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DRAFT

Supporting Information for Comparison of OPP Aquatic Life Benchmarks, OW Aquatic Life Criteria and Alternative Criteria-Related Approaches When Data are Insufficient to Develop Aquatic Life Criteria

Data supporting the analyses in
Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)

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U.S. Environmental Protection Agency
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Table of Contents

1 INSECTICIDES

1.1 DATA-RICH PESTICIDES

1.1.1 Comparison of Aquatic Life Toxicity Values for Carbaryl: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S.EPA 2024) for carbaryl were obtained from Appendix A of the 2012 carbaryl criteria document, supplemented with additional data reported in Table L-6 of U.S. EPA (2007), the OPP pesticide effects determination document that served as the basis for the invertebrate OPP benchmark concentration.

1.1.1.1 Carbaryl Acute Toxicity Data

The EPA obtained acute data from the carbaryl Aquatic Life Criteria (ALC; 2012) and the OPP pesticide effects determination value document (2007) (See Table 1). Table L-6 of Appendix L in U.S. EPA (2007) included three LC_{50}s that were not included in Appendix A of the 2012 carbaryl ALC. These were an LC_{50} of 26 µg/L for *Gammarus fasciatus*, an LC_{50} of 8 µg/L for *Gammarus pseudolimnaeus*, and an LC_{50} of 1,900 µg/L for *Procambarus sp*. All three of these LC_{50}s were reported in Mayer and Ellersieck (1986). The *G. fasciatus* LC_{50} was not included in Appendix A of the carbaryl ALC (U.S. EPA 2012) because the test chemical included excessive solvent. The *G. pseudolimnaeus* LC_{50} was not included in Appendix A because it was a 48-hour test, not the recommended 96-hour duration of a test for this species. The *Procambarus sp.* LC_{50} test was not used because no species was reported, and a more sensitive LC_{50} of 1,000 µg/L was available for the clearly specified *P. clarkii*.

The most sensitive species according to Table L-6 of U.S. EPA (2007) of the OPP pesticide effects determination was the stonefly *Pteronarcella badia*, with an LC_{50} of 1.7 µg/L. An LC_{50} of 1.7 µg/L for *P. badia* is reported in Mayer and Ellersieck (1986) and is the most sensitive value in U.S. EPA (2007). This is one of four LC_{50}s used to generate the *P. badia* Species Mean Acute Value (SMAV) of 9.163 µg/L in the 2012 carbaryl ALC.

The final dataset consists of 61 SMAVs and 47 Genus Mean Acute Values (GMAVs), including 26 invertebrate species representing 20 invertebrate genera. Ranked SMAVs and GMAVs for all invertebrates included in this analysis are listed in Table 2 below.

Table 1. Acute toxicity data of carbaryl to freshwater aquatic organisms.
(MDR specifies OW minimum data requirements under the Guidelines.)

OW MDR Group[a]	Species	LC50/EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
H	Oligochaete worm, Lumbriculus variegatus	8,200	8,200	8,200	Bailey and Liu 1980
G	Snail (adult), Aplexa hypnorum	>27,000	>27,000	>27,00	Phipps and Holcombe 1985
G	Mussel (juvenile; 1-2 d), Anodonta imbecillis	23,700	24,632	24,632	Johnson et al. 1993
G	Mussel (juvenile; 7-10 d), Anodonta imbecillis	25,600			Johnson et al. 1993
D	Cladoceran (<24 hr), Ceriodaphnia dubia	3.06	5.958	5.958	Brooke 1990; 1991
D	Cladoceran (<12 hr), Ceriodaphnia dubia	11.6			Oris et al. 1991
D	Cladoceran (adult; 2-2.5 mm), Daphnia carinata	35	35	18.80	Santharam et al. 1976
D	Cladoceran (5 d), Daphnia magna	7.2	29.658		Lakota et al. 1981
D	Cladoceran (<24 hr), Daphnia magna	1,900			Johnson et al. 1993
D	Cladoceran (<24 hr), Daphnia magna	5.6			Sanders et al. 1983
D	Cladoceran (<24 hr), Daphnia magna	10.1			Brooke 1991
D	Cladoceran (<24 hr), Daphnia pulex	6.4	6.4		Sanders and Cope 1966
D	Cladoceran (<24 hr), Simocephalus serrulatus	11	8.781	8.781	Mayer and Ellersieck 1986
D	Cladoceran (<24 hr), Simocephalus serrulatus	8.1			Mayer and Ellersieck 1986
D	Cladoceran (<24 hr), Simocephalus serrulatus	7.6			Sanders and Cope 1966
E	Mysid, Mysis relicta	230	230	230	Landrum and Dupuis 1990
E	Aquatic sowbug (mature), Asellus brevicaudus	280	280	280	Johnson and Finley 1980; Mayer and Ellersieck 1986
E	Amphipod (2 mo), Gammarus lacustris	16	18.76	16.76	Sanders 1969
E	Amphipod (mature), Gammarus lacustris	22			Johnson and Finley 1980; Mayer and Ellersieck 1986
E	Amphipod, Gammarus fasciatus	26	26		MRID 40098001; Mayer and Ellersieck 1986
E	Amphipod, Gammarus pseudolimnaeus	8	9.65		MRID 40098001; Mayer and Ellersieck 1986
E	Amphipod, Gammarus pseudolimnaeus	13			Woodward and Mauck 1980
E	Amphipod (mature), Gammarus pseudolimnaeus	7			Woodward and Mauck 1980
E	Amphipod (mature), Gammarus pseudolimnaeus	7.2			Woodward and Mauck 1980

OW MDR Group[a]	Species	LC50/EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
E	Amphipod (mature), Gammarus pseudolimnaeus	16			Sanders et al. 1983
E	Amphipod (14 d), Hyalella azteca	15.2	15.2	15.2	McNulty et al. 1999
E	Amphipod, Pontoporeia hoyi	250	250	250	Landrum and Dupuis 1990
E	Crayfish (3-4 cm), Cambarus bartoni	839.6	839.6	839.6	Simon 1982
E	Crayfish (3.9 g), Orconectes immunis	2,870	2,870	2,462	Phipps and Holcombe 1985
E	Crayfish (5-8 cm; males), Orconectes virilis	2,112	2,112		Simon 1982
E	Crayfish (15-38 g), Procambarus clarkii	1,000	1,000	1,378	Andreu-Moliner et al. 1986
E	Crayfish, Procambarus sp.	1,900	1,900		MRID 40098001; Mayer and Ellersieck 1986
F	Stonefly (nymph), Claassenia sabulosa	5.6	5.6	5.6	Sanders and Cope 1968
F	Stonefly (1st yr class), Isogenus sp.	2.8	3.175	3.175	Mayer and Ellersieck 1986
F	Stonefly (1st yr class), Isogenus sp.	3.6			Mayer and Ellersieck 1986
F	Stonefly (1st yr class; 15-20 mm), Pteronarcella badia	1.7	9.163	9.163	Sanders and Cope 1968
F	Stonefly (1st yr class), Pteronarcella badia	11			Woodward and Mauck 1980; Mayer and Ellersieck 1986
F	Stonefly (1st yr class), Pteronarcella badia	13			Woodward and Mauck 1980; Mayer and Ellersieck 1986
F	Stonefly (1st yr class), Pteronarcella badia	29			Woodward and Mauck 1980; Mayer and Ellersieck 1986
F	Stonefly (1st yr class), Pteronarcys californica	4.8	4.8	4.8	Sanders and Cope 1968
F	Stonefly (naiad), Skwala sp.	3.6	3.6	3.6	Johnson and Finley 1980
F	Backswimmer (adult), Notonecta undulata	200	200	200	Federle and Collins 1976
A	Apache trout (0.38-0.85 g), Oncorhynchus apache	1,540	1,540	1,994	Dwyer et al. 1995
A	Coho salmon (2.7-4.1 g), Oncorhynchus kisutch	997	1,654		Katz 1961
A	Coho salmon, Oncorhynchus kisutch	764			Macek and McAllister 1970
A	Coho salmon (1.50 g), Oncorhynchus kisutch	1,300			Post and Schroeder 1971
A	Coho salmon (1.0 g), Oncorhynchus kisutch	4,340			Johnson and Finley 1980; Mayer and Ellersieck 1986
A	Coho salmon (10.10 g), Oncorhynchus kisutch	2,700			Mayer and Ellersieck 1986
A	Coho salmon (19.1 g), Oncorhynchus kisutch	1,150			Mayer and Ellersieck 1986

OW MDR Group[a]	Species	LC50/EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
A	Coho salmon (4.6 g), Oncorhynchus kisutch	2,400			Mayer and Ellersieck 1986
A	Coho salmon (5.1g), Oncorhynchus kisutch	1,750			Mayer and Ellersieck 1986
A	Chinook salmon (fingerling), Oncorhynchus tshawytscha	2,400	2,541		Johnson and Finley 1980; Mayer and Ellersieck 1986
A	Chinook salmon (3.0 g), Oncorhynchus tshawytscha	2,690			Phipps and Holcombe 1985; 1990
A	Cutthroat trout (0.37 g), Oncorhynchus clarkii	1,500	3,300		Post and Schroeder 1971
A	Cutthroat trout (1.30 g), Oncorhynchus clarkii	2,169			Post and Schroeder 1971
A	Cutthroat trout (0.5 g), Oncorhynchus clarkii	7,100			Johnson and Finley 1980; Mayer and Ellersieck 1986
A	Cutthroat trout (0.6 g), Oncorhynchus clarkii	6,000			Woodward and Mauck 1980; Mayer and Ellersieck 1986
A	Cutthroat trout (0.7 g), Oncorhynchus clarkii	5,000			Woodward and Mauck 1980; Mayer and Ellersieck 1986
A	Cutthroat trout (0.6 g), Oncorhynchus clarkii	970			Woodward and Mauck 1980; Mayer and Ellersieck 1986
A	Cutthroat trout (0.5 g), Oncorhynchus clarkii	3,950			Woodward and Mauck 1980; Mayer and Ellersieck 1986
A	Cutthroat trout (0.5 g), Oncorhynchus clarkii	6,800			Mayer and Ellersieck 1986
A	Cutthroat trout (0.9 g), Oncorhynchus clarkii	6,700			Mayer and Ellersieck 1986
A	Cutthroat trout, Oncorhynchus clarkii	3,950			Woodward and Mauck 1980
A	Greenback cutthroat trout (0.31 g), Oncorhynchus clarkii stomias	1,550			Dwyer et al. 1995
A	Lahontan cutthroat trout (0.34-0.57 g), Oncorhynchus clarkii henshawi	2,250			Dwyer et al. 1995
A	Rainbow trout (3.2 g), Oncorhynchus mykiss	1,350	1,476		Katz 1961
A	Rainbow trout, Oncorhynchus mykiss	4,340			Macek and McAllister 1970
A	Rainbow trout (1.24 g), Oncorhynchus mykiss	1,470			Post and Schroeder 1971
A	Rainbow trout (1.5 g), Oncorhynchus mykiss	1,950			Johnson and Finley 1980; Mayer and Ellersieck 1986;
A	Rainbow trout, Oncorhynchus mykiss	2,200			Sanders et al. 1983
A	Rainbow trout, Oncorhynchus mykiss	2,800			Sanders et al. 1983
A	Rainbow trout, Oncorhynchus mykiss	1,100			Sanders et al. 1983
A	Rainbow trout, Oncorhynchus mykiss	800			Sanders et al. 1983
A	Rainbow trout, Oncorhynchus mykiss	1,500			Sanders et al. 1983

OW MDR Group[a]	Species	LC50/EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
A	Rainbow trout, Oncorhynchus mykiss	900			Sanders et al. 1983
A	Rainbow trout, Oncorhynchus mykiss	800			Sanders et al. 1983
A	Rainbow trout (1.0 g), Oncorhynchus mykiss	935			Marking et al. 1984
A	Rainbow trout (1.0 g), Oncorhynchus mykiss	1,000			Marking et al. 1984
A	Rainbow trout (1.0 g), Oncorhynchus mykiss	1,400			Marking et al. 1984
A	Rainbow trout (1.0 g), Oncorhynchus mykiss	1,000			Marking et al. 1984
A	Rainbow trout (1.0 g), Oncorhynchus mykiss	1,740			Marking et al. 1984
A	Rainbow trout (juvenile), Oncorhynchus mykiss	4,835			Douglas et al. 1986
A	Rainbow trout (1.5 g), Oncorhynchus mykiss	1,200			Mayer and Ellersieck 1986
A	Rainbow trout (0.8 g), Oncorhynchus mykiss	1,360			Mayer and Ellersieck 1986
A	Rainbow trout (0.8 g), Oncorhynchus mykiss	2,080			Mayer and Ellersieck 1986
A	Rainbow trout (1.1 g), Oncorhynchus mykiss	1,900			Mayer and Ellersieck 1986
A	Rainbow trout (1.1 g), Oncorhynchus mykiss	2,300			Mayer and Ellersieck 1986
A	Rainbow trout (0.5 g), Oncorhynchus mykiss	1,330			Mayer and Ellersieck 1986
A	Rainbow trout (0.8 g), Oncorhynchus mykiss	<750			Mayer and Ellersieck 1986
A	Rainbow trout (1.1 g), Oncorhynchus mykiss	<320			Mayer and Ellersieck 1986
A	Rainbow trout (1.2 g), Oncorhynchus mykiss	1,090			Mayer and Ellersieck 1986
A	Rainbow trout (1.1 g), Oncorhynchus mykiss	1,460			Mayer and Ellersieck 1986
A	Rainbow trout (1.2 g), Oncorhynchus mykiss	3,500			Mayer and Ellersieck 1986
A	Rainbow trout (1.2 g), Oncorhynchus mykiss	3,000			Mayer and Ellersieck 1986
A	Rainbow trout (1.0 g), Oncorhynchus mykiss	1,600			Mayer and Ellersieck 1986
A	Rainbow trout (1.0 g), Oncorhynchus mykiss	1,100			Mayer and Ellersieck 1986
A	Rainbow trout (1.0 g), Oncorhynchus mykiss	1,200			Mayer and Ellersieck 1986
A	Rainbow trout (1.0 g), Oncorhynchus mykiss	780			Mayer and Ellersieck 1986
A	Rainbow trout (1.0 g), Oncorhynchus mykiss	1,450			Mayer and Ellersieck 1986

OW MDR Group[a]	Species	LC50/EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
A	Rainbow trout (0.48-1.25 g), Oncorhynchus mykiss	1,880			Dwyer et al. 1995
A	Rainbow trout (juvenile; 2.7 g), Oncorhynchus mykiss	5,400			Ferrari et al. 2004
A	Rainbow trout (19.7 g), Oncorhynchus mykiss	860			Phipps and Holcombe 1985
A	Atlantic salmon (0.4 g), Salmo salar	4,500	1,119	1,510	Mayer and Ellersieck 1986
A	Atlantic salmon (0.8 g), Salmo salar	2,070			Mayer and Ellersieck 1986
A	Atlantic salmon (0.8 g), Salmo salar	1,180			Mayer and Ellersieck 1986
A	Atlantic salmon (0.4 g), Salmo salar	905			Mayer and Ellersieck 1986
A	Atlantic salmon (0.8 g), Salmo salar	2,010			Mayer and Ellersieck 1986
A	Atlantic salmon (0.8 g), Salmo salar	1,430			Mayer and Ellersieck 1986
A	Atlantic salmon (0.2 g), Salmo salar	500			Mayer and Ellersieck 1986
A	Atlantic salmon (0.2 g), Salmo salar	1,000			Mayer and Ellersieck 1986
A	Atlantic salmon (0.2 g), Salmo salar	1,150			Mayer and Ellersieck 1986
A	Atlantic salmon (0.2 g), Salmo salar	1,100			Mayer and Ellersieck 1986
A	Atlantic salmon (0.2 g), Salmo salar	1,350			Mayer and Ellersieck 1986
A	Atlantic salmon (0.2 g), Salmo salar	220			Mayer and Ellersieck 1986
A	Atlantic salmon (0.2 g), Salmo salar	900			Mayer and Ellersieck 1986
A	Atlantic salmon (0.2 g), Salmo salar	1,000			Mayer and Ellersieck 1986
A	Brown trout, Salmo trutta	1,950	2,036		Macek and McAllister 1970
A	Brown trout (0.6 g), Salmo trutta	6,300			Johnson and Finley 1980; Mayer and Ellersieck 1986
A	Brown trout (fingerling), Salmo trutta	2,000			Mayer and Ellersieck 1986
A	Brown trout (fry), Salmo trutta	700			Lakota et al. 1981
A	Brook trout (1.15 g), Salvelinus fontinalis	1,070	1,629	1,269	Post and Schroeder 1971
A	Brook trout (2.04 g), Salvelinus fontinalis	1,450			Post and Schroeder 1971
A	Brook trout (1.0 g), Salvelinus fontinalis	680			Mayer and Ellersieck 1986
A	Brook trout (0.7 g), Salvelinus fontinalis	4,560			Mayer and Ellersieck 1986

OW MDR Group[a]	Species	LC50/EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
A	Brook trout (0.7 g), Salvelinus fontinalis	2,130			Mayer and Ellersieck 1986
A	Brook trout (0.7 g), Salvelinus fontinalis	1,130			Mayer and Ellersieck 1986
A	Brook trout (0.8 g), Salvelinus fontinalis	1,200			Mayer and Ellersieck 1986
A	Brook trout (0.8 g), Salvelinus fontinalis	1,290			Mayer and Ellersieck 1986
A	Brook trout (1.3 g), Salvelinus fontinalis	4,500			Mayer and Ellersieck 1986
A	Lake trout (1.7 g), Salvelinus namaycush	690			Johnson and Finley 1980; Mayer and Ellersieck 1986
A	Lake trout (1.7 g), Salvelinus namaycush	740			Mayer and Ellersieck 1986
A	Lake trout (1.7 g), Salvelinus namaycush	920	988.1		Mayer and Ellersieck 1986
A	Lake trout (0.5 g), Salvelinus namaycush	872			Mayer and Ellersieck 1986
A	Lake trout (2.6 g), Salvelinus namaycush	2,300			Mayer and Ellersieck 1986
B	Goldfish (0.9 g), Carassius auratus	13,200			Macek and McAllister 1970
B	Goldfish (0.9 g), Carassius auratus	12,800	14,907	14,907	Mayer and Ellersieck 1986
B	Goldfish (juvenile; 1.3-3.3 g), Carassius auratus	17,500			Pfeiffer et al. 1997
B	Goldfish (14.2 g), Carassius auratus	16,700			Phipps and Holcombe 1985
B	Common carp (0.6 g), Cyprinus carpio	5,280			Macek and McAllister 1970
B	Common carp (0.38 g), Cyprinus carpio	1,700	4,153	4,153	Chin and Sudderuddin 1979
B	Common carp (fry), Cyprinus carpio	4,220			Lakota et al. 1981
B	Common carp (20-34 mm), Cyprinus carpio	7,850			de Mel and Pathiratne 2005
B	European chub (12.43 cm; 18.14 g), Leuciscus cephalus	8,656	8,656	8,656	Verep 2006
B	Fathead minnow (0.5 g), Pimephales promelas	14,000			Mayer and Ellersieck 1986
B	Fathead minnow (0.8 g), Pimephales promelas	14,600			Macek and McAllister 1970; Sanders et al. 1983
B	Fathead minnow (0.8 g), Pimephales promelas	7,700	7,367	7,367	Mayer and Ellersieck 1986
B	Fathead minnow (larvae), Pimephales promelas	>1,600			Norberg-King 1989
B	Fathead minnow (0.32-0.56 g), Pimephales promelas	5,210			Dwyer et al. 1995
B	Fathead minnow (2 mo), Pimephales promelas	9,000			Carlson 1971

OW MDR Group[a]	Species	LC50/EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
B	Fathead minnow (0.3 g), Pimephales promelas	5,010			Phipps and Holcombe 1985
B	Fathead minnow (28 d), Pimephales promelas	8,930			Geiger et al. 1985; 1988
B	Fathead minnow (28 d), Pimephales promelas	10,400			Geiger et al. 1985; 1988
B	Fathead minnow (29 d), Pimephales promelas	6,670			Geiger et al. 1985; 1988
B	Fathead minnow (31 d), Pimephales promelas	9,470			Geiger et al. 1985; 1988
B	Bonytail chub (0.29-0.52 g), Gila elegans	3,490	2,655	2,655	Dwyer et al. 1995
B	Bonytail chub (6 d), Gila elegans	2,020			Beyers et al. 1994
B	Colorado pikeminnow (0.32-0.34 g), Ptychochelius lucius	3,070	2,005	2,005	Dwyer et al. 1995
B	Colorado pikeminnow (26 d), Ptychochelius lucius	1,310			Beyers et al. 1994
B	Razorback sucker (0.31-0.32 g), Xyrauchen texanus	4,350	4,350	4,350	Dwyer et al. 1995
B	Black bullhead (1.2 g), Ameiurus melas	20,000	20,000	20,000	Macek and McAllister 1970
B	Channel catfish (1.5 g), Ictalurus punctatus	15,800	8,075	8,075	Macek and McAllister 1970
B	Channel catfish (0.3 g), Ictalurus punctatus	1,300			Brown et al. 1979
B	Channel catfish (1.5 g), Ictalurus punctatus	7,790			Mayer and Ellersieck 1986
B	Channel catfish (fingerling), Ictalurus punctatus	17,300			Mayer and Ellersieck 1986
B	Channel catfish (27.6 g), Ictalurus punctatus	12,400			Phipps and Holcombe 1985
B	Walking catfish (17-18 cm; 60-70 g), Clarias batrachus	46,850	27,609	27,609	Tripathi and Shukla 1988
B	Walking catfish (14 cm; 25 g), Clarias batrachus	16,270			Lata et al. 2001
B	Guppy (2.0 cm), Poecilia reticulata	2,515	2,515	2,515	Gallo et al. 1995
B	Gila topminnow (219 mg), Poeciliopsis occidentalis	>3,000	>3,000	>3,000	Dwyer et al. 1999b
B	Striped bass (56 d), Morone saxatilis	760	1,322	1,322	Palawski et al. 1985
B	Striped bass, Morone saxatilis	2,300			Palawski et al. 1985
B	Green sunfish (1.1 g), Lepomis cyanellus	9,460	9,460	9,460	Mayer and Ellersieck 1986
B	Redear sunfish (1.1 g), Lepomis microlophus	11,200	11,200	7,920	Macek and McAllister 1970

OW MDR Group[a]	Species	LC50/EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
B	Bluegill, Lepomis macrochirus	14,000			McCann and Young 1969
B	Bluegill (1.2 g), Lepomis macrochirus	6,760			Macek and McAllister 1970
B	Bluegill, Lepomis macrochirus	16,000			Sanders et al. 1983
B	Bluegill, Lepomis macrochirus	8,200			Sanders et al. 1983
B	Bluegill, Lepomis macrochirus	5,400			Sanders et al. 1983
B	Bluegill, Lepomis macrochirus	5,200			Sanders et al. 1983
B	Bluegill, Lepomis macrochirus	1,800			Sanders et al. 1983
B	Bluegill, Lepomis macrochirus	2,200			Sanders et al. 1983
B	Bluegill, Lepomis macrochirus	1,000			Sanders et al. 1983
B	Bluegill (1.2 g), Lepomis macrochirus	5,230			Mayer and Ellersieck 1986
B	Bluegill (0.6 g), Lepomis macrochirus	5,047			Mayer and Ellersieck 1986
B	Bluegill (0.4 g), Lepomis macrochirus	7,400	5,261		Mayer and Ellersieck 1986
B	Bluegill (0.4 g), Lepomis macrochirus	5,200			Mayer and Ellersieck 1986
B	Bluegill (0.8 g), Lepomis macrochirus	16,000			Mayer and Ellersieck 1986
B	Bluegill (0.8 g), Lepomis macrochirus	7,000			Sanders et al. 1983; Mayer and Ellersieck 1986
B	Bluegill (0.8 g), Lepomis macrochirus	8,200			Mayer and Ellersieck 1986
B	Bluegill (0.4 g), Lepomis macrochirus	6,200			Mayer and Ellersieck 1986
B	Bluegill (0.7 g), Lepomis macrochirus	5,400			Mayer and Ellersieck 1986
B	Bluegill (0.7 g), Lepomis macrochirus	5,200			Mayer and Ellersieck 1986
B	Bluegill (0.7 g), Lepomis macrochirus	1,800			Mayer and Ellersieck 1986
B	Bluegill (0.7 g), Lepomis macrochirus	2,600			Mayer and Ellersieck 1986
B	Bluegill (0.5 g), Lepomis macrochirus	6,970			Phipps and Holcombe 1985
B	Largemouth bass (0.9 g), Micropterus salmoides	6,400	6,400	6,400	Macek and McAllister 1970
B	Black crappie (1.0 g), Pomoxis nigromaculatus	2,600	2,600	2,600	Johnson and Finley 1980; Mayer and Ellersieck 1986;
B	Greenthroat darter (133 mg), Etheostoma lepidum	2,140	2,140	2,079	Dwyer et al. 1999b

OW MDR Group[a]	Species	LC50/EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
B	Fountain darter (62 mg), Etheostoma fonticola	2,020	2,020		Dwyer et al. 2005
B	Yellow perch (1.4 g), Perca flavescens	745	2,480	2,480	Macek and McAllister 1970
B	Yellow perch (0.6 g), Perca flavescens	5,100			Johnson and Finley 1980; Mayer and Ellersieck 1986
B	Yellow perch (1.0 g), Perca flavescens	13,900			Mayer and Ellersieck 1986
B	Yellow perch (1.0 g), Perca flavescens	5,400			Mayer and Ellersieck 1986
B	Yellow perch (1.0 g), Perca flavescens	3,400			Mayer and Ellersieck 1986
B	Yellow perch (1.0 g), Perca flavescens	1,200			Mayer and Ellersieck 1986
B	Yellow perch (0.9 g), Perca flavescens	4,000			Mayer and Ellersieck 1986
B	Yellow perch (0.9 g), Perca flavescens	4,200			Mayer and Ellersieck 1986
B	Yellow perch (0.9 g), Perca flavescens	480			Mayer and Ellersieck 1986
B	Yellow perch (0.9 g), Perca flavescens	350			Mayer and Ellersieck 1986
B	Yellow perch (1.0 g), Perca flavescens	3,800			Mayer and Ellersieck 1986
B	Yellow perch (1.0 g), Perca flavescens	5,000			Mayer and Ellersieck 1986
B	Yellow perch (1.0 g), Perca flavescens	3,750			Mayer and Ellersieck 1986
B	Yellow perch (fingerling), Perca flavescens	1,420			Mayer and Ellersieck 1986
B	Shortnosed sturgeon, Acipenser brevirostrum	1,810	1,810	1,810	Dwyer et al. 2000
B	Nile tilapia (45-55 mm; 3.17 g), Oreochromis niloticus	2,930	2,930	2,930	dela Cruz and Cagauan 1981
C	Green frog (Gosner stage 25 tadpole), Rana clamitans	22,020	16,296	16,296	Boone and Bridges 1999
C	Green frog (Gosner stage 25 tadpole), Rana clamitans	17,360			Boone and Bridges 1999
C	Green frog (Gosner stage 25 tadpole), Rana clamitans	11,320			Boone and Bridges 1999
C	Boreal toad (200 mg), Bufo boreas	12,310	12,310	12,310	Dwyer et al. 1999b
C	Gray tree frog (tadpole), Hyla versicolor	2,470	2,470	2,470	Zaga et al. 1998
C	African clawed frog (embryo), Xenopus laevis	15,250	5,136	5,136	Zaga et al. 1998
C	African clawed frog (tadpole), Xenopus laevis	1,730			Zaga et al. 1998

a OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark value for carbaryl is 0.85 µg/L, which is ½ the LC_{50} of 1.7 µg/L, the stonefly *Pteronarcella badia* as described above.

