibaetis	246.5	2.3918	81%	37	5.8820	5.3956	0.2366
Asellus	378.2	2.5777	83%	38	5.9674	5.9175	0.0025
Caecidotea	387	2.5877	86%	39	6.0606	5.9456	0.0132
Drunella	442.4	2.6458	88%	40	6.1639	6.1087	0.0030
Chironomus	681.8	2.8337	90%	41	6.2816	6.6361	0.1257
Orconectes	686.2	2.8365	92%	42	6.4202	6.6440	0.0501
Stenelmis	735.9	2.8668	94%	43	6.5932	6.7292	0.0185
Philarctus	994.5	2.9976	97%	44	6.8339	7.0964	0.0689
Erythromma	2515	3.4005	99%	45	7.2865	8.2277	0.8859

PARAMETERS	
Slope	2.808
Intercept	-1.320
R^2	0.885
Grand Mean	2.250
Sum SQ	232.822
CSSQ	4.912
MSE	0.117
T critical	1.681
N	45
df	43

Proportion	Probit	Log Central Tendency	SSQ	Log Upper PI	Log Lower PI	Central Tendency	Upper PI	Lower PI
0.05	3.355	1.665	0.016	1.879	1.451	46.247	75.693	28.256
0.1	3.718	1.794	0.016	2.006	1.583	62.299	101.332	38.301
0.2	4.158	1.951	0.015	2.160	1.742	89.365	144.554	55.247
0.4	4.747	2.161	0.015	2.368	1.954	144.774	233.281	89.847
0.5	5.000	2.251	0.015	2.458	2.044	178.207	287.044	110.637
0.7	5.524	2.438	0.015	2.645	2.230	273.967	442.021	169.806
0.8	5.842	2.551	0.015	2.760	2.342	355.371	574.850	219.689
0.9	6.282	2.707	0.016	2.919	2.496	509.765	829.187	313.392
0.95	6.645	2.837	0.016	3.051	2.623	686.698	1123.977	419.541



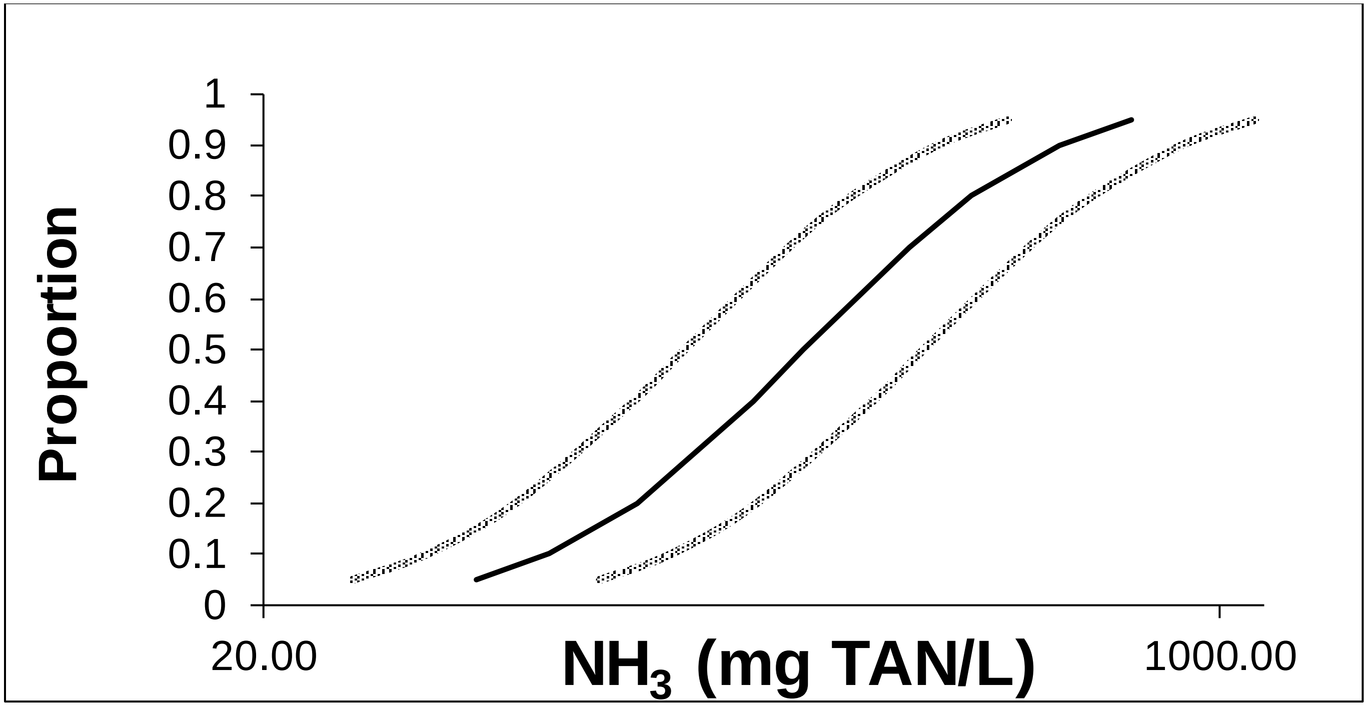
Appendix 11. Results of Species Sensitivity Distributions probit regressions using EPA CADDIS Volume 4: Data Analysis SSD_Generator_V1.xlt ***Fluminicola not resident*** *(https://www3.epa.gov/caddis/da_software_ssdmacro.html)*

