Water Quality Criteria Report for Malathion

Phase III: Application of the pesticide water quality criteria methodology

Prepared for the Central Valley Regional Water Quality Control Board

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List of acronyms and abbreviations

ACR	Acute to Chronic Ratio
AF	Assessment Factor
APHA	American Public Health Association
ASTM	American Society for Testing and Materials
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
BMF	Biomagnification Factor
CAS	Chemical Abstract Service
CDFG	California Department of Fish and Game
CDPR	Department of Pesticide Regulation
CVRWQCB	Central Valley Regional Water Quality Control Board
EC_x	Concentration that affects x% of exposed organisms
FT	Flow-through test
GMAV	Genus Mean Acute Value
HC_x	Hazardous Concentration potentially harmful to x% of species
IC_x	Inhibition concentration; concentration causing *x*% inhibition
ICE	Interspecies Correlation Estimation
IUPAC	International Union of Pure and Applied Chemistry
K	Interaction Coefficient
K_H	Henry's law constant
K_{ow}	Octanol-Water partition coefficient
K_p or K_d	Solid-Water partition coefficient
LC_x	Concentration lethal to *x*% of exposed organisms
LD_x	Dose lethal to *x*% of exposed organisms
LL	Less relevant, less reliable study
LOEC	Lowest Observed Effect Concentration
LR	Less relevant, reliable study
MATC	Maximum Acceptable Toxicant Concentration
N	Not relevant or not reliable study
n/a	Not applicable
NOEC	No Observed Effect Concentration
NR	Not reported
OECD	Organization for Economic Co-operation and Development
QSAR	Quantitative Structure Activity Relationship
pK_a	Acid dissociation constant
RL	Relevant, less reliable study
RR	Relevant and reliable study
S	Static test
SMACR	Species Mean Acute to Chronic Ratio
SMAV	Species Mean Acute Value
SMCV	Species Mean Chronic Value
SR	Static renewal test
SSD	Species Sensitivity Distribution
TES	Threatened and Endangered Species

TU	Toxic Unit
US	United States
USEPA	United States Environmental Protection Agency
USFDA	Food and Drug Administration

1. Introduction

A new methodology for deriving freshwater water quality criteria for the protection of aquatic life was developed by the University of California, Davis (TenBrook *et al.* 2009a). The need for a new methodology was identified by the California Central Valley Regional Water Quality Control Board (CVRWQCB 2006) and findings from a review of existing methodologies (TenBrook & Tjeerdema 2006, TenBrook *et al.* 2009b). This new methodology is currently being used to derive aquatic life criteria for several pesticides of particular concern in the Sacramento River and San Joaquin River watersheds. The methodology report (TenBrook *et al.* 2009a) contains an introduction (Chapter 1); the rationale of the selection of specific methods (Chapter 2); detailed procedures for criteria derivation (Chapter 3); and a chlorpyrifos criteria report (Chapter 4). This criteria report for malathion describes, section by section, the procedures used to derive criteria according to the UC-Davis methodology. Also included are references to specific sections of the methodology procedures detailed in Chapter 3 of the report so that the reader can refer to the report for further details (TenBrook *et al.* 2009a).

2. Basic information

Chemical: Malathion (Fig. 1)
IUPAC: diethyl 2-dimethoxyphosphinothioylsulfanylbutanedioate
Alternate names: diethyl (dimethoxyphosphinothioylthio) succinate,
S-1,2-bis(ethoxycarbonyl)ethyl O,O-dimethyl phosphorodithioate
Chemical Formula: $C_{10}H_{19}O_6PS_2$

CAS Number: 121-75-5
USEPA PC Code: 057701 (Kegley *et al.* 2008)
CDPR Chem Code: 367 (Kegley *et al.* 2008)

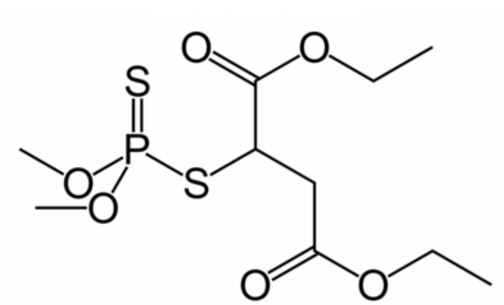

Figure 1. Structure of malathion (public domain: http://en.wikipedia.org/wiki/File:Malathion.png)

Synonyms: carbofos, carbophos, maldison, mercaptothion (ExToxNet)
Trade names: celthion, cythion, dielathion, El 4049, emmaton, exathios, fyfanon and hilthion, karbofos, maltox (ExToxNet 2009)

3. Physical-chemical data

<u>Molecular Weight</u>
330.358 g/mol (Howard 1989; Mackay 2006)

Water Solubility

130 mg/L (25 ^{o}C)	(Kidd *et al.* 1991)
143 mg/L (20 ^{o}C)	(Howard 1989)
145 mg/L (20-23^{o}C)	(Cheminova 1988)
145, 164 mg/L (20^{o}C, 30^{o}C)	(Kamrin and Montgomery 2000)
148.2 mg/L (25^{o}C) ^{14}C-malathion	(Kabler 1989)
150 mg/L (25 ^{o}C)	(Hartley and Graham-Bryce 1980)

Geometric mean: 146.16 mg/L

Melting Point

1.4	(Lide 2004)
2.85^{o}C	(Kidd *et al.* 1991)
2.9 ^{o}C	(Budavari *et al.* 1996; Howard 1989)
3^{o}C	(Barton 1988)

Geometric mean: 2.43^{o}C

Boiling Point

120^{o}C (0.2 mmHg)	(Melnikov 1971)
156-157^{o}C (0.7 mmHg)	(Barton 1988; Howard 1989)

Density

1.23 g/mL (20^{o}C)	(Barton 1988)
1.23 g/mL (25^{o}C)	(Mackay 2006)
1.2 g/mL (25^{o}C)	(Verschueren 1996)

Geometric mean: 1.22 g/mL

Vapor Pressure

1.05×10^{-3} Pa (20^{o}C)	(Howard 1989)
1.30×10^{-3} Pa (20^{o}C)	(Hartley and Graham-Bryce 1980)
5.33×10^{-3} Pa (20^{o}C)	(Verschueren 1996)
5.30×10^{-3} Pa (30^{o}C)	(Kidd *et al.* 1991; Tondreau 1987)
1.67×10^{-4} Pa (20^{o}C)	(Melnikov 1971)
4.57×10^{-4} Pa (25^{o}C)	(Barton 1988)

Geometric mean: 1.20×10^{-3} Pa

Henry's Law Constant (K_H)

2.03×10^{-3} Pa m^{3}/mol (25 ^{o}C, calculated)	(Howard 1989)
2.30×10^{-3} Pa m^{3}/mol (20^{o}C, calculated)	(Mackay 2006)
3.22×10^{-3} Pa m^{3}/mol (25 ^{o}C, calculated)	
4.90×10^{-4} Pa m^{3}/mol (23 ^{o}C)	(Kamrin and Montgomery 2000)

Geometric mean: 1.65×10^{-3} Pa m^{3}/mol

Log K_{OW}

2.36-2.89	(Kamrin and Montgomery 2000)
2.36	(Howard 1989)

2.75 (Barton 1988)
2.75 (Tomlin *et al.* 1994)
2.89 (Verschueren 1996)
3.38-3.57 (HPLC correlations) (Mackay 2006)
Geometric mean: 2.84

Organic Carbon Sorption Partition Coefficients (log K_{OC})
2.36-2.45 (Mackay 2006)
2.61 (Kamrin and Montgomery 2000)
3.25 (Karickhoff 1981)
2.83, 3.29, 2.50 (estimated K_{OW})
3.07 (Sabljic *et al.* 1995)
Geometric mean: 2.77

Bioconcentration Factor

Table 1. Bioconcentration factors (BCF) for malathion.

Species	**Common name**	**log BCF**	**Tissue, exposure duration**	**Reference**
Cyprinus carpio	Common carp	0.65	Muscle, 7 d	Tsuda *et al.* 1990
Cyprinus carpio	Common carp	0.75	Flesh, 4 d	Bender 1969b
Cyprinus carpio	Common carp	1.11	NR	Mackay 2006
Cyprinus carpio	Common carp	0.85	NR	Debruijn and Hermens 1991
Gnathopogon coerulescens	Willow shiner	1.53	Whole fish, 7 d	Tsuda *et al.* 1989
Lepomis macrochirus	Bluegill	1.25	Fillet, 28 d	Forbis 1994
Lepomis macrochirus	Bluegill	2.01	Whole fish, 28 d	Forbis 1994
Oncorhynchus kisutch	Coho salmon	1.47	NR	Howard 1991
Paneaus setiferus	White shrimp	2.94	NR	Howard 1991
Paneaus aztecus	Brown shrimp	2.98	NR	Howard 1991
Pseudorasbora parva	Topmouth gudgeon	2.00	Whole fish, 30 d	Kanazawa 1975
Salvelinus namaycush	Lake trout	0.87	NR	Howard 1991
Triaenodes tardus	Caddisfly	0.40	NR	Howard 1991

Environmental Fate

Table 2. Malathion hydrolysis and photolysis and other degradation. (NR: not reported).

	Half- life (d)	Water	Temp (°C)	pH	Reference
Hydrolysis	40	Buffer	0	8	Wolfe *et al.* 1977
	36 hr	Buffer	27	8	Wolfe *et al.* 1977
	1 hr	Buffer	40	8	Wolfe *et al.* 1977
	10.5	Phosphate buffer	20	7.4	Freed *et al.* 1979
	1.3	Phosphate buffer	37.5	7.4	Freed *et al.* 1979
	107	Phthalate buffer	25	5	Teeter 1988
	6.21	Phosphate buffer	25	7	Teeter 1988
	0.49	Borate buffer	25	9	Teeter 1988
Aqueous Photolysis	156	Acetate buffer	25	4	Carpenter 1990
	94	Acetate buffer	25	4	Carpenter 1990
Degradation	4.4-4.7	Estuarine	20	NR	Druzina & Stegu 2007
	77.9	Surface	4	8	Druzina & Stegu 2007
	19.8	Surface	25	8	Druzina & Stegu 2007
	51.3	Groundwater	25	6	Druzina & Stegu 2007
	13.1	Groundwater	25	7	Druzina & Stegu 2007
	7.1	Groundwater	25	8.5	Druzina & Stegu 2007
	68.6	Groundwater	4	7	Druzina & Stegu 2007

4. Human and wildlife dietary values

Food tolerances and USFDA action levels are not established for malathion (USEPA 2000a; 2002; USFDA 2000).

Wildlife LC_{50} values (dietary) for animals with significant food sources in water

A dietary LD_{50} of 1485 mg/kg body weight was reported for mallard ducks by Hudson *et al.* (1984). A single dose of malathion was administered by oral gavage to 3 month old ducks and mortality was recorded after 14 d.

Wildlife dietary NOEC values for animals with significant food sources in water

Pedersen and Fletcher (1993) exposed 23-week old mallard ducks to three treatment levels of malathion in feed (240, 1200, 2400 mg/kg feed) for a 20-week period. The dietary NOEC was determined to be 1200 mg/kg feed based on reproductive effects. No other dietary values were found for malathion for wildlife species with significant food sources in water.

5. Ecotoxicity data

Approximately 200 original studies on the effects of malathion on aquatic life were identified and reviewed. In the review process, many parameters are rated for documentation and acceptability for each study, including, but not limited to: organism source and care, control description and response, chemical purity, concentrations tested, water quality conditions, and statistical methods (see Tables 3.6, 3.7, 3.8 in TenBrook *et al.* 2009a). Single-species effects studies that were rated as relevant (R) or less relevant (L), according to the method, were summarized in data summary sheets. Information in these summaries was used to evaluate each study for reliability using the rating systems described in the methodology (Tables 3.7 and 3.8, section 3-2.2, TenBrook *et al.* 2009a), to give a reliability rating of reliable (R), less reliable (L), or not reliable (N). Copies of completed data summaries for all studies are included in the Appendix of this report. Malathion studies deemed irrelevant by an initial screening were not summarized (e.g., studies involving rodents or *in vitro* exposures). Ecosystem level studies were summarized in section 14. All data rated as acceptable (RR) or supplemental (RL, LR, LL) for criteria derivation are summarized in Tables 3-8 found at the end of this report. Acceptable studies rated as RR are used for numeric criteria derivation, while supplemental studies rated as RL, LR or LL are used for evaluation of the criteria to check that they are protective of particularly sensitive species and threatened and endangered species. These considerations are reviewed in sections 12 and 14 of this report, respectively. Studies that were rated not relevant (N) or not reliable (RN or LN) were not used for criteria derivation.

Using the data evaluation criteria (section 3-2.2, TenBrook *et al.* 2009a), 18 acute toxicity studies, yielding 87 toxicity values were judged reliable and relevant (RR; Tables 3 and 4). Six chronic studies, yielding 16 toxicity values, were judged reliable and relevant (RR; Table 5 and 6). Seventy studies were rated RL, LL, or LR and may be used as supplemental information for evaluation of derived criteria in sections 12 and 14 (Table 8).

Ten mesocosm, microcosm and ecosystem (field and laboratory) studies were identified and reviewed. Two of these studies were rated R or L and may be used as supporting data in section 13 (Table 9). Two relevant studies on the effects of malathion on wildlife were identified and reviewed for consideration of bioaccumulation in section 15.

6. Data reduction

Multiple toxicity values for malathion for the same species were reduced into one species mean acute value (SMAV) or one species mean chronic value (SMCV) according to procedures described in the methodology (section 3-2.4, TenBrook *et al.* 2009a). Acceptable acute and chronic data that were reduced, and the reasons for their exclusion, are shown in Tables 4 and 6, respectively. Reasons for reduction of data included: more sensitive endpoints were available for the same test, more appropriate or more sensitive test durations were available for the same test, a more sensitive life-stage was available for a species, tests with measured concentrations are preferred over tests with nominal concentrations, flow-through tests are preferred over static or static renewal tests, tests at standard conditions are preferred over tests at non-standard conditions. The final acute and chronic data sets are shown in Tables 3 and 5, respectively. The final acute data set contains 26 SMAVs, and the final chronic data set contains seven SMCVs.