The OPP fish acute benchmark value is 110 µg/L, which is ½ the LC_{50} of 220 µg/L for the Atlantic salmon (*Salmo salar*).

OW Acute Criterion

The acute criterion, or CMC, for carbaryl is 2.1 µg/L (U.S. EPA 2012).

Genus-Level Invertebrate-Only HC_{05}

The invertebrate acute HC_{05} OW calculated using invertebrate genera data only is shown in Table 2. The invertebrate-only value was calculated following the U.S. EPA (1985) methodology, resulting in a value of 3.074 µg/L (Table 3).

Table 2. Carbaryl invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Aplexa	*hyonorum*	27,000	27,000	20
Anodonta	*imbecillis*	24,632	24,632	19
Lumbriculus	*variegatus*	8,200	8,200	18
Orconectes	*virilis*	2,112	2,462	17
Orconectes	*immunis*	2,870		
Procambarus	*clarkii*	1,000	1,378	16
Procambarus	*sp.*	1,900		
Cambarus	*bartoni*	839.6	840	15
Asellus	*brevicaudus*	280	280	14
Pontoporeia	*hoyi*	250	250	13
Mysis	*relicta*	230	230	12
Notonecta	*undulata*	200	200	11
Daphnia	*magna*	29.66	18.80	10
Daphnia	*pulex*	6.4		
Daphnia	*carinata*	35		
Gammarus	*pseudolimnaeus*	9.654	16.76	9
Gammarus	*lacustris*	18.76		
Gammarus	*fasciatus*	26.00		
Hyalella	*azteca*	15.2	15.2	8
Pteronarcella	*badia*	9.163	9.163	7
Simocephalus	*serrulatus*	8.781	8.781	6
Ceriodaphnia	*dubia*	5.958	5.958	5

Genus	Species	SMAV	GMAV	GMAV Rank
Claassenia	*sabulosa*	5.6	5.6	4
Pteronarcys	*californica*	4.8	4.8	3
Skwala	*sp.*	3.6	3.6	2
Isogenus	*sp.*	3.175	3.175	1

Table 3. Invertebrate-Only acute HC_{05} value calculated using the only the genus-level carbaryl invertebrate data calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
20	4	5.6	1.723	2.97	0.1905	0.4364
	3	4.8	1.569	2.46	0.1429	0.3780
	2	3.6	1.281	1.64	0.0952	0.3086
	1	3.175	1.155	1.335	0.0476	0.2182
	Sum:		5.73	8.40	0.4762	1.3412
	S^2 =	7.654				
	L =	0.504				
	A =	1.123				
	HC_{05} =	**3.074**				

Table 4. Summary and comparison of acute values for carbaryl.

Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW ALC (FAV/2) (Year published, # of genera, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)	Notes
Carbaryl	0.85 µg/L (2022; *P. badia*)	2.1 µg/L (2012, 47 genera, 0.40X)	1.54 µg/L (20 genera, 0.55X)	FIFRA ALB is based on one of four LC_{50} values used to generate the *P. badia* SMAV of 9.163 µg/L in the 2012 carbaryl ALC.

Figure 1 shows a genus-level sensitivity distribution for the carbaryl dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the CMC, invertebrate HC_{05}/2, and OPP acute benchmark values are also included.

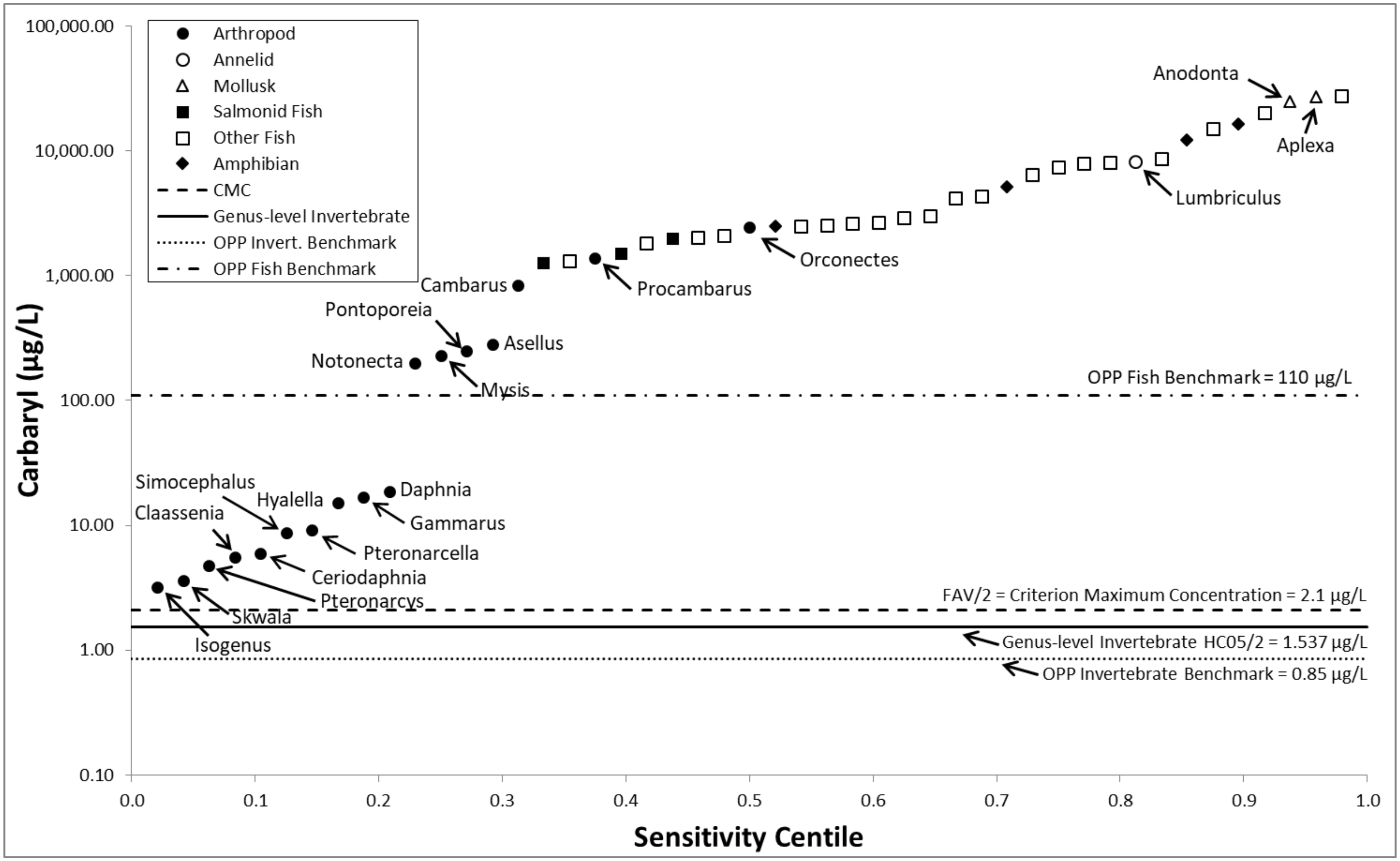

Figure 1. Carbaryl genus-level SD.
Symbols represent GMAVs calculated using all quantitative data from the aquatic life criteria document for carbaryl (U.S. EPA 2012), and additional data from the OPP benchmark document for carbaryl (U.S. EPA 2007).

1.1.1.2 Carbaryl Chronic Toxicity Data

For chemicals lacking sufficient chronic data to satisfy the minimum taxonomic data requirements, such as the pesticide carbaryl, EPA Office of Water (OW) calculates the final chronic value (FCV) as the final acute value (FAV) divided by the final acute-to chronic ratio (FACR). The Office of Pesticide Programs (OPP) will also apply Acute to Chronic Ratios (ACRs) to acute data to calculate chronic benchmarks when chronic test data are not available. Calculations of ACRs following OPP and OW methodologies were conducted, and the effects of these ACRs on the resulting OPP and OW chronic values were compared.

Chronic Data Sources

The primary data source for this analysis was the 2012 freshwater carbaryl criteria document (U.S. EPA 2012). The OPP-authored carbaryl problem formulation (U.S. EPA 2010) and California red legged frog effects determination (U.S. EPA 2007) reports were also examined. The latter reports did not include additional test data but did report test concentrations used to calculate ACRs that were used to calculate chronic benchmarks. In addition, one chronic value for *Ceriodaphnia dubia* was obtained from Oris et al. (1991) that was not included in the other data sources.

ACR Calculations

ACR calculations following OW and OPP methodologies are described below. All available chronic carbaryl data are shown in Table 5. All available acute data for species that also have chronic data are shown in Table 6. Table 7 lists all ACRs by species and calculation method.

Invertebrate ACRs

Ceriodaphnia dubia

The ACR following the OW approach is 1.328, calculated as the acute value from Oris et al. (1991) divided by the geometric mean of the MATCs from two replicate chronic tests performed in the same laboratory.

The ACR following the OPP approach is 1.609, calculated as the acute value from Oris et al. (1991) divided by the geometric mean of the NOECs from two replicate chronic tests performed in the same laboratory as per the OPP ACR guidelines (U.S. EPA 2005).

Daphnia magna

The ACR described in the 2012 ALC deviated from the conventional OW approach. Brooke (1991) conducted paired acute and chronic tests, with an EC50 of 10.1 µg/L, a NOEC of 4.04 µg/L, and a LOEC of >4.04 µg/L. Because there was no MATC, OW noted the "theoretical ACR" could fall anywhere between 1.0-2.5, and estimated the ACR as 1.581, calculated as the acute value (10.1 µg/L) divided by the geometric mean of the NOEC and the acute value (6.388 µg/L).

The ACR following the OPP approach is 2.5, calculated as the acute value from Brooke (1991) divided by the NOEC for the paired chronic test.

Americamysis bahia

The ACR following the OW approach is 0.8530, calculated as the acute value of 8.46 µg/L from Thursby and Champlin (1991) divided by the MATC of 9.918 µg/L from the paired chronic test. The ACR following the OPP approach is 1.178, calculated as the acute value of 8.46 µg/L from Thursby and Champlin (1991) divided by the No Observed Effect Concentration (NOEC) of 7.18 µg/L from the paired chronic test. As described in the carbaryl ALC document, these ACRs are treated as qualitative because control survival and number of young produced per female did not meet American Society for Testing and Materials (ASTM) test requirements (U.S. EPA 2012).

Vertebrate (Fish) ACRs

Gila elegans

An ACR for this species could not be calculated following the OW approach. Beyers et al. (1994) performed an early life stage (ELS) chronic test and a static renewal acute test. Although the acute and chronic tests were performed in the same laboratory, the Guidelines (U.S. EPA 1985) specifies that acute test data should also be from a flow through study (except for Daphnids, where static acute tests are acceptable). The ACR following the more flexible OPP approach is 3.108, calculated as the acute value of 2,020 µg/L from Beyers et al. (1994) divided by the NOEC of 650 µg/L from ELS test performed in the same laboratory.

Pimephales promelas

Two ACRs for *P. promelas* could be calculated following the OW approach. An ACR of 23.82 was calculated as the acute value of 9,000 µg/L reported in Carlson (1971) divided by the MATC of 377.9 µg/L from a paired life cycle test. An ACR of 6.256 was calculated using test data from three studies performed at the same laboratory. The geometric mean of two acute LC50s from tests performed at the same laboratory, 9,000 µg/L as reported in Carlson (1971) and 5,100 µg/L as reported in Phipps and Holcombe (1985) was divided by the MATC of 1,073 µg/L from an ELS test performed in the same laboratory (Norberg-King 1989). Because ACRs calculated from life cycle tests are preferable to those calculated from ELS test, the ACR of 23.82 is used for this species.

The corresponding *P. promelas* ACRs calculated following the OPP approach are 42.86 for the life cycle ACR and 9.326 for the ELS ACR, using the acute data described above divided by a NOEC of 210 µg/L from the life cycle test (Carlson 1971), and a NOEC of 720 µg/L from the ELS test (Norberg-King 1989). As described above, the life cycle ACR of 42.86 is used by OPP for this species.

Ptychocheilus lucius

An ACR for this species could not be calculated following the OW approach. Beyers et al. (1994) performed an early life stage (ELS) chronic test and a static renewal acute test. Although the acute and chronic tests were performed in the same laboratory, the Guidelines (U.S. EPA 1985) specifies that acute test data should also be from a flow through study (except for Daphnids, where static acute tests are acceptable). Also worth noting is the study authors reported that the water for the acute and chronic tests was inadvertently aged differently, with the acute tests having higher dissolved oxygen and pH, and lower hardness and alkalinity, than the chronic tests.

The ACR following the more flexible OPP approach is 2.944, calculated as the acute value of 1,310 µg/L from Beyers et al. (1994) divided by the NOEC of 445 µg/L from ELS test performed in the same laboratory. Despite the differences in water quality from the acute and chronic Beyers et al. (1994) tests, they were still treated as being more similar to one another than the other acute test for this species, which was an unmeasured static test (Dwyer et al. 1995).

Final ACRs

The final ACRs (FACRs) for the two approaches, expressed as the geometric mean of all available ACRs, is 3.684 following the OW approach, and 4.361 following the OPP approach. The OW FACR consists of ACRs for *C. dubia*, *D. magna* (using the estimated Maximum Acceptable Toxicant Concentration (MATC) following the 2012 ALC methodology), and the life cycle ACR for *P. promelas*.

The Guidelines (U.S. EPA 1985) specify that if the ACRs appear to increase or decrease as the species mean acute values (SMAVs) increase, the FACR should be calculated as the geometric mean for those species whose SMAVs are close to the final acute value (FAV).This is the case for carbaryl, and following the approach used in the 2005 ALC, the FACR is calculated as the geometric mean of the acutely sensitive invertebrate species. When limited to invertebrate species, the FACR following the OW approach is calculated as the geometric mean of the ACRs for *C. dubia* (1.328) and *D. magna* (1.581). Because the final chronic value cannot be larger than the final acute value, the calculated ACR of 1.449 is rounded up to 2. The invertebrate-only FACR following the OPP approach, but applying the Guidelines stipulation that the FACR should be calculated using species with SMAVs close to the FAV if ACRs are proportional to acute sensitivity, is the geometric mean of the ACRs for *C. dubia* (1.609) and *D. magna* (2.5), or 2.006.

The OPP FACR consists of ACRs for *C. dubia*, *D. magna*, and *P. promelas*, as well as *G. elegans*, and *P. lucius*. The *A. bahia* qualitative ACR was not included here because the chronic test did not meet ASTM test acceptability guidelines.

<u>Comparison of Freshwater Chronic Values for Carbaryl</u>

OPP Chronic Benchmarks

For carbaryl, the freshwater invertebrate chronic benchmark is 0.5 µg/L, calculated as an LC50 of 1.7 µg/L for *Pteronarcella badia* (Mayer and Ellersieck 1986) divided by the OPP-calculated ACR of 3.73 for *D. magna*.

The freshwater fish chronic benchmark is 6.8 µg/L, calculated as the LC50 of 250 µg/L for *Salmo salar* divided by the OPP-calculated ACR of 36.67 for *P. promelas*.

OW Freshwater Chronic Values – All Taxa

Final chronic concentrations following the ACR methodology are calculated by dividing the final acute value by a final ACR (FACR). For carbaryl, the FAV calculated using data from all taxa is 4.219 µg/L (U.S. EPA 2012). The final chronic value following the OW-ACR approach is 2.110 µg/L (4.219 µg/L ÷ 2), and the final chronic value following the OPP-ACR approach (with the Guidelines stipulation described above) is 2.103 µg/L (4.219 µg/L ÷ 2.006).

OW Freshwater Chronic Values – Invertebrate-Only Data

Final chronic concentrations for the invertebrate-only carbaryl dataset are calculated by dividing the final invertebrate acute value by an ACR. This dataset was comprised of acute invertebrate test data found in the 2012 ALC and Appendix L of U.S. EPA (2007). The resulting acute HC_{05} calculated from the 20 invertebrate genera using the calculated following the Guidelines (U.S. EPA 1985) methodology was 3.074 µg/L. The final invertebrate chronic value following the OW-ACR approach is 1.537 µg/L (3.074 µg/L ÷ 2), and the final chronic value following the OPP-ACR approach is 1.532 µg/L (3.074 µg/L ÷ 2.006).

Table 8 lists all chronic values calculated following the different approaches.

Table 5. Chronic test data for carbaryl.

All concentrations expressed as µg/L, values are grouped by genus.

Genus	Species	NOEC	LOEC	MATC	Reference	Test data reported in: 2012 ALC	2007 OPP	2010 OPP	Notes
Invertebrates									
Ceriodaphnia	*dubia*	8	14	10.58	Oris et al. 1991	Appendix C			
Ceriodaphnia	*dubia*	6.5	8	7.211	Oris et al. 1991	Appendix C[b]			
Daphnia	*magna*	1.5	3.3	2.225	Surprenant 1985	Appendix C	Table 21		
Daphnia	*magna*	4.04	>4.04	6.388[c]	Brooke 1991	Appendix C			
Americamysis	*bahia*	7.18	13.7	9.918	Thursby and Champlin 1991	Appendix D			Low control survival and young per female
Vertebrates									
Gila	*elegans*	650	1,240	897.8	Beyers et al. 1994	Appendix C			ELS test
Pimephales	*promelas*	210	680	377.9	Carlson 1971	Appendix C			Life cycle test
Pimephales	*promelas*	720	1,600	1,073	Norberg-King 1989	Appendix C			ELS test
Ptychocheilus	*lucius*	445	866	620.8	Beyers et al. 1994	Appendix C			ELS test

[a] – Estimated from Figure 1 of Oris et al. (1991) using WebPlotDigitizer (https://automeris.io/WebPlotDigitizer/)

[b] – Reported in Table 2 of Oris et al. (1991)

[c] – Calculated in 2012 ALC as geometric mean of NOEC and acute value

Table 6. Acute Carbaryl Test Data for Species with Chronic Data.
All concentrations expressed as µg/L.

Genus	Species	EC50 or LC50	Reference	Test data reported in:			Notes
				2012 ALC	2007 OPP	2010 OPP	
				Invertebrates			
Ceriodaphnia	*dubia*	11.6	Oris et al. 1991	Appendix A			Paired with Oris et al. 1991 chronic values
Ceriodaphnia	*dubia*	3.6	Brooke 1990, 1991	Appendix A			Not used
Daphnia	*magna*	7.2	Lakota et al. 1981	Appendix A			Not used
Daphnia	*magna*	5.6	Sanders et al. 1983	Appendix A	Table 21		Not used
Daphnia	*magna*	10.1	Brooke 1991	Appendix A			Paired with Brooke 1991 chronic values
Americamysis	*bahia*	8.46	Thursby and Champlin 1991	Appendix B			Paired with Thursby and Champlin 1991 chronic values
Americamysis	*bahia*	5.7	Lintott 1992a	Appendix B		Table 4	Not used
				Vertebrates			
Gila	*elegans*	2,020	Beyers et al. 1994	Appendix A			Paired with Beyers et al. 1994 chronic value (OPP-ACR only)
Gila	*elegans*	3,490	Dwyer et al. 1995	Appendix A			Not used
Pimephales	*promelas*	14,000	Mayer and Ellersieck 1986	Appendix A			Not used
Pimephales	*promelas*	14,600	Macek and McAllister 1970; Sanders et al. 1983	Appendix A			Not used
Pimephales	*promelas*	7,700	Mayer and Ellersieck 1986	Appendix A			Not used
Pimephales	*promelas*	>1,600	Norberg-King 1989	Appendix A			Not used
Pimephales	*promelas*	5,210	Dwyer et al. 1995	Appendix A			Not used
Pimephales	*promelas*	9,000	Carlson 1971	Appendix A			Paired with Carlson 1971 (LC-ACR) and Norberg-King 1989 (ELS ACR) chronic value
Pimephales	*promelas*	5,010	Phipps and Holcombe 1985	Appendix A			Paired with Norberg-King 1989 (ELS ACR) chronic value
Pimephales	*promelas*	9,470	Geiger et al. 1985; 1988	Appendix A			Not used
Pimephales	*promelas*	8,930	Geiger et al. 1985; 1988	Appendix A			Not used
Pimephales	*promelas*	10,400	Geiger et al. 1985; 1988	Appendix A			Not used
Pimephales	*promelas*	6,670	Geiger et al. 1985; 1988	Appendix A			Not used
Ptychocheilus	*lucius*	1,310	Beyers et al. 1994	Appendix A			Paired with Beyers et al. 1994 chronic value (OPP-ACR only)
Ptychocheilus	*lucius*	3,070	Dwyer et al. 1995	Appendix A			Not used

Table 7. ACRs by species and calculation method.

Genus	Species	ACR		Notes
		OW-ACR	OPP-ACR	
Invertebrates				
Ceriodaphnia	*dubia*	1.328	1.609	
Daphnia	*magna*	1.581	2.5	
Americamysis	*bahia*	0.8530	1.178	Qualitative ACR
Vertebrate				
Gila	*elegans*	N/A	3.108	ELS chronic test
Pimephales	*promelas*	23.82	42.86	Life cycle chronic test
Pimephales	*promelas*	6.256	9.326	ELS chronic test
Ptychocheilus	*lucius*	N/A	2.944	ELS chronic test
All Taxa[a]		3.684	4.361	
All Invertebrates (FACR)		2	2.006	OW-FACR rounded up to 2

[a] Of the two ACRs for *P. promelas*, only the life cycle test was included in this calculation.