Genera	MGAV NH_3 (mg TAN/L)	MGAV Log NH_3 (mg TAN/L) Geometric Mean	Proportion	Rank	Probit	Probit Predicted	Difference
Notemigonus	63.02	1.7995	1%	1	2.7220	3.6947	0.9460
Pseudacris	71.56	1.8547	3%	2	3.1762	3.8506	0.4549
Hybognathus	72.55	1.8606	6%	3	3.4179	3.8675	0.2021
Etheostoma	74.25	1.8707	8%	4	3.5919	3.8959	0.0925
Micropterus	89.06	1.9497	10%	5	3.7313	4.1192	0.1505
Musculium	89.36	1.9511	13%	6	3.8497	4.1233	0.0749
Rana	96.38	1.9840	15%	7	3.9538	4.2161	0.0688
Notropis	96.72	1.9855	17%	8	4.0476	4.2205	0.0299
Cyprinus	106.3	2.0265	19%	9	4.1338	4.3364	0.0411
Lepomis	106.9	2.0290	22%	10	4.2139	4.3433	0.0167
Cyprinella	110	2.0414	24%	11	4.2893	4.3784	0.0079
Campostoma	115.9	2.0641	26%	12	4.3609	4.4425	0.0067
Sander	117.1	2.0686	28%	13	4.4293	4.4552	0.0007
Dendrocoelum	119.5	2.0774	31%	14	4.4951	4.4801	0.0002
Daphnia	125	2.0969	33%	15	4.5588	4.5353	0.0006
Morone	134.8	2.1297	35%	16	4.6208	4.6279	0.0001
Procambarus	138	2.1399	38%	17	4.6814	4.6567	0.0006
Ictalurus	142.4	2.1535	40%	18	4.7408	4.6953	0.0021
Simocephalus	142.9	2.1550	42%	19	4.7993	4.6996	0.0099
Ceriodaphnia	143.9	2.1581	44%	20	4.8571	4.7081	0.0222
Catostomus	146.5	2.1658	47%	21	4.9144	4.7301	0.0340
Chasmistes	146.5	2.1658	47%	21	4.9144	4.7301	0.0340
Pimephales	159.2	2.2019	51%	23	5.0285	4.8322	0.0385
Chydorus	162.6	2.2111	53%	24	5.0856	4.8581	0.0517
Enallagma	164	2.2148	56%	25	5.1429	4.8686	0.0752
Physa	164.5	2.2162	58%	26	5.2007	4.8724	0.1078
Limnodrilus	170.2	2.2310	60%	27	5.2592	4.9142	0.1191
Crangonyx	181.8	2.2596	63%	28	5.3186	4.9951	0.1047