7. Acute criterion calculation

Acceptable acute toxicity data were available for four of the five required taxa for the application of the species sensitivity distribution (SSD) procedure (section 3-3.1, TenBrook *et al.* 2009a). The five taxa requirements are a warm water fish, a fish in the family Salmonidae, a planktonic crustacean, a benthic crustacean, and an insect; benthic crustacean data was not available for malathion, and therefore the SSD method could not be used (section 3-3.1, TenBrook *et al.* 2009a). The acute toxicity values for malathion were plotted in a histogram (Figure 2); the data set is possibly bimodal, but the trend is not clearly defined. The Assessment Factor (AF) method was used to estimate the median 5th percentile value (acute value) of the SSD, which was subsequently used to calculate the acute criterion (section 3-3.3, TenBrook *et al.* 2009a).

The AF method requires an acceptable acute toxicity value for a species in the family Daphniidae, which was met in the acute toxicity data set by *Ceriodaphnia dubia* or *Daphnia magna* (Table 3). The lowest SMAV was divided by an AF to estimate the median 5th percentile acute value of the SSD. The magnitude of the AF was determined by the number of taxa available that fulfill the five SSD taxa requirements (section 3-3.3, TenBrook *et al.* 2009a). Because there were acceptable data for four of the five required taxa, an AF of 5.1 was used for the malathion data set (Table 3.13, TenBrook *et al.* 2009a). The lowest SMAV in the data set was 1.7 μg/L for *Neomysis mercedis* (Brandt *et al.* 1993). To calculate the acute criterion from the acute value, a factor of 2 was applied because the acute value was derived using EC_{50} or LC_{50} data, and 50% effect is not acceptable (section 3-3.3, TenBrook *et al.* 2009a). The acute criterion was reported with two significant digits because the SMAV used to calculate the acute value reported two significant digits, as did almost all of the data in the acceptable data set (Table 3). The cumulative probabilities of the SMAVs are plotted with the acute criterion for comparison in Figure 3.

Acute value = lowest SMAV ÷ assessment factor
= 1.7 μg/L ÷ 5.1
= 0.333 μg/L

Acute criterion = acute value ÷ 2
= 0.333 μg/L ÷ 2
= 0.167 μg/L

Acute criterion = 0.17 μg/L

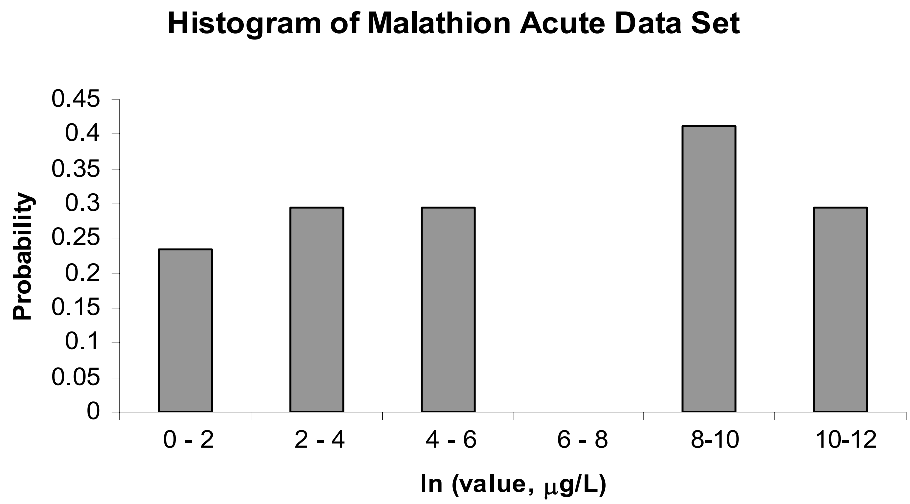

Figure 2. Histogram of the natural logarithm of the acute values for the malathion data set. There are no toxicity values that fall into the ranges without probability values.

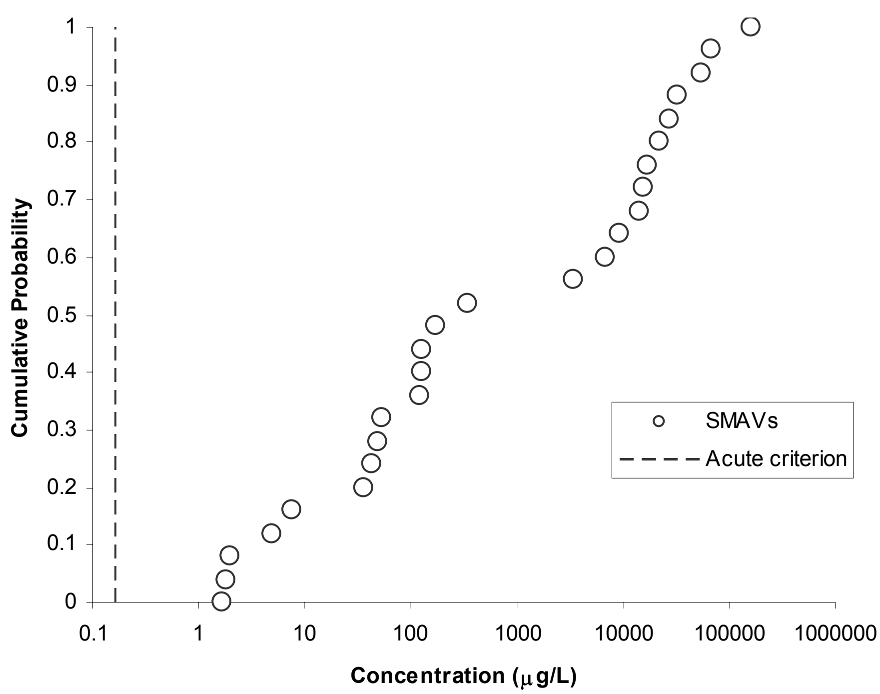

Figure 3. Malathion acute toxicity data set.

8. Chronic criterion calculation

Chronic toxicity values from fewer than five different families were available, thus, the acute-to-chronic ratio (ACR) procedure was used to calculate the chronic criterion (section 3-4.2, TenBrook *et al.* 2009a). There are seven SMCVs in the acceptable (rated RR) data set (Table 5), which satisfy three of the five taxa requirements for use of a SSD (section 3-3.1, TenBrook *et al.* 2009a): warm water fish (*Clarias gariepinus*, and others), species from the family Salmonidae (*Oncorhynchus mykiss*), and planktonic crustacean (*Daphnia magna)*. The two missing taxa are a benthic crustacean and an insect.

Three of the chronic toxicity values could be paired with an appropriate corresponding acute toxicity value in order to calculate a ACR with measured toxicity data. The species mean ACRs (SMACRs) were calculated for each of the three species by dividing the acute LC_{50} value by the chronic MATC value for a given species (section 3-4.2.1, TenBrook *et al.* 2009a). Three SMACRs were calculated from data for three fish: 11, bonytail (*Gila elegans);* 4, Colorado squawfish *(Ptychocheilus lucius);* and 36, flagfish (*Jordanella floridae)*. All three ACRs that could be calculated were for fish, which did not fulfill the three family requirements for the ACR method: a fish, an invertebrate, and another sensitive species (section 3-4.2.1, TenBrook *et al.* 2009a). A default ACR of 12.4 was included in the ACR data set to account for an invertebrate (section 3-4.2.2, TenBrook *et al.* 2009a). The final multispecies ACR was determined by taking the geometric mean of the three data-based SMACRs and the default ACR. Data used to calculate the final multispecies ACR are shown in Table 7. The chronic criterion was calculated by dividing the acute value by the final multispecies ACR. The chronic criterion was reported with two significant digits because the SMAV used to calculate the acute value, which is subsequently used to calculate the chronic criterion, reported two significant digits.

Chronic criterion = Acute value ÷ final multispecies ACR
= 0.333 ÷ 11.80
= 0.0282 μg/L

Chronic criterion = 0.028 μg/L
= 28 ng/L

9. Bioavailability

Few studies were identified that investigated the effects of suspended and dissolved solids on the bioavailability of malathion. Ciglasch *et al.* (2008) reported that malathion in the previously unextractable fractions of geosorbents became biodegradable after about 200 hours of incubation. These results suggest that malathion was temporarily incorporated by plants or soil biota and then released upon turnover or/decay of these organisms.

In a study that evaluated the effect of the amount of organic matter on the bioavailability of malathion to earthworms (*Lumbricus terrestris*), results suggested that sorption to organic matter was not a limiting factor for malathion bioavailability (Henson-Ramsey *et al.* 2008). According to a study by Olvera-Hernandez *et al.* (2004), malathion did not seem to sorb strongly to the sediment, and was therefore bioavailable. For freshwater snails (*Stagnicola sp.*) the uptake of malathion occurred quickly (up to 0.1 μg/g in 36 hr), indicating that malathion was bioavailable in sediment (Martinez-Tabche *et al.* 2002).

Based on the modest available information, malathion appears to be bioavailable and compliance with criteria should be determined on a total concentration basis (section 3-5.1, TenBrook *et al.* 2009a).

10. Mixtures

The effects of pesticide mixtures are evaluated and recommendations for criteria compliance determination when chemical mixtures are present are discussed according to section 3-5.2 of the methodology (TenBrook *et al.* 2009a). Definitions of additivity, synergism, antagonism, and non-additivity are available in the literature (Lydy and Austin 2004) and more detailed descriptions of the recommended models can be found in the methodology (section 3-5.2, TenBrook *et al.* 2009a).

Malathion has been shown to have moderate additive and/or synergistic effects with other acetylcholinesterase (AChE) inhibitors. In a study by Laetz *et al.* (2009) Coho salmon (*Oncorhynchus kisutch*) exposed to combinations of diazinon with malathion and chlorpyrifos with malathion had synergistic, rather than additive effects on AChE activities. Mixtures were designed to produce 50% AChE inhibition based on additive interactions, however, the pairing of diazinon (7.3 μg/L) with malathion (3.7 μg/L) produced severe AChE inhibition (> 90%). Many fish species die after high rates of acute brain AChE inhibition (> 70–90%) (Fulton and Key 2001). While the mixtures of these organophosphates (OPs) with malathion were found to have synergistic toxicity effects, the study did not provide a way to incorporate the interaction of malathion with other OPs quantitatively into compliance. We do not recommend the concentration addition model for criteria compliance when malathion and other OPs are present, because it appears that malathion can have a synergistic, rather than additive effect. However, in light of the recent dramatic decline of Chinook salmon and the ban on commercial salmon fishing off the coast of California, this finding has possibly very important implications for environmentally relevant concentrations of OPs in mixtures and their toxic effects on endangered Salmonids.

Malathion was shown to produce abnormalities in developing circulatory systems of Japanese killifish embryos. In the same study malathion and carbaryl together produced only slightly greater than additive toxic effects, and at the highest concentrations of the two insecticides (40 mg/L of malathion and 5 mg/L of carbaryl) antagonistic effects were noted (Solomon and Weiss 1979). In a study by Overmyer *et al.* (2003), mixtures of carbaryl with malathion or chlorpyrifos, and all three pesticides together, showed greater than additive toxicity towards black fly larvae (*Simulium vittatum*). These results are expressed in toxic units (TU) and no synergistic ratios were calculated, so this information cannot be used for compliance determination.

Synergistic toxicity effects on bluegills were reported by Macek (1975) for mixtures of malathion with Baytex, sevin, EPN, Perthane and copper sulfate, whereas additive effects were observed in the case of mixtures with DDT and toxaphene. For midge larvae

(*Chironomus tentans*) in a mixture of atrazine and malathion, atrazine did not have any effect on the toxicity of malathion. Synergistic ratio values were equal to 1 for the range of atrazine concentrations (0-200µg/L) investigated. This result shows that there was no difference between the EC_{50} control (without atrazine) and the EC_{50} treatment (in the presence of atrazine) (Belden and Lydy 2000).

The toxicity of malathion on toad larvae (*Bufo arenarum*) was potentiated by the exogenously applied polyamines spermidine and spermine at concentrations of 0.2 mM (Venturino *et al.* 1992). Putrescine and spermidine were shown to synergistically enhance the toxicity of malathion. Polyamines may affect malathion toxicity by altering its rate of absorption, as well as its activation and/or detoxification pathways, but they do not possess the same mode of action for toxicity.

Mixtures of malathion and endrin (nerve membrane toxin) were studied by Hermanutz (1985) in flagfish (*Jordanella floridae*). Investigators reported enhanced toxicity effects "at concentrations not causing death when the pesticides were tested individually". These two compounds possess independent modes of action and from the data provided in the paper there is currently no way to consider the interaction of these two compounds for compliance determination. Endrin has not been produced or sold for general use in the United States since 1986; therefore, the interaction with malathion is not likely to be a problem.

A study by Rawash *et al.* (1975) found that mixtures of malathion with DDT and keltane in the ratio 3:10:5 tested with *Culex pipiens* and *Daphnia magna* had an antagonistic toxicity effect. A malathion concentration of 35 µg/L corresponded to 95% larval mortality for *C. pipiens* but when the same concentration was combined with DDT and kelthane it only induced 50% mortality. The same result was observed for *Daphnia magna*. These compounds possess independent modes of action and from the data provided in the paper there is currently no way to consider the antagonistic interaction of these compounds for compliance determination.

There is not clear evidence for additive interactions when multiple acetylcholinesterase inhibitors are present, so the concentration addition model cannot be used when malathion is detected with other AChE inhibitors. There are no multi-species coefficients of interaction reported in the literature, so the non-additive interaction model cannot be used to assess water quality criteria compliance.