Table 8. Summary and comparison of freshwater chronic values for carbaryl.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Most Sensitive ALB (Year published, species)	OW ALC (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)
Carbaryl	0.5 µg/L (2022; estimated NOAEC value for *Pteronarcella badia* calculated using the ACR for *Daphnia magna*)	2.1 µg/L (ALC, 0.24X)	1.54 µg/L (0.32X)

1.1.1.3 Carbaryl References

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1.1.2 Comparison of Aquatic Life Toxicity Values for Methomyl: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) are described below. Data for methomyl were gathered by OW in 2015 and combined with data from OPP's registration review document for methomyl (U.S. EPA 2010).

1.1.2.1 Methomyl Acute Toxicity Data

Acute data for methomyl were gathered by OW in 2015 and combined with data from OPP's registration review document for methomyl (U.S. EPA 2010). (See Table 1.) Methomyl data include thirty-nine acute effect LC_{50}s representing 14 species in 13 genera that were classified as "quantitative" data; and two 96-hour LC_{50}s for the species *Daphnia magna* and *Ictalurus punctatus* conducted in acute toxicity tests using a 24% formulation of methomyl that served as the basis for the invertebrate and fish freshwater acute OPP benchmarks. Additional studies using 24% and 29% methomyl formulations were included in the OPP document; however, only the two LC_{50}s noted above that served as the basis of the OPP fish and invertebrate benchmarks were added to the final dataset. The final acute methomyl dataset consisted of 41 LC_{50}s for 14 species across 13 genera, including six invertebrate species representing six genera. Ranked invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity data of methomyl to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
D	Daphnia	magna	5	11.17	11.17	Mayer and Ellersieck 1985
D	Daphnia	magna	8.8			Mayer and Ellersieck 1986
D	Daphnia	magna	31.7			Goodman 1978
F	Chironomus	plumosus	88	88	88	Mayer and Ellersieck 1986
F	Isogenus	sp	343	343	343	Mayer and Ellersieck 1986
F	Skwala	sp	34	34	34	Johnson and Finley 1980
F	Pteronarcella	badia	69	69	69	Mayer and Ellersieck 1986
E	Gammarus	pseudolimnaeus	920	920	920	Mayer and Ellersieck 1986
B	Pimephales	promelas	2,089	2,419	2,419	Geiger et al. 1988
B	Pimephales	promelas	2,800			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	1,200	896.4	896.4	Mayer and Ellersieck 1986
B	Lepomis	macrochirus	840			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	480			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	600			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	620			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	1,050			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	2,000			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	1,150			Mayer and Ellersieck 1986

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
B	Lepomis	macrochirus	860			Mayer and Ellersieck 1986
B	Micropterus	salmoides	1,250	1,250	1,250	Mayer and Ellersieck 1986
A	Oncorhynchus	clarkii	6,800	6,800	3,015	Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	1,700	1,337		Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	1,400			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	2,000			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	1,050			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	860			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	1,500			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	1,100			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	1,200			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	1,600			Mayer and Ellersieck 1986
A	Salmo	salar	1,120	939.6	939.6	Mayer and Ellersieck 1986
A	Salmo	salar	560			Mayer and Ellersieck 1986
A	Salmo	salar	700			Mayer and Ellersieck 1986
A	Salmo	salar	1,220			Mayer and Ellersieck 1986
A	Salmo	salar	1,050			Mayer and Ellersieck 1986
A	Salmo	salar	1,000			Mayer and Ellersieck 1986
A	Salmo	salar	1,150			Mayer and Ellersieck 1986
A	Salvelinus	fontinalis	2,200	1,817	1,817	Mayer and Ellersieck 1986
A	Salvelinus	fontinalis	1,500			Mayer and Ellersieck 1986
B	Ictalurus	punctatus	320	412	412	Mayer and Ellersieck 1986
B	Ictalurus	punctatus	530			Mayer and Ellersieck 1986

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark is 2.5 µg/L, which is ½ of the *D. magna* LC_{50} of 5.0 µg/L from a test conducted with a 24% formulation of methomyl (U.S. EPA 2010).

The OPP fish acute benchmark is 160 µg/L, which is ½ of the *I. punctatus* LC_{50} of 320 µg/L from a test conducted with a 24% formulation of methomyl (U.S. EPA 2010).

OW Acute Criterion

There is no acute criterion, or criterion maximum concentration (CMC), for methomyl.

An illustrative example calculated for this analysis, using all available data (Table 2) was developed.

The FAV calculated following the U.S. EPA (1985) methodology for the 13 genera in the methomyl dataset was 8.652 µg/L (Table 3).

Table 2. Methomyl SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Oncorhynchus	*clarkii*	6,800	3,015	13
Oncorhynchus	*mykiss*	1,337		
Pimephales	*promelas*	2,419	2,419	12
Salvelinus	*fontinalis*	1,817	1,817	11
Micropterus	*salmoides*	1,250	1,250	10
Salmo	*salar*	939.6	939.6	9
Gammarus	*pseudolimnaeus*	920	920	8
Lepomis	*macrochirus*	896.4	896.4	7
Ictalurus	*punctatus*	411.8	411.8	6
Isogenus	*sp*	343	343	5
Chironomus	*plumosus*	88	88	4
Pteronarcella	*badia*	69	69	3
Skwala	*sp*	34	34	2
Daphnia	*magna*	11.17	11.17	1

Table 3. Genus-level acute HC_{05} for methomyl calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	ln(GMAV)^2	P=R/(N+1)	sqrt(P)
13	4	88	4.477	20.05	0.2857	0.5345
	3	69	4.234	17.93	0.2143	0.4629
	2	34	3.526	12.44	0.1429	0.3780
	1	11.17	2.413	5.82	0.0714	0.2673
	Sum:		14.65	56.2	0.714	1.643
	S^2 =	64.73				
	L =	0.359				
	A =	2.158				
	HC_{05} =	**8.652**				

Genus-Level Invertebrate-only HC_{05}

The genus-level invertebrate acute HC_{05} calculated following the U.S. EPA (1985) methodology for the four most sensitive invertebrate genera (Table 4) in the methomyl dataset was 5.109 µg/L (Table 5). If the *D. magna* OPP benchmark value was excluded from the dataset (i.e., the value of 5.0 µg/L from a test using a 24% formulation of methomyl), the GMAV for *D. magna* would increase to 16.70 µg/L, and the genus-level invertebrate acute HC_{05} would increase to 8.310 µg/L.

Table 4. Methomyl invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Gammarus	*pseudolimnaeus*	920.0	920.0	6
Isogenus	*sp.*	343.0	343.0	5
Chironomus	*plumosus*	88.00	88.00	4
Pteronarcella	*badia*	69.00	69.00	3
Skwala	*sp.*	34.00	34.00	2
Daphnia	*magna*	11.17*	11.17	1

* The *D. magna* SMAV represents two LC_{50} values (31.7 and 8.8 µg/L, respectively) classified as quantitative, and an LC_{50} of 5.0 µg/L from a test using a 24% formulation of methomyl that is the basis of the OPP acute invertebrate benchmark.

Table 5. Genus-level invertebrate-only acute HC_{05} for methomyl calculated using the Guidelines algorithm.

N	Rank	GMAV	ln(GMAV)	$ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
6	4	88	4.477	20.05	0.5714	0.7559
	3	69	4.234	17.93	0.4286	0.6547
	2	34	3.526	12.44	0.2857	0.5345
	1	11.17	2.413	5.82	0.1429	0.3780
	Sum:		14.65	56.2	1.429	2.323
	S^2 =	32.36				
	L =	0.359				
	A =	1.631				
	HC_{05} =	**5.109**				

Note: The most sensitive GMAV for *Daphnia* includes an LC_{50} of 5.0 µg/L conducted in a test using a 24% methomyl formulation that is the basis for the OPP invertebrate acute benchmark value.

Table 6. Summary and comparison of acute values for methomyl. Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value.

Pesticide	Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW ALC (FAV/2) (Year published, # of genera, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)	Notes
Methomyl	2.5 µg/L (2010; *Daphnia magna*)	4.326 µg/L (illustrative example calculated for this analysis, 8 genera, 0.58X)	2.55 µg/L (6 genera, 0.98X)	The FIFRA ALB of 2.5 µg/L was calculated as half the LC_{50} from a water flea (*D. magna*) test conducted with 24% pure methomyl (Mayer and Ellersieck 1986).

Figure 1 shows a genus-level sensitivity distribution for the methomyl dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values, the illustrative ALC example, and invertebrate-only acute HC_{05}/2 are included.

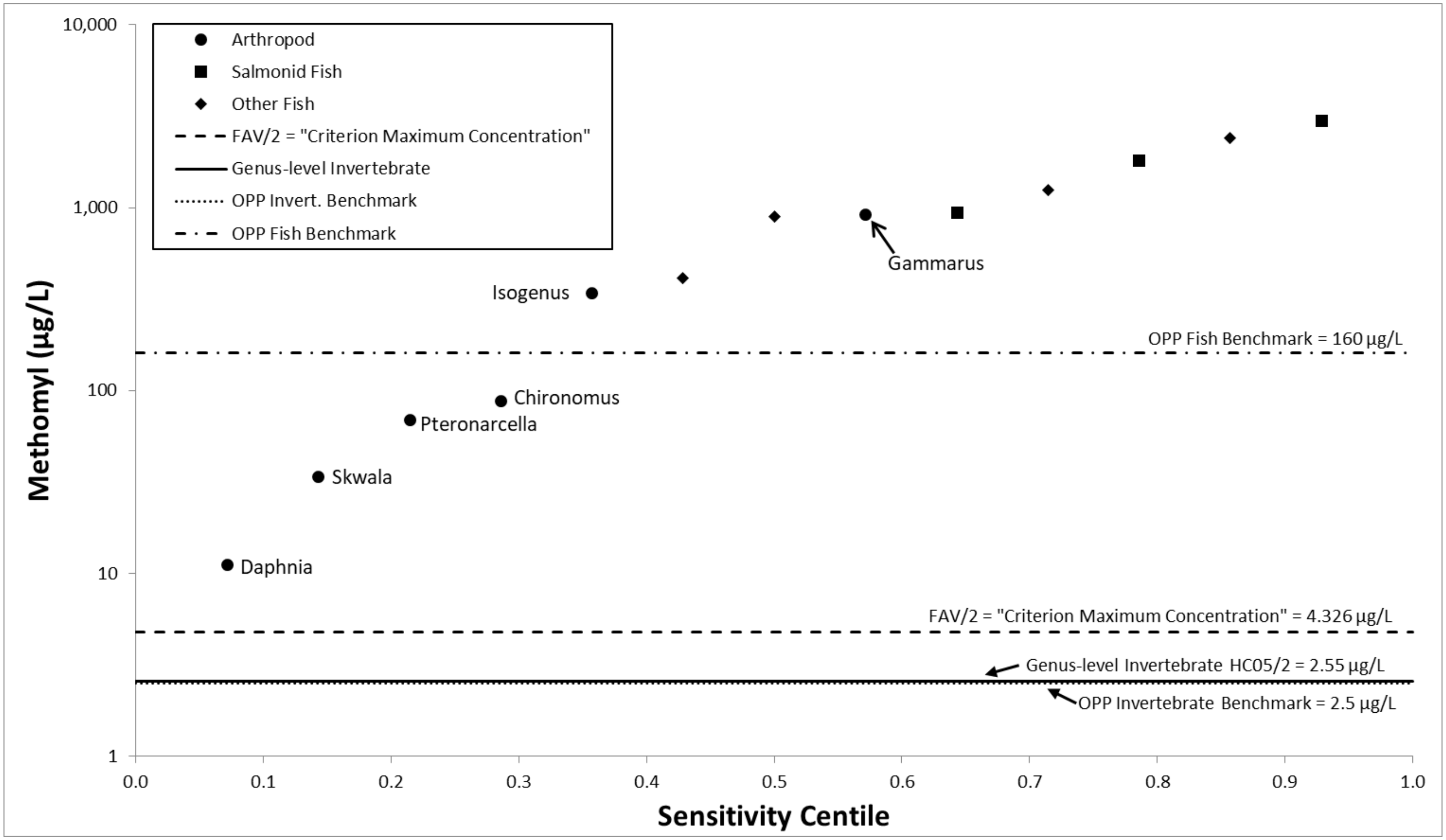

Figure 1. Methomyl genus-level acute SD.
Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from an Office of Water data analysis in 2015, supplemented the Office of Pesticide Programs (OPP) registration review document for methomyl (U.S. EPA 2010). **The "Criterion Maximum Concentration" is an illustrative example calculated for these analyses**.

1.1.2.2 Methomyl Chronic Toxicity Data

Chronic Data Sources

Data for methomyl were gathered by OW in 2015 and combined with data from OPP's registration review document for methomyl (U.S. EPA 2010). The final chronic methomyl dataset consisted of three NOECs/LOECS for two species across two genera, of which one was an invertebrate and one was a vertebrate (Table 7).

Table 7. Chronic toxicity data of methomyl to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference
D	Daphnia	magna	>0.4	0.9	Number of young/adult	MRID 00118512; Muska and Britelli 1982
D	Daphnia	magna	0.700	10.00	Delayed reproduction	MRID 131254; Britelli and Muska 1982
B	Pimephales	promelas	57.00	117.0	Early lifestage; reduced survival	MRID 131255; Driscoll and Muska 1982
B	Pimephales	promelas	76	142	Life cycle test; growth	MRID 43072101; Strawn et al. 1993

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark for methomyl is 0.6 µg/L, which is the MATC for *Daphnia magna*, the geometric mean of the NOEC (>0.4 µg/L) and LOEC (0.9 µg/L).

The OPP fish chronic benchmark is 57 µg/L, which is the NOEC for *Pimephales promelas*.

GLI Tier II Chronic Value Calculation

Paired acute and chronic toxicity data were available for water flea (*Daphnia magna*) and fathead minnow (*Pimephales promelas*) allowing for the calculation of two Acute-to-Chronic Ratios (ACR). The water flea (*Daphnia magna*) chronic test reported NOAEC and LOAEC values of 0.700 and 10.00 µg/L, respectively based on measurements of delayed reproduction (Britelli and Muska 1982). The fathead minnow (*Pimephales promelas*) chronic test reported NOAEC and LOAEC values of 57.00 and 117.0 µg/L based on reduced survival (Driscoll and Muska 1982). Because three experimentally determined ACRs were not available for methomyl, a Tier I chronic value could not be derived. However, the GLI Tier II approach was used to calculate the chronic value. Under the GLI Tier II approach, the default value of 18 was used in place of the third, missing ACR.

The paired acute and chronic tests were conducted in different laboratories using water of different physical characteristics; therefore, OPP's ACR approach was used in the calculations, which involves the use of the NOAEC values. The chronic Secondary ACR and Secondary Chronic Value (SCV) calculations are displayed below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{12.57 * 36.65 * 18} = 20.24$$

$$SCV = \frac{FAV}{SACR}$$

$$SCV = \frac{9.541}{20.24} = 0.471\ \mu g\ a.i./L$$

Table 8. Summary and comparison of chronic values for methomyl. Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Methomyl	0.6 µg/L (2020, *Daphnia magna*)	0.47 µg/L (GLI Tier II; 2 ACRs, 1.3X)	NA	One default ACR of 18 used to derive GLI Tier II value.

1.1.2.3 Methomyl References

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1.1.3 Comparison of Aquatic Life Toxicity Values for Propoxur: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S.EPA 2024) were gathered from the OPP registration review document for propoxur (U.S. EPA 2009) and an EPA ECOTOX Knowledgebase search conducted in 2013. There is no chronic OPP ALB for propoxur, so no chronic value analyses were conducted for this pesticide.

1.1.3.1 Propoxur Acute Toxicity Data

Acute data were gathered from the OPP registration review document for propoxur (U.S. EPA 2009) and an ECOTOX search conducted in 2013 (see Table 1). The propoxur acute dataset consisted of 20 acceptable LC_{50}s for a total of 12 species across 11 genera, of which six were invertebrate species representing five genera. Ranked invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity data of propoxur to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
G	Lumbriculus	variegatus	146,000	146,000	146,000	Brooke 1991
D	Daphnia	magna	3,990	107.0	107.0	Lejczak 1977
D	Daphnia	magna	27.2			Brooke 1991
D	Daphnia	magna	110			Lakota et al. 1981
D	Daphnia	magna	11			MRID: 00149172; Lamb 1981
F	Aedes	aegypti	150	150	150	Lakota et al. 1981
F	Pteronarcys	californica	13	15.3	15.3	Sanders and Cope 1968
F	Pteronarcys	californica	18			Mayer and Ellersieck 1986
E	Gammarus	fasciatus	50	50	41.2	Sanders 1972
E	Gammarus	lacustris	34	34		Mayer and Ellersieck 1986
B	Cyprinus	carpio	7,340	7,340	7,340	Lakota et al. 1981
B	Pimephales	promelas	25,000	14,832	14,832	Mayer and Ellersieck 1986
B	Pimephales	promelas	8,800			Geiger et al. 1988/Call et al. 1989
B	Poecilia	reticulata	2,980	2,277	2,277	Lejczak 1977
B	Poecilia	reticulata	1,740			Lakota et al. 1981
B	Lepomis	macrochirus	4,800	5,455	5,455	Mayer and Ellersieck 1986
B	Lepomis	macrochirus	6,200			Lamb 1981
A	Oncorhynchus	mykiss	8,200	5,508	5,508	Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	3,700			Lamb 1981
A	Salmo	trutta	2,110	2,110	2,110	Lakota et al. 1981

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)

E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark for propoxur is 5.5 µg/L, which is ½ of the *D. magna* LC_{50} of 11 µg/L cited in Lamb (1981).

The OPP fish acute benchmark is 1,850 µg/L, which is ½ of the *O. mykiss* LC_{50} of 3,700 µg/L cited in Lamb (1981).

OW Acute Criterion

There is no acute criterion, or criterion maximum concentration (CMC), for propoxur.

An illustrative example calculated for this analysis, using all available data (Table 2) was conducted.

The HC_{05} calculated following the U.S. EPA (1985) methodology for the eleven genera in the propoxur dataset was 9.151 µg/L (Table 3)

Table 2. Propoxur SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Lumbriculus	*variegatus*	146,000	146,000	11
Pimephales	*promelas*	14,832	14,832	10
Cyprinus	*carpio*	7,340	7,340	9
Oncorhynchus	*mykiss*	5,508	5,508	8
Lepomis	*macrochirus*	5,455	5,455	7
Poecilia	*reticulata*	2,277	2,277	6
Salmo	*trutta*	2,110	2,110	5
Aedes	*aegypti*	150.0	150.0	4
Daphnia	*magna*	107.0	107.0	3
Gammarus	*fasciatus*	50.00	41.23	2
Gammarus	*lacustris*	34.00		
Pteronarcys	*californica*	15.30	15.30	1

Table 3. Genus-level acute FAV for propoxur calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
11	4	150.0	5.011	25.11	0.3333	0.5774
	3	107.0	4.673	21.84	0.2500	0.5000
	2	41.23	3.719	13.83	0.1667	0.4082
	1	15.3	2.728	7.441	0.0833	0.2887
	Sum:		16.13	68.22	0.833	1.774
	S^2 =	68.37				
	L =	0.3649				
	A =	2.214				
	FAV =	**9.151**				
	FAV/2 =	**4.6**				

Genus-Level Invertebrate-only acute HC_{05}

The genus level invertebrate-only acute HC_{05} calculated following the U.S. EPA (1985) methodology for the five invertebrate genera (Table 3) in the propoxur dataset was 5.324 µg/L (Table 4).

Table 3. Propoxur invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Lumbriculus	*variegatus*	146,000	146,000	5
Aedes	*aegypti*	150.0	150.0	4
Daphnia	*magna*	107.0	107.0	3
Gammarus	*fasciatus*	50.00	41.23	2
Gammarus	*lacustris*	34.00		
Pteronarcys	*californica*	15.30	15.30	1

Table 4. Genus-level invertebrate-only acute HC_{05} for propoxur calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
5	4	150.0	5.011	25.11	0.6667	0.8165
	3	107.0	4.673	21.84	0.5000	0.7071
	2	41.23	3.719	13.83	0.3333	0.5774
	1	15.3	2.728	7.441	0.1667	0.4082
	Sum:		16.13	68.22	1.667	2.509
	S^2 =	34.19				
	L =	0.3649				
	A =	1.672				
	HC_{05} =	**5.324**				

Table 5. Summary and comparison of acute values for propoxur.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	ALC (FAV/2) (Year published, # of genera, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)
Propoxur	5.5 µg/L (2009; *D. magna*)	4.6 µg/L (illustrative example calculated for this analysis, 11 genera, 1.2X)	2.66 µg/L (5 genera, 2.1X)

Figure 1 shows a genus-level sensitivity distribution for the propoxur dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. The OPP benchmark acute values, illustrative ALC example, and invertebrate-only acute HC_{05}/2 are included.

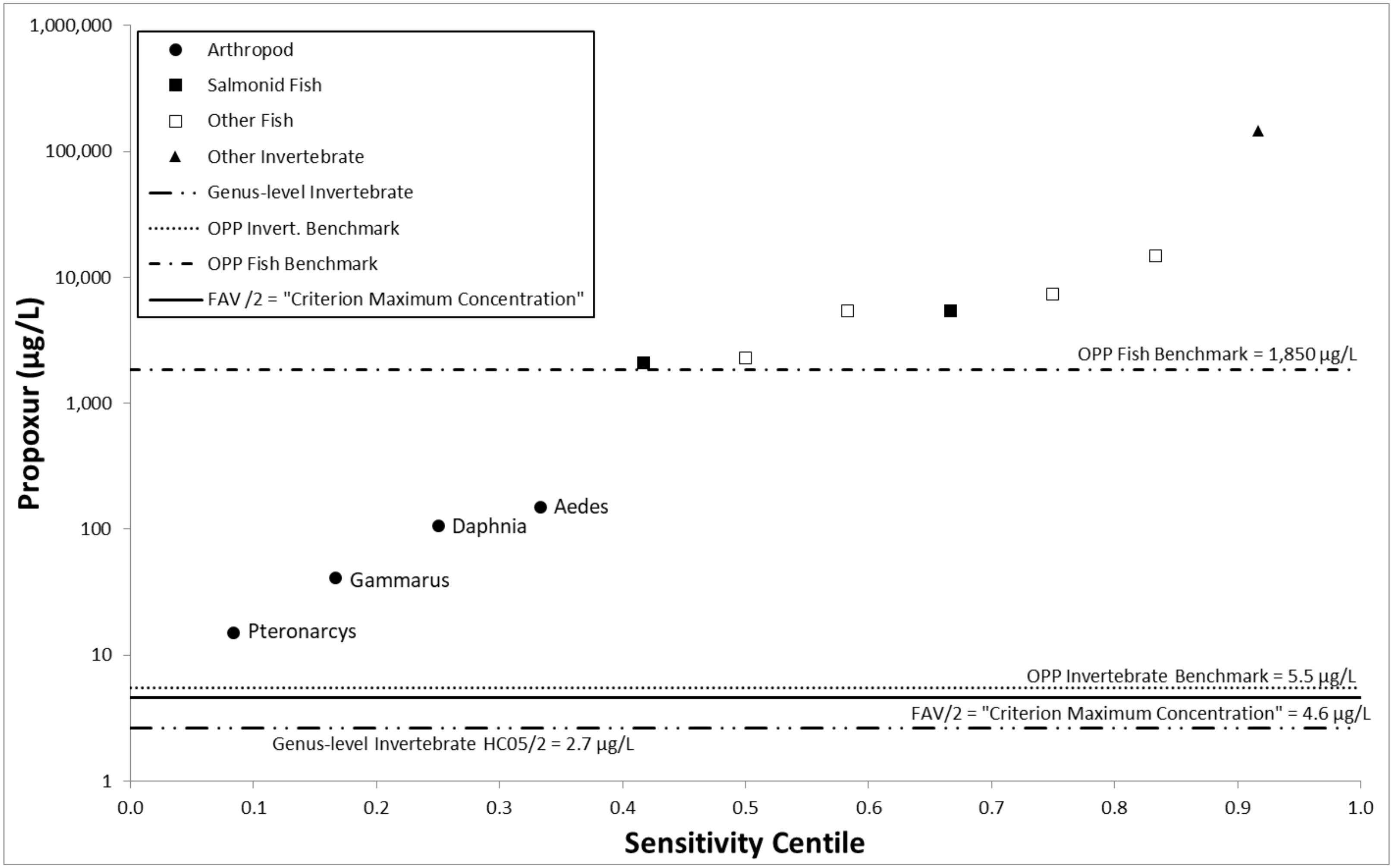

Figure 1. Propoxur genus-level SD.

Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from the Office of Pesticide Program's registration review document for propoxur (U.S. EPA 2009) and an ECOTOX search conducted by Office of Water in 2013. Propoxur does not have a recommended 304(a) aquatic life criteria. **The "Criterion Maximum Concentration" is an illustrative example calculated for these analyses**.