Skwala	192.4	2.2842	65%	29	5.3792	5.0647	0.0989
Hyalella	192.6	2.2847	67%	30	5.4412	5.0659	0.1408
Planorbella	211.6	2.3255	69%	31	5.5049	5.1814	0.1046
Tubifex	216.5	2.3355	72%	32	5.5707	5.2095	0.1305
Lumbriculus	218.7	2.3398	74%	33	5.6391	5.2219	0.1741
Gambusia	219.3	2.3410	76%	34	5.7107	5.2253	0.2356
Pachydiplax	233	2.3674	78%	35	5.7861	5.2997	0.2366
Callibaetis	246.5	2.3918	81%	36	5.8662	5.3688	0.2474
Asellus	378.2	2.5777	83%	37	5.9524	5.8942	0.0034
Caecidotea	387	2.5877	85%	38	6.0462	5.9225	0.0153
Drunella	442.4	2.6458	88%	39	6.1503	6.0867	0.0041
Chironomus	681.8	2.8337	90%	40	6.2687	6.6176	0.1217
Orconectes	686.2	2.8365	92%	41	6.4081	6.6255	0.0472
Stenelmis	735.9	2.8668	94%	42	6.5821	6.7113	0.0167
Philarctus	994.5	2.9976	97%	43	6.8238	7.0810	0.0661
Erythromma	2515	3.4005	99%	44	7.2780	8.2198	0.8870

PARAMETERS	
Slope	2.826
Intercept	-1.391
R^2	0.878
GrandMean	2.261
SumSQ	229.606
CSSQ	4.698
MSE	0.124
Tcrit	1.682
N	44
df	42

Proportion	Probit	Log Central Tendency	SSQ	Log Upper PI	Log Lower PI	Central Tendency	Upper PI	Lower PI
0.05	3.355	1.679	0.017	1.899	1.460	47.792	79.238	28.825
0.1	3.718	1.808	0.017	2.025	1.591	64.253	105.833	39.010
0.2	4.158	1.964	0.016	2.178	1.749	91.950	150.568	56.152
0.4	4.747	2.172	0.016	2.384	1.959	148.488	242.162	91.049
0.5	5.000	2.261	0.016	2.474	2.049	182.528	297.556	111.967
0.7	5.524	2.447	0.016	2.660	2.234	279.815	456.954	171.344
0.8	5.842	2.559	0.016	2.773	2.345	362.334	593.339	221.266
0.9	6.282	2.715	0.017	2.932	2.498	518.518	854.091	314.791
0.95	6.645	2.843	0.017	3.063	2.624	697.117	1155.868	420.439



Appendix 12. Results of Species Sensitivity Distributions probit regressions using EPA CADDIS Volume 4: Data Analysis SSD_Generator_V1.xlt ***with three rare and not resident taxa removed*** *(https://www3.epa.gov/caddis/da_software_ssdmacro.html)*