11. Temperature, pH, other water quality effects

Temperature, pH, and other water quality effects on the toxicity of malathion were examined to determine if any effects are described well enough in the literature to incorporate into criteria compliance (section 3-5.3, TenBrook *et al.* 2009a). Malathion undergoes hydrolysis in aqueous solutions and reaction products are dependent upon pH of the media. Muhlmann and Schroder (1957) studied the hydrolysis products of malathion and found that in basic solutions (pH > 8) the primary products are diethyl fumarate and dimethyl phosphorodithionic acid. In acidic solutions (pH < 5), the products are dimethyl phosphorothionic acid and 2-mercaptodiethylsuccinate. The toxicity of these hydrolysis products to Mudminnows (*Umbra pygmaea*) was studied by Bender (1969a). Results showed that malathion was more toxic than either of the hydrolysis products and that basic hydrolysis products were more toxic than the acid hydrolysis products. The 96-hr LC_{50} values in mg/L were as follows:

malathion - 0.24;
basic hydrolysis products: diethyl fumarate - 8.5; dimethyl phosphorodithioic acid – 17;
acid hydrolysis products: 2-mercaptodiethylsuccinate - 47; dimethyl phosphorothionic acid – 26.

Wolfe *et al.* (1977) found that malathion is stable in water at pH 2.59 for up to 10 days; however, in basic conditions malathion is much more susceptible to basic degradation and significant chemical breakdown. Malathion was shown to have a half-life of 36 hr in water at 27 ^{o}C and pH 8. With increasing temperature at pH 8 a decrease in malathion half-life occurs with $t_{1/2}$ 40 d at 0 ^{o}C to $t_{1/2}$ 1 hr at 40 ^{o}C (Wolfe *et al.* 1977). Freed *et al.* (1979) reported the decrease of malathion half-life with increasing temperature from 10.5 d at 20 ^{o}C to 1.3 d at 37.5 ^{o}C.

Keller and Ruessler (1997) studied the effect of temperature and pH on the toxicity of three species of bivalves, *Utterbackia imbecillis*, *Villosa lienosa* and *Villosa villosa*. Two pH values were studied, pH 7.5 and 7.9, that corresponded to soft water and moderately hard water, respectively. No significant variation in toxicity values was observed for the two pH conditions investigated and for that reason the LC_{50} values at both pH values were considered in the acute dataset. The study of temperature effects on malathion toxicity indicates that malathion toxicity decreases with increasing temperature due to increased degradation.

Although there is evidence of temperature effects on malathion toxicity, data for enough species is not available to adequately quantify the relationship of toxicity with temperature. Data rated relevant and reliable (RR) for at least two species, a fish and an invertebrate, are required to establish this relationship (section 3-5.0, TenBrook *et al.* 2009a). Therefore, only results of tests conducted at standard temperatures (i.e., temperatures recommended in standard toxicity test methods) are included in the data set and equations are not needed for criteria expression.

12. Sensitive species

The derived criteria are compared to toxicity values for the most sensitive species in both the acceptable (RR) and supplemental (RL, LR, LL) data sets to ensure that these species will be adequately protected (section 3-6.1, TenBrook *et al.* 2009a). The calculated acute and chronic criteria (0.17 μg/L and 0.028 μg/L, respectively) are below the lowest acute and chronic values in the data set. The lowest acute value in either the acceptable data set (rated RR), or the supplemental data set (rated RL, LR, or LL) is 0.21 μg/L for *Chironomus riparius* (Hoffman and Fisher 1994). The lowest measured chronic value in either data set is a maximum acceptable toxicant concentration (MATC) of 0.08 μg/L for *Daphnia magna* (Blakemore and Burgess 1990). Both the acute and chronic criteria, as calculated, should be adequately protective based on currently available data from single-species toxicity tests.

13. Ecosystem and other studies

The derived criteria are compared to acceptable laboratory, field, or semi-field multispecies studies (rated R or L) to determine if the criteria will be protective of ecosystems (section 3-6.2, TenBrook *et al.* 2009a). Several studies were found on the effects of malathion in mesocosms and ecosystems, however, the majority of them rated as non-reliable due to lack of information provided in the studies, such as water quality parameters, lack of replication, controls and concentrations used. Two studies of malathion effects on microcosms, mesocosm and model ecosystems were rated acceptable (R or L reliability rating, using Table 3.9, TenBrook *et al.* 2009a) and are listed in Table 9. Studies rated as not reliable (Cone & Parker 1975, Crane *et al.* 1995, Jensen *et al.* 1999, Kuhajda *et al.* 1996, Mackey & Boone 2009, Mulla & Isaak 1961, Mulla & Khasawin 1969, Tagatz *et al.* 1974) are not discussed in this section

Relyea (2005) tested the effect of malathion on an artificial mesocosm sprayed with a concentration of 0.32 mg/L of a commercial formulation of malathion (50.6%) for two weeks. Of the tested predators, *Dytiscus sp.* beetles were eliminated ($p=0.05$) from the ecosystem, the survival of the dragonfly *Tramea sp.* was significantly reduced ($p=0.01$) and no diving beetles (*Acilius semisulcatus*) survived. Of the zooplankton tested, *Daphnia pulex* was completely absent with malathion treatment ($p<0.001$), eurytemora showed an increased abundance ($p<0.03$), and mesocyclops were unaffected. Of the large herbivores there were no effects on the three snail species tested. Among the tadpoles, survival of leopard frog and wood frog increased but was not significant ($p>0.1$). Malathion reduced the diversity and biomass of the insect predators, completely exterminating Dytiscus beetles and reducing the abundance of *Tramea sp.* and backswimmers (*Notonecta undulata*). Malathion also affected zooplankton by eliminating cladocerans while favoring copepods.

In a study by Kennedy and Walsh (1970), bluegill and channel catfish were exposed to four applications of malathion at two concentrations in ponds over an 11-week summer period. No significant differences were observed in the growth of the fish between treated and untreated systems at the two concentrations tested, 0.002 mg/L and 0.02 mg/L. The effects of malathion exposure on aquatic insects in those same ponds were also evaluated. The total number of aquatic insects in the 0.002 mg/L treated pond was not significantly different from the control, whereas for the 0.02 mg/L treated pond that number was significantly different from both the low-concentration treated and the control ponds. The benthic invertebrate population in the 0.02 mg/L treated ponds was affected by the exposure to malathion. Chironomidae and baetid mayflies, which made up 70% and 24% of the total benthos, respectively, showed a significant reduction in numbers after three applications. Heptageniid mayflies, which made up 5% of the benthos, did not recover after application of malathion. No measurable effects were observed in fish at the applied concentrations in these ponds.

These studies applied malathion at concentrations well above the derived criteria and did not calculate ecosystem-level NOEC values. Based on this limited information, it appears that an acute criterion of 0.17 μg/L and a chronic criterion of 0.028 μg/L will be protective of organisms in ecosystems. These results are not entirely conclusive because, as discussed in section 9, the potential effects of suspended and dissolved solids in natural waters on malathion bioavailability cannot be predicted.

14. Threatened and endangered species

The derived criteria are compared to measured toxicity values for threatened and endangered species (TES), as well as to predicted toxicity values for TES, to ensure that they will be protective of these species (section 3-6.3, TenBrook *et al.* 2009a). Current lists of state and federally listed threatened and endangered animal species in California were obtained from the California Department of Fish and Game (CDFG) web site (www.dfg.ca.gov/hcpb/species/t_e_spp/tespp.shtml; CDFG 2006a, b). The species *Oncorhynchus mykiss, Oncorhynchus clarki*, *Oncorhynchus kisutch* and *Oncorhynchus tshawytscha* are all listed as federally endangered or threatened in California. The data set used to calculate the acute criterion includes values for all these species (also shown in Table 10), indicating that the determined acute criterion of 0.17 μg/L should be protective of these species. No threatened or endangered species are listed in the supplemental data. Of the endangered species not present in the data set there were no appropriate surrogates available to predict toxicity values.

Based on the available data there is no evidence that the calculated acute and chronic criteria will be underprotective of threatened and endangered species. The information in this assessment is limited because for the most sensitive species in the data set, the crustaceans and insects, there is no information on the effects of malathion on federally endangered crustaceans or insects, or acceptable surrogates (i.e., in the same family). No single species plant studies were found for criteria derivation, so no estimation could be made about plants on the state of federal endangered, threatened or rare species lists. Based on the mode of action, plants should be relatively insensitive to malathion and the calculated criteria should be protective.

15. Bioaccumulation

Bioaccumulation was assessed to ensure that the derived criteria will not lead to unacceptable levels of malathion in food items (section 3-7.1, TenBrook *et al.* 2009a). A chemical has the potential to bioaccumulate if it possesses any of the following characteristics: log $K_{OW} > 3$, molecular weight < 1000, molecular diameter < 5.5 Å, molecular length < 5.5 nm, solid-water partition coefficient (log K_d) > 3 or if it has a high adsorption affinity. Chemicals are not expected to bioaccumulate if they are reactive and/or readily metabolized (EC 1996; OECD 1995).

Malathion has a low log K_{OW} (< 3), and from the studies available, listed in Table 1, it does not appear to bioaccumulate significantly, is readily metabolized and shows high depuration rates. For these reasons malathion is not expected to bioaccumulate significantly.

In fish, data suggests slight bioaccumulation of malathion. For topmouth gudgeon (*Pseudorasbora parva*) the uptake of malathion was very low and its metabolism occurred very rapidly (Kanazawa 1975). Bluegill Sunfish (*Lepomis macrochirus*) accumulated malathion, with a log-normalized bioconcentration factor (log BCF) of 2.01, but depuration occurred quickly ($t_{1/2}$ 0.69 d) (Forbis 1994). Tsuda *et al*. (1989) reported that malathion bioaccumulated to some extent (log BCF = 1.54) in the freshwater fish willow shiner (*Gnathopogon coerulescens*), however, the concentration of this chemical in the fish whole body decreased rapidly after 24 – 168 hr. The biological half-life of malathion in willow shiner was 1.4 hr. Malathion uptake occurred in carp (log BCF = 0.65), but concentrations of malathion in muscle and liver of the fish decreased rapidly (rate of elimination = 0.13 hr^{-1}), which is indicative of no bioaccumulation (Tsuda *et al.* 1990).

In a study with the water flea (*Simocephalus vetulus*), malathion accumulated slightly, with log BCF values of 2.1 (Olvera-Hernandez *et al.* 2004). For the freshwater snail (*Stagnicola sp.*), uptake of malathion occurred quickly (up to 0.1 µg/g in 36 hr), however, the short elimination half life ($t_{1/2\ e}$ = 46.79 hr) led to the conclusion that this compound was not being stored in snails (Martinez-Tabche *et al.* 2002).

To check that these criteria are protective of terrestrial wildlife that may consume aquatic organisms, a bioaccumulation factor (BAF) was used to estimate the water concentration that would roughly equate to a reported toxicity value for consumption of fish by terrestrial wildlife. The BAF of a given chemical is the product of the BCF and a biomagnification factor (BMF), such that BAF=BCF*BMF. No BAF or BMF values were found for malathion. Chronic dietary toxicity values (NOEC or LOEC) for relevant terrestrial species are preferred for this calculation. One dietary NOEC was available for reproductive effects on mallard duck of 1200 mg/kg (Pedersen and Fletcher 1993). A conservative estimate can be made using the dietary NOEC of 1200 mg/kg feed for mallard duck and a BCF value of $10^{2.98}$ L/kg for brown shrimp (*Paneaus aztecus*) given by Howard (1991) (Table 1). These values were translated to a water value using a default BMF value of 1, based on the log K_{ow} of malathion (Table 3.15, TenBrook *et al.* 2009a).

$$NOEC_{water} = \frac{NOEC_{oral\_predator}}{BCF_{food\_item} * BMF_{food\_item}}$$

Mallard:

$$NOEC_{water} = \frac{1200\ {}^{mg}/_{kg}}{10^{2.98}\ {}^{L}/_{kg} * 1} = 1.26\ {}^{mg}/_{L} = 1{,}260\ {}^{\mu g}/_{L}$$

In this example, the calculated chronic criterion is 45,000- fold below the estimated $NOEC_{water}$ value for wildlife and is not expected to cause adverse effects due to bioaccumulation.

16. Harmonization with air and sediment criteria

This section addresses how the maximum allowable concentration of malathion might impact life in other environmental compartments through partitioning (section 3-7.2, TenBrook *et al.* 2009a). However, there are no federal or state sediment or air quality standards for malathion (California Air Resources Board 2008; California Department of Water Resources 1995; USEPA 2009a; USEPA 2009b) to enable this kind of extrapolation. For biota, the limited data on bioconcentration or biomagnification of malathion is addressed in section 15.

17. Assumptions and limitations

The assumptions, limitations, and uncertainties involved in criteria generation are available to inform environmental managers of the accuracy and confidence in criteria (section 3-8.0, TenBrook *et al.* 2009a). Chapter 2 of the methodology (TenBrook *et al.* 2009a) discusses these points for each section as different procedures were chosen, such as the list of assumptions associated with using an SSD (section 2-3.1.5.1), and reviews them in section 2-7.0. This section summarizes any data limitations that affected the procedures used to determine the final malathion criteria.

Lack of data was the most important limitation in both the acute and chronic data sets for malathion. In the acute data set the taxa requirement for the benthic crustacean was not met, which precluded the use of an SSD. The final acute criterion was derived using an assessment factor procedure (see section 7); uncertainty cannot be quantified when an AF is used because the criterion is based on one datum. Two of five taxa requirements were not met for the chronic data set (the benthic crustacean and insect), which also precluded the use of a SSD; therefore, an ACR was used to derive the chronic criterion. Three acceptable ACRs were available, but an ACR could not be calculated with data for a Daphniidae, which is required by the methodology, so a default ACR of 12.4 was added to the ACR data set. Uncertainty could not be quantified for the chronic criterion either, because it was not calculated from a distribution.