1.1.3.2 Propoxur Chronic Toxicity Data

There is no chronic OPP Aquatic Life Benchmark for propoxur, so no chronic analysis was conducted for this pesticide.

1.1.3.3 Propoxur References

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1.1.4 Comparison of Aquatic Life Toxicity Values for Malathion: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S.EPA 2024) for malathion were obtained from the 1986 criteria which serves as the base dataset, supplemented with an update to this data from EPA ECOTOX Knowledgebase in 2010, and with additional data from the U.S. EPA (2010) OPP pesticide effects determination document that served as the basis for the OPP benchmark concentrations.

1.1.4.1 Malathion Acute Toxicity Data

Acceptable acute data for malathion were obtained from the 1986 criteria which serves as the base dataset, supplemented with an update to this data from ECOTOX in 2010, and with additional LC_{50}s reported in Table 4-8 of U.S. EPA (2010), the OPP pesticide effects determination document that served as the basis for the OPP benchmark concentrations. (See Table 1.) The final dataset consists of 69 SMAVs and 54 GMAVs, including 36 invertebrate species representing 29 invertebrate genera. Ranked SMAVs and GMAVs for all invertebrates included in this analysis are listed in Table 2, below.

Table 1. Acute toxicity data of malathion to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
A	Oncorhynchus	clarkii	150	215.5	149.1	Post and Schroeder 1971
A	Oncorhynchus	clarkii	201			Post and Schroeder 1971
A	Oncorhynchus	clarkii	280			Johnson 1980b; Mayer and Ellersieck 1986
A	Oncorhynchus	clarkii	174			Mayer and Ellersieck 1986
A	Oncorhynchus	clarkii	237			Mayer and Ellersieck 1986
A	Oncorhynchus	clarkii	270			Mayer and Ellersieck 1986
A	Oncorhynchus	clarkii	230			Mayer and Ellersieck 1986
A	Oncorhynchus	kisutch	101	168.5		Macek and McAllister 1970
A	Oncorhynchus	kisutch	265			Post and Schroeder 1971
A	Oncorhynchus	kisutch	170			Johnson 1980b; Mayer and Ellersieck 1986
A	Oncorhynchus	kisutch	177			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	77	91.2		Cope 1965
A	Oncorhynchus	mykiss	68			Cope 1965
A	Oncorhynchus	mykiss	110			Cope 1965
A	Oncorhynchus	mykiss	170			Macek and McAllister 1970
A	Oncorhynchus	mykiss	122			Post and Schroeder 1971
A	Oncorhynchus	mykiss	93.5			Schoettger 1970
A	Oncorhynchus	mykiss	200			Johnson 1980b; Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	94			Mayer and Ellersieck 1986

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
A	Oncorhynchus	mykiss	4.1			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	138			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	100			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	66			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	80			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	160			McKim et al. 1987
A	Oncorhynchus	mykiss	250			Li and Fan 1996
A	Salmo	trutta	200	142.1	142.1	Macek and McAllister 1970
A	Salmo	trutta	101			Johnson 1980b; Mayer and Ellersieck 1986
A	Salvelinus	fontinalis	130	124.9	113.9	Post and Schroeder 1971
A	Salvelinus	fontinalis	120			Post and Schroeder 1971
A	Salvelinus	namaycush	76	103.9		Johnson 1980b; Mayer and Ellersieck 1986
A	Salvelinus	namaycush	142			Mayer and Ellersieck 1986
B	Perca	flavescens	263	263.0	263.0	Macek and McAllister 1970; Johnson 1980b; Mayer and Ellersieck 1986
B	Sander	vitreus	64	64.0	64.0	Johnson 1980b; Mayer and Ellersieck 1986
B	Oreochromis	mossambica	2,000	2,000	1,181	Mayer and Ellersieck 1986
B	Oreochromis	niloticus	140	140.0		Liong et al. 1988
B	Oreochromis	niloticus x mossambica	5,880	5,880		Sulaiman et al. 1989
B	Umbra	pygmaea	240	240.0	240.0	Bender and Westman 1976
B	Carassius	auratus	2,610	2,867	2,867	Birge et al. 1979
B	Carassius	auratus	3,150			Birge et al. 1979
B	Cyprinus	carpio	6,590	6,590	6,590	Macek and McAllister 1970; Johnson 1980b; Mayer and Ellersieck 1986
B	Danio	rerio	760.2	893.4	893.4	Ton et al. 2006
B	Danio	rerio	1,050			Kumar and Ansari 1984
B	Gila	elegans	15,300	15,300	15,300	Beyers et al. 1994
B	Pimephales	promelas	14,100	12,225	12,225	Geiger et al. 1988
B	Pimephales	promelas	10,600			Geiger et al. 1988
B	Ptychocheilus	lucius	9,140	9,140	9,140	Beyers et al. 1994
B	Ameiurus	melas	12,900	12,285	12,285	Macek and McAllister 1970; Johnson 1980b; Mayer and Ellersieck 1986
B	Ameiurus	melas	11,700			Mayer and Ellersieck 1986
B	Ictalurus	punctatus	8,970	8,268	8,268	Macek and McAllister 1970; Johnson 1980b; Mayer and Ellersieck 1986
B	Ictalurus	punctatus	7,620			Mayer and Ellersieck 1986
B	Jordanella	floridae	349	349.0	349.0	Hermanutz 1978

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
B	Gambusia	affinis	700	700.0	700.0	Li and Fan 1996
B	Poecilia	reticulata	840	1,614	1,614	Pickering et al. 1962
B	Poecilia	reticulata	3,100			Maas 1982
B	Morone	saxatilis	24.5	39.9	39.9	Palawski et al. 1985
B	Morone	saxatilis	65			Palawski et al. 1985
B	Lepomis	cyanellus	175	163.2	103.8	Johnson 1980b; Mayer and Ellersieck 1986
B	Lepomis	cyanellus	146			Mayer and Ellersieck 1986
B	Lepomis	cyanellus	170			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	90	66.7		Pickering et al. 1962
B	Lepomis	macrochirus	120			Macek et al. 1969
B	Lepomis	macrochirus	55			Macek et al. 1969
B	Lepomis	macrochirus	46			Macek et al. 1969
B	Lepomis	macrochirus	131			Eaton 1970
B	Lepomis	macrochirus	89			Eaton 1970
B	Lepomis	macrochirus	103			Macek and McAllister 1970; Johnson 1980b; Mayer and Ellersieck 1986
B	Lepomis	macrochirus	20			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	40			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	55			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	84			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	87			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	30			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	110			Mayer and Ellersieck 1986
B	Lepomis	microlophus	170	102.7		Macek and McAllister 1970
B	Lepomis	microlophus	62			Johnson 1980b; Mayer and Ellersieck 1986
B	Micropterus	salmoides	50	152.7	152.7	Pickering et al. 1962
B	Micropterus	salmoides	285			Macek and McAllister 1970; Johnson 1980b; Mayer and Ellersieck 1986
B	Micropterus	salmoides	250			Mayer and Ellersieck 1986
C	Bufo	woodhousei fowleri	420	420.0	420.0	Sanders 1970; Mayer and Ellersieck 1986
C	Pseudacris	triseriata	200	200.0	200.0	Sanders 1970; Mayer and Ellersieck 1986
C	Rana	boylii	2,137	2,137	2,137	Sparling and Fellers 2007
C	Xenopus	laevis	10,900	10,900	10,900	Snawder and Chambers 1989
D	Ceriodaphnia	dubia	0.5	0.5	0.5	Foster et al. 1998
D	Daphnia	magna	1.0	2.4	2.1	Johnson 1980b
D	Daphnia	magna	1.8			Kikuchi et al. 2000
D	Daphnia	magna	1.6			Maas 1982

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
D	Daphnia	magna	33			Hermens et al. 1984
D	Daphnia	magna	0.90			Ren et al. 2007
D	Daphnia	magna	2.2			MRID 41029701; Burgess 1989
D	Daphnia	pulex	2	1.9		Cope 1966
D	Daphnia	pulex	1.8			Sanders and Cope 1966; Johnson 1980b
D	Simocephalus	serrulatus	3	2.5	2.7	Cope 1966
D	Simocephalus	serrulatus	3.5			Sanders and Cope 1966; Johnson 1980b
D	Simocephalus	serrulatus	6.2			Sanders and Cope 1966
D	Simocephalus	serrulatus	0.59			MRID 40098001; Mayer and Ellersick 1986
D	Simocephalus	vetulus	2.9	2.9		Olvera-Hernandez et al. 2004
D	Cypridopsis	vidua	47	47.0	47.0	MRID 40098001; Mayer and Ellersick 1986
E	Asellus	brevicaudus	3,000	3,000	3,000	Sanders 1972; Johnson 1980b; Mayer and Ellersieck 1986
E	Gammarus	fasciatus	0.76	0.7	1.0	Sanders 1972; Johnson 1980b; Mayer and Ellersieck 1986
E	Gammarus	fasciatus	0.90			Sanders 1972; Mayer and Ellersieck 1986
E	Gammarus	fasciatus	0.50			Sanders 1972; Mayer and Ellersieck 1986
E	Gammarus	lacustris	1.62	1.4		Gaufin et al. 1965
E	Gammarus	lacustris	1.0			Sanders 1969
E	Gammarus	lacustris	1.8			MRID 05009242; Sanders 1969
E	Orconectes	nais	180	180.0	180.0	Sanders 1972; Johnson 1980b; Mayer and Ellersieck 1986
E	Palaemonetes	kadiakensis	12	32.6	24.8	Sanders 1972; Mayer and Ellersieck 1986
E	Palaemonetes	kadiakensis	90			Sanders 1972; Johnson 1980b; Mayer and Ellersieck 1986
E	Palaemonetes	kadiakensis	32			Mayer and Ellersieck 1986
E	Palaemonetes	pugio	8.94	18.9		Key and Fulton 2006
E	Palaemonetes	pugio	39.92			Key and Fulton 2006
E	Procambarus	clarkii	49,170	49,170	49,170	Holck and Meek 1987
F	Drunella	grandis	100	100.0	100.0	Gaufin et al. 1965
F	Lestes	congener	10	10.0	10.0	Johnson 1980b; Mayer and Ellersieck 1986
F	Claassenia	sabulosa	2.8	2.8	2.8	Sanders and Cope 1968; Johnson 1980b; Mayer and Ellersieck 1986
F	Isoperla	sp.	0.69	0.7	0.7	Johnson 1980b; Mayer and Ellersieck 1986

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
F	Pteronarcella	badia	1.1	3.9	3.9	Sanders and Cope 1968; Johnson 1980b; Mayer and Ellersieck 1986
F	Pteronarcella	badia	6.2			Mayer and Ellersieck 1986
F	Pteronarcella	badia	8.8			Mayer and Ellersieck 1986
F	Pteronarcys	californicus	10	10.0	10.0	Sanders and Cope 1968; Johnson 1980b; Mayer and Ellersieck 1986
F	Peltodytes	sp.	1,000	1,000	1,000	Federle and Collins 1976
F	Arctopsyche	grandis	32	32.0	32.0	Gaufin et al. 1965
F	Hydropsyche	californica	22.5	22.5	10.6	Gaufin et al. 1965
F	Hydropsyche	sp.	5	5		MRID 40098001; Mayer and Ellersick 1986
F	Limnephilus	sp.	1.3	1.3	1.3	Johnson 1980b; Mayer and Ellersieck 1986
F	Atherix	sp.	385	385.0	385.0	Johnson 1980b
F	Chironomus	plumosus	8.4	8.4	72.2	Vedamanikam 2009
F	Chironomus	dilutus	620	620.0		Hansen and Kawatski 1976
F	Notonecta	undulata	80	80.0	80.0	Federle and Collins 1976
H	Limnodrilus	sp.	16,700	16,700	16,700	Whitten and Goodnight 1966
H	Lumbriculus	variegatus	20,500	20,500	20,500	Bailey and Liu 1980
H	Tubifex	sp.	16,700	16,700	16,700	Whitten and Goodnight 1966
G	Elliptio	icterina	32,000	32,000	32,000	Keller and Ruessler 1997
G	Lampsilis	straminea claibornen	24,000	24,000	25,923	Keller and Ruessler 1997
G	Lampsilis	subangulata	28,000	28,000		Keller and Ruessler 1997
G	Utterbackia	imbecillis	215,000	108,654	108,654	Keller and Ruessler 1997
G	Utterbackia	imbecillis	219,000			Keller and Ruessler 1997
G	Utterbackia	imbecillis	40,000			Keller and Ruessler 1997
G	Utterbackia	imbecillis	74,000			Keller and Ruessler 1997
G	Villosa	lienosa	109,000	96,382	124,133	Keller and Ruessler 1997
G	Villosa	lienosa	111,000			Keller and Ruessler 1997
G	Villosa	lienosa	74,000			Keller and Ruessler 1997
G	Villosa	villosa	142,000	159,875		Keller and Ruessler 1997
G	Villosa	villosa	180,000			Keller and Ruessler 1997

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark for malathion is 0.049 µg/L, which is one half of the LC_{50} of 0.098 µg/L for *D. magna*.

The OPP fish acute benchmark for malathion is 2.05 µg/L, which is one half of the LC_{50} of 4.1 µg/L for rainbow trout (*Oncorhynchus mykiss*), the lowest LC_{50} of any fish species.

OW Acute Criterion

The 1986 acute criterion, or CMC, for malathion of 0.1 µg/L was not calculated using calculated the U.S. EPA (1985) methodology, as it pre-dates the Guidelines. Rather, it was calculated by dividing the effect acute LC50 for *G. lacustrus*, *G. fasciatis*, and *D. magna*, which were all approximately 1 µg/L, by an application factor of ten (U.S. EPA 1976 – EPA Red Book).

Genus-Level Invertebrate-only Acute HC_{05}

The acute HC_{05} calculated from invertebrate-only GMAVs shown in Table 2 was calculated following the U.S. EPA (1985) methodology is 0.8360 µg/L (Table 3).

Table 2. Malathion Invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Villosa	*lienosa*	96,382	124,133	29
Villosa	*villosa*	108,653		
Utterbackia	*imbecillis*	108,653	108,653	28
Procambarus	*clarkii*	49,170	49,170	27
Elliptio	*icterina*	32,000	32,000	26
Lampsilis	*straminea claibornen*	24,000	25,923	25
Lampsilis	*subangulata*	28,000		
Lumbriculus	*variegatus*	20,500	20,500	24
Limnodrilus	*sp.*	16,700	16,700	23
Tubifex	*sp.*	16,700	16,700	22
Asellus	*brevicaudus*	3,000	3,000	21
Peltodytes	*sp.*	1,000	1,000	20
Atherix	*sp.*	385.0	385.0	19
Orconectes	*nais*	180.0	180.0	18
Drunella	*grandis*	100.0	100.0	17
Notonecta	*undulata*	80.00	80.00	16
Chironomus	*plumosus*	8.400	72.17	15
Chironomus	*dilutus*	620.0		
Cypridopsis	*vidua*	47.00	47.00	14
Arctopsyche	*grandis*	32.00	32.00	13
Palaemonetes	*pugio*	18.89	24.81	12
Palaemonetes	*kadiakensis*	32.57		
Hydropsyche	*californica*	22.50	22.50	11
Lestes	*congener*	10.00	10.00	10
Pteronarcys	*californicus*	10.00	10.00	9
Pteronarcella	*badia*	3.915	3.915	8
Claassenia	*sabulosa*	2.800	2.800	7
Simocephalus	*vetulus*	2.900	2.687	6
Simocephalus	*serrulatus*	2.489		

Genus	Species	SMAV	GMAV	GMAV Rank
Daphnia	*magna*	2.394	2.131	5
Daphnia	*pulex*	1.897		
Limnephilus	*sp.*	1.300	1.300	4
Ceriodaphnia	*dubia*	1.294	1.294	3
Gammarus	*lacustris*	1.429	0.9995	2
Gammarus	*fasciatus*	0.6993		
Isoperla	*sp.*	0.6900	0.6900	1

Table 3. Genus-level invertebrate-only acute HC_{05} for malathion calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$\ln(\text{GMAV})^2$	P=R/(N+1)	sqrt(P)
29	4	1.3	0.262	0.07	0.1333	0.3651
	3	1.294	0.258	0.07	0.1000	0.3162
	2	0.9995	-0.001	0.00	0.0667	0.2582
	1	0.69	-0.371	0.138	0.0333	0.1826
	Sum:		0.15	0.27	0.3333	1.1221
	S^2 =	14.44				
	L =	-1.029				
	A =	-0.179				
	HC_{05} =	**0.8360**				

Table 4. Summary and comparison of acute values for malathion by approach.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW ALC (FAV/2) (Year published, # of genera, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)
Malathion	0.049 µg/L (2016; *C. dubia*)	0.1 µg/L (1986, “Gold Book”, 0.49X)	0.418 µg/L (29 genera, 0.12X)

Figure 1 shows a genus-level sensitivity distribution for the malathion dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the CMC, invertebrate acute HC_{05}/2, and OPP acute benchmark values are also included.

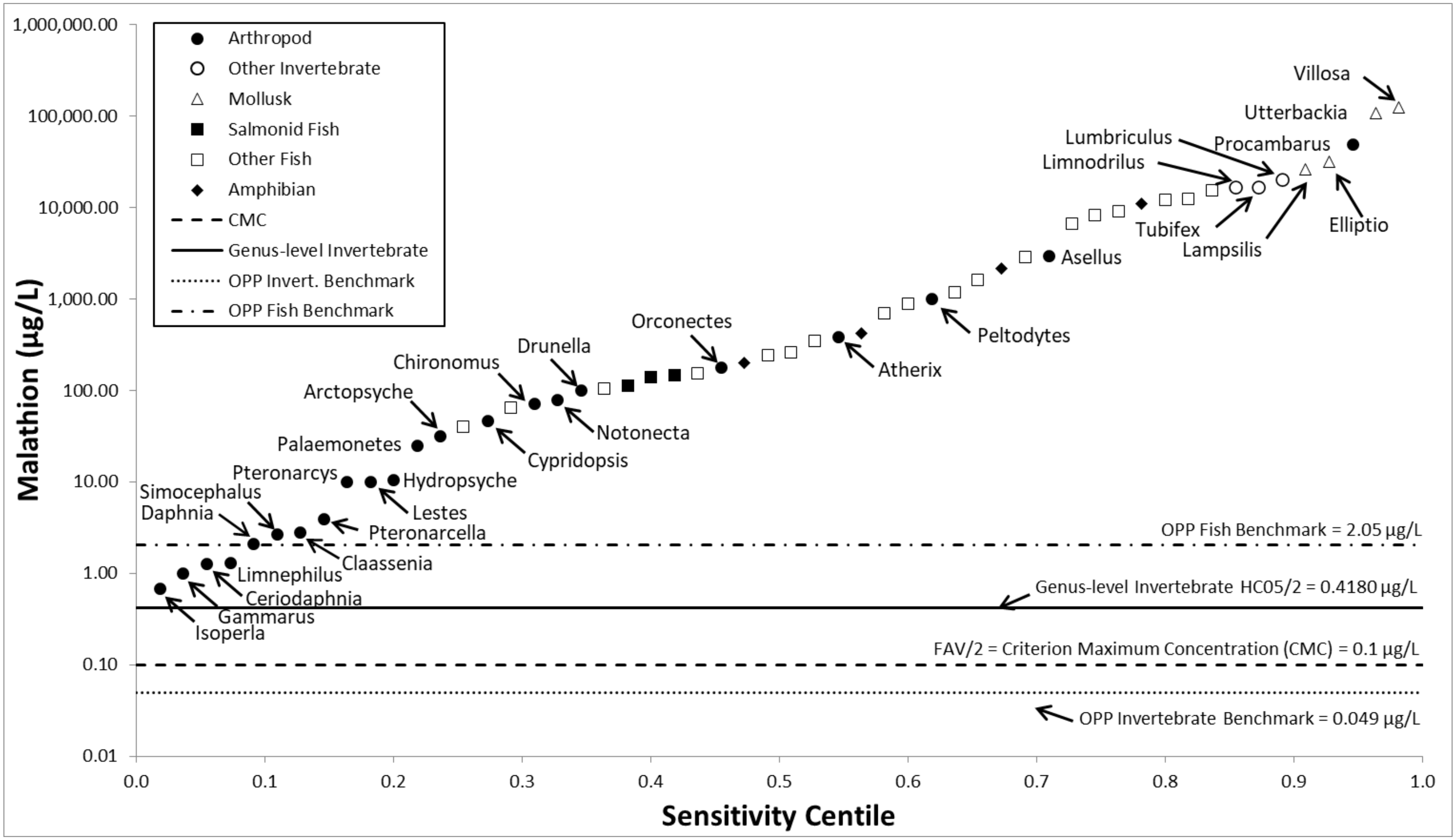

Figure 1. Malathion acute genus-level SD.

Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from the malathion ALC (U.S. EPA 1986), the Office of Pesticide Program's registration review document for malathion (U.S. EPA 2010), and an ECOTOX search conducted by Office of Water in 2010.

1.1.4.2 Malathion Chronic Toxicity Data

For chemicals lacking sufficient chronic data to satisfy the minimum taxonomic data requirements, such as malathion, the EPA Office of Water (OW) calculates the final chronic value (FCV) as the final acute value (FAV) divided by the final acute-to chronic ratio (FACR). The Office of Pesticide Programs (OPP) will also apply ACRs to acute data for sensitive taxonomic groups to calculate chronic benchmarks when chronic test data are not available. Calculations of ACRs following OPP and OW methodologies were conducted, and the effects of these ACRs on the resulting OPP and OW chronic values were compared.

Chronic Data Sources

The data sources for this analysis were a 2010 ECOTOX search for malathion and the OPP-authored malathion effects determination reports for delta smelt and California tiger salamander (U.S. EPA 2010) and California red legged frog (U.S. EPA 2007). Many values were reported across all three data sources.

ACR Calculations

ACR calculations following OW and OPP methodologies are described below. All available chronic malathion data are shown in Table 5. All available acute data for species that also have chronic data are shown in Table 6. Table 7 lists all ACRs by species and calculation method.

Invertebrate ACRs

Daphnia magna

An ACR for *D. magna* could not be calculated following the Guidelines requirements, as there were no acute and chronic tests for this species conducted in the same study or laboratory (Stephan et al. 1985). However, invertebrates are the most sensitive taxonomic group to malathion, and *D. magna* is the only invertebrate species with chronic malathion data. In addition, the Guidelines requires ACR from at least three families; including at least one fish, one invertebrate, and one acutely sensitive species. For these reasons, a *D. magna* ACR was calculated for this analysis.

The "qualitative" OW *D. magna* ACR is 5.942, calculated as the geometric mean of the two acute values identified as EC_{50s} (Johnson 1980b, Kikuchi et al. 2000) divided by the geometric mean of the two chronic tests with MATCs (Biesinger 1973, Blakemore and Burgess 1990). The acceptable registrant submitted acute study by Burgess (1989) was not included in this calculation because it was a formulation (57% active ingredient), and below the 80% purity threshold recommended in the Guidelines (U.S. EPA 1985).

The ACR calculated following the OPP approach is 13.22, calculated as the geometric mean of all 48-hour acute values divided by the geometric mean of the NOECs from all chronic studies. The OPP ACR guidance offers flexibility when multiple acceptable acute and chronic values are available for the same species (U.S. EPA 2005).

Vertebrate (Fish) ACRs

Oncorhynchus mykiss

An ACR for this species could not be calculated following the OW approach. Cohle (1989) reported test results following a 97-day ELS test in an unpublished report, but there are no acute studies conducted in the same laboratory.

Following the rationale used for *D. magna*, the OPP ACR for *O. mykiss* is 4.074, calculated as the geometric mean of all acute tests listed in Table 2 (all of which were 96 hours), divided by the NOEC reported by Cohle (1989).

Gila elegans

An ACR for this species could not be calculated following the OW approach. Beyers et al. (1994) performed an early life stage (ELS) chronic test and a static-renewal acute test. Although the acute and chronic tests were performed in the same laboratory, the Guidelines (U.S. EPA 1985) specifies that acute test data should also be from a flow-through study (except for Daphnids, where static acute tests are acceptable). The ACR following the OPP approach is 15.46, calculated as the acute value of 15,300 μg/L from Beyers et al. (1994) divided by the NOEC of 990 μg/L from ELS test performed in the same laboratory.

Pimephales promelas

An ACR for this species could not be calculated following the OW approach. Mount and Stephan (1967) performed an acute and chronic test in the same laboratory, but the acute test was static. The OPP ACR for *P. promelas* is 63.18, calculated as the geometric mean of the three acute flow-through tests listed in **Table 6** divided by the NOEC of the Mount and Stephan (1967) chronic test.