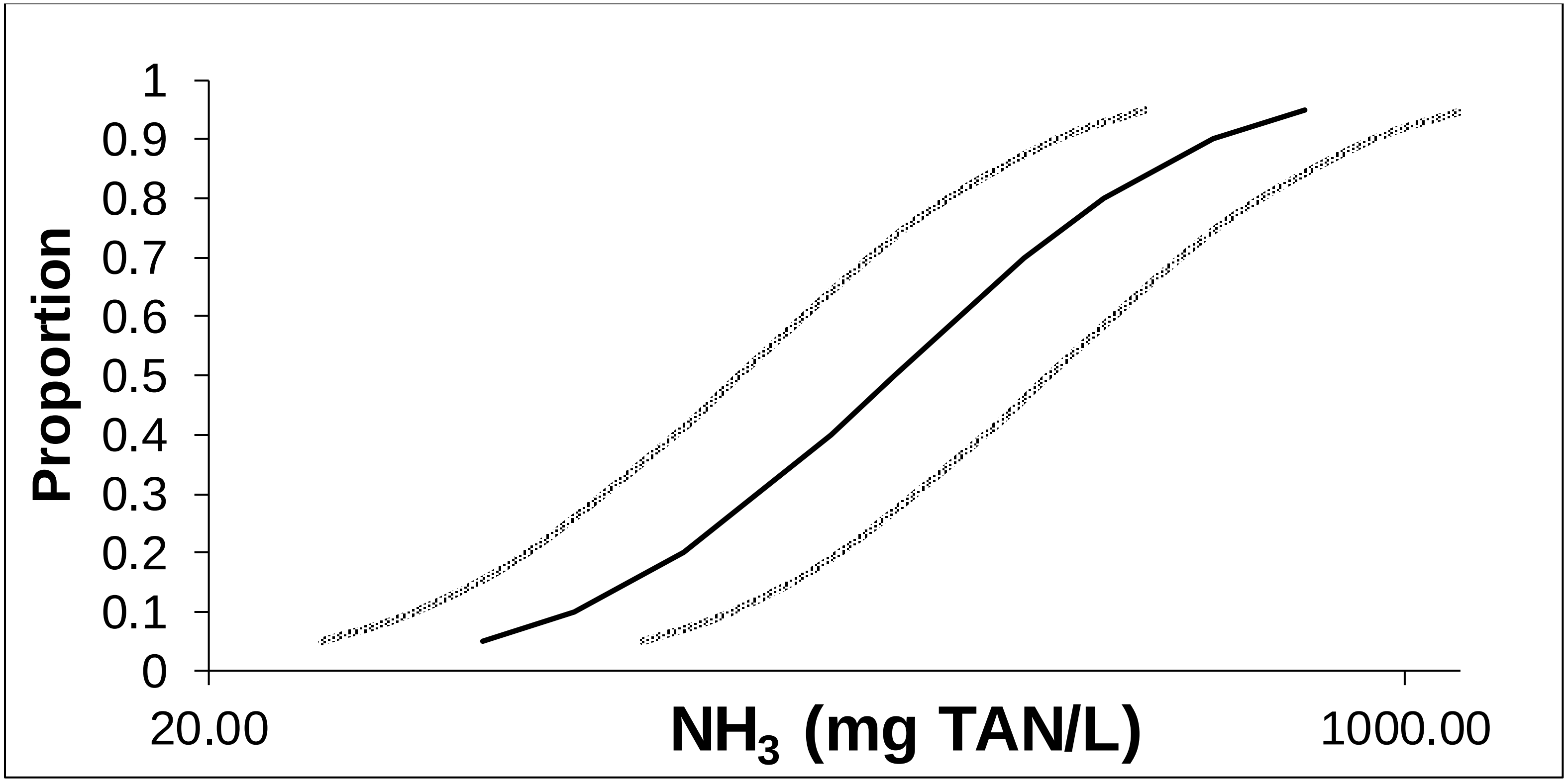
Taxa	GMAV (mg TAN/L)	Log GMAV Geometric Mean	Proportion	Rank	Probit	Probit Predicted	Difference²
Pseudacris	71.56	1.8547	1%	1	2.7398	3.8184	1.1635
Hybognathus	72.55	1.8606	4%	2	3.1973	3.8353	0.4070
Etheostoma	74.25	1.8707	6%	3	3.4412	3.8636	0.1784
Micropterus	89.06	1.9497	8%	4	3.6170	4.0861	0.2200
Musculium	89.36	1.9511	11%	5	3.7581	4.0902	0.1103
Rana	96.38	1.9840	13%	6	3.8781	4.1827	0.0928
Notropis	96.72	1.9855	15%	7	3.9838	4.1870	0.0413