Synergistic and antagonistic effects have been observed when malathion is mixed with many other chemicals, but the interactions are not described well enough at this time to incorporate into criteria compliance. This is especially important for mixtures of malathion with other OPs and AChE-inhibitors, because it appears that malathion has a synergistic effect on some of these chemicals. Temperature effects on malathion toxicity could not be quantified either, but there does appear to be a trend of decreased malathion toxicity as temperature increases, which can potentially be incorporated in the future if data for more species becomes available. When additional highly rated data is available, the criteria should be recalculated to incorporate new research on these subjects.

18. Comparison to National standard methods

This section is provided as a comparison between the UC-Davis methodology for criteria calculation (TenBrook *et al.* 2009a) and the current USEPA (1985) national standard. In this section we aim to develop acute and chronic criteria using the EPA 1985 methods for the data set generated for malathion in this report. The following taxonomic information is required for the derivation of acute or chronic criteria by the SSD method (minimum of 8 acute or chronic data) according to the USEPA (1985) method.

a. The family Salmonidae in the class Osteichthyes; criteria met with *Oncorhynchus kisutch*
b. One other family (preferably a commercially or recreationally important, warm water species) in the class Osteichthyes; met with *Jordanella floridae*
c. A third family in the phylum Chordata; met with *Pimephales promelas*
d. A planktonic crustacean; met with *Ceriodaphnia dubia*
e. A benthic crustacean; criteria not met
f. An insect; met with *Chironomus tentans*, family Chironomidae
g. A family in a phylum other than Arthropoda or Chordata; met with *Villosa lienosa* in the phylum Mollusca
h. A family in any order of insect or any phylum not already represented; criteria met with *Acroneuria pacifica* an insect in the Perlidae family

Technically, the USEPA methodology cannot be used to calculate an acute criterion for malathion because one of the taxa requirements is not available. However, since the California Department of Fish and Game have used data sets that met only seven of eight requirements in the USEPA methodology, this will be done here. This calculation was done as a comparison to the results obtained using the new methodology (TenBrook *et al.* 2009a).

Criteria were calculated using the Log-triangular (log T) distribution following the EPA 1985 guidelines with the malathion data set from Table 3 with 26 species values. It is worth noting that the EPA method uses genus mean acute values, whereas species mean acute values are reported in Table 3. Calculations were done with both genus and species mean values, however, criterion did not differ significantly. Presented next are the results obtained using the previously shown data set (using species mean values). According to the USEPA (1985) method, the example criterion is rounded to two significant digits.

Example Acute value by log T distribution (5^{th} percentile value) = 1.47 μg/L

Example Acute Criterion = acute value ÷ 2
= 1.47 μg/L ÷ 2
= 0.73 μg/L

The example acute criterion is a factor of 4.3 higher than the acute criterion derived using the UC-Davis methodology.

For the chronic criterion, the malathion data set consisted of seven species, a daphnid and six fish, which do not fulfill the taxa requirements for use of a log-T distribution. The USEPA (1985) methodology contains a similar ACR procedure as the UC-Davis methodology, to be used when acceptable ACRs for three taxa are available, but could not be used because of the lack of an ACR for an invertebrate. No chronic criterion can be calculated using the USEPA (1985) methodology.

19. Final criteria statement

The final criteria statement is:

Aquatic life in the Sacramento River and San Joaquin River basins should not be affected unacceptably if the four-day average concentration of malathion does not exceed 0.028 μg/L more than once every three years on the average and if the one-hour average concentration does not exceed 0.17 μg/L more than once every three years on average.

Although the criteria were derived to be protective of aquatic life in the Sacramento and San Joaquin Rivers, these criteria would be appropriate for any freshwater ecosystem in North America, unless species more sensitive than are represented by the species examined in the development of these criteria are likely to occur in those ecosystems.

The final acute criterion was derived using the Assessment Factor procedure (section 7). The chronic criterion was derived by use of an ACR, using both measured ACRs and one default ACR (section 8).

To date, there are no USEPA water quality criteria or aquatic life benchmarks for malathion. The California Department of Fish and Game (CDFG) composed a hazard assessment report for malathion (Siepmann & Slater 1998). CDFG calculated a freshwater acute criterion of 0.43 μg/L for malathion using the USEPA (1985) methods, which is a factor of 2.5 higher than the acute criterion calculated by the UC-Davis methodology. CDFG had data for eight of the eight required taxa for use of the USEPA (1985) methodology. The missing data in the UC-Davis acute data set for malathion was a benthic crustacean. The CDFG report fulfilled this taxa requirement with data for *Gammarus fasciatus* and *Orconectes nais*, which were from studies that rated as unreliable according to the UC-Davis methodology. These data were from Johnson & Finley (1980)/Mayer & Ellersieck (1986), which rated as LL because controls were not described, control results were not reported, and few study details were provided; thus, these data cannot be used in the UC-Davis methodology. The four lowest genus mean acute values (GMAVs) in the CDFG acute data set (0.69, 0.70, 1.0, 1.3 μg/L) were lower than all of the SMAVs in the UC-Davis acute data set, but they all came from studies that rated poorly. The CDFG report used a total of 43 GMAVs to calculate the acute criterion, which is significantly more than the 26 values in the UC-Davis data set. The difference between the data sets accounts for the difference in the acute criteria calculated by CDFG and UC-Davis. The CDFG report concluded that there were not enough chronic data to calculate a chronic criterion using a distribution or an ACR.

The derived criteria can also be compared to the current USEPA aquatic life benchmark values for malathion, but it should be emphasized that benchmark values are not equivalent to aquatic life criteria. Benchmark values were calculated based on the lowest 96-hour LC_{50} values for acute tests or lowest NOEC from a life-cycle or early life stage test for chronic tests in standardized tests. These tests were usually with rainbow trout, fathead minnow, or bluegill for fish and midge, scuds, or daphnids for invertebrates. Benchmark values are not water quality objectives, and cannot be used for regulatory purposes; they are used for risk assessment. The USEPA aquatic life benchmarks for malathion are:

Fish: 0.295 μg/L (Acute) and 0.014 μg/L (Chronic)
Invertebrates: 0.005 μg/L (Acute) and 0.000026 μg/L (Chronic)

The fish benchmark values are similar to the acute (0.17 μg/L) and chronic (0.028 μg/L) criteria calculated using the methodology, however, the invertebrate benchmark values are significantly lower. The data used to calculate these benchmark values are based on the studies by Rawash *et al.* (1975) and Wong *et al.* (1995) which presented an LC_{50} of 0.01 μg/L and a LOEC of 0.01 μg/L, respectively. Both these studies rated LN (low relevance, non-reliable) using the methodology rating guidelines. The reason for low relevance scores was due to the lack of use of an acceptable standard, non-reporting of chemical purity, and no description/use of controls. The reliability scores were very low due to the lack of information on the study conditions such as water quality parameters and statistical methods used. For these reasons, we recommend that these studies should not be included in criteria calculations. The criteria calculated using the UC-Davis methodology are more reliable and robustly calculated than the EPA benchmarks.

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Data Tables

Table 3. Final acute toxicity data set for malathion. All studies were rated RR and were conducted at standard temperature. Values in bold are species mean acute values. S: static; SR: static renewal; FT: flow-through.

Species	Common identifier	Family	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference
Acroneuria pacifica	Stonefly	Perlidae	FT	Nom	95%	96 h	12.8	Mortality	Naiads	**7.7**	Jensen & Gaufin 1964b
Anisops sardeus	Insect	Notonectidae	S	Nom	>99%	48 h	27	Immobility /Mortality	Adult	**42.2 (40.5-44.9)**	Lahr *et al.* 2001
Ceriodaphnia dubia	Cladoceran	Daphniidae	S	Nom	99.2%	48 h	25	Mortality	≤ 24 h	3.35 (2.68-3.93)	Maul *et al.* 2006
Ceriodaphnia dubia	Cladoceran	Daphniidae	S	Nom	97%	48 h	25	Mortality	≤ 24 h	1.14 (1.04-0.25)	Nelson & Roline 1998
Geomean										**1.95**	
Chironomus tentans	Midge	Chironomidae	S	Meas	98%	96 h	20	Immobility/ Mortality	4th instar	1.5 (1.2–1.9)	Belden & Lydy 2000
Chironomus tentans	Midge	Chironomidae	S	Nom	99%	96 h	20	Immobility/ Mortality	4th instar	19.09 (11.98-30.44)	Pape-Lindstrom & Lydy 1997
Geomean										**5.35**	
Daphnia magna	Cladoceran	Daphniidae	S	Nom	Analytical	48 h	21	Immobility /Mortality	< 24 h	**1.8 (1.5-2.0)**	Kikuchi *et al.* 2000
Elliptio icterina	Bivalve	Unionidae	S	Nom	96%	96 h	25	Mortality	Juvenile	**32000**	Keller and Ruessler 1997
Gambusia affinis	Mosquito fish	Poeciliidae	S	Nom	> 90 %	48 h	27	Mortality	5 d	**3440 (2720-4370)**	Tietze *et al.* 1991
Gila elegans	Bonytail	Cyprinidae	SR	Meas	93%	96 h	22	Mortality	6 d	**15300**	Beyers *et al.* 1994
Jordanella floridae	Flagfish	Cyprinodontidae	FT	Meas	95%	96 h	24.4-25.2	Mortality	33 d	**349**	Hermanutz 1978
Lampsilis siliquoidea	Bivalve	Unionidae	S	Nom	96%	48 h	25°C / pH7.5	Mortality	Glochidia	**7000**	Keller and Ruessler 1997
Lampsilis subangulata	Bivalve	Unionidae	S	Nom	96%	96 h	25°C / pH7.5	Mortality	Juvenile	**28000**	Keller and Ruessler 1997

Species	Common identifier	Family	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference
Megalonaias nervosa	Bivalve	Unionidae	S	Nom	96%	24 h	25°C / pH7.5	Mortality	Glochidia	**22000**	Keller and Ruessler 1997
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	11 d	16 (13-19)	Fujimura *et al.* 1991
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	45 d	25 (19-34)	Fujimura *et al.* 1991
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	29 d	12 (11-14)	Fujimura *et al.* 1991
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	13 d	64 (55-77)	Fujimura *et al.* 1991
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	45 d	100 (87-150)	Fujimura *et al.* 1991
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	45 d	66 (58-74)	Fujimura *et al.* 1991
Geomean										**36**	
Neomysis mercedis	Mysid	Mysidae	FT	Meas	94.2%	96 h	17	Mortality	Neonates: ≤ 5d	2.2 (2.0-2.5)	Brandt et al 1993
Neomysis mercedis	Mysid	Mysidae	FT	Meas	94.2%	96 h	17	Mortality	Neonates: ≤ 5d	1.5 (1.2-1.8)	Brandt et al 1993
Neomysis mercedis	Mysid	Mysidae	FT	Meas	94.2%	96 h	17	Mortality	Neonates: ≤ 5d	1.4 (1.3-1.5)	Brandt et al 1993
Geomean										**1.7**	
Oncorhynchus clarki	Cutthroat trout	Salmonidae	SR	Nom	95%	96 h	13	Mortality	0.33	Test 1: 150 (133-170)	Post & Schroeder 1971
Oncorhynchus clarki	Cutthroat trout	Salmonidae	SR	Nom	95%	96 h	13	Mortality	1.25g	Test 2: 201 (175-231)	Post & Schroeder 1971
Geomean										**174**	
Oncorhynchus kisutch	Coho salmon	Salmonidae	SR	Nom	95%	96 h	13	Mortality	1.7 g	**130 (208-388)**	Post & Schroeder 1971
Oncorhynchus mykiss	Rainbow trout	Salmonidae	SR	Nom	95%	96 h	13	Mortality	0.41g	**122 (98-153)**	Post & Schroeder 1971

Species	Common identifier	Family	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference
Pimephales promelas	Fathead minnow	Cyprinidae	FT	Meas	95%	96 h	25	Mortality	29-30 d; 0.069 g; 1.7 cm	**14100 (12300-16100)**	Geiger *et al.* 1984
Pteronarcys californica	Stonefly	Pteronarcyidae	S	Nom	95%	96 h	11.5	Mortality	Naiads, 4-6 cm	**50**	Jensen & Gaufin 1964a
Ptychocheilus lucius	Colorado squawfish	Cyprinidae	SR	Meas	93%	96 h	22	Mortality	26d	**9140**	Beyers *et al.* 1994
Rana palustris	Pickerel Frog	Ranidae	S	Meas	98%	48 h	16.5	Mortality	Tadpole, Gosner 26	**17100**	Budischak *et al.* 2009
Salvelinus fontinalis	Brook trout	Salmonidae	SR	Nom	95%	96 h	13	Mortality	Test 1: 1.15g	Test 1: 130 (110-154)	Post & Schroeder 1971
Salvelinus fontinalis	Brook trout	Salmonidae	SR	Nom	95%	96 h	13	Mortality	Test 2: 2.13 g	Test 2: 120 (96-153)	Post & Schroeder 1971
Geomean										**125**	
Simulium vittatum	Black fly	Simuliidae	S	Meas	98%	48 h	21	Mortality	6th & 7th instar	**54.20 (44.70-66.43)**	Overmyer *et al.* 2003
Streptocephalus sudanicus	Crustacean	Streptocepha-lidae	S	Nom	>99%	48 h	27	Immobility /Mortality	Adult	**67750 (52220-90300)**	Lahr *et al.* 2001
Villosa lienosa	Bivalve	Unionidae	S	Nom	96%	24 h	25	Mortality	Glochidia	**54000**	Keller and Ruessler 1997
Villosa villosa	Bivalve	Unionidae	S	Nom	96%	96 h	32°C / pH7.5	Mortality	Juvenile	180000	Keller and Ruessler 1997
Villosa villosa	Bivalve	Unionidae	S	Nom	96%	96 h	32°C / pH7.9	Mortality	Juvenile	142000	Keller and Ruessler 1997
Geomean										**159875**	

Table 4. Acceptable acute data excluded in data reduction process.