Ptychocheilus lucius

An ACR for this species could not be calculated following the OW approach. Beyers et al. (1994) performed an early life stage (ELS) chronic test and a static-renewal acute test. Although the acute and chronic tests were performed in the same laboratory, the Guidelines (U.S. EPA 1985) states that acute test data must also be from a flow-through study (except for Daphnids, where static acute tests are acceptable). Also worth noting is the study authors reported that the water for the acute and chronic tests was inadvertently aged differently, with the acute tests having higher dissolved oxygen and pH, and lower hardness and alkalinity, than the chronic tests. The ACR following the OPP approach is 5.440, calculated as the acute value of 9,140 μg/L from Beyers et al. (1994) divided by the NOEC of 1,680 μg/L from ELS test performed in the same laboratory.

Jordanella floridae

The OW ACR for *J. floridae* is 15.98, calculated as the acute value from a flow-through test conducted by Hermanutz (1978) divided by the MATC for the survival endpoint from a life cycle test conducted by Hermanutz (1978). The OPP ACR for *J. floridae* is 40.58, calculated as the acute value from a flow-through test conducted by Hermanutz (1978), divided by the NOEC for the growth endpoint from a life cycle test conducted by Hermanutz (1978).

Lepomis macrochirus

The OW ACR for *L. macrochirus* is 15.27, calculated as the geometric mean of two flow through acute tests conducted by Eaton (1970) divided by the MATC of an ELS test conducted in the same laboratory (Eaton 1970). The OPP ACR is 21.60, calculated as the geometric mean of the Eaton (1970) acute tests divided by the NOEC of the Eaton (1970) ELS test.

Oryzias latipes

An OW ACR could not be calculated for *O. latipes*. An OPP ACR of 48.60 was calculated as the ratio of the definitive acute value 9,700 µg/L divided by the NOEC of 199.6 µg/L from Beaman et al. (1999). This ACR is considered qualitative and is not used to calculate a final ACR for this chemical.

Oreochromis mossambica

An OW ACR could not be calculated because there were no paired acute and chronic tests. An OPP ACR was also not calculated for this species because there was no definitive NOEC for the chronic test. If a NOEC of <500 µg/L is used as the denominator, the ACR would be >1.523, calculated as the geometric mean of the two definitive acute values divided by the NOEC. Because this is a small greater than value, it is not included in the final ACR calculations.

Channa punctata

An OW ACR could not be calculated for this species. An acute (Pandey et al. 2005) and chronic (Pandey et al. 1981) test were conducted by the same author, but it could not be confirmed if the tests were performed in the same laboratory. Because the chronic test duration was only 15 days, an OW ACR would not have been calculated even if the acute and chronic tests were from the same laboratory. An OPP ACR of 4.234 was calculated as the geometric mean of the four acute tests divided by the NOEC from Pandey et al. (1981). This ACR is considered qualitative and is not used to calculate a final ACR for this chemical.

Cyprinodon variegatus

The OW ACR is 8.5, calculated as the acute value of 51 µg/L reported in Hansen and Parish (1977) and Parish et al. (1977) divided by the paired chronic MATC of 6 µg/L. The OPP ACR of 12.75 is calculated by the Hansen and Parish (1977) and Parish et al. (1977) acute value divided by the paired NOEC of 4 µg/L.

Final ACRs

The final ACRs (FACRs) for the two approaches, expressed as the geometric mean of all available ACRs, is 10.54 following the OW approach, and 15.42 following the OPP approach. The OW FACR consists of ACRs for *J. floridae*, *L. macrochirus*, and *C. variegatus*. The OW FACR also includes the qualitative ACR for *D. magna* that could not be calculated following the OW methodology, but which is included because it is the only invertebrate species for which chronic data are available. The OPP FACR consists of ACRs for the species listed above, as well as *O. mykiss*, *G. elegans*, *P. promelas*, and *P. lucius.* Qualitative ACRs for *O. latipes* and *C. punctata* were not included here because of chronic test duration. Table 7 lists all final and invertebrate only ACRs.

The Guidelines notes that a range of ACRs that is greater than 10-fold may indicate a potential cause for concern. ACRs calculated following the OPP approach vary by a factor of 11.6. While there is no clear relationship between the size of ACRs and acute sensitivity for this chemical, the largest ACR is for the acutely insensitive fish species *P. promelas*. A second option would be to exclude the *P. promelas* ACR of 63.18 from the OPP FACR calculation, which would result in a FACR of 12.61 (Table 7).

Comparison of Freshwater Chronic Values for Malathion

OPP Chronic Benchmarks

For malathion, the freshwater invertebrate chronic benchmark is 0.06 µg/L (Table 8), the NOEC of a registrant submitted *D. magna* test (Blakemore and Burgess 1990). The freshwater fish chronic benchmark is 8.6 µg/L, the NOEC for the growth endpoint reported in Hermanutz (1978).

OW Freshwater Chronic Values – All Taxa

Final chronic concentrations following the ACR methodology are calculated by dividing the final acute value by a final ACR (FACR). For malathion, a freshwater FAV of 0.8927 µg/L was calculated from the 53 genera included in the 2010 ECOTOX update. The final chronic value following the OW-ACR approach (including the *D. magna* ACR that deviated from the Guidelines), is 0.0847 µg/L (0.8927 µg/L ÷ 10.54), and the final chronic value following the OPP-ACR approach is 0.0579 µg/L (0.8927 µg/L ÷ 15.42). The OPP FACR following the second option (excluding the ACR of 63.18 for P. promelas) is 0.0708 (0.8927 µg/L ÷ 12.61).

OW Freshwater Chronic Values – Invertebrate Taxa

Final chronic concentrations for the invertebrate-only malathion dataset are calculated by dividing the final invertebrate acute value by an ACR. This dataset was comprised of acute invertebrate test data found in the 2010 ECOTOX update and the 2010 effects determination report U.S. EPA (2010). The resulting acute HC_{05} calculated from the 29 invertebrate genera using the Guidelines methology was 0.8360 µg/L. The final invertebrate chronic value following the OW-ACR approach (using the *D. magna* ACR that deviated from the Guidelines) is 0.1407 µg/L (0.8360 µg/L ÷ 5.942), and the final chronic value following the OPP-ACR approach is 0.0632 µg/L (0.8360 µg/L ÷ 13.22). Table 8 lists all chronic values calculated following the different approaches.

Table 5. Chronic test data for malathion.
All concentrations expressed as μg/L.

Genus	Species	NOEC	LOEC	MATC	Reference	Test data reported in: 2010 ECOTOX Search	2007 OPP	2010 OPP	OPP Classification	Notes[a]
Invertebrates										
Daphnia	*magna*	0.57	0.76	0.658	Biesinger 1973	X				OW,OPP
Daphnia	*magna*	0.06	0.1	0.077	Blakemore and Burgess 1990		Table 23	Table 4-10	Acceptable	OW,OPP
Daphnia	*magna*	0.15	NR	0.150	Dortland 1980		Table 23		Qualitative	OPP
Vertebrates										
Oncorhynchus	*mykiss*	21	44	30.40	Cohle 1989		Table 20	Table 4-7	Qualitative	ELS; OPP
Gila	*elegans*	990	2,000	1,407	Beyers et al. 1994	X				ELS; OPP
Pimephales	*promelas*	200	580	340.6	Mount and Stephan 1967	X				LC; OPP
Ptychocheilus	*lucius*	1680	3,510	2,428	Beyers et al. 1994	X				ELS; OPP
Jordanella	*floridae*[b]	19.3	25	21.83	Hermanutz 1978	X				LC; OW
Jordanella	*floridae*[c]	8.6	10.9	9.682	Hermanutz 1978		Table 20	Table 4-7	Quantitative	LC; OPP
Lepomis	*macrochirus*	5	10	7.071	Eaton 1970	X				ELS; OW,OPP
Oryzias	*latipes*	199.6	798	399.2	Beaman et al. 1999		Table 20	Table 4-7	Qualitative	14d; OPP
Oreochromis	*mossambica*	ND	500		Sweilum 2006		Table 20	Table 4-7	Qualitative	168d
Channa	*punctata*	500	ND		Pandey et al. 1981		Table 20	Table 4-7	Qualitative	15d; OPP
Cyprinodon	*variegatus*	4	9	6	Hansen and Parrish 1977	X				ELS; OW,OPP

[a] – LC-life cycle test, ELS-early life stage test, OW – used in OW-ACR calculation, OPP – used in OPP-ACR calculation

Table 6. Acute malathion test data for species with chronic test data. All concentrations expressed as µg/L.

Genus	Species	EC50 or LC50	Reference	Test data reported in: 2010 ECOTOX Search	2007 OPP	2010 OPP	OPP Classification	Notes[a]
Invertebrates								
Daphnia	*magna*	1.0	Johnson 1980b	X	Table 22	Table 4-8	Acceptable	EC50; S,U; OW, OPP
Daphnia	*magna*	1.6	Maas 1982	X				LC50; S,U; OPP
Daphnia	*magna*	33	Hermens et al. 1984	X				LC50; S,M; OPP
Daphnia	*magna*	1.8	Kikuchi et al. 2000	X				EC50; S,U; OW,OPP
Daphnia	*magna*	0.90	Ren et al. 2007	X				LC50; S,U; OPP
Daphnia	*magna*	2.20	Burgess 1989		Table 22	Table 4-8	Acceptable	57% a.i.; OPP
Daphnia	*magna*	0.098	Rawesh et al. 1975		Table 22		Qualitative – 2007; Invalid - 2010	Not used, 24hr.
Daphnia	*magna*	1.7	ECOREF 6449		Table 22		Qualitative	OPP
Daphnia	*magna*	2.35	Cano et al. 1999		Table 22		Qualitative	Not used, 24 hr.
Vertebrates								
Oncorhynchus	*mykiss*	77	Cope 1965	X				S,U; OPP
Oncorhynchus	*mykiss*	68	Cope 1965	X				S,U; OPP
Oncorhynchus	*mykiss*	110	Cope 1965	X				S,U; OPP
Oncorhynchus	*mykiss*	170	Macek and McAllister 1970	X		Table 4-3		S,U; OPP
Oncorhynchus	*mykiss*	122	Post and Schroeder 1971	X				S,U; OPP
Oncorhynchus	*mykiss*	93.5	Schoettger 1970	X				S,U; OPP
Oncorhynchus	*mykiss*	200	Johnson 1980b; Mayer and Ellersieck 1986	X				S,U; OPP
Oncorhynchus	*mykiss*	94	Mayer and Ellersieck 1986	X				S,U; OPP
Oncorhynchus	*mykiss*	4.1	Mayer and Ellersieck 1986	X	Table 19	Table 4-3	Qualitative	S,U; OPP
Oncorhynchus	*mykiss*	138	Mayer and Ellersieck 1986	X				S,U; OPP
Oncorhynchus	*mykiss*	100	Mayer and Ellersieck 1986	X				S,U; OPP
Oncorhynchus	*mykiss*	66	Mayer and Ellersieck 1986	X				S,U; OPP
Oncorhynchus	*mykiss*	80	Mayer and Ellersieck 1986	X				S,U; OPP
Oncorhynchus	*mykiss*	160	McKim et al. 1987	X	Table 19		Qualitative	S,U; OPP
Oncorhynchus	*mykiss*	250	Li and Fan 1996	X				S,U; OPP
Oncorhynchus	*mykiss*	32.8	Animal Biology Lab 1968			Table 4-3	Acceptable	OPP
Gila	*elegans*	15,300	Beyers et al. 1994	X				R,M; OPP

Genus	Species	EC50 or LC50	Reference	Test data reported in:			OPP Classification	Notes[a]
				2010 ECOTOX Search	2007 OPP	2010 OPP		
Pimephales	*promelas*	16,000	Pickering et al. 1962	X				S,U
Pimephales	*promelas*	23,000	Pickering et al. 1962	X				S,U
Pimephales	*promelas*	9,000	Mount and Stephan 1967	X				S,U
Pimephales	*promelas*	13,500	Bender 1969a	X				F,U; OPP
Pimephales	*promelas*	9,700	Bender 1969b	X				S,U
Pimephales	*promelas*	8,650	Macek and McAllister 1970; Johnson 1980b; Mayer and Ellersieck 1986	X	Table 19	Table 4-3	Acceptable	S,U
Pimephales	*promelas*	11,000	Mayer and Ellersieck 1986	X				S,U
Pimephales	*promelas*	14,100	Geiger et al. 1988	X	Table 19		Qualitative	F,M; OPP
Pimephales	*promelas*	10,600	Geiger et al. 1988	X				F,M; OPP
Pimephales	*promelas*	12,500	Henderson and Pickering 1958		Table 19		Qualitative	
Ptychocheilus	*lucius*	9,140	Beyers et al. 1994	X				R,M; OPP
Jordanella	*floridae*	349	Hermanutz 1978	X	Table 19		Qualitative	F,M; OW,OPP
Jordanella	*floridae*	280	Hermanutz et al. 1985		Table 19		Qualitative	
Lepomis	*macrochirus*	90	Pickering et al. 1962	X				S,U
Lepomis	*macrochirus*	120	Macek et al. 1969	X				S,U
Lepomis	*macrochirus*	55	Macek et al. 1969	X				S,U
Lepomis	*macrochirus*	46	Macek et al. 1969	X				S,U
Lepomis	*macrochirus*	131	Eaton 1970	X				F,U; OW,OPP
Lepomis	*macrochirus*	89	Eaton 1970	X				F,U; OW,OPP
Lepomis	*macrochirus*	103	Macek and McAllister 1970; Johnson 1980b; Mayer and Ellersieck 1986	X		Table 4-3	Qualitative	S,U
Lepomis	*macrochirus*	20	Mayer and Ellersieck 1986	X	Table 19	Table 4-3	Qualitative	S,U
Lepomis	*macrochirus*	40	Mayer and Ellersieck 1986	X		Table 4-3	Qualitative	S,U
Lepomis	*macrochirus*	55	Mayer and Ellersieck 1986	X		Table 4-3	Qualitative	S,U
Lepomis	*macrochirus*	84	Mayer and Ellersieck 1986	X				S,U
Lepomis	*macrochirus*	87	Mayer and Ellersieck 1986	X				S,U
Lepomis	*macrochirus*	30	Mayer and Ellersieck 1986	X	Table 19	Table 4-3	Qualitative	S,U
Lepomis	*macrochirus*	110	Mayer and Ellersieck 1986	X				S,U
Lepomis	*macrochirus*	336.6	ECOTOX 77525		Table 19		Qualitative	

Genus	Species	EC50 or LC50	Reference	Test data reported in:			OPP Classification	Notes[a]
				2010 ECOTOX Search	2007 OPP	2010 OPP		
Lepomis	*macrochirus*	48	Gries and Purghart 2001			Table 4-3	Acceptable	
Oryzias	*latipes*	<2,800	ECOTOX 8977		Table 19		Qualitative	
Oryzias	*latipes*	9,700	ECOTOX 89099		Table 19		Qualitative	OPP
Oreochromis	*mossambica*	<2,400	Mayer and Ellersieck 1986	X				S,U
Oreochromis	*mossambica*	2,000	Mayer and Ellersieck 1986	X	Table 19	Table 4-3	Qualitative	S,U
Oreochromis	*mossambica*	290.1	Liu et al. 1983		Table 19		Qualitative	
Channa	*punctata*	3890	ECOTOX 11888		Table 19		Qualitative	
Channa	*punctata*	894	Kaur and Toor 1995		Table 19		Qualitative	
Channa	*punctata*	874	Kaur and Toor 1995		Table 19		Qualitative	
Channa	*punctata*	6610	Pandey et al. 2005		Table 19		Qualitative	OPP
Cyprinodon	*variegatus*	51	Hansen and Parrish 1977	X				F,M; OW,OPP
Cyprinodon	*variegatus*	33	Bowman 1989	X				F,U

[a] F – flow through, R – renewal, S – static, M – measured, U – unmeasured, OW – used in OW-ACR calculation, OPP – used in OPP-ACR calculation

Table 7. ACRs by species and calculation method.

Genus	Species	ACR		Notes
		OW-ACR	OPP-ACR	
Invertebrates				
Daphnia	*magna*	5.942[a]	13.22	OW ACR following Guidelines could not be calculated.
Vertebrates				
Oncorhynchus	*mykiss*	N/A	4.074	
Gila	*elegans*	N/A	15.46	
Pimephales	*promelas*	N/A	63.18	
Ptychocheilus	*lucius*	N/A	5.440	
Jordanella	*floridae*	15.98	40.58	
Lepomis	*macrochirus*	15.27	21.60	
Oryzias	*latipes*	N/A	48.60	OPP ACR should be considered qualitative due to chronic test duration (14-d)
Oreochromis	*mossambica*	N/A	N/A	ACR not calculated because no NOAEC was available
Channa	*punctata*	N/A	4.234	OPP ACR should be considered qualitative due to chronic test duration (15-d)
Cyprinodon	*variegatus*	8.5	12.75	
All Taxa FACR (OPP Option 1)[b]		10.54	15.42	
All Taxa FACR (OPP Option 2)[c]		10.54	12.61	
All Invertebrates		5.942	13.22	

[a] – An ACR following the Guidelines could not be calculated, as there were no acute and chronic studies from same study/laboratory/test water. The resulting qualitative ACR was included because no other ACRs for invertebrate taxa were available.

[b] – OPP all taxa ACR does not include qualitative ACRs for *O. latipes* or *C. punctata*. OW all taxa ACR does include the "qualitative" *D. magna* ACR.

[c] – Does not include ACR for *P. promelas* ((>10x spread and acutely insensitive).

Table 8. Summary and comparison of freshwater chronic values for malathion.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value.

Pesticide	OPP Most Sensitive ALB (Year published, species)	OW Illustrative ALC (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only $HC_{05}/2$ (# of ACRs filled, magnitude relative to ALB)
Malathion	0.06 µg/L (2016, *Daphnia magna*)	0.08 µg/L (illustrative ALC example calculated for this analysis; 0.75X)	0.14 µg/L (See Table 7 for ACRs, 0.43X)

1.1.4.3 Malathion References

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1.1.5 Comparison of Aquatic Life Toxicity Values for Diazinon: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for diazinon were obtained from the 2005 diazinon aquatic life criteria (ALC) document (U.S. EPA 2005a), which serves as the based dataset, supplemented with an update to this data from EPA ECOTOX Knowledgebase in 2010.

1.1.5.1 Diazinon Acute Toxicity Data

Acute data for diazinon were obtained from the 2005 diazinon aquatic life criteria (ALC) document (U.S. EPA 2005a), which serves as the based dataset, supplemented with an update to this data from ECOTOX in 2010. (See Table 1.) The ECOTOX 2010 update included additional LC_{50}s for *Ceriodaphnia dubia*, and one LC_{50} (and SMAV) for *Chironomus riparius* not in the ALC document. The OPP pesticide effects determination document that served as the basis for the invertebrate OPP benchmark concentration was also examined (U.S. EPA 2007). The invertebrate (*Ceriodaphnia dubia*) and fish (*Oncorhynchus mykiss*) tests that served as the basis for the OPP acute benchmarks were both included in the ALC document and/or the 2010 ECOTOX update.

The final diazinon acute dataset consisted of 27 SMAVs and 21 GMAVs, of which 14 SMAVs and 11 GMAVs were for invertebrate taxa. Ranked species and genus mean acute values for all invertebrates included in this analysis are listed in Table 2 below.

Table 1. Acute toxicity data of diazinon to freshwater aquatic organisms.

OW MDR Group[a]	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
H	Planaria, *Dugesia tigrina*	11,640	11,640	11,640	Phipps 1988
H	Ogliochate, *Lumbriculus variegates*	9,980	-		Phipps 1988
H	Ogliochate (adult), *Lumbriculus variegates*	9,700	-		Brooke 1989
H	Ogliochate, *Lumbriculus variegates*	6,160	8,417	8,417	Ankley and Collyard 1995
G	Snail (2.4 g), *Gillia altilis*	11,000	11,000	11,000	Robertson and Mazzella 1989
G	Apple snail (1 d), *Pomacea paludosa*	2,950	-		Call 1993
G	Apple snail (7 d), *Pomacea paludosa*	3,270	-		Call 1993
G	Apple snail (7 d), *Pomacea paludosa*	3,390	3,198	3,198	Call 1993
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.57			Norberg-King 1987
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.66			Norberg-King 1987
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.57			Norberg-King 1987

OW MDR Group[a]	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	1			Norberg-King 1987
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.6			Norberg-King 1987
D	Cladoceran (<6 hr), *Ceriodaphnia dubia*	0.66			Norberg-King 1987
D	Cladoceran (<48 hr), *Ceriodaphnia dubia*	0.35	-		Norberg-King 1987
D	Cladoceran (<48 hr), *Ceriodaphnia dubia*	0.35	-		Norberg-King 1987
D	Cladoceran (<6 hr), *Ceriodaphnia dubia*	0.25	-		Norberg-King 1987
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.33	-		Norberg-King 1987
D	Cladoceran (<48 hr), *Ceriodaphnia dubia*	0.35	-		Norberg-King 1987
D	Cladoceran (<48 hr), *Ceriodaphnia dubia*	0.59	-		Norberg-King 1987
D	Cladoceran (<48 hr), *Ceriodaphnia dubia*	0.43	-		Norberg-King 1987
D	Cladoceran (<48 hr), *Ceriodaphnia dubia*	0.35	-		Norberg-King 1987
D	Cladoceran (<48 hr), *Ceriodaphnia dubia*	0.36	-		Norberg-King 1987
D	Cladoceran (<48 hr), *Ceriodaphnia dubia*	0.5	-		Ankley et al. 1991
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.58	-		Bailey et al. 1997
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.48	-		Bailey et al. 1997
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.26	-		Bailey et al. 1997
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.29	-		Bailey et al. 1997
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.38	-		Bailey et al. 2001
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.33	-		Bailey et al. 2001
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.45	-		Banks et al. 2003
D	Cladoceran (<24 hr), *Ceriodaphnia dubia*	0.21	0.4248	0.4248	Banks et al. 2005
D	Cladoceran (<20 hr), *Daphnia magna*	0.96	-		Vilkas 1976
D	Cladoceran (<24 hr), *Daphnia magna*	1.5	-		Dortland 1980
D	Cladoceran (<48 hr), *Daphnia magna*	0.8	1.048		Ankley et al. 1991
D	Cladoceran (1st instar), *Daphnia pulex*	0.90	-		Cope 1965a; Sanders and Cope 1966

OW MDR Group[a]	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
D	Cladoceran (1st instar), *Daphnia pulex*	0.8	-		Johnson and Finley 1980; Mayer and Ellersieck 1986
D	Cladoceran (<48 hr), *Daphnia pulex*	0.65	0.7764	0.9022	Ankley et al. 1991
D	Cladoceran (1st instar), *Simocephalus serrulatus*	1.8	-		Cope 1965a; Sanders and Cope 1966; Mayer and Ellersieck 1986
D	Cladoceran (1st instar), *Simocephalus serrulatus*	1.4	1.587	1.587	Sanders and Cope 1966; Johnson and Finley 1980; Mayer and Ellersieck 1986
E	Amphipod (mature), *Gammarus fasciatus*	2.04	2.04		Johnson and Finley 1980; Mayer and Ellersieck 1986
E	Amphipod (mature), *Gammarus pseudolimnaeus*	16.82	16.82	5.858	Hall and Anderson 2004
E	Amphipod (7-14 d), *Hyalella azteca*	6.51	6.51	6.510	Ankley and Collyard 1995
F	Stonefly (larva, 30-35 mm), *Pteronarcys californica*	25	25	25.000	Cope 1965a; Sanders and Cope 1968; Johnson and Finley 1980; Mayer and Ellersieck 1986
F	Midge (2nd-3rd instar), *Chironomus riparius*	450	450		Brooke 1989
F	Midge (3rd instar), *Chironomus tentans*	10.7	10.7	69.39	Ankley and Collyard 1995
A	Cutthroat trout (2.0 g), *Oncorhynchus clarki*	1,700	-		Johnson and Finley 1980; Mayer and Ellersieck 1986
A	Cutthroat trout (2.0 g), *Oncorhynchus clarki*	2,760	2,166		Mayer and Ellersieck 1986
A	Rainbow trout (3.7 cm), *Oncorhynchus mykiss*	400	-		Beliles 1965
A	Rainbow trout (1.20 g), *Oncorhynchus mykiss*	90	-		Cope 1965a; Johnson and Finley 1980; Mayer and Ellersieck 1986
A	Rainbow trout (25-50 g), *Oncorhynchus mykiss*	3,200	-		Bathe et al. 1975a
A	Rainbow trout, *Oncorhynchus mykiss*	90	-		Ciba-Giegy 1976
A	Rainbow trout, *Oncorhynchus mykiss*	1,350	425.8		Meier et al. 1979; Dennis et al. 1980
A	Chinook salmon (alevin), *Oncorhynchus tshawytscha*	29,500	29,500	3,008	Pincetich 2004; Viant et al. 2006
A	Brook trout (1 yr), *Salvelinus fontinalis*	800	-		Allison and Hermanutz 1977
A	Brook trout (1 yr), *Salvelinus fontinalis*	450	-		Allison and Hermanutz 1977
A	Brook trout (1 yr), *Salvelinus fontinalis*	1,050	723.0		Allison and Hermanutz 1977
A	Lake trout (3.20 g), *Salvelinus namaycush*	602	602	659.8	Johnson and Finley 1980; Mayer and Ellersieck 1986
B	Splittail (larva, 6 wk), *Pogonichthys macrolepidotus*	8,900	8,900	8,900	Teh et al. 2004

OW MDR Group[a]	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
B	Zebrafish (0.4 g), *Danio rerio*	8,000	8,000	8,000	Keizer et al. 1991
B	Fathead minnow (juvenile), *Pimephales promelas*	6,600	-		Allison and Hermanutz 1977
B	Fathead minnow (juvenile), *Pimephales promelas*	6,800	-		Allison and Hermanutz 1977
B	Fathead minnow (juvenile), *Pimephales promelas*	10,000	-		Allison and Hermanutz 1977
B	Fathead minnow (newly hatched larva), *Pimephales promelas*	6,900	-		Jarvinen and Tanner 1982
B	Fathead minnow (juvenile), *Pimephales promelas*	9,350	7,804	7,804	University of Wisconsin-Superior 1988
B	Goldfish (2.5-6.0 cm), *Carassius auratus*	9,000	9,000	9,000	Beliles 1965
B	Flagfish (6 wk), *Jordanella floridae*	1,500	-		Allison and Hermanutz 1977
B	Flagfish (7 wk), *Jordanella floridae*	1,800	1,643	1,643	Allison and Hermanutz 1977
B	Guppy (0.6 g), *Poecilia reticulata*	800	800	800	Keizer et al. 1991
B	Bluegill (1 yr), *Lepomis macrochirus*	480	-		Allison and Hermanutz 1977
B	Bluegill (1 yr), *Lepomis macrochirus*	440	459.6	460	Allison and Hermanutz 1977
B	Bluegill (0.8 g), *Lepomis macrochirus*	120[c]	-		Meier et al. 1979; Dennis et al. 1980
B	Bluegill (1.00 g), *Lepomis macrochirus*	168.0[c]			Johnson and Finley 1980; Mayer and Ellersieck 1986
C	Green frog (stage 8), *Rana clamitans*	50	50	50	Harris et al. 1998

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The invertebrate OPP benchmark for diazinon is 0.105 µg/L, which is ½ of the LC_{50} for the cladoceran species *C. dubia* reported in a study by Banks et al. (2005). This test is the lowest of 24 LC_{50}s that comprise the SMAV for *C. dubia*.