Cyprinus	106.3	2.0265	18%	8	4.0792	4.3026	0.0499
Lepomis	106.9	2.0290	20%	9	4.1669	4.3095	0.0203
Cyprinella	110	2.0414	23%	10	4.2485	4.3444	0.0092
Campostoma	115.9	2.0641	25%	11	4.3255	4.4083	0.0069
Sander	117.1	2.0686	27%	12	4.3987	4.4209	0.0005
Dendrocoelum	119.5	2.0774	30%	13	4.4687	4.4458	0.0005
Daphnia	125	2.0969	32%	14	4.5363	4.5008	0.0013
Morone	134.8	2.1297	35%	15	4.6018	4.5932	0.0001
Procambarus	138	2.1399	37%	16	4.6656	4.6219	0.0019
Ictalurus	142.4	2.1535	39%	17	4.7281	4.6603	0.0046
Simocephalus	142.9	2.1550	42%	18	4.7896	4.6645	0.0156
Ceriodaphnia	143.9	2.1581	44%	19	4.8502	4.6731	0.0314
Catostomus	146.5	2.1658	46%	20	4.9104	4.6950	0.0464
Pimephales	159.2	2.2019	49%	21	4.9702	4.7967	0.0301
Chydorus	162.6	2.2111	51%	22	5.0298	4.8225	0.0430
Enallagma	164	2.2148	54%	23	5.0896	4.8330	0.0659
Physa	164.5	2.2162	56%	24	5.1498	4.8368	0.0980
Limnodrilus	170.2	2.2310	58%	25	5.2104	4.8784	0.1102
Crangonyx	181.8	2.2596	61%	26	5.2719	4.9591	0.0978
Skwala	192.4	2.2842	63%	27	5.3344	5.0284	0.0936
Hyalella	192.6	2.2847	65%	28	5.3982	5.0297	0.1358
Planorbella	211.6	2.3255	68%	29	5.4637	5.1448	0.1017
Tubifex	216.5	2.3355	70%	30	5.5313	5.1728	0.1285
Lumbriculus	218.7	2.3398	73%	31	5.6013	5.1852	0.1732
Gambusia	219.3	2.3410	75%	32	5.6745	5.1885	0.2362
Pachydiplax	233	2.3674	77%	33	5.7515	5.2626	0.2389
Callibaetis	246.5	2.3918	80%	34	5.8331	5.3315	0.2516
Asellus	378.2	2.5777	82%	35	5.9208	5.8552	0.0043
Caecidotea	387	2.5877	85%	36	6.0162	5.8834	0.0177
Drunella	442.4	2.6458	87%	37	6.1219	6.0470	0.0056
Chironomus	681.8	2.8337	89%	38	6.2419	6.5762	0.1118
Orconectes	686.2	2.8365	92%	39	6.3830	6.5840	0.0404
Stenelmis	735.9	2.8668	94%	40	6.5588	6.6696	0.0123
Philarctus	994.5	2.9976	96%	41	6.8027	7.0380	0.0553

Erythromma	2515	3.4005	99%	42	7.2602	8.1730	0.8333

PARAMETERS	
Slope	2.817
Intercept	-1.406
R^2	0.870
GrandMean	2.274
SumSQ	221.677
CSSQ	4.469
MSE	0.132
Tcrit	1.684
N	42
df	40