Species	Common identifier	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference	Reason for exclusion
Acroneuria pacifica	Stonefly	S	Nom	95%	24 h	11.5	Mortality	Naiads, 2-2.5 cm	12	Jensen & Gaufin 1964a	2,5
Acroneuria pacifica	Stonefly	S	Nom	95%	48 h	11.5	Mortality	Naiads, 2-2.5 cm	16	Jensen & Gaufin 1964a	2,5
Acroneuria pacifica	Stonefly	S	Nom	95%	96 h	11.5	Mortality	Naiads, 2-2.5 cm	7	Jensen & Gaufin 1964a	5
Anisops sardeus	Insect	S	Nom	>99%	24 h	27	Immobility /Mortality	Adult	70.7 (57.4-78.0)	Lahr *et al.* 2001	2
Ceriodaphnia dubia	Cladoceran	S	Nom	97%	24 h	25	Mortality	≤ 24 h	3.18 (2.36-4.27)	Nelson & Roline 1998	2
Elliptio icterina	Bivalve	S	Nom	96%	24 h	25°C / pH 7.5	Mortality	Juvenile	61000	Keller and Ruessler 1997	2
Elliptio icterina	Bivalve	S	Nom	96%	48 h	25°C / pH 7.5	Mortality	Juvenile	54000	Keller and Ruessler 1997	2
Elliptio icterina	Bivalve	S	Nom	96%	72 h	25°C / pH 7.5	Mortality	Juvenile	50000	Keller and Ruessler 1997	2
Gambusia affinis	Mosquito fish	S	Nom	> 90 %	24 h	27	Mortality	5 d	12680 (12110-13200)	Tietze *et al.* 1991	2
Jordanella floridae	Flagfish	FT	Meas	95%	9 d	24.4-25.2	Mortality	33 d	235	Hermanutz 1978	2
Jordanella floridae	Flagfish	FT	Meas	95%	7 d	23.4-24.5	Mortality	37 d	320 (24hr)	Hermanutz 1985	2
Jordanella floridae	Flagfish	FT	Meas	95%	7d	23.4-24.5	Mortality	37 d	280 (48hr)	Hermanutz 1985	2
Lampsilis siliquoidea	Bivalve	S	Nom	96%	24 h	25°C / pH 7.9	Mortality	Glochidia	8000	Keller and Ruessler 1997	2
Lampsilis siliquoidea	Bivalve	S	Nom	96%	24 h	25°C / pH 7.5	Mortality	Glochidia	8000	Keller and Ruessler 1997	2

Species	Common identifier	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference	Reason for exclusion
Lampsilis subangulata	Bivalve	S	Nom	96%	24 h	25°C / pH 7.5	Mortality	Juvenile	43000	Keller and Ruessler 1997	2
Lampsilis subangulata	Bivalve	S	Nom	96%	48 h	25°C / pH 7.5	Mortality	Juvenile	32000	Keller and Ruessler 1997	2
Lampsilis subangulata	Bivalve	S	Nom	96%	72 h	25°C / pH 7.5	Mortality	Juvenile	32000	Keller and Ruessler 1997	2
Neomysis mercedis	Mysid/ Crustacean	FT	Meas	94.2%	96 h	17	Mortality	Juveniles: > 15d	3.8 (2.9-5.3)	Brandt et al 1993	3
Oncorhynchus clarki	Cutthroat trout	SR	Nom	95%	24 h	13	Mortality	0.33	Test 1: 200 (163-245)	Post & Schroeder 1971	2
Oncorhynchus kisutch	Coho salmon	SR	Nom	95%	24 h	13	Mortality	1.7 g	300 (211-346)	Post & Schroeder 1971	2
Oncorhynchus mykiss	Rainbow trout	SR	Nom	95%	24 h	13	Mortality	0.41g	240 (198-291)	Post & Schroeder 1971	2
Oncorhynchus mykiss	Rainbow trout	SR	Nom	95%	48 h	13	Mortality	0.41g	196 (165-223)	Post & Schroeder 1971	2
Oncorhynchus mykiss	Rainbow trout	SR	Nom	95%	72 h	13	Mortality	0.41g	175 (146-209)	Post & Schroeder 1971	2
Pteronarcys californica	Stonefly	S	Nom	95%	24 h	11.5	Mortality	Naiads, 4-6 cm	180	Jensen & Gaufin 1964a	2
Pteronarcys californica	Stonefly	S	Nom	95%	48 h	11.5	Mortality	Naiads, 4-6 cm	72.5	Jensen & Gaufin 1964a	2
Salvelinus fontinalis	Brook trout	SR	Nom	95%	72 h	13	Mortality	Test 1: 1.15g	Test 1: 160 (144-182)	Post & Schroeder 1971	2
Salvelinus fontinalis	Brook trout	SR	Nom	95%	72 h	13	Mortality	Test 2: 2.13 g	Test 2: 150 (104-216)	Post & Schroeder 1971	2
Utterbackia imbecillis	Bivalve	S	Nom	96%	48 h	25°C / pH 7.5	Mortality	Glochidia	324000	Keller and Ruessler 1997	2, 7

Species	Common identifier	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference	Reason for exclusion
Utterbackia imbecillis	Bivalve	S	Nom	96%	96 h	32°C / pH 7.5	Mortality	Juvenile	40000	Keller and Ruessler 1997	6
Utterbackia imbecillis	Bivalve	S	Nom	96%	96 h	32°C / pH 7.9	Mortality	Juvenile	74000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	24 h	25°C / pH 7.5	Mortality	Juvenile	463000	Keller and Ruessler 1997	1
Villosa lienosa	Bivalve	S	Nom	96%	48 h	25°C / pH 7.5	Mortality	Juvenile	192000	Keller and Ruessler 1997	1
Villosa lienosa	Bivalve	S	Nom	96%	72 h	25°C / pH 7.5	Mortality	Juvenile	140000	Keller and Ruessler 1997	1
Villosa lienosa	Bivalve	S	Nom	96%	96 h	25°C / pH 7.5	Mortality	Juvenile	111000	Keller and Ruessler 1997	1
Villosa lienosa	Bivalve	S	Nom	96%	48 h	32°C / pH 7.9	Mortality	Juvenile	181000	Keller and Ruessler 1997	1
Villosa lienosa	Bivalve	S	Nom	96%	72 h	32°C / pH 7.9	Mortality	Juvenile	154000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	96 h	32°C / pH 7.9	Mortality	Juvenile	109000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	24 h	32°C / pH 7.5	Mortality	Juvenile	263000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	48 h	32°C / pH 7.5	Mortality	Juvenile	160000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	72 h	32°C / pH 7.5	Mortality	Juvenile	96000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	96 h	32°C / pH 7.5	Mortality	Juvenile	74000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	24 h	32°C / pH 7.9	Mortality	Glochidia	117000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	48 h	32°C / pH 7.9	Mortality	Glochidia	119000	Keller and Ruessler 1997	6

Species	Common identifier	Test type	Meas /Nom	Chemical grade	Duration	Temp (^oC)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference	Reason for exclusion
Villosa villosa	Bivalve	S	Nom	96%	24 h	32^{o}C / pH 7.5	Mortality	Juvenile	326000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	48 h	32^{o}C / pH 7.5	Mortality	Juvenile	220000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	72 h	32^{o}C / pH 7.5	Mortality	Juvenile	199000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	24 h	32^{o}C / pH 7.9	Mortality	Juvenile	431000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	48 h	32^{o}C / pH 7.9	Mortality	Juvenile	354000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	72 h	32^{o}C / pH 7.9	Mortality	Juvenile	255000	Keller and Ruessler 1997	6

1. More sensitive endpoint available
2. Later time point result available
3. More sensitive life-stage available
4. Test with measured concentrations available
5. Flow-through test available
6. Test with standard condition available (temperature or pH)

Table 5. Final chronic toxicity data set for malathion. All studies were rated RR and were conducted at standard temperature. SR: static renewal; FT: flow-through.

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration	Temp (^oC)	Endpoint	Age/size	NOEC (µg/L)	LOEC (µg/L)	MATC (µg/L)	Reference
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Length/ Weight	Eggs	630	1250	887	Nguyen & Janssen 2002
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Length	Eggs, 3-5 h old	1250	2500	1768	Lien et al 1997
Geomean											**1252**	
Daphnia magna	Daphnia magna	FT	Meas	94%	21 d	20	Mortality	1st instar <24hr	0.06	0.1	**0.077**	Blakemore & Burgess 1990
Gila elegans	Bonytail	FT	Meas	93%	32 d	22	Growth	48 d	990	2000	**1407**	Beyers *et al.* 1994
Jordanella floridae	Flagfish	FT	Meas	95%	30 d	25.1-25.4	Growth	1-2 d	8.6	10.9	**9.68**	Hermanutz 1978
Lepomis macrochirus	Bluegill	FT	Meas	95%	10 mon	9-29	Mortality	8 cm, 12 g, 1.5 yr	7.4	14.6	10.4	Eaton 1970
Oncorhynchus mykiss	Rainbow trout	FT	Meas	94%	97 d	7.8-13.6	Mortality	eggs 8hr post fert.	21	44	**30.4**	Cohle 1989
Ptychocheilus lucius	Colorado squawfish	FT	Meas	93%	32 d	22	Growth	41 d	1680	3510	2428	Beyers *et al.* 1994
Ptychocheilus lucius	Colorado squawfish	FT	Meas	93%	32 d	22	Mortality	41 d	1680	3510	2428	Beyers *et al.* 1994
Geomean											**2428**	

Table 6. Acceptable chronic data excluded in data reduction process.

Species	Common identifier	Test type	Meas /Nom	Chemical grade	Duration	Temp (^oC)	Endpoint	Age/ size	NOEC (µg/L)	LOEC (µg/L)	MATC (µg/L)	Reference	Reason for exclusion
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Survival	Eggs	1250	2500	1768	Nguyen & Janssen 2002	2
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Survival	Eggs	1250	2500	1768	Nguyen & Janssen 2002	2
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Mortality	Eggs, 3-5 h old	2500	5000	3536	Lien et al 1997	2
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Length	Eggs, 3-5 h old	1250	2500	1768	Lien et al 1997	2
Gila elegans	Bonytail	FT	Meas	93%	32 d	22	Survival	48d	2000	4060	2849	Beyers *et al.* 1994	1
Jordanella floridae	Flagfish	FT	Meas	95%	30 d	25.1-25.4	Survival	1-2d	19.3	24.7	21.83	Hermanutz 1978	1
Jordanella floridae	Flagfish	FT	Meas	95%	140 d	24.1-25.5	Growth	2-3d	13.8 (30d)	18.5 (30d)	15.98 (30d)	Hermanutz 1985	1

1. More sensitive endpoint available

2. More sensitive exposure duration available

Table 7. Calculation of the final acute-to-chronic ratio. Values in bold were used in the calculation.

Species	Common identifier	LC_{50} (µg/L)	Reference	Chronic Endpoint	MATC (µg/L)	Reference	ACR (LC_{50}/MATC)
Gila elegans	Bonytail	15300	Beyers *et al.* 1994	Growth	1407	Beyers *et al.* 1994	**10.8**
Jordanella floridae	Flagfish	349	Hermanutz 1978	Growth	9.68	Hermanutz 1978	**36.0**
Ptychocheilus lucius	Colorado squawfish	9140	Beyers *et al.* 1994	Growth	2428	Beyers *et al.* 1994	**3.7**
Invertebrate	*Default ACR*						**12.4**
						Final ACR	**11.8**

Table 8. Supplemental studies excluded from criteria derivation (rated RL, LR, or LL). S = static, SR = static renewal, FT = flow-through