The fish OPP benchmark for diazinon is 45 µg/L, which is ½ of the LC_{50} of 90 µg/L, the two lowest LC_{50}s for rainbow trout (*Oncorhynchus mykiss*), which is the second most sensitive fish genera.

OW Acute Criterion

The acute criterion, or criterion maximum concentration (CMC) for diazinon in the 2005 ALC document is 0.17 µg/L.

Genus-Level Invertebrate-only HC_{05}

The acute HC_{05} calculated from invertebrate genera shown in Table 2 above following the U.S. EPA (1985) methodology is 0.1935 µg/L (Table 3).

Table 2. Diazinon invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Dugesia	*tigrina*	11,640	11,640	11
Gillia	*altilis*	11,000	11,000	10
Lumbriculus	*variegatus*	8,417	8,417	9
Pomacea	*paludosa*	3,198	3,198	8
Chironomus	*riparius*	450	69.39	7
Chironomus	*tentans*	10.7		
Pteronarcys	*californica*	25	25	6
Hyalella	*azteca*	6.51	6.51	5
Gammarus	*fasciatus*	2.04	5.858	4
Gammarus	*pseudolimnaeus*	16.82		
Simocephalus	*serrulatus*	1.587	1.587	3
Daphnia	*pulex*	0.7764	0.9022	2
Daphnia	*magna*	1.048		
Ceriodaphnia	*dubia*	0.4248	0.4248	1

Table 3. HC_{05} calculated from the genus-level diazinon invertebrate-only data following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
11	4	5.858	1.768	3.13	0.3333	0.5774
	3	1.588	0.462	0.21	0.2500	0.5000
	2	0.9022	-0.103	0.01	0.1667	0.4082
	1	0.4248	-0.856	0.733	0.0833	0.2887
	Sum:		1.27	4.08	0.8333	1.7743
	S^2 =	79.414				
	L =	-3.635				
	A =	-1.642				
	HC_{05} =	0.1935				

Table 4. Summary and comparison of acute values for diazinon.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OWALC (FAV/2) (Year published, # of genera, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)	Notes
Diazinon	0.105 µg/L (2016; *C. dubia*)	0.170 µg/L (2005, 20 genera, 0.61X)	0.097 µg/L (11 genera, 1.1X)	*C. dubia* is the most sensitive species in the invertebrate dataset and FIFRA ALB is based on the lowest of 24 LC_{50} values that comprise the SMAV.

Figure 1 shows a genus-level sensitivity distribution for the diazinon dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the CMC, invertebrate HC_{05}/2, and OPP benchmark values are also included.

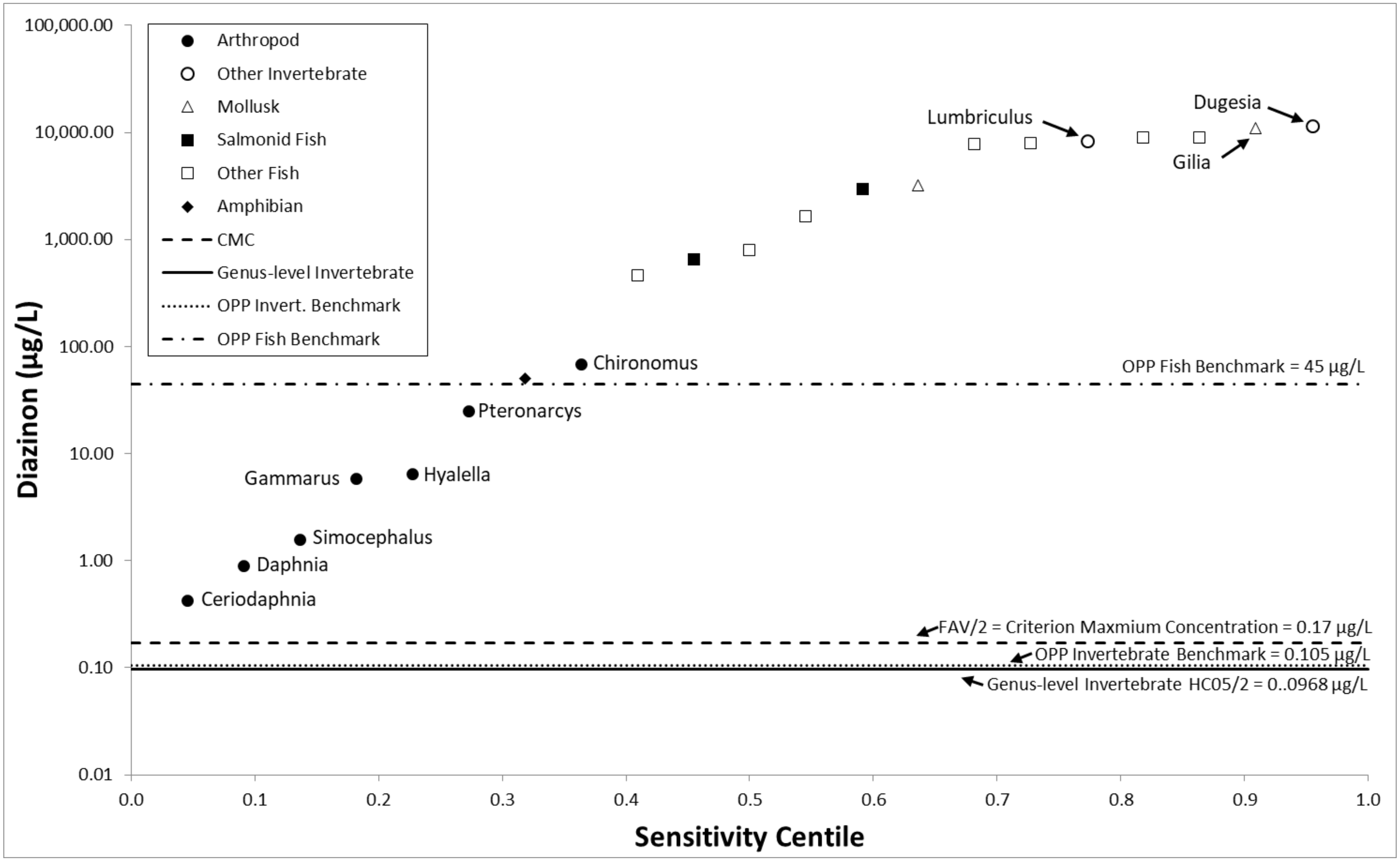

Figure 1. Diazinon genus-level SD.
Symbols represent GMAVs calculated using all quantitative data from the aquatic life criteria document for diazinon (U.S. EPA 2005), additional data from a 2010 ECOTOX update, and the OPP benchmark document for diazinon (U.S. EPA 2007).

1.1.5.2 Diazinon Chronic Toxicity Data

For chemicals lacking sufficient chronic data to satisfy the minimum taxonomic data requirements, such as diazinon, OW calculates the final chronic value (FCV) as the final acute value (FAV) divided by the final acute-to chronic ratio (FACR). OPP will also apply ACRs to acute data for sensitive taxonomic groups to calculate chronic benchmarks when chronic test data are not available. Calculations of ACRs following OPP and OW methodologies were conducted, and the effects of these ACRs on the resulting OPP and OW chronic values were compared.

Data Sources

The data sources for this analysis include data originally reported in the 2005 aquatic life criteria (ALC) document (U.S. EPA 2005a), supplemented by additional test data from a 2010 ECOTOX search update for diazinon, as well as additional data obtained from OPP-authored pesticide effects determination (U.S. EPA 2007) and problem formulation (U.S. EPA 2008) reports.

ACR Calculations

ACR calculations following OW and OPP methodologies are described below. All available chronic diazinon data are shown in Table 5. All available acute data for species that also have chronic data are shown in Table 6. Table 7 lists all ACRs by species and calculation method. ACRs could be calculated for two invertebrate and four fish species following the OW approach, and for three invertebrate and four fish species following the OPP approach (U.S. EPA 2005b).

Invertebrate ACRs

Ceriodaphnia dubia

The ACR following the OW approach was 1.112, which was the geometric mean of ten acute values from the same laboratory (nine reported in Norberg-King 1987 and one reported in Ankley et al. 1991) divided by the MATC from a chronic test performed in the same laboratory (Norberg-King 1987). The ACR following the OPP approach was 1.709, using the same acute test data and the NOEC from the paired chronic test.

Daphnia magna

An ACR could not be calculated following the OW approach, because none of the acute tests were performed in the same laboratory using the same dilution water as any of the chronic tests. The ACR following the OPP approach was 5.190, which was the geometric mean of the three acceptable acute values divided by the geometric mean of the two acceptable NOECs.

Americamysis bahia

The ACR following the OW approach was 1.586, which was acute value reported in Nimmo et al. (1981) divided by the corresponding MATC for the paired chronic test. The ACR following the OPP approach was 2.295, which was acute value reported in Nimmo et al. (1981) divided by the corresponding NOEC for the paired chronic test

Vertebrate (Fish) ACRs

Salvelinus fontinalis

The ACR following the OW approach was >903.8, which was the geometric mean of three acceptable acute values reported in Allison and Hermanutz (1977) divided by the paired OW-calculated NOEC of <0.8 µg/L. The ACR following the OPP approach was >1,315, which was the geometric mean of three acceptable acute values reported in Allison and Hermanutz (1977) divided by the paired OPP-calculated NOEC of <0.55 µg/L.

Pimephales promelas

In both the OW- and OPP-approaches, two ACRs were calculated using paired data from Jarvinen and Tanner (1982) and University of Wisconsin-Superior (1988) - Norberg-King (1989). The final *P. promelas* ACRs, calculated as the geometric mean of the two paired tests, was 196.2 following the OW approach and 279.6 following the OPP approach.

Jordanella floridae

The ACR following the OW approach was 23.84, which was the geometric mean of two acute values reported in Allison (1977) divided by the paired MATC. The ACR following the OPP approach was 30.43, which was the geometric mean of two acute values reported in Allison (1977) divided by the paired NOEC.

Cyprinodon variegatus

The ACR following the OW approach was >2,979, which was the Goodman et al. (1979), Mayer (1987) acute value divided by the OW-calculated paired NOEC of <0.47 µg/L. The ACR following the OPP approach was 3,590, which was the Goodman et al. (1979) – Mayer (1987) acute value divided by the OPP-calculated paired NOEC of 0.36 µg/L.

Final ACRs

The final ACRs (FACRs) for the two approaches, expressed as the geometric mean of all available ACRs, is 53.01 following the OW approach, and 50.33 following the OPP approach. The OW-calculated FACR is larger the OPP FACR because the OPP FACR includes a relatively small ACR of 5.190 for *D. magna* that could not be calculated following the OW approach. When the comparison is limited to those ACRs both approaches have in common, the OPP FACR is 73.49.

FACRs following both approaches are comprised of two to three relatively small ACRs for acutely sensitive invertebrate taxa, and four much larger ACRs for acutely insensitive fish species. The Guidelines (U.S. EPA 1985) specify that if the ACRs appear to increase or decrease as the species mean acute values (SMAVs) increase, the FACR should be calculated as the geometric mean for those species whose SMAVs are close to the final acute value (FAV). This is the case for diazinon, and following the approach used in the 2005 ALC, the FACR is calculated as the geometric mean of the acutely sensitive invertebrate species. When limited to invertebrate species, the FACR following the OW approach is calculated as the geometric mean of the ACRs for *C. dubia* (1.112) and *A. bahia* (1.586). Because the final chronic value cannot be larger than the final acute value, the calculated ACR of 1.328 is rounded up to 2. The invertebrate-only

FACR following the OPP approach is the geometric mean of the ACRs for *C. dubia* (1.709), *D. magna* (5.190), and *A. bahia* (2.295), or 2.731.

Comparison of Freshwater Chronic Values for Diazinon

OPP Chronic Benchmarks

For diazinon, the freshwater invertebrate chronic benchmark is 0.17 μg/L, which is a NOEC from a registrant submitted test for *Daphnia magna* (Table 27 in U.S. EPA 2007); and the freshwater fish chronic benchmark is <0.55 μg/L, which a NOEC from Allison and Hermanutz (1977) for *Salvelinus fontinalis* based on reduced growth (Table 27 in U.S. EPA 2007).

OW Freshwater Chronic Values – All Taxa

Final chronic concentrations following the ACR methodology are calculated by dividing the final acute value by an ACR. For diazinon, the only available FAV calculated from all taxa is the FAV of 0.3397 μg/L reported in the diazinon ALC (U.S. EPA 2005a). The final chronic value following the OW-ACR approach is 0.1699 μg/L (0.3397 μg/L ÷ 2), and the final chronic value following the OPP-ACR approach is 0.1244 μg/L (0.3397 μg/L ÷ 2.731).

OW Freshwater Chronic Values – Invertebrate Taxa

Final chronic concentrations for the invertebrate-only diazinon dataset are calculated by dividing the final invertebrate acute value by an ACR. This dataset was comprised of acute invertebrate test data found in the 2005 ALC and the 2010 ECOTOX update. The 2007 and 2008 OPP documents were also examined but these did not include additional acute invertebrate test data. The resulting acute HC_{05} calculated from the 11 invertebrate genera using the Guidelines SSD was 0.1935 μg/L. The final invertebrate chronic value following the OW-ACR approach is 0.09675 μg/L (0.1935 μg/L ÷ 2), and the final chronic value following the OPP-ACR approach is 0.07085 μg/L (0.1935 μg/L ÷ 2.731). Table 8 lists all chronic values calculated following the different approaches.

Table 5. Chronic test data for diazinon.

All concentrations expressed as µg/L. Bolded rows are chronic test results reported by OPP that differ from results reported by OW.

Genus	Species	NOEC	LOEC	MATC	Reference	Test data reported in: 2005 ALC	2010 ECOTOX Search	2007 OPP	2008 OPP	Notes
Invertebrates										
Ceriodaphnia	*dubia*	0.22	0.52	0.338	Norberg-King 1987	Table 2	X			
Daphnia	*magna*	0.24	0.64	0.392	Biesinger 1973		X			
Daphnia	*magna*	0.17	<0.32	0.233	Surprenant 1988			Table 27	Table 3	
Americamysis	*bahia*	2.1	4.4	3.040	Nimmo et al. 1981		X		Table 3	
Vertebrates										
Salvelinus	*fontinalis*	<0.8	0.8	-	Allison and Hermanutz 1977	Table 2	X			OW calculated value
Salvelinus	***fontinalis***	**<0.55**	**0.55**	**-**	**Allison and Hermanutz 1977**			**Table 27**	**Table 3**	**OPP calculated value**
Pimephales	*promelas*	50	90	67.08	Jarvinen and Tanner 1982	Table 2	X			
Pimephales	*promelas*	16.5	38	24.97	Norberg-King 1989	Table 2	X			Paired with University of Wisconsin-Superior 1988
Jordanella	*floridae*	54	88	68.93	Allison 1977	Table 2	X			
Cyprinodon	*variegatus*	<0.47	0.47	-	Goodman et al. 1979	Table 2	X			OW calculated value
Cyprinodon	***variegatus***	**0.39**	**0.56**	**0.47**	**Goodman et al. 1979**				**Table 3**	**OPP calculated value**

Table 6. Acute diazinon test data for species with chronic test data.
All concentrations expressed as µg/L.

Genus	Species	EC50 or LC50	OW-ACR Acute Value	OPP-ACR Acute Value	Reference	Test data reported in: 2005 ALC	2010 ECOTOX	2008 OPP	Notes
					Invertebrates				
Ceriodaphnia	*dubia*	0.35	0.3760	0.3760	Norberg-King 1987	Table 1	X		OW, OPP-ACR acute value
Ceriodaphnia	*dubia*	0.35			Norberg-King 1987	Table 1	X		OW, OPP -ACR acute value
Ceriodaphnia	*dubia*	0.25			Norberg-King 1987	Table 1	X		OW, OPP -ACR acute value
Ceriodaphnia	*dubia*	0.33			Norberg-King 1987	Table 1	X		OW, OPP -ACR acute value
Ceriodaphnia	*dubia*	0.35			Norberg-King 1987	Table 1	X		OW, OPP -ACR acute value
Ceriodaphnia	*dubia*	0.59			Norberg-King 1987	Table 1	X		OW, OPP -ACR acute value
Ceriodaphnia	*dubia*	0.43			Norberg-King 1987	Table 1	X		OW, OPP -ACR acute value
Ceriodaphnia	*dubia*	0.35			Norberg-King 1987	Table 1	X		OW, OPP -ACR acute value
Ceriodaphnia	*dubia*	0.36			Norberg-King 1987	Table 1	X		OW, OPP -ACR acute value
Ceriodaphnia	*dubia*	0.5			Ankley et al. 1991	Table 1	X		OW, OPP -ACR acute value
Ceriodaphnia	*dubia*	0.58			Bailey et al. 1997	Table 1	X		
Ceriodaphnia	*dubia*	0.48			Bailey et al. 1997	Table 1	X		
Ceriodaphnia	*dubia*	0.26			Bailey et al. 1997	Table 1	X		
Ceriodaphnia	*dubia*	0.29			Bailey et al. 1997	Table 1	X		
Ceriodaphnia	*dubia*	0.38			Bailey et al. 2001		X		
Ceriodaphnia	*dubia*	0.33			Bailey et al. 2001		X		
Ceriodaphnia	*dubia*	0.45			Banks et al. 2003		X		
Ceriodaphnia	*dubia*	0.21			Banks et al. 2005		X	Table 3	
Ceriodaphnia	*dubia*	0.57			Norberg-King 1987	Table 1	X		Not used to calculate SMAV
Ceriodaphnia	*dubia*	0.66			Norberg-King 1987	Table 1	X		Not used to calculate SMAV
Ceriodaphnia	*dubia*	0.57			Norberg-King 1987	Table 1	X		Not used to calculate SMAV
Ceriodaphnia	*dubia*	>1.0			Norberg-King 1987	Table 1	X		Not used to calculate SMAV
Ceriodaphnia	*dubia*	>0.6			Norberg-King 1987	Table 1	X		Not used to calculate SMAV
Ceriodaphnia	*dubia*	0.66			Norberg-King 1987	Table 1	X		Not used to calculate SMAV
Ceriodaphnia	*dubia*	0.57			Norberg-King 1987	Table 1	X		Not used to calculate SMAV
Ceriodaphnia	*dubia*	0.66			Norberg-King 1987	Table 1	X		Not used to calculate SMAV
Daphnia	*magna*	0.96	n/a	1.048	Vilkas 1976	Table 1	X		OPP-ACR acute value
Daphnia	*magna*	1.5			Dortland 1980	Table 1	X		OPP-ACR acute value
Daphnia	*magna*	0.8			Ankley et al. 1991	Table 1	X		OPP-ACR acute value
Americamysis	*bahia*	4.82	4.82	4.82	Nimmo et al. 1981	Table 1	X		OW, OPP-ACR acute value

Genus	Species	EC50 or LC50	OW-ACR Acute Value	OPP-ACR Acute Value	Reference	Test data reported in:			Notes
						2005 ALC	2010 ECOTOX	2008 OPP	
Americamysis	*bahia*	4.2			Suprenant 1988			Table 3	
Americamysis	*bahia*	8.5			Thursby and Berry 1988	Table 1	X		Not used to calculate SMAV
Americamysis	*bahia*	8.5			Cripe 1994	Table 1	X		Not used to calculate SMAV
Vertebrates									
Salvelinus	*fontinalis*	800	723.0	723.0	Allison and Hermanutz 1977	Table 1	X		OW, OPP-ACR acute value
Salvelinus	*fontinalis*	450			Allison and Hermanutz 1977	Table 1	X		OW, OPP-ACR acute value
Salvelinus	*fontinalis*	1,050			Allison and Hermanutz 1977	Table 1	X		OW, OPP-ACR acute value
Pimephales	*promelas*	6,900	6,900	6,900	Jarvinen and Tanner 1982	Table 1	X		OW, OPP-ACR acute value
Pimephales	*promelas*	9,350	9,350	9,350	University of Wisconsin-Superior 1988	Table 1	X		OW, OPP-ACR acute value. Paired with Norberg-King 1989
Pimephales	*promelas*	6,600			Allison and Hermanutz 1977	Table 1	X		
Pimephales	*promelas*	6,800			Allison and Hermanutz 1977	Table 1	X		
Pimephales	*promelas*	10,000			Allison and Hermanutz 1977	Table 1	X		
Pimephales	*promelas*	4,300			Jarvinen and Tanner 1982	Table 1	X		Not used to calculate SMAV
Pimephales	*promelas*	2,100			Jarvinen and Tanner 1982	Table 1	X		Not used to calculate SMAV
Pimephales	*promelas*	10,300			Meier et al. 1979; Dennis et al. 1980	Table 1	X		Not used to calculate SMAV
Jordanella	*floridae*	1,500	1,643	1,643	Allison 1977	Table 1	X		OW-ACR acute value
Jordanella	*floridae*	1,800			Allison 1977	Table 1	X		OW-ACR acute value
Cyprinodon	*variegatus*	1,400	1,400	1,400	Goodman et al. 1979; Mayer 1987	Table 1	X		OW-ACR acute value

Table 7. ACRs by species and calculation method.

Genus	Species	ACR		Notes
		OW-ACR	OPP-ACR	
Invertebrates				
Ceriodaphnia	*dubia*	1.112	1.709	
Daphnia	*magna*	N/A	5.190	
Americamysis	*bahia*	1.586	2.295	
Vertebrates				
Salvelinus	*fontinalis*	>903.8	>1,315	
Pimephales	*promelas*	196.2	279.6	Value in parentheses used lowest acute flow-through test. Used in final "All Taxa" calculation.
Jordanella	*floridae*	23.84	30.43	
Cyprinodon	*variegatus*	>2,979	3,590	
All Taxa		53.01	50.33	
All Invertebrates (FACR)		1.328	2.731	OW-FACR rounded up to 2.