Proportion	Probit	Log Central Tendency	SSQ	Log Upper PI	Log Lower PI	Central Tendency	Upper PI	Lower PI
0.05	3.355	1.690	0.018	1.918	1.462	49.000	82.821	28.991
0.1	3.718	1.819	0.018	2.044	1.594	65.943	110.659	39.297
0.2	4.158	1.975	0.017	2.197	1.753	94.481	157.534	56.665
0.4	4.747	2.184	0.017	2.404	1.964	152.820	253.671	92.064
0.5	5.000	2.274	0.017	2.494	2.054	187.983	311.900	113.298
0.7	5.524	2.460	0.017	2.681	2.240	288.589	479.742	173.601
0.8	5.842	2.573	0.017	2.795	2.351	374.019	623.625	224.317
0.9	6.282	2.729	0.018	2.954	2.504	535.880	899.253	319.340
0.95	6.645	2.858	0.018	3.086	2.630	721.173	1218.936	426.675


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Proportion
20.00
NH_3 (mg TAN/L)
1000.00

Appendix 13. Species, Genus, and Taxon-specific Acute Chronic Ratios (ACRs) for Freshwater Aquatic Animals Exposed to Ammonia (from Table F.1. USEPA 2013b).

Table F.1. Species, Genus and Taxon-specific ACRs for Freshwater Aquatic Animals Exposed to Ammonia

Species Scientific Name	Acute and Chronic Test Endpoint	pH	Temp	Normalized Values	Reference	ACR	SMACR	GMACR	TSACR (Family)	TSACR (Class)
Class Gastropoda (Family: Lithoglyphidae)										
	LC50	8.25	20.2	>62.15						
Fluminicola sp.	EC20 - Change in Length	8.22	20.1	7.828	Besser 2011	7.94	7.94	7.94	7.94	7.94
Class Bivalvia (Families Unionidae and Pasidiidae)										
	EC50	8.5	20	69.63	Wang et al. 2007b					
Lampsilis fasciola	EC20 - Survival	8.2	20	1.408	Wang et al. 2007a	49.45	49.45	21.13		
	EC50	8.2	20	28.99	Wang et al. 2007a					
Lampsilis siliquoidea	EC20 - Survival	8.25	20	3.211	Wang et al. 2011	9.028	9.028		15.52	
	EC50	8.4	20	23.29	Wang et al. 2007b					
Villosa iris	EC50	8.3	20	68.4	Wang et al. 2007b	11.4	11.4	11.4		25.68
	EC20 - Survival	8.2	20	3.501	Wang et al. 2007a					
	EC50	8.1	14.6	109	West 1985; Arthur et al. 1987					
Musculium transversum	EC20 - Survival	7.8	21.8	2.565	Sparks and Sandusky 1981	42.5	42.5	42.5	42.5	

Class Branchiopda (Family: Daphniidae)										
	EC50	7.06	24	154.3						
Ceriodaphnia acanthina	EC20 - Reproduction	7.15	24.5	64.1	Mount 1982	2.406	2.406	3.073		
	EC50	7.8	25	152.9						
Ceriodaphnia dubia	EC20 - Reproduction	7.8	25	38.96	Nimmo et al. 1989	3.924	3.924			
	EC50	8.5	20	296.9	Gersich and Hopkins 1986				5.113	5.113
Daphnia magna	EC20 - Reproduction	8.45	19.8	36.27	Gersich et al. 1985	8.186	8.507	8.507		
	EC50	8.34	19.7	419.1						
	EC20 - Reproduction	7.92	20.1	47.4	Reinbold and Pescitelli 1982a	8.841				
Class Malacostraca (Family: Dogielinotidae)										
	EC50	8.3	25	461.2	Ankley et al. 1995					
Hyalella azteca	EC20 - Biomass	8.04	25	29.17	Borgmann 1994	15.81	15.81	15.81	15.81	15.81

Table F.1. Species, Genus and Taxon-specific ACRs for Freshwater Aquatic Animals Exposed to Ammonia

Species Scientific Name	Acute and Chronic Test Endpoint	pH	Temp	Normalized Values	Reference	ACR	SMACR	GMACR	TSACR (Family)	TSACR (Class)
Class Actinopterygii (Families Salmonidae, Catostomidae, Cyprinidae, Ictaluridae and Centrarchidae)										