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Acroneuria pacifica	Stonefly	FT	Nom	95%	30d/12.8	Mortality	Naiads	--------	0.71	Jensen & Gaufin 1964b	LR 6
Alonella sp	Cladoceran	S	Nom	56%	48h/21	Mortality	NR	2.0 (1.5-2.51)	--------	Naqvi & Hawkins 1989	LL 1,7
Ambystoma mexicanum	Salamander	SR	Meas	99%	96h/20	Mortality	Early larvae, stage L44	20000-25000	--------	Robles-Mendoza *et al.* 2009	LR 6
Ambystoma mexicanum	Salamander	SR	Meas	99%	96h/20	Embryo development	Early larvae, stage L44	--------	LOEC 10000	Robles-Mendoza *et al.* 2009	LR 6
Ambystoma mexicanum	Salamander	SR	Nom	99%	96h/20	Mortality	embryos	-------		Robles-Mendoza et al 2009	LL 5,6
Ambystoma mexicanum	Salamander	SR	Nom	99%	96h/20	Mortality	larvae	--------		Robles-Mendoza et al 2009	LL 5,6
Anabaena fertilissima	Bluegreen algae	NR	NR	95%	30d/29	Growth inhibition	NR	--------	22361	Tandon *et al.* 1988	RL 7
Anodonta anatina	Bivalve	S	Nom	95%	24h/22	Mortality	larvae	25000 (22370-27900)	--------	Varanka 1986	RL 7
Anodonta anatina	Bivalve	S	Nom	95%	48h/22	Mortality	larvae	2030 (1820-2270)	--------	Varanka 1986	RL 7
Anodonta anatina	Bivalve	S	Nom	95%	72h/22	Mortality	larvae	210 (180-250)	--------	Varanka 1986	RL 7
Anodonta anatina	Bivalve	S	Nom	95%	96h/22	Mortality	larvae	80 (50-140)	--------	Varanka 1986	RL 7
Anodonta cygnea	Bivalve	S	Nom	95%	24h/22	Mortality	larvae	43800 (39600-48500)	--------	Varanka 1986	RL 7
Anodonta cygnea	Bivalve	S	Nom	95%	48h/22	Mortality	larvae	10210 (9410-11360)	--------	Varanka 1986	RL 7
Anodonta cygnea	Bivalve	S	Nom	95%	72h/22	Mortality	larvae	3260 (2960-3460)	--------	Varanka 1986	RL 7
Anodonta cygnea	Bivalve	S	Nom	95%	96h/22	Mortality	larvae	310 (280-360)	--------	Varanka 1986	RL 7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Anopheles quadrimaculatus	Insect	S	Nom	NR	48h/32	Mortality	2nd and 3rd instar	1	--------	Milam *et al.* 2000	LL 1,4,7
Asellus brevicaudus	Insect	S	Nom	Technical	24h/21	Mortality	Mature	6000.0	--------	Sanders 1972	RL 7
Asellus brevicaudus	Insect	S	Nom	Technical	96h/21	Mortality	Mature	3000.0	--------	Sanders 1972	RL 7
Atherix	Insect	S	NR	95%	96h/21	Mortality	Mature	385 (246-602)	--------	Johnson & Finley 1980	LL 4,7
Aulosira fertilissima	Bluegreen algae	NR	NR	95%	30d/29	Growth inhibition	NR	--------	LOEC 10000	Tandon *et al.* 1988	LL 6,7
Aulosira fertilissima	Bluegreen algae	NR	NR	95%	30d/29	Photos-thesis	NR	--------	22361	Tandon *et al.* 1988	LL 2,7
Aulosira fertilissima	Bluegreen algae	NR	NR	95%	30d/29	Nitrogenase activity	NR	--------	LOEC 10000	Tandon *et al.* 1988	LL 2,6,7
Brachionus calyciflorus	Rotifer	S	Nom	95%	24h/25	Mortality	Newly hatched	33720	--------	Fernández-Casalderrey *et al.* 1992	RL 7
Brachionus plicatilis	Rotifer	S	Nom	50%	24h/25	Mortality	Neonates	35300	--------	Snell & Persoone 1989	LL 1,7
Bufo americanus	American toad	SR	Nom	50%	16d/20.1-20.3	Mortality	tadpole (stage 25)	5900	--------	Relyea 2004	LL 1,4
Carassius auratus	Goldfish	FT	Meas	NR	4d/18.2-25.8	Mortality	1-2 h old eggs	2610 (2250-3080)	--------	Birge et al 1979	LR 1
Carassius auratus	Goldfish	FT	Meas	NR	4d/18.2-25.8	Mortality	1-2 h old eggs	3159 (2810-3560)	--------	Birge et al 1979	LR 1
Carassius auratus	Goldfish	FT	Meas	NR	8d/18.2-25.8	Mortality	1-2 h old eggs	1200 (1060-1350)	--------	Birge et al 1979	LR 1
Carassius auratus	Goldfish	FT	Meas	NR	8d/18.2-25.8	Mortality	1-2 h old eggs	1650 (1500-1800)	--------	Birge et al 1979	LR 1
Carassius auratus	Goldfish	S	NR	95%	96h/18	Mortality	0.9 g	10700 (8340-13800)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (μg/L)	MATC (μg/L)	Reference	Rating/ Reason
Ceratopsyche slossonae	Caddisfly	FT	Nom	96.7%	20d/15.6	net spinning /AChE act	4th instar larvae	0.11-0.28	--------	Tessier et al 2000	LL 2
Channa gachu	Snakehead fish	S	Nom	50%	24h/24 ± 2, pH 7.5	Mortality	140 ±10 mm	9200	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	48h/24 ± 2, pH 7.5	Mortality	140 ±10 mm	8100	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	72h/24 ± 2, pH 7.5	Mortality	140 ± 10 mm	7900	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	96h/24 ± 2, pH 7.5	Mortality	140 ±10 mm	7600	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	24h/35 ± 3, pH 7.5	Mortality	140 ±10 mm	8800	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	48h/35 ± 3, pH 7.5	Mortality	140 ±10 mm	7950	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	72h/35 ± 3, pH 7.5	Mortality	140 ±10 mm	7600	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	96h/35 ± 3, pH 7.5	Mortality	140 ±10 mm	7350	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	24h/24 ± 2, pH 8.4	Mortality	140 ±10 mm	8700	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	48h/24 ± 2, pH 8.4	Mortality	140 ±10 mm	7850	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	72h/24 ± 2, pH 8.4	Mortality	140 ±10 mm	7300	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	96h/24 ± 2, pH 8.4	Mortality	140 ±10 mm	7050	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	24h/24 ± 2, pH 7.5	Mortality	110 ±10 mm	8750	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	48h/24 ± 2, pH 7.5	Mortality	110 ±10 mm	8000	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	72h/24 ± 2, pH 7.5	Mortality	110 ±10 mm	7650	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	96h/24 ± 2, pH 7.5	Mortality	110 ±10 mm	6950	--------	Dalela et al 1978	LL 1,7
Channa	Snakehead	SR	Nom	Technical	24h/18	Mortality	59.8 g,	9.48	--------	Haider &	LL

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
punctatus	fish						19 cm	(8.59-10.47)		Inbaraj 1986	7
Channa punctatus	Snakehead fish	SR	Nom	Technical	48h/18	Mortality	59.8 g, 19 cm	6510 (5740-7307)	--------	Haider & Inbaraj 1986	LL 7
Channa punctatus	Snakehead fish	SR	Nom	Technical	72h/18	Mortality	59.8 g, 19 cm	5240 (4770-5770)	--------	Haider & Inbaraj 1986	LL 7
Channa punctatus	Snakehead fish	SR	Nom	Technical	96h/18	Mortality	59.8 g, 19 cm	4600 (4220-5020)	--------	Haider & Inbaraj 1986	LL 7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	111.7	--------	Hoffman 1995, Hoffman & Fisher1994	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	191.7	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	240.3	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	206.4	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	139.7	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	118.2	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	124.3	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	115.2	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	191	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	142.1	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	74.9	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	150	--------	Hoffman 1995	LL 4,7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	225.6	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	206.1	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	128.7	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	124.5	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	127.7	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	130.7	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.44	--------	Hoffman 1995, Hoffman & Fisher1994	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.362	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.324	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.375	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.362	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.212	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.444	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.499	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.437	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.324	--------	Hoffman 1995	LL 4,7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.481	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.571	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.457	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.423	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.3	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.34	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.39	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.37	--------	Hoffman 1995	LL 4,7
Cirrhina mrigala	Asian carp	SR	Nom	50%	96h/23	Mortality	4 d, 0.051g	880	--------	Verma *et al.* 1984	LL 1,4
Cirrhina mrigala	Asian carp	SR	Nom	50%	60d/23	Growth	4 d, 0.051g	--------	56.9	Verma *et al.* 1984	LL 1,4
Claassenia	Insect	S	NR	95%	96h/21	Mortality	Second year class	2.6 (1.4-4.3)	--------	Johnson & Finley 1980	LL 4,7
Claassenia sabulosa	Stonefly	S	Nom	Technical	96h/15.5	Mortality	15-20mm	24hr LC50 13 (9.6-17)	--------	Sanders and Cope 1968	LL 4,9
Claassenia sabulosa	Stonefly	S	Nom	Technical	96h/15.5	Mortality	15-20mm	48hr LC50 6.0 (4.1-8.7)	--------	Sanders and Cope 1968	LL 4,9
Claassenia sabulosa	Stonefly	S	Nom	Technical	96h/15.5	Mortality	15-20mm	96hr LC50 2.8 (1.8-4.3)	--------	Sanders and Cope 1968	LL 4,9
Clarias gariepinus	Airbreathin g catfish	SR	Nom	98%	5d/27	Larval mortality	eggs, 2-4 cell stage	3420 (2910-4010)	--------	Nguyen & Janssen 2001	LL 4
Clarias gariepinus	Airbreathin g catfish	SR	Nom	98%	5d/27	Embryo mortality	eggs, 2-4 cell stage	--------	LOEC >5000	Nguyen & Janssen 2001	LL 4,6
Clarias gariepinus	Airbreathin g catfish	SR	Nom	98%	5d/27	Hatching	eggs, 2-4 cell stage	--------	LOEC >5000	Nguyen & Janssen 2001	LL 4,6

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5d/27	Larval mortality	eggs, 2-4 cell stage	--------	LOEC =2500	Nguyen & Janssen 2001	LL 4,6
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5d/27	Abnormality	eggs, 2-4 cell stage	--------	900	Nguyen & Janssen 2001	LL 4,2
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5d/27	Growth	eggs, 2-4 cell stage	--------	900	Nguyen & Janssen 2001	LL 4
Colisa fasciatus	Gourami fish	SR	Nom	94%	24h/23	Mortality	2.4 g	3150 (2930-3490)	--------	Singh *et al.* 2004	LL 3,4,7
Colisa fasciatus	Gourami fish	SR	Nom	94%	48h/23	Mortality	2.4 g	2850 (2670-3070)	--------	Singh *et al.* 2004	LL 3,4,7
Colisa fasciatus	Gourami fish	SR	Nom	94%	72h/23	Mortality	2.4 g	2430 (2270-2580)	--------	Singh *et al.* 2004	LL 3,4,7
Colisa fasciatus	Gourami fish	SR	Nom	94%	96h/23	Mortality	2.4 g	2120 (1940-2250)	--------	Singh *et al.* 2004	LL 3,4,7
Crassostrea virginica	Eastern Oyster	FT	Meas	57%	96h/24	Inhibit shell growth	24-37mm	2960 (2040-6970)	96hr 2457	Wade and Wisk 1992	LR 1
Cypria sp	Ostracods/ Crustacean	S	Nom	56%	48h/21	Mortality	NR	2.0 (1.6-2.7)	--------	Naqvi & Hawkins 1989	LL 1,7
Cypridopsis	Crustacean	S	NR	95%	96h/21	Mortality	Mature	47 (32-69)	--------	Johnson & Finley 1980	LL 4,7
Cyprinodon variegatus	Minnow	FT	Meas	94%	96h/22	Mortality	0.033g, 11mm	40 (18-74)	NOEC 96hr 18	Bowman 1989a	LR 5
Cyprinodon variegatus	Minnow	FT	Meas	57%	96h/22	Mortality	0.16g, 17mm	55 (47-64)	NOEC 14	Bowman 1989b	LR 1,5
Cyprinus carpio	Carp	SR	Nom	57%	96h/25	Mortality	Juvenile	11870	--------	Alam & Maugham 1992	LL 1,7
Cyprinus carpio	Carp	SR	Nom	57%	96h/25	Mortality	Adult	11531	--------	Alam & Maugham 1992	LL 1,7
Cyprinus carpio	Carp	S	Nom	50%	96h/24	Mortality	Eggs	12930 (10810-15450)	--------	Kaur & Dhawn 1993	LL 1,7
Cyprinus carpio	Carp	S	Nom	50%	96h/24	Mortality	Larvae: 7d	710 (240-1240)	--------	Kaur & Dhawn 1993	LL 1,7
Cyprinus carpio	Carp	S	Nom	50%	96h/24	Mortality	Fry: 30d	2100 (1220-3610)	--------	Kaur & Dhawn 1993	LL 1,7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Cyprinus carpio	Carp	S	NR	95%	96h/18	Mortality	0.6 g	6590 (4920-8820)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7
Danio rerio	Zebrafish	S	Nom	NR	72h/26	Hatchability	Eggs	165 (161- 169)	--------	Ansari & Kumar 1986	LL 1,7
Danio rerio	Zebrafish	S	Nom	NR	96h/26	Mortality	Eggs	155 (150-160)	--------	Ansari & Kumar 1986	LL 1,7
Danio rerio	Zebrafish	S	Nom	NR	120h/26	Mortality	Eggs	105 (101-108)	--------	Ansari & Kumar 1986	LL 1,7
Danio rerio	Zebrafish	S	Nom	NR	144h/26	Mortality	Eggs	50 (46-53)	--------	Ansari & Kumar 1986	LL 1,7
Danio rerio	Zebrafish	S	Nom	NR	168h/26	Mortality	Eggs	35 (27-44)	--------	Ansari & Kumar 1986	LL 1,7
Danio rerio	Zebrafish	S	Nom	99%	120h/28	Mortality	Eggs	--------	2236	Cook et al 2005	RL 7
Danio rerio	Zebrafish	S	Nom	99%	120h/28	Length	Eggs	--------	1732	Cook et al 2005	RL 7
Danio rerio	Zebrafish	S	Nom	99%	120h/28	Abdominal area	Eggs	--------	2236	Cook et al 2005	LL 2,7
Danio rerio	Zebrafish	S	Nom	99%	120h/28	Hatching	Eggs	--------	No effect	Cook et al 2005	LL 2,7
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Larval mortality	eggs, blastula stage	1800 (1500-2000)	--------	Nguyen & Janssen 2001	LL 4
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Embryo survival	eggs, blastula stage	--------	LOEC = 10,000	Nguyen & Janssen 2001	LL 4,6
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Hatching	eggs, blastula stage	--------	1700	Nguyen & Janssen 2001	LL 4
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Larval survival	eggs, blastula stage	--------	1700	Nguyen & Janssen 2001	LL 4