Table 8. Summary and comparison freshwater chronic values for diazinon.
Magnitude relative to ALB is the OPP ALB/OW value; a ratio < 1 means the OPP ALB value is lower than the OW value, a ratio >1 means the OPP ALB is higher than the OW value. Note: For GLI Tier II values, a default ACR of 18 is used when empirically derived ACRs are not available.

Pesticide	Most Sensitive OPP ALB (Year published, species)	OW ALC (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)
Diazinon	0.17 µg/L (2016, *Daphnia magna*)	0.17 µg/L (ALC, 1X)	0.097 µg/L (See Table 7 for ACRs, 1.8X)

1.1.5.3 Diazinon References

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1.1.6 Comparison of Aquatic Life Toxicity Values for Chlorpyrifos: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for chlorpyrifos were obtained from the 1986 OW criteria, which serves as the base dataset, supplemented with an update to this data from the EPA's ECOTOX Knowledgebase in 2010, and with additional data reported in the OPP's chlorpyrifos re-registration eligibility assessment document U.S. EPA (2000). There was no comparative analysis for chlorpyrifos chronic data.

1.1.6.1 Chlorpyrifos Acute Toxicity Data

Acceptable acute data for chlorpyrifos were obtained from the 1986 criteria, which serves as the base dataset, supplemented with an update to this data from ECOTOX in 2010, and with additional LC_{50}s reported in the chlorpyrifos re-registration eligibility assessment document U.S. EPA (2000). (See Table 1.) Four acute tests were included in U.S. EPA (2000) that were not in the 2010 ECOTOX update: two LC_{50}s (0.1 µg/L, 1.7 µg/L) for *Daphnia magna*, including the value upon which the OPP invertebrate benchmark is based; an LC_{50} of 8.2 µg/L for the stonefly species *Classenia sabulosa*, and an LC_{50} of 150 µg/L for *Pimephales promelas*. The *C. sabulosa* LC_{50} of 8.2 µg/L was considered for inclusion but ultimately not included. This was a the 24-hr LC_{50} from a test reported in Mayer and Ellersieck (1986) that also reported a 96-hr LC_{50} of 0.57 µg/L. The 96-hr LC_{50} was included in the 2010 ECOTOX update, but not the 24-hr LC_{50}, due to the shorter exposure duration. Because the 96-hr result from this test was already represented, the 24-hr LC_{50} of 8.2 µg/L was not used in this evaluation.

The final dataset consisted of 94 acceptable LC_{50}s for 32 SMAVs and 28 GMAVs, of which 18 SMAVs and 15 GMAVs were for invertebrates. Ranked invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity data of chlorpyrifos to freshwater aquatic organisms

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
G	Amblema	plicata	1,200	1,200	1,200	Doran et al. 2001
G	Lampsilis	siliquoidea	250	250	250	Bringolf et al. 2007
G	Aplexa	hypnorum	806	806	806	Phipps and Holcombe 1985a; b
D	Ceriodaphnia	dubia	0.06	0.0627	0.0627	Bailey et al. 1996
D	Ceriodaphnia	dubia	0.06			Bailey et al. 1996
D	Ceriodaphnia	dubia	0.053			Bailey et al. 1997
D	Ceriodaphnia	dubia	0.055			Bailey et al. 1997
D	Ceriodaphnia	dubia	0.058			Bailey et al. 1997
D	Ceriodaphnia	dubia	0.078			Bailey et al. 1997
D	Ceriodaphnia	dubia	0.058			Bailey et al. 1997
D	Ceriodaphnia	dubia	0.064			Bailey et al. 1997
D	Ceriodaphnia	dubia	0.066			Bailey et al. 1997
D	Ceriodaphnia	dubia	0.079			Bailey et al. 1997
D	Ceriodaphnia	dubia	0.08			Foster et al. 1998
D	Ceriodaphnia	dubia	0.056			Harmon et al. 2003
D	Ceriodaphnia	dubia	0.050			El-Merhib et al. 2004
D	Ceriodaphnia	dubia	0.07			Pablo et al. 2008
D	Daphnia	ambigua	0.035	0.035	0.1298	Harmon et al. 2003
D	Daphnia	magna	1.0	0.4811		Kersting and Van Wijngaarden 1992
D	Daphnia	magna	0.325			Diamantino et al. 1998
D	Daphnia	magna	0.344			Diamantino et al. 1998
D	Daphnia	magna	0.19			Kikuchi et al. 2000
D	Daphnia	magna	1.074			Gaizick et al. 2001
D	Daphnia	magna	0.74			Palma et al. 2008
D	Daphnia	magna	0.10			MRID 40840902; Burgess 1988
D	Daphnia	magna	1.7			MRID 00102520; McCarthy 1977
D	Simocephalus	vetulus	0.09	0.09	0.09	Pablo et al. 2008

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
F	Peltodytes	sp.	0.8	0.8	0.8	Federle and Collins 1976
F	Chironomus	plumosus	1.3	1.3	0.7817	Vedamanikam 2009
F	Chironomus	tentans	0.47	0.47		Ankley and Collyard 1995
F	Classenia	sabulosa	0.57	0.57	0.57	Sanders and Cope 1968; Johnson and Finley 1980; Mayer and Ellersieck 1986
H	Pteronarcella	badia	0.38	0.38	0.38	Sanders and Cope 1968
H	Pteronarcys	californicus	10	10	10	Sanders and Cope 1968; Johnson and Finley 1980; Mayer and Ellersieck 1986
E	Gammarus	fasciatus	0.32	0.32	0.1876	Sanders 1972
E	Gammarus	lacustris	0.11	0.11		Sanders 1969; Johnson and Finley 1980; Mayer and Ellersieck 1986
E	Hyalella	azteca	0.04	0.0908	0.0908	Ankley and Collyard 1995
E	Hyalella	azteca	0.1192			Steevens 1999
E	Hyalella	azteca	0.2191			Steevens 1999
E	Hyalella	azteca	0.0651			Trimble and Lydy 2006
E	Orconectes	immunis	6	6	6	Phipps and Holcombe 1985a; b
E	Procambarus	clarkii	21	21	21	Cebrian et al. 1992
E	Eriocheir	sinensis	22.9	63.91	63.91	Li et al. 2006
E	Eriocheir	sinensis	24.4			Li et al. 2006
E	Eriocheir	sinensis	75.9			Li et al. 2006
E	Eriocheir	sinensis	78.50			Li et al. 2006
E	Eriocheir	sinensis	142.2			Li et al. 2006
E	Eriocheir	sinensis	143.9			Li et al. 2006
B	Pimephales	promelas	170	194.1	194.1	Jarvinen and Tanner 1982
B	Pimephales	promelas	130			Jarvinen and Tanner 1982
B	Pimephales	promelas	122.2			Jarvinen et al. 1988
B	Pimephales	promelas	150			MRID 00154732; Jarvinen and Tanner 1982
B	Pimephales	promelas	140			Jarvinen and Tanner 1982; Office of Pesticide Programs 2000

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
B	Pimephales	promelas	120			Jarvinen and Tanner 1982; Office of Pesticide Programs 2000
B	Pimephales	promelas	203.0			Holcombe et al. 1982; Office of Pesticide Programs 2000
B	Pimephales	promelas	542			Phipps and Holcombe 1985a; b
B	Pimephales	promelas	200			Geiger et al. 1988
B	Pimephales	promelas	506			Geiger et al. 1988
B	Gambusia	affinis	297.6	297.6	297.6	Rao et al. 2005
B	Pungitius	pungitius	4.7	4.7	4.7	Van Wijngaarden et al. 1993
B	Lepomis	macrochirus	2.4	3.281	3.281	Johnson and Finley 1980; Mayer and Ellersieck 1986
B	Lepomis	macrochirus	1.7			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	1.8			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	2.5			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	4.2			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	3			Alexander and Batchelder 1965; Office of Pesticide Programs 2000
B	Lepomis	macrochirus	5.8			Bowman 1988b; Office of Pesticide Programs 2000
B	Lepomis	macrochirus	10			Phipps and Holcombe 1985a; b
B	Oreochromis	mossambica	4.8	11.12	11.12	Moorthy et al. 1982
B	Oreochromis	mossambica	25.78			Rao 2008
B	Tilapia	zillii	240	240	240	Shereif 1989
A	Oncorhynchus	clarkii	18.4	13.64	11.66	Johnson and Finley 1980
A	Oncorhynchus	clarkii	26			Mayer and Ellersieck 1986
A	Oncorhynchus	clarkii	5.4			Mayer and Ellersieck 1986
A	Oncorhynchus	clarkii	13.4			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	7.1	9.97		Macek et al. 1969; Johnson and Finley 1980; Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	15			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	51			Mayer and Ellersieck 1986

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
A	Oncorhynchus	mykiss	1			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	25			Bowman 1988a; Office of Pesticide Programs 2000
A	Oncorhynchus	mykiss	8.0			Holcombe et al. 1982; Office of Pesticide Programs 2000
A	Oncorhynchus	mykiss	9			Phipps and Holcombe 1985a; b
A	Salvelinus	namaycush	98	150.0	150.0	Johnson and Finley 1980; Mayer and Ellersieck 1986
A	Salvelinus	namaycush	73			Mayer and Ellersieck 1986
A	Salvelinus	namaycush	140			Mayer and Ellersieck 1986
A	Salvelinus	namaycush	205			Mayer and Ellersieck 1986
A	Salvelinus	namaycush	227			Mayer and Ellersieck 1986
A	Salvelinus	namaycush	244			Mayer and Ellersieck 1986
B	Ictalurus	punctatus	280	475.1	475.1	Johnson and Finley 1980; Mayer and Ellersieck 1986
B	Ictalurus	punctatus	806			Phipps and Holcombe 1985a; b
B	Carassius	auratus	806	806	806	Phipps and Holcombe 1985a; b
B	Morone	saxatilis	1,000	1,000	1,000	Office of Pesticide Programs 2000
C	Xenopus	laevis	560	2,701	2,701	Richards 2000; Richards and Kendall 2002
C	Xenopus	laevis	14,600			Richards 2000; Richards and Kendall 2002
C	Xenopus	laevis	2,410			El-Merhibi et al. 2004

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark for chlorpyrifos is 0.05 µg/L, which is ½ the lowest LC_{50} for *Daphnia magna* reported in U.S. EPA (2000).

The OPP fish acute benchmark for chlorpyrifos is 0.9 µg/L, which is ½ the LC_{50} of 1.8 µg/L for *Lepomis macrochirus* reported in U.S. EPA (2000).

OW Acute Criterion

The acute criterion, or criterion maximum concentration (CMC), for chlorpyrifos is 0.083 µg/L (U.S. EPA 1986). The acute criterion dataset was smaller than the 2010 ECOTOX updated dataset, and was comprised of 15 total genera, including 8 invertebrate genera.

Genus Level Invertebrate-only HC_{05}

The genus-level invertebrate acute HC_{05} was calculated following the U.S. EPA (1985) methodology for the 15 invertebrate genera (Table 2) in the combined chlorpyrifos dataset was 0.0580 µg/L (Table 3).

Table 2. Chlorpyrifos invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Amblema	*plicata*	1,200	1,200	15
Aplexa	*hypnorum*	806.0	806.0	14
Eriocheir	*sinensis*	63.91	63.91	13
Procambarus	*clarkii*	21.00	21.00	12
Pteronarcys	*californicus*	10.00	10.00	11
Orconectes	*immunis*	6.000	6.000	10
Peltodytes	*sp.*	0.8000	0.8000	9
Chironomus	*plumosus*	1.300	0.7817	8
Chironomus	*tentans*	0.4700		
Classenia	*sabulosa*	0.5700	0.5700	7
Pteronarcella	*badia*	0.3800	0.3800	6
Gammarus	*fasciatus*	0.3200	0.1876	5
Gammarus	*lacustris*	0.1100		
Daphnia	*ambigua*	0.0350	0.1298	4
Daphnia	*magna*	0.4811		
Hyalella	*azteca*	0.0908	0.0908	3
Simocephalus	*vetulus*	0.0900	0.0900	2
Ceriodaphnia	*dubia*	0.0627	0.0627	1

Table 3. Genus level invertebrate-only acute HC_{05} for chlorpyrifos calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
15	4	0.1298	-2.042	4.169	0.2500	0.5000
	3	0.0908	-2.399	5.756	0.1875	0.4330
	2	0.09	-2.408	5.798	0.1250	0.3536
	1	0.0627	-2.769	7.670	0.0625	0.2500
	Sum:		-9.618	23.39	0.6250	1.537
	S^2 =	7.621				
	L =	-3.465				
	A =	-2.848				
	HC_{05} =	**0.0580**				

Table 4. Summary and comparison of acute values for chlorpyrifos.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW ALC (FAV/2) (Year published, # of genera, magnitude relative to ALB)	OW Genus level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)
Chlorpyrifos	0.05 µg/L (2000; *D. magna*)	0.083 µg/L (1986 15 genera, 0.60X)	0.029 µg/L (15 genera, 1.7X)

Figure 1 shows a genus level sensitivity distribution for the full chlorpyrifos dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. The CMC, OPP acute benchmark values, and genus-level invertebrate only acute HC_{05}/2 are included.

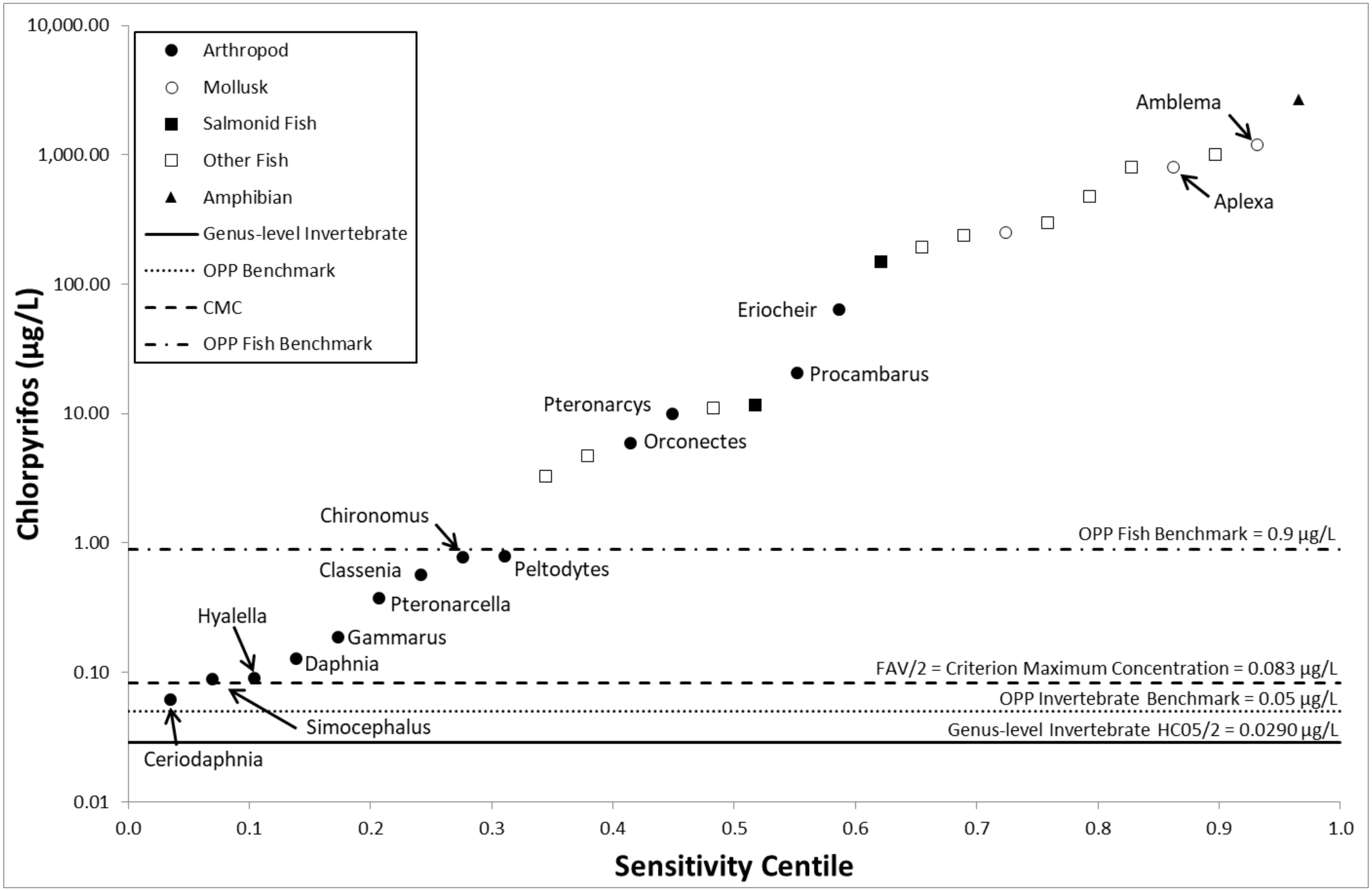

Figure 1. Chlorpyrifos acute genus-level SD.

Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from the chlorpyrifos ALC (U.S. EPA 1986), the Office of Pesticide Program's registration review document for chlorpyrifos (U.S. EPA 2000), and an ECOTOX search conducted by Office of Water in 2010.

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1.1.7 Comparison of Aquatic Life Toxicity Values for Dichlorvos: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for dichlorvos were gathered from the OPP registration review document for dichlorvos (U.S. EPA 2009) and an EPA ECOTOX Knowledgebase search conducted in 2013. There was no comparative analysis for dichlorvos chronic data.

1.1.7.1 Dichlorvos Acute Toxicity Data

Acute data were gathered from the Office of Pesticide Programs (OPP) registration review document for dichlorvos (U.S. EPA 2009) and an ECOTOX search conducted in 2013 (see Table 1).

The dichlorvos acute dataset consisted of 27 acceptable acute effect LC_{50}s for 15 total species across 12 genera, of which eight were vertebrate species across six invertebrate genera. Ranked invertebrate GMAVs are listed in Table 4.

Table 1. Acute toxicity data of dichlorvos to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
G	Lumbriculus	variegatus	2,180	2,180	2,180	Brooke 1991
G	Physa	sp.	170	170	170	Brooke 1991
D	Daphnia	magna	0.266	0.266	0.1333	Brooke 1991
D	Daphnia	pulex	0.0668	0.0668		Mayer and Ellersieck 1986
D	Simocephalus	serrulatus	0.28	0.2698	0.2698	Mayer and Ellersieck 1986
D	Simocephalus	serrulatus	0.26			Mayer and Ellersieck 1986
F	Pteronarcys	californica	0.1	0.1	0.1	Mayer and Ellersieck 1986
E	Gammarus	fasciatus	0.4	0.4	0.4472	Sanders 1972
E	Gammarus	lacustris	0.5	0.5		Mayer and Ellersieck 1986
B	Pimephales	promelas	4,000	5,234	5,234	Pickering and Henderson 1966
B	Pimephales	promelas	11,600			Mayer and Ellersieck 1986
B	Pimephales	promelas	3,090			Brooke 1991
B	Gambusia	affinis	5,270	5,270	5,270	Mayer and Ellersieck 1986
B	Lepomis	macrochirus	869	445.6	445.6	Mayer and Ellersieck 1986
B	Lepomis	macrochirus	480			Cope 1965
B	Lepomis	macrochirus	350			Pickering and Henderson 1966
B	Lepomis	macrochirus	270			Pickering and Henderson 1966
B	Tilapia	mossambica	1,934	1,671	1,671	Rath and Misra 1979
B	Tilapia	mossambica	1,710			Rath and Misra 1979
B	Tilapia	mossambica	1,410			Rath and Misra 1979
A	Oncorhynchus	clarki	170	199.8	141.4	Mayer and Ellersieck 1986

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
A	Oncorhynchus	clarki	170			Mayer and Ellersieck 1986
A	Oncorhynchus	clarki	170			Mayer and Ellersieck 1986
A	Oncorhynchus	clarki	213			Mayer and Ellersieck 1986
A	Oncorhynchus	clarki	304			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	100	100		Stalin and Johnson 1977
A	Salvelinus	namaycush	187	185.0	185.0	Mayer and Ellersieck 1986
A	Salvelinus	namaycush	183			Mayer and Ellersieck 1986

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark is 0.0334 µg/L, which is ½ of the *D. pulex* LC_{50} of 0.0668 µg/L reported in Mayer and Ellersieck (1986).

The OPP fish acute benchmark is 50 µg/L, which is ½ of the *O. mykiss* LC_{50} of 100 µg/L reported in Stalin and Johnson (1977).

OW Acute Criterion

There is no acute criterion, or criterion maximum concentration (CMC), for dichlorvos. An illustrative example was calculated for this analysis, using all available data (Table 2). The illustrative FAV calculated calculated following the U.S. EPA (1985) methodology for the 12 genera in the dichlorvos dataset was 0.06330 µg/L (Table 3).

Table 2. Dichlorvos Ranked Species Mean Acute Values (SMAV) and Genus Mean Acute Values (GMAV).

Genus	Species	SMAV (µg/L)	GMAV (µg/L)	GMAV Rank
Gambusia	*affinis*	5,270	5,270	12
Pimephales	*promelas*	5,234	5,234	11
Lumbriculus	*variegatus*	2,180	2,180	10
Tilapia	*mossambica*	1,671	1,671	9
Lepomis	*macrochirus*	445.6	445.6	8
Salvelinus	*namaycush*	185.0	185.0	7
Physa	*sp.*	170.0	170.0	6
Oncorhynchus	*clarki*	199.8	141.3	5
Oncorhynchus	*mykiss*	100		

Genus	Species	SMAV (µg/L)	GMAV (µg/L)	GMAV Rank
Gammarus	*fasciatus*	0.4000	0.4472	4
Gammarus	*lacustris*	0.5000		
Simocephalus	*serrulatus*	0.2698	0.2698	3
Daphnia	*magna*	0.2660	0.1333	2
Daphnia	*pulex*	0.0700		
Pteronarcys	*californica*	0.1000	0.1000	1

Table 3. Dichlorvos Illustrative FAV/2.

N	Rank	GMAV	ln(GMAV)	ln(GMAV)^2	P=R/(N+1)	sqrt(P)
12	4	0.4472	-0.805	0.648	0.3077	0.5547
	3	0.2698	-1.310	1.716	0.2308	0.4804
	2	0.1333	-2.015	4.061	0.1538	0.3922
	1	0.1000	-2.303	5.302	0.0769	0.2774
	Sum:		-6.433	11.73	0.769	1.705
	S^2 =	32.326				
	L =	-4.031				
	A =	-2.760				
	FAV =	**0.06330**				
	FAV/2	**0.032**				

Genus Level Invertebrate-only HC_{05}

The genus level invertebrate-only acute HC_{05} calculated following the U.S. EPA (1985) methodology for the six invertebrate genera (Table 4) in the dichlorvos dataset was 0.04513 µg/L (Table 5).

Table 4. Dichlorvos invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Lumbriculus	*variegatus*	2,180	2,180	6
Physa	*sp.*	170.0	170.0	5
Gammarus	*fasciatus*	0.4000	0.4472	4
Gammarus	*lacustris*	0.5000		
Simocephalus	*serrulatus*	0.2698	0.2698	3
Daphnia	*magna*	0.2660	0.1365	2
Daphnia	*pulex*	0.0668		
Pteronarcys	*californica*	0.1000	0.1000	1

Table 5. Genus-level invertebrate acute HC_{05} for dichlorvos calculated using following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$\ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
6	4	0.4472	-0.805	0.648	0.5714	0.7559
	3	0.2698	-1.310	1.716	0.4286	0.6547
	2	0.1333	-2.015	4.061	0.2857	0.5345
	1	0.1000	-2.303	5.302	0.1429	0.3780
	Sum:		-6.433	11.73	1.429	2.323
	S^2 =	17.406				
	L =	-4.031				
	A =	-3.098				
	HC_{05} =	**0.04513**				

Table 6. Summary and comparison of acute values for dichlorvos.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW Illustrative ALC (FAV/2) (Year published, # of genera, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)
Dichlorvos	0.0334 µg/L (2021; *D. pulex*)	0.032 µg/L (illustrative example calculated for this analysis, 12 genera, 1.1X)	0.023 µg/L (6 genera, 1.5X)

Figure 1 shows a genus level sensitivity distribution for the dichlorvos dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values, illustrative ALC example, and invertebrate-only acute HC_{05}/2 are included.