Oncorhynchus clarkii	LC50	7.81	13.1	132.3	Thurston et al. 1978	5.122	5.122	5.518	5.518	8.973
O. clarkii henshawi	EC20 - Survival	7.57	13.7	25.83	Koch et al. 1980					
Oncorhynchus mykiss	LC50	7.4	14.5	31.47	Calamari et al. 1981	9.696	5.945			
	EC20 - Survival	7.4	14.5	3.246	Calamari et al. 1977, 1981					
	LC50	7.67	7.7	40.4	Thurston et al. 1981a	3.646				
	EC20 - 5 yr Life Cycle	7.7	7.5-10.5	>11.08	Thurston et al. 1984a					
Catostomus commersoni	LC50	8.16	15	176.6	Reinbold and Pescitelli 1982c	14.75	14.75	14.75	14.75	
	LC50	8.14	15.4	166.3						
	EC20 - Biomass	8.32	18.6	11.62	Reinbold and Pescitelli 1982a					
Notropis topeka	LC50	8.09	13.2	147.3	Adelman et al. 2009 (EC20 from Appendix C)	8.437	8.437	8.437	10.96	
	EC20 - Growth Rate	8.07	12.4	17.45						
Pimephales promelas	LC50	7.76	19	139.3	Thurston et al. 1983, 1986	36.53	19.24	19.24		
	LC50	7.83	22	158.7						
	LC50	7.91	18.9	178.9						
	LC50	7.94	19.1	162.3						
	LC50	8.06	22	205						
	LC50	8.03	22.1	216.3						
	EC20 - LC Hatchability	8	24.2	4.784						
	LC50	8.14	22	141.2						

	EC20 - Survival	8	24.8	12.43	Mayes et al. 1986	11.35				
	LC50	7.78	25.9	117.3	Swigert and Spacie 1983	17.17				
	LC50	7.8	25.6	126.8						
	EC20 - Biomass	7.82	25.1	7.101						
Cyprinus carpio	LC50	7.72	28	133.9	Hasan and MacIntosh 1986	8.1	8.1	8.1		
	EC20 - Growth: Weight	7.85	23	16.53	Mallet and Sims 1994					
Ictalurus punctatus	LC50	7.8	25.7	97.67	Swigert and Spacie 1983	4.8	4.8	4.8	4.8	
	EC20 - Biomass	7.76	26.9	20.35						
Lepomis cyanellus	LC50	7.72	22.4	144.3	McCormick et al. 1984	12.18	6.468	13.58	13.59	
	EC20 - Biomass	7.9	22	11.85						
	LC50	8.28	26.2	62.07	Reinbold and Pescitelli 1982a	3.437				

Table F.1. Species, Genus and Taxon-specific ACRs for Freshwater Aquatic Animals Exposed to Ammonia

Species Scientific Name	Acute and Chronic Test Endpoint	pH	Temp	Normalized Values	Reference	ACR	SMACR	GMACR	TSACR (Family)	TSACR (Class)
	EC20 - Survival	8.16	25.4	18.06						
Lepomis macrochirus	LC50	7.6	21.7	93.31	Smith et al. 1984	28.51	28.51			
	EC20 - Biomass	7.76	22.5	3.273						
	LC50 (pH 6.5)	6.53	22.3	269.2						

	EC20 (pH 6.5) - Biomass	6.6	22.3	8.65		31.12				
	LC50 (pH 7.0)	7.16	22.3	144.3						
	EC20 (pH 7.0) - Biomass	7.25	22.3	9.726		14.84				
Micropterus dolomieui	LC50 (pH 7.5)	7.74	22.3	105.2	Broderius et al. 1985		13.61	13.61		
	EC20 (pH 7.5) - Biomass	7.83	22.3	15.77		6.67				
	LC50 (pH 8.5)	8.71	22.3	126						
	EC20 (pH 8.5) - Biomass	8.68	22.3	11.31		11.14				