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Abnormalit y	eggs, blastula stage	--------	1700	Nguyen & Janssen 2001	LL 4,2
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Growth	eggs, blastula stage	--------	LOEC >1000	Nguyen & Janssen 2001	LL 4,6
Daphnia magna	Cladoceran	S	Nom	95%	24h/20	Mortality	4th instar/ juvenile	1.0 (0.7-1.4)	--------	Barata *et al.* 2004	LL 4,7
Daphnia magna	Cladoceran	S	NR	95%	48h/25	Immobility/ Mortality	1st instar	1.0 (0.7-1.4)	--------	Johnson & Finley 1980	LL 4,7
Daphnia magna	Cladoceran	S	NR	99%	48h/20	Immobility/ Mortality	< 24 h	3.6 (3.35-3.89)	--------	Printes & Callaghan 2004	LR 7,8
Daphnia magna	Cladoceran	FT	Meas	57%	48h/19-20	Mortality	neonates <24hr	2.2 (1.9-2.5)	48hr 0.26	Burgess 1989a	LR 1
Daphnia pulex	Cladoceran	S	NR	95%	48h/25	Immobility/ Mortality	1st instar	1.8 (1.4-2.4)	--------	Johnson & Finley 1980	LL 4,7
Diaptomus sp	Copepods/ crustacean	S	Nom	56%	48h/21	Mortality	NR	2.0 (1.8-2.5)	--------	Naqvi & Hawkins 1989	LL 1,7
Eucyclops sp	Copepods/ crustacean	S	Nom	56%	48h/21	Mortality	NR	1.0 (0.8-1.3)	--------	Naqvi & Hawkins 1989	LL 1,7
Euphlyctis hexadactylus	Frog	SR	Nom	50%	24h/14	Mortality	20 mm, 0.5g	0.846 (0.798-0.94)	--------	Khangarot *et al.* 1985	LL 1,7
Euphlyctis hexadactylus	Frog	SR	Nom	50%	48h/14	Mortality	20 mm, 0.5g	0.613 (0.55-0.69)	--------	Khangarot *et al.* 1985	LL 1,7
Euphlyctis hexadactylus	Frog	SR	Nom	50%	72h/14	Mortality	20 mm, 0.5g	0.613 (0.55-0.69)	--------	Khangarot *et al.* 1985	LL 1,7
Euphlyctis hexadactylus	Frog	SR	Nom	50%	96h/14	Mortality	20 mm, 0.5g	0.59 (0.43-0.78)	--------	Khangarot *et al.* 1985	LL 1,7
Gambusia affinis	Mosquito fish	S	Nom	NR	48h/32	Mortality	Adult	1230	--------	Milam *et al.* 2000	LL 1,4,7
Gambusia affinis	Mosquito fish	S	Nom	56.1%	96h/20	Mortality	adult, 0.289g, 2.76 cm	200 (190-250)	--------	Naqvi & Hawkins 1988	LL 1,7
Gammarus	Amphipod	S	NR	95%	96h/21	Mortality	Mature	0.76	--------	Johnson &	LL

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
fasciatus								(0.63-0.92)		Finley 1980	4,7
Gammarus fasciatus	Amphipod	IF	Nom	Technical	24h/21	Mortality	NR	1.2	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	IF	Nom	Technical	48h/21	Mortality	NR	0.5	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	IF	Nom	Technical	96h/21	Mortality	NR	0.5	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	IF	Nom	Technical	120h/21	Mortality	NR	0.5	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	24h/21, recons water	Mortality	NR	3.8	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	24h/21, well water	Mortality	NR	3.2	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	48h/21, well water	Mortality	NR	2.0	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	96h/21, well water	Mortality	NR	0.9	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	96h/21, recons water	Mortality	NR	0.8	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	120h/21, well water	Mortality	NR	0.5	--------	Sanders 1972	RL 7
Gammarus palustris	Amphipod	S	NR	Technical	96h/20	Mortality	amphipod s	4.65 (3.47-6.21)	--------	Leight & Van Dolah 1999	LL 5
Gammarus palustris	Amphipod	SR	NR	Technical	96h/20	Mortality	amphipod s	2.29 (1.74-3.03)	--------	Leight & Van Dolah 1999	LL 5
Heteropneust es fossilis	Stinging catfish	S	Nom	50%	24h/18	Mortality	5-10 g	11750	--------	Verma *et al.* 1982	LL 1,7
Heteropneust es fossilis	Stinging catfish	S	Nom	50%	24h/18	Mortality	5-10 g	18490	--------	Verma *et al.* 1982	LL 1,7
Heteropneust es fossilis	Stinging catfish	S	Nom	50%	48h/18	Mortality	5-10 g	10960	--------	Verma *et al.* 1982	LL 1,7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	48h/18	Mortality	5-10 g	17180	--------	Verma *et al.* 1982	LL 1,7
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	72h/18	Mortality	5-10 g	10580	--------	Verma *et al.* 1982	LL 1,7
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	72h/18	Mortality	5-10 g	16180	--------	Verma *et al.* 1982	LL 1,7
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	96h/18	Mortality	5-10 g	9790	--------	Verma *et al.* 1982	LL 1,7
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	96h/18	Mortality	5-10 g	15000	--------	Verma *et al.* 1982	LL 1,7
Hexagenia	Mayfly	S	Nom	95%	24h/24	Mortality	Naiad	631 (429-834)	--------	Carlson 1966	RL 7
Hydropsyche	Caddisfly	S	Nom	95%	24h/24	Mortality	Naiad	12.3 (10.2-15.1)	--------	Carlson 1966	RL 7
Hydropsyche	Caddisfly	S	NR	95%	96h/15	Mortality	Juvenile	5 (2.9-8.6)	--------	Johnson & Finley 1980	LL 4,7
Hyla versicolor	Grey tree frog	SR	Nom	50%	16d/20.1-20.2	Mortality	Tadpole stage 25	2000-4100	--------	Relyea 2004	LL 1,4
Ictalurus melas	Black bullhead	S	NR	95%	96h/18	Mortality	1.2 g	12900 (10700-15600)	--------	Johnson & Finley 1980	LL 4,7
Ictalurus melas	Black bullhead	S	Nom	95%	96h/18	Mortality	0.6-1.7 g	12900 (10700-15600)	--------	Macek & McAllister 1970	LL 4,7
Ictalurus punctatus	Channel catfish	S	NR	95%	96h/18	Mortality	1.5 g	8970 (6780-12000)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7
Isoperia	Stonefly	S	NR	95%	96h/15	Mortality	Second year class	0.69 (0.20-2.4)	--------	Johnson & Finley 1980	LL 4,7
Labeo rohita	Carp	SR	Nom	50%	96h/24	Mortality	5 g	9.0 µL/L (9.98 - 8.11)	--------	Patil & David 2008	LR 1,4
Lepomis cyanellus	Green sunfish	S	NR	95%	96h/18	Mortality	1.1 g	175 (134-228)	--------	Johnson & Finley 1980	LL 4,7
Lepomis macrochirus	Bluegill sunfish	S	Nom	95%	48h/18.3	Mortality	35-75mm	24hr LC50 - 125	--------	Ludman 1969	LL 7,8

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Lepomis macrochirus	Bluegill	S	Nom	95%	48h/18.3	Mortality	35-75mm	48hr LC50 - 88	--------	Ludman 1969	LL 7,8
Lepomis macrochirus	Bluegill	FT	Meas	95%	96h/NR	Mortality	1.5 g	131	--------	Eaton 1970	LL 4,7
Lepomis macrochirus	Bluegill	FT	Meas	95%	96h/NR	Mortality	1.5 g	89	--------	Eaton 1970	LL 4,7
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	Spawning	1.5 g	--------	--------	Eaton 1970	LL 6
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	AChE inhibition	1.5 g	--------	IC52 = 14.6	Eaton 1970	LL 2
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	AChE inhibition	1.5 g	--------	IC54 = 7.4	Eaton 1970	LL 2
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	AChE inhibition	1.5 g	--------	IC67 = 3.6	Eaton 1970	LL 2
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	AChE inhibition	1.5 g	--------	IC65 = 1.6	Eaton 1970	LL 2
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	AChE inhibition	1.5 g	--------	IC79 = 0.7	Eaton 1970	LL 2
Lepomis macrochirus	Bluegill	S	Nom	Technical	24h/12.7	Mortality	0.6 – 1.5 g	220 (200-240)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	Technical	24h/18.3	Mortality	0.6 – 1.5 g	140 (120-160)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	Technical	24h/23.8	Mortality	0.6 – 1.5 g	110 (97-1200)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	Technical	96h/12.7	Mortality	0.6 – 1.5 g	120 (67-210)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	Technical	96h/18.3	Mortality	0.6 – 1.5 g	55 (51-59)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	Technical	96h/23.8	Mortality	0.6 – 1.5 g	46 (40-52)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	NR	95%	96h/18	Mortality	1.5 g	103 (87-122)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	100%	24h/25	Mortality	1.5-2.5 in., 1-2 g,	140	--------	Pickering *et al.* 1962	LL 4,8

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Lepomis macrochirus	Bluegill	S	Nom	100%	48h/25	Mortality	1.5-2.5 in., 1-2 g,	120	--------	Pickering *et al.* 1962	LL 4,8
Lepomis macrochirus	Bluegill	S	Nom	100%	96h/25	Mortality	1.5-2.5 in., 1-2 g,	90	--------	Pickering *et al.* 1962	LL 4,8
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	Mortality	1.5 g	-------	10.4	Eaton 1970	LL 4,6
Lepomis microlophus	Redear sunfish	S	NR	95%	96h/24	Mortality	3.2 g	62 (58-67)	--------	Johnson & Finley 1980	LL 4,7
Lepomis microlophus	Redear sunfish	S	Nom	95%	96h/18	Mortality	0.6-1.7 g	170 (132-220)	--------	Macek & McAllister 1970	LL 4,7
Lestes	Insect	S	NR	95%	96h/15	Mortality	Juvenile	10 (6.5-15)	--------	Johnson & Finley 1980	LL 4,7
Lestes congener	Insect	S	Nom	94%	96h/25	Mortality	Late instar nymphs	300	--------	Federle & Collins 1976	RL 7
Limnephilius	Insect	S	NR	95%	96h/15	Mortality	Juvenile	1.3 (0.8-2.0)	--------	Johnson & Finley 1980	LL 4,7
Micropterus salmoides	Largemout h bass	S	NR	95%	96h/18	Mortality	0.9 g	285 (254-320)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7
Moina macrocopa	Cladoceran	SR	Nom	81%	11d/25	Longevity	< 18 h	--------	LOEC 0.01	Wong *et al.* 1995	LL 6,7
Mysidopsis bahia	Fairy shrimp	S	Nom	94.5%	96h/25	Mortality	≤ 24 h	5.2	--------	Cripe *et al.* 1989	LR 5
Mysidopsis bahia	Fairy shrimp	S	Nom	94.5%	96h/25	Mortality	≤ 24 h	5.7	--------	Cripe *et al.* 1989	LR 4,5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	8-9d	5.2 (24h)	---------	Burgess 1989b MRID4118920 1	LR 5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	8-9d	3.7 (48h)	---------	Burgess 1989b	LR 5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	8-9d	2.8 (72h)	---------	Burgess 1989b	LR 5

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	8-9d	2.1 (1.5-2.6) (96h)	NOEC 96hr 0.87	Burgess 1989b	LR 5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	9-10d	3.6 (48h)	---------	Forbis 1990	LR 5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	9-10d	2.3 (72h)	---------	Forbis 1990	LR 5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	9-10d	2.2 (1.5-2.6) (96h)	NOEC 96hr 1.5	Forbis 1990	LR 5
Mysidopsis bahia	Fairy shrimp	S	NR	99.9%	96h/25	Mortality	≤ 24 h	11	--------	Cripe 1994	LR 5
Notonecta undulata	Insect	S	Nom	94%	24h/25	Mortality	Late instar nymphs	220	--------	Federle & Collins 1976	RL 7
Notonecta undulata	Insect	S	Nom	94%	48h/25	Mortality	Late instar nymphs	110	--------	Federle & Collins 1976	RL 7
Notonecta undulata	Insect	S	Nom	94%	72h/25	Mortality	Late instar nymphs	80	--------	Federle & Collins 1976	RL 7
Notonecta undulata	Insect	S	Nom	94%	96h/25	Mortality	Late instar nymphs	80	--------	Federle & Collins 1976	RL 7
Notopterus-notopterus	Knifefish	SR	Nom	Technical	96h/22	Mortality	8.6-11 cm, 14.4-19.0 g	77 (61-103)	--------	Gupta et al 1994	LL 3,7
Oncorhynchus clarki	Cutthroat trout	S	NR	95%	96h/12	Mortality	1.0 g	280 (270-310)	--------	Johnson & Finley 1980	LL 4,7
Oncorhynchus kisutch	Coho salmon	SR	Meas	98%	96h/12	AChE inhibition	1.3 g	74.5	--------	Laetz *et al.* 2009	LR 2
Oncorhynchus kisutch	Coho salmon	S	NR	95%	96h/12	Mortality	0.9 g	170 (160-180)	--------	Johnson & Finley 1980	LL 4,7
Oncorhynchus kisutch	Coho salmon	S	Nom	95%	96h/13	Mortality	0.6-1.7 g	101 (89-115)	--------	Macek & McAllister	LL 4,7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
										1970	
Oncorhynchus mykiss	Rainbow trout	SR	Nom	99.5%	24h/15	AChE inhibition	40 d, 30.8 mm, 0.24 g	--------	LOEC 20	Beauvais *et al.* 2000	LL 2,6,7
Oncorhynchus mykiss	Rainbow trout	SR	Nom	99.5%	96h/15	AChE inhibition	40 d, 30.8 mm, 0.24 g	--------	NOEC 40	Beauvais *et al.* 2000	LL 2,6,7
Oncorhynchus mykiss	Rainbow trout	SR	Nom	99.5%	96h + recov/15	AChE inhibition	40 d, 30.8 mm, 0.24 g	--------	LOEC 20	Beauvais *et al.* 2000	LL 2,6,7
Oncorhynchus mykiss	Rainbow trout	S	NR	95%	96h/12	Mortality	1.4 g	200 (160-240)	--------	Johnson & Finley 1980	LL 4,7
Oncorhynchus mykiss	Rainbow trout	S	Nom	95%	96h/13	Mortality	0.6-1.7 g	170 (160-180)	--------	Macek & McAllister 1970	LL 4,7
Oncorhynchus tshawytscha	Chinook salmon	S	Nom	50%	24h/9	Mortality	3.8 cm	170	--------	Parkhurst & Johnson 1955	LL 1,7
Oncorhynchus tshawytscha	Chinook salmon	S	Nom	50%	48h/9	Mortality	3.8 cm	150	--------	Parkhurst & Johnson 1955	LL 1,7
Oncorhynchus tshawytscha	Chinook salmon	S	Nom	50%	96h/9	Mortality	3.8 cm	120	--------	Parkhurst & Johnson 1955	LL 1,7
Orconectes nais	Crayfish	S	Nom	Technical	24h/21	Mortality	Early instar, 3-5 w old, 30-50mg	290	--------	Sanders 1972	RL 7
Orconectes nais	Crayfish	S	Nom	Technical	96h/21	Mortality	Early instar, 3-5 w old, 30-50mg	180	--------	Sanders 1972	RL 7
Oreochromis niloticus	Nile Tilapia	S	Nom	98%	96h/28	Mortality	5-8g	2200	--------	Pathiratne & George 1998	RL
Palaemonetes kadiakensis	Glass shrimp	IF	Nom	Technical	24h/21	Mortality	NR	150	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	IF	Nom	Technical	48h/21	Mortality	NR	25	--------	Sanders 1972	RL 7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Palaemonetes kadiakensis	Glass shrimp	IF	Nom	Technical	96h/21	Mortality	NR	15	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	IF	Nom	Technical	120h/21	Mortality	NR	9	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	S	Nom	Technical	24h/21	Mortality	NR	320	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	S	Nom	Technical	48h/21	Mortality	NR	100.0	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	S	Nom	Technical	96h/21	Mortality	NR	90.0	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	S	Nom	Technical	120h/21	Mortality	NR	60.0	--------	Sanders 1972	RL 7
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	1-2d old	9.06 (7.56-10.73)	--------	Key et al 1998	LR 5
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	18day larvae	13.24 (9.91-17.70)	--------	Key et al 1998	LR 5
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	adults	38.19 (31.91-45.69)	--------	Key et al 1998	LR 5
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	1-2d old	8.94 (7.53-10.63)	96hr 2.66	Key and Fulton 2006	LR 5
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	18day larvae	13.26 (9.67-15.98)	LOEC 96hr 12.5	Key and Fulton 2006	LR 5
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	adults	38.19 (31.91-45.69)	96hr 17.68	Key and Fulton 2006	LR 5
Paratya compressa improvisa	Shrimp	S	Nom	98%	96h/22	Mortality	4 wk; 8.27 mm	4	--------	Shigehisa & Shiraishi 1998	LL 4,6,7
Pelophylax ridibundus	Marsh frog	S	Nom	95%	96h/NR	Mortality	21st Gosner stage	38,000 □g/L (35.11-48.25)	--------	Sayim 2008	RL 7
Peltodytes spp.	Crawling water beetles	S	Nom	94%	24h/25	Mortality	Adult; 0.005 g	6800	--------	Federle & Collins 1976	RL 7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Peltodytes spp.	Crawling water beetles	S	Nom	94%	48h/25	Mortality	Adult; 0.005 g	1500	--------	Federle & Collins 1976	RL 7
Peltodytes spp.	Crawling water beetles	S	Nom	94%	72h/25	Mortality	Adult; 0.005 g	1200	--------	Federle & Collins 1976	RL 7
Peltodytes spp.	Crawling water beetles	S	Nom	94%	96h/25	Mortality	Adult; 0.005 g	1000	--------	Federle & Collins 1976	RL 7
Penaeus duorarum	Pink shrimp	S	NR	99.9%	96h/25	Mortality	3-5d	12	--------	Cripe 1994	LR 5
Perca flavescens	Yellow perch	S	NR	95%	96h/18	Mortality	1.4 g	64 (59-70)	--------	Johnson & Finley 1980	LL 4,7
Perca flavescens	Yellow perch	S	Nom	95%	96h/18	Mortality	0.6-1.7 g	263 (205-338)	--------	Macek & McAllister 1970	LL 4,7
Pimephales promelas	Fathead minnow	FT	Meas	95%	96h/25	Loss of equilibrium, spinal deformity, hemorrhaging	29-30 d; 0.069 g; 1.7 cm	EC50: 10,600	--------	Geiger *et al.* 1984	LR 2
Pimephales promelas	Fathead minnow	S	Meas	95%	96h/18	Mortality	0.9 g	8650 (6450-11,500)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7
Pimephales promelas	Fathead minnow	FT	Meas	95%	10mo/15-26	Mortality	2.5 cm	--------	341	Mount & Stephan 1967	LR 6
Pimephales promelas	Fathead minnow	FT	Meas	95%	10mo/15-26	Spawning	2.5 cm	--------	NR	Mount & Stephan 1967	LR 6
Pimephales promelas	Fathead minnow	S	Nom	100%	24h/25	Mortality (softwater)	1.5-2.5 in., 1-2 g	26,000	--------	Pickering *et al.* 1962	LL 4,8
Pimephales promelas	Fathead minnow	S	Nom	100%	24h/25	Mortality (hardwater)	1.5-2.5 in., 1-2 g	23,000	--------	Pickering *et al.* 1962	LL 4,8

Species	**Common identifier**	**Test type**	**Meas/ Nom**	**Chemical grade**	**Duration/ temp (°C)**	**Endpoint**	**Age/ size**	**LC_{50}/ EC_{50} (µg/L)**	**MATC (µg/L)**	**Reference**	**Rating/ Reason**
Pimephales promelas	Fathead minnow	S	Nom	100%	48h/25	Mortality (softwater)	1.5-2.5 in., 1-2 g	24,000	--------	Pickering *et al.* 1962	LL 4,8
Pimephales promelas	Fathead minnow	S	Nom	100%	48h/25	Mortality (hardwater)	1.5-2.5 in., 1-2 g	18,000	--------	Pickering *et al.* 1962	LL 4,8
Pimephales promelas	Fathead minnow	S	Nom	100%	96h/25	Mortality (softwater)	1.5-2.5 in., 1-2 g	23,000	--------	Pickering *et al.* 1962	LL 4,8
Pimephales promelas	Fathead minnow	S	Nom	100%	96h/25	Mortality (hardwater)	1.5-2.5 in., 1-2 g	16,000	--------	Pickering *et al.* 1962	LL 4,8
Poecilia reticulata	Guppy	S	Nom	100%	24h/25	Mortality	0.75-1 in., 0.1-0.2 g	930	--------	Pickering *et al.* 1962	LL 4,8
Poecilia reticulata	Guppy	S	Nom	100%	24h/25	Mortality	0.75-1 in., 0.1-0.2 g	880	--------	Pickering *et al.* 1962	LL 4,8
Poecilia reticulata	Guppy	S	Nom	100%	96h/25	Mortality	0.75-1 in., 0.1-0.2 g	840	--------	Pickering *et al.* 1962	LL 4,8
Procambarus clarkii	Crayfish	S	Nom	NR	96h/19	Mortality	15-38 g	No adverse effects	--------	Andreu-Moliner *et al.* 1986	LL 1,6,7
Pteronarcella badia	Stonefly	S	Nom	Technical	96h/15.5	Mortality	20-25mm	24hr LC50 - 10 (6.7-15)	--------	Sanders and Cope 1968	LL 4,9
Pteronarcella badia	Stonefly	S	Nom	Technical	96h/15.5	Mortality	20-25mm	48hr LC50 - 6 (4.1-8.7)	--------	Sanders and Cope 1968	LL 4,9
Pteronarcella badia	Stonefly	S	Nom	Technical	96h/15.5	Mortality	20-25mm	96hr LC50 - 1.1 (0.78-1.5)	--------	Sanders and Cope 1968	LL 4,9
Pteronarcella sp.	Insect	S	NR	95%	96h/15	Mortality	Naiad	1.1 (0.8-1.5)	--------	Johnson & Finley 1980	LL 4,7
Pteronarcys californica	Stonefly	FT	Nom	95%	30d/12.8	Mortality	Naiads	--------	4.5	Jensen & Gaufin 1964b	LR 6
Pteronarcys californica	Stonefly	S	Nom	Technical	96h/15.5	Mortality	30-35mm	24hr LC50 - 35 (23-54)	--------	Sanders and Cope 1968	LL 4,9
Pteronarcys californica	Stonefly	S	Nom	Technical	96h/15.5	Mortality	30-35mm	48hr LC50 - 20 (15-27)	--------	Sanders and Cope 1968	LL 4,9
Pteronarcys californica	Stonefly	S	Nom	Technical	96h/15.5	Mortality	30-35mm	96hr LC50 - 10 (7-13)	--------	Sanders and Cope 1968	LL 4,9

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Pteronarcys sp.	Insect	S	NR	95%	96h/15	Mortality	Second year class	10 (7.0-13)	--------	Johnson & Finley 1980	LL 4,7
Rana catesbeiana	Bullfrog	SR	Nom	50%	16d/21.2-21.5	Mortality	tadpole (stage 25)	1500	--------	Relyea 2004	LL 1,4
Rana catesbeiana	Bullfrog	SR	Nom	96.0%	28d/22-25	Loss of equilibrium	Tadpoles (stage 26)	----------	LOEC 500	Fordham et al 2001	LL 6
Rana clamitans	Green frog	SR	Nom	50%	16d/21.2-21.4	Mortality	tadpole (stage 25)	3700	--------	Relyea 2004	LL 1,4
Rana pipiens	Leopard frog	SR	Nom	50%	16d/18.6-18.7	Mortality	tadpole (stage 25)	2400	--------	Relyea 2004	LL 1,4
Rana sylvatica	Wood frog	SR	Nom	50%	16d/18.7-19	Mortality	tadpole (stage 25)	1300	--------	Relyea 2004	LL 1,4
Salmo gairdneri	Rainbow trout	S	Nom	95%	96h/12.7	Mortality	63.7mm, 2.28g	24hr LC50 - 59	--------	Ludman 1969	LL 7,8
Salmo gairdneri	Rainbow trout	S	Nom	95%	96h/12.7	Mortality	63.7mm, 2.28g	48hr LC50 - 42	--------	Ludman 1969	LL 7,8
Salmo gairdneri	Rainbow trout	S	Nom	95%	96h/12.7	Mortality	63.7mm, 2.28g	96hr LC50 - 34	--------	Ludman 1969	LL 7,8
Salmo trutta	Brown trout	S	NR	95%	96h/12	Mortality	1.1 g	101 (84-115)	--------	Johnson & Finley 1980	LL 4,7
Salmo trutta	Brown trout	S	Nom	95%	96h/13	Mortality	0.6-1.7 g	200 (160-240)	--------	Macek & McAllister 1970	LL 4,7
Salvelinus namaycush	Lake trout	S	NR	95%	96h/12	Mortality	0.3 g	76 (47-123)	--------	Johnson & Finley 1980	LL 4,7
Simocephalus spp.	Cladoceran	S	NR	95%	48h/15	Immobility/ Mortality	1st instar	3.5 (2.6-4.8)	--------	Johnson & Finley 1980	LL 4,7
Simocephalus vetulus	Cladoceran	S	Nom	Technical	48h/23.5	Mortality	≤ 24 h	2.9 (2.4-3.6)	--------	Olvera-Hernandez *et al.* 2004	LL 4,7
Tigriopus brevicornis	Copepod	S	NR	99.9%	96h/20	Mortality	Nauplii	7.2 (5.2-9.2)	--------	Forget et al 1998	LL 4,5
Tigriopus brevicornis	Copepod	S	NR	99.9%	96h/20	Mortality	Copepodid	20.5 (18.5-22.5)	--------	Forget et al 1998	LL 4,5

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Tigriopus brevicornis	Copepod	S	NR	99.9%	96h/20	Mortality	Ovigerous female	24.3 (22.3-26.3)	--------	Forget et al 1998	LL 4,5
Wyeomyia smithii	Mosquito	S	Nom	> 92%	96h/27	Mortality	2nd instar	50-100	--------	Strickman 1985	LL 6,7
Xenopus laevis	African clawed frog	S	Nom	90%	96h/23	Mortality	Tadpole	10,900 (10,600-11,300)	--------	Snawder & Chambers 1989	LL 4,7
Xenopus laevis	African clawed frog	S	Nom	90%	96h/23	Notochordal defect	Eggs	2,160 (2030-2310)	--------	Snawder & Chambers 1989	LL 4,7
Xenopus laevis	African clawed frog	S	Nom	90%	96h/23	Length	Eggs	--------	LOEC: 100 ug/L	Snawder & Chambers 1989	LL 6,7
Xenopus laevis	African clawed frog	S	Nom	95%	96h/23	Notochord Index	Eggs	--------	LOEC: 990 ug/L	Snawder & Chambers 1993	LL 2,6,7

NR = Not reported, S = Static, SR = Static renewal, FT = Flow-through

1. Chemical grade
2. Endpoint not linked to population effects
3. Family not in N. America
4. Control response
5. Not freshwater
6. No toxicity value calculated
7. Low reliability score
8. Control not described
9. No standard method

Table 9. Acceptable multispecies field, semi-field, laboratory, microcosm, and mesocosm studies. R = reliable; L = less reliable.

Reference	Habitat	Rating
Relyea 2005	Laboratory microcosm	L
Kennedy and Walsh 1970	Outdoor pond	R

Table 10. Measured LC_{50} values for threatened or endangered species in the data set.

Species	Common Name	Family	LC_{50} (µg/L)
Oncorhynchus mykiss	Rainbow trout	Salmonidae	122
Oncorhynchus kisutch	Coho salmon	Salmonidae	130
Oncorhynchus clarki	Cutthroat trout	Salmonidae	150
Gila elegans	Bonytail	Cyprinidae	15300
Ptychocheilus lucius	Colorado squawfish	Cyprinidae	9140