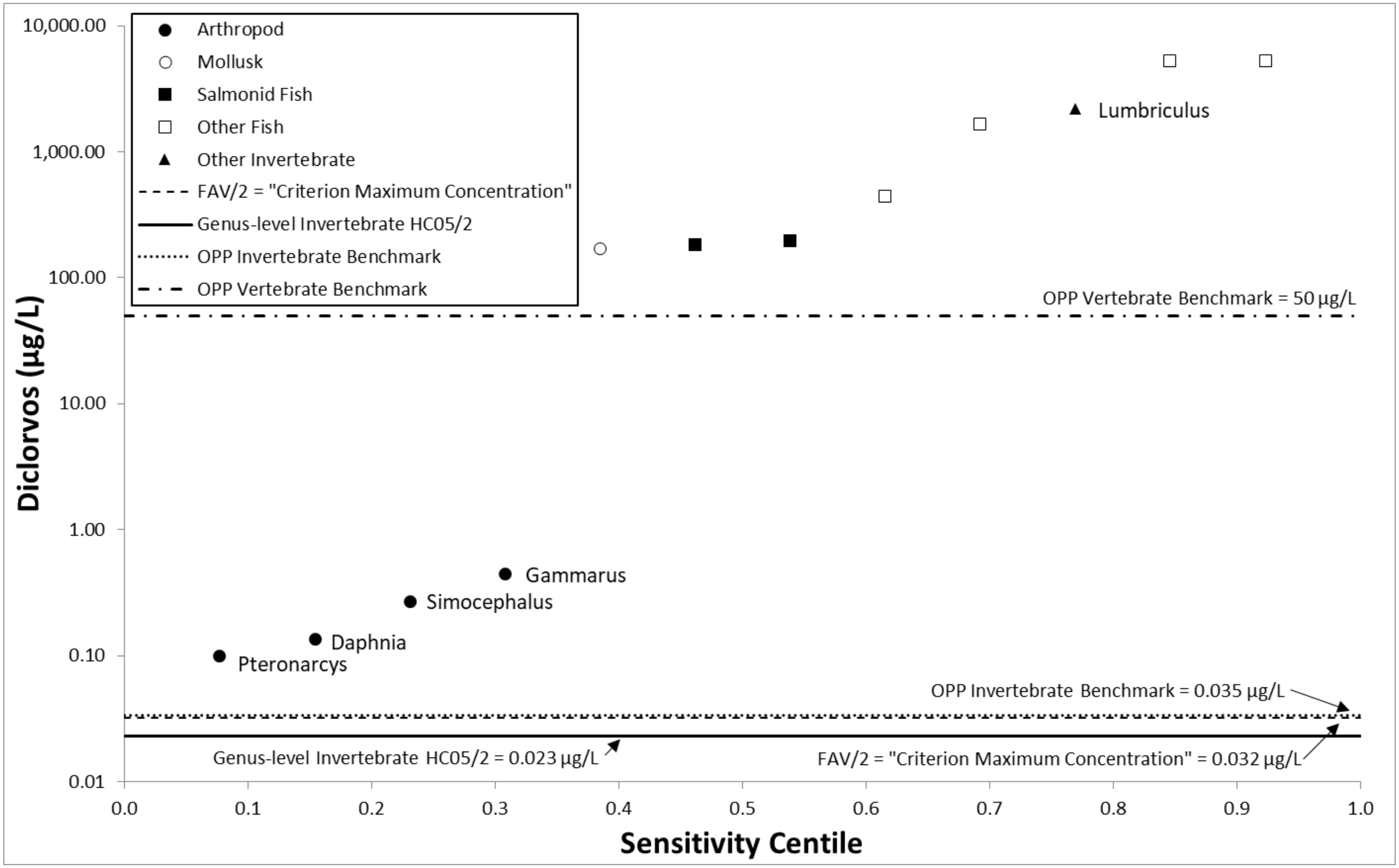

Figure 1. Dichlorvos genus-level acute SD.
Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from the Office of Pesticide Program's registration review document for dichlorvos (U.S. EPA 2009) and an ECOTOX search conducted by Office of Water in 2013. Dichlorvos does not have a recommended 304(a) aquatic life criteria. **The "Criterion Maximum Concentration" is an illustrative example calculated for these analyses.**

1.1.7.2 Dichlorvos References

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1.1.8 Comparison of Aquatic Life Toxicity Values for Acrolein: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for acrolein were obtained from Table 1 of the acrolein freshwater aquatic life criteria (ALC) document (U.S. EPA 2009a). There was no comparative analysis for chronic acrolein values.

1.1.8.1 Acrolein Acute Toxicity Data

Acceptable acute data for acrolein were obtained from Table 1 of the acrolein freshwater aquatic life criteria (ALC) document (U.S. EPA 2009a). Data were available for 36 acute tests encompassing 15 species and 14 genera. Data for invertebrate taxa were available for 12 acute tests encompassing seven species and seven genera. The OPP benchmark document (2009b) was examined to determine whether any additional acute tests were available that were not included in the criteria document. All values in the OPP benchmark document were included in Table 1 of the acrolein ALC. Ranked invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity data of acrolein to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
G	Aplexa	hypnorum	>151	>151	>151	Holcomb et al. 1987
G	Physa	heterostropha	368	368	368	Horne and Oblad 1983
D	Daphnia	magna	57	61.79	61.79	Macek et al. 1976
D	Daphnia	magna	80			USEPA 1978
D	Daphnia	magna	93			Randall and Knopp 1980
D	Daphnia	magna	83			LeBlanc 1980
D	Daphnia	magna	51			Holcomb et al. 1987
D	Daphnia	magna	<31			Blakemore 1990
E	Gammarus	minus	180	180	180	Horne and Oblad 1983
H	Peltoperla	maria	5,920	5,920	5,920	Horne and Oblad 1983
F	Chironomus	riparius	510	510	510	Horne and Oblad 1983
F	Tanytarsus	dissimilis	>151	>151	>151	Holcomb et al. 1987
A	Oncorhynchus	kisutch	68	68	57.05	Lorz et al. 1979
A	Oncorhynchus	mykiss	74	47.86		Birge et al. 1982
A	Oncorhynchus	mykiss	180			Horne and Oblad 1983
A	Oncorhynchus	mykiss	38			Venturino et al. 2007
A	Oncorhynchus	mykiss	<31			Bowman 1990a
A	Oncorhynchus	mykiss	16			Holcomb et al. 1987
B	Pimephales	promelas	320	35.79	35.79	Union Carbide Corp. 1974
B	Pimephales	promelas	45			Birge et al. 1982
B	Pimephales	promelas	14			Geiger et al. 1986
B	Pimephales	promelas	19.5			Geiger et al. 1986
B	Pimephales	promelas	61			Birge et al. 1982

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
B	Pimephales	promelas	29.7			Sabourin 1986
B	Pimephales	promelas	27			Spehar 1989
B	Pimephales	promelas	14			Holcom et al. 1987
B	Catostomus	commersoni	14	14	14	Holcomb et al. 1987
B	Jordanella	floridae	60	55.32	55.32	Spehar 1989
B	Jordanella	floridae	51			Spehar 1989
B	Lepomis	macrochirus	100	56.94	56.94	Louder and McCoy 1962
B	Lepomis	macrochirus	90			USEPA 1978
B	Lepomis	macrochirus	90			Buccafusco et al. 1981
B	Lepomis	macrochirus	33			Holcomb et al. 1987
B	Lepomis	macrochirus	22.4			Bowman 1990b
B	Micropterus	salmoides	160	160	160	Louder and McCoy 1962
C	Xenopus	laevis	7	7	7	Holcomb et al. 1987

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark for acrolein is <15.5 µg/L, which is ½ the lowest LC_{50} for *Daphnia magna*. This is also the lowest LC_{50} for *D. magna* reported in Table 1 of the ALC document.

The OPP vertebrate acute benchmark for acrolein is 3.5 µg/L, which is ½ the lowest LC_{50} for the African clawed frog, *Xenopus laevis*.

OW Acute Criterion

The criterion maximum concentration (CMC) for acrolein is 3.0 µg/L.

Genus Level Invertebrate-only HC_{05}

The genus level invertebrate-only acute HC_{05} calculated following the U.S. EPA (1985) methodology for the seven invertebrate genera (Table 2) in the acrolein dataset was 45.74 µg/L (Table 3).

Table 2. Acrolein Invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Tallaperla[a]	*maria*	5,920	5,920	7

Genus	Species	SMAV	GMAV	GMAV Rank
Chironomus	*riparius*	510.0	510.0	6
Physa	*heterostropha*	368.0	368.0	5
Gammarus	*minus*	180.0	180.0	4
Aplexa	*hypnorum*	151.0	151.0	3
Tanytarsus	*dissimilis*	151.0	151.0	2
Daphnia	*magna*	61.79	61.79	1

a – Genus changed from *Peltoperla*

Table 3. Genus level invertebrate-only acute HC_{05} for acrolein calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$\ln(\text{GMAV})^2$	P=R/(N+1)	sqrt(P)
7	4	180	5.193	26.97	0.5000	0.7071
	3	151	5.017	25.17	0.3750	0.6124
	2	151	5.017	25.17	0.2500	0.5000
	1	61.79	4.124	17.01	0.1250	0.3536
	Sum:		19.35	94.3	1.250	2.173
	S^2 =	10.08				
	L =	3.113				
	A =	3.823				
	HC_{05} =	**45.74**				

Table 4. Summary and comparison of acute values for acrolein.

Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Most Sensitive ALB (lowest LC_{50}/2) (Year published, species)	OW ALC (FAV/2) (Year published, # of genera, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)
Acrolein (contact herbicide)	3.5 µg/L (2023; *Xenopus laevis*)	3.0 µg/L (2009, 14 genera, 1.2X)	22.87 µg/L (7 genera, 0.68X) Note the magnitude comparison is with the invertebrate ALB of <15.5 µg/L.

Figure 1 shows a genus-level sensitivity distribution for the full acrolein dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. The CMC, OPP invertebrate and vertebrate acute benchmark values, and invertebrate-only acute HC_{05}/2 are included.

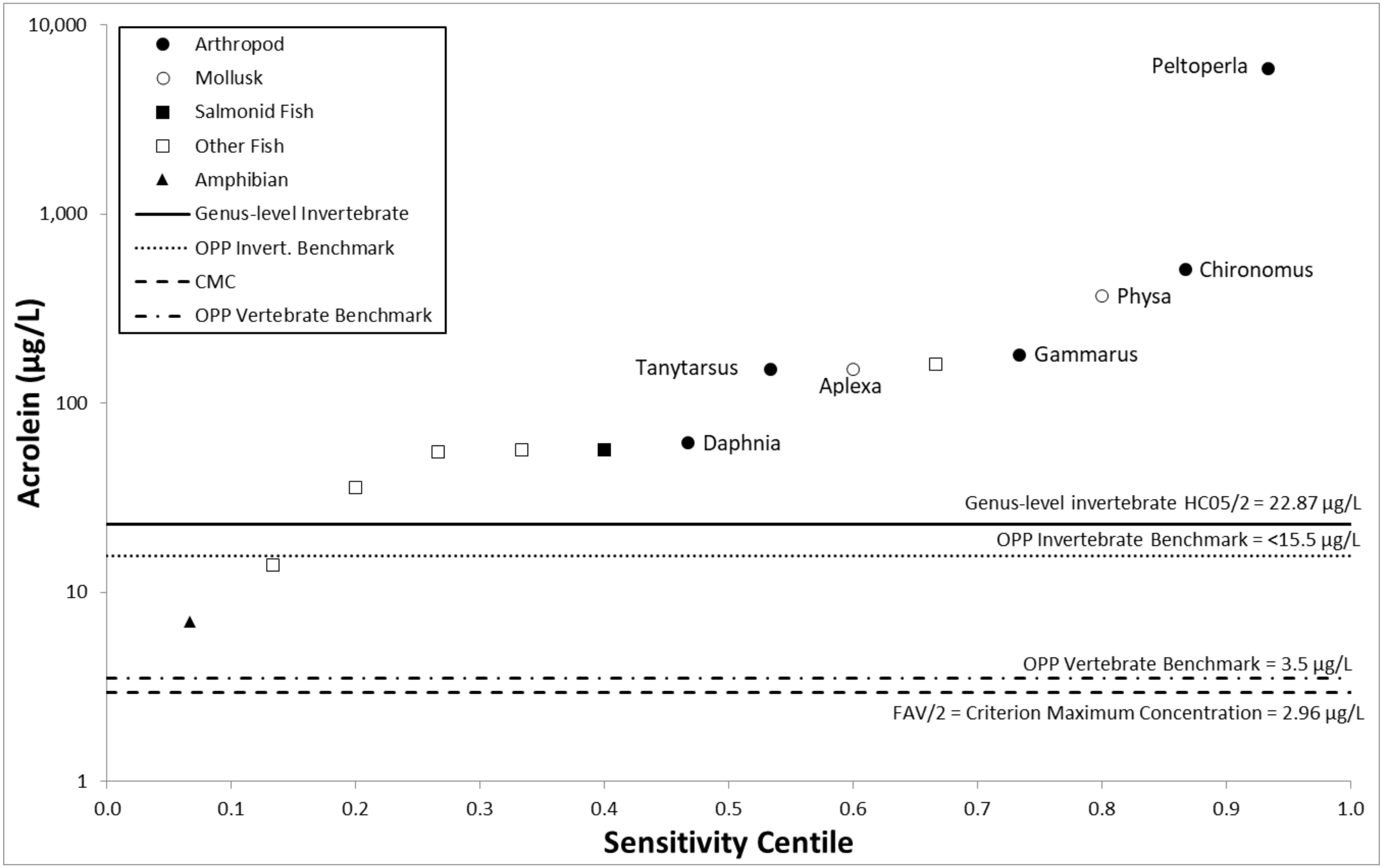

Figure 1. Acrolein genus-level acute SD.
Symbols represent GMAVs calculated using all available data from Table 1 of the 2009 acrolein ALC.

1.1.8.2 Acrolein References

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1.2 DATA-LIMITED PESTICIDES

1.2.1 Comparison of Aquatic Life Toxicity Values for Oxamyl: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) are described below. Toxicity data for oxamyl were gathered by OW in 2015 and combined with data from OPP's registration review document for oxamyl (U.S. EPA 2009).

1.2.1.1 Oxamyl Acute Toxicity Data

The oxamyl acute data include nine LC_{50}s representing six species in six genera that were classified as "quantitative" data, and two 96-hour LC_{50}s for the amphipod species *Gammarus italicus* and *Echinogammarus tibaldii* (classified as qualitative, but included in this analysis to increase the number of invertebrate genera to four), thereby enabling calculation of an invertebrate only genus-level HC_{05}. Tests were classified as qualitative because both the *G. italicus and E. tibaldi* studies were conducted with field-collected organisms, and the *G. italicus* study was not replicated.

The final acute oxamyl dataset consisted of 11 LC_{50}s for eight species across eight genera, of which four were invertebrate species and four were invertebrate genera. Acute data for oxamyl are shown in Table 1. Ranked invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity of oxamyl to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
D	Daphnia	magna	320.0	387.8	387.8	MRID 45067801; Boeri and Ward. 2000	Quantitative
D	Daphnia	magna	470.0			ECOTOX 6797; Mayer and Ellersieck. 1986	Quantitative
F	Chironomus	plumosus	180.0	180.0	180.0	ECOTOX 6797; Mayer and Ellersieck. 1986	Quantitative
E	Echinogammarus	tibaldii	297.0	297.0	297.0	ECOTOX 18621; Pantani et al. 1997	Qualitative
E	Gammarus	italicus	217.8	217.8	217.8	ECOTOX 18621; Pantani et al. 1997	Qualitative
B	Carassius	auratus	27,500	27,500	27,500	MRID 66915; Knott and Johnston. 1969	Quantitative
C	Lepomis	macrochirus	5,600	7,483	7,483	MRID 66914; Knott and Johnston. 1969	Quantitative
C	Lepomis	macrochirus	10,000			ECOTOX 6797; Mayer and Ellersieck. 1986	Quantitative
A	Oncorhynchus	mykiss	4,200	4,200	4,200	MRID 66916; Knott and Johnston. 1969	Quantitative
A	Oncorhynchus	mykiss	4,200			ECOTOX 6797; Mayer and Ellersieck. 1986	Quantitative
B	Ictalurus	punctatus	19,400	19,400	19,400	ECOTOX 6797; Mayer and Ellersieck. 1986	Quantitative

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark for oxamyl is 90 µg/L, which is ½ of the *Chironomus plumosus* acute effect LC_{50} of 180 µg/L.

The OPP fish acute benchmark is 2,100 µg/L, which is ½ of one of the two *Oncorhynchus mykiss* acute LC_{50}s of 4,200 µg/L.

GLI Tier II Acute Value Calculation

The acceptable dataset for oxamyl fulfills six of the eight OW MDRs, corresponding to the use of a Secondary Acute Factor (SAF) of 5.2. Applying the SAF to the lowest (most sensitive) GMAV (i.e., 180 µg/L for midge (*Chironomus pulmosus*)) yields the calculated Secondary Acute Value (SAV) of34.6 µg/L. Half of the SAV is 17.3 µg/L.

Detailed calculations are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{180}{5.2} = 34.6\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{34.6}{2} = 17.3\ \mu g/L$$

Genus-Level Invertebrate-only HC_{05}

The genus level invertebrate-only acute HC_{05} calculated following the U.S. EPA (1985) methodology for the four invertebrate genera in the oxamyl dataset (Table 2) is 114.7 µg/L (Table 3).

Table 2. Oxamyl invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Daphnia	*magna*	387.8	387.8	4
Echinogammarus	*tibaldii*	297.0	297.0	3
Gammarus	*italicus*	217.8	217.8	2
Chironomus	*plumosus*	180.0	180.0	1

Note: The *G. italicus* and *E. tibaldii* GMAVs are based on data classified as qualitative that were included to allow for sufficient sample size to calculate an invertebrate genus-level HC_{05}.

Table 3. Genus-level invertebrate-only acute HC_{05} for oxamyl calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
4	4	387.8	5.961	35.53	0.8000	0.8944
	3	297	5.694	32.42	0.6000	0.7746
	2	217.8	5.384	28.98	0.4000	0.6325
	1	180	5.193	26.97	0.2000	0.4472
	Sum:		22.23	123.9	2.000	2.749
	S^2 =	3.095				
	L =	4.349				
	A =	4.742				
	HC_{05} =	**114.7**				

Table 4. Comparison of acute values for oxamyl.

Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)	Notes
Oxamyl	90 µg/L (2016; *Chironomus plumosus*)	17.3 µg/L (6 MDRs filled, 5.2X)	57.35 µg/L (4 genera*, 1.6X)	* Two GMAVs included are based on data classified as qualitative were included to allow for sufficient sample size to calculate an invertebrate genus-level HC_{05}. Tests were classified as qualitative because they were conducted with field-collected organisms.

Figure 1 shows a genus-level sensitivity distribution for the oxamyl dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values, GLI Tier II calculated acute value, and invertebrate-only acute HC_{05}/2 are included.

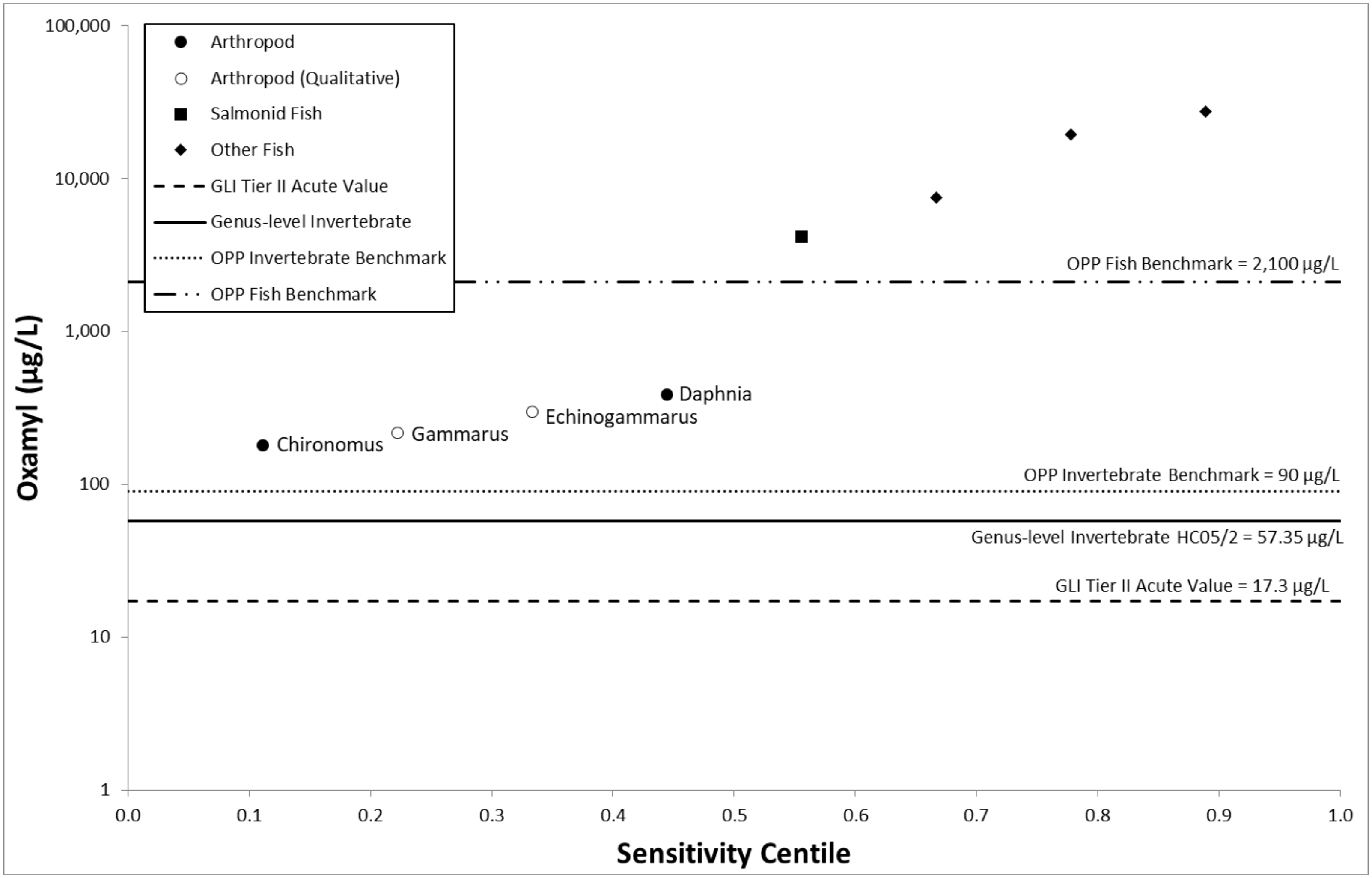

Figure 1. Oxamyl genus-level acute SD.

Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from an EPA literature search in 2015, supplemented the Office of Pesticide Programs (OPP) registration review document for oxamyl (U.S. EPA 2009).

1.2.1.2 Oxamyl Chronic Toxicity Data

Chronic Data Sources and Considerations

Chronic toxicity data for oxamyl were consolidated by OW in 2015 and combined with data from OPP's registration review document for oxamyl (U.S. EPA 2009). The final chronic oxamyl dataset consisted of three NOECs/LOECS for three species across three genera, of which one was an invertebrate genus and two were vertebrate genera (Table 5).

Table 5. Chronic toxicity data of oxamyl to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference	Comment
D	Daphnia	magna	27	50	Growth (adult length), time to first brood and number of offspring	MRID 45067801; Boeri and Ward. 2000	Acceptable
A	Oncorhynchus	mykiss	770	1,500	Embryo hatching and larval swim-up	MRID 40901101; Hutton. 1988	Acceptable
B	Pimephales	promelas	500	1,000	Larval survival	MRID 94663; Muska and Driscoll. 1982	Acceptable

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark for oxamyl is 27 µg/L, which is the NOEC for *Daphnia magna*. The OPP fish chronic benchmark is 500 µg/L, which is the NOEC for *Pimephales promelas*.

GLI Tier II Chronic Value Calculation

Per the 1985 Tier I Guidelines, ACRs can be calculated for a given species only if the acute and chronic studies were conducted in the same laboratory and using test water of the same physical and chemical characteristics. The OW approach for calculating an ACR involves the use of the MATC, which is the geometric mean of the NOAEC and LOAEC obtained from the chronic tests for that species. Only one ACR (for the water flea, *Daphnia magna*) could be calculated using the OW approach because the chronic study for rainbow trout (*Oncorhynchus mykiss*) was not performed in the same laboratory or with water of the same physical characteristics as the water used in the analogous acute test. Per the GLI Tier II methodology, the default ACR value of 18 was used for the remaining two ACRs.

Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{8.71 * 18 * 18} = 14.1$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{34.6}{14.1} = 2.4\ \mu g/L$$

Table 6. Comparison of chronic values for oxamyl.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW GLI Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Oxamyl	27 µg/L (2016; *Daphnia magna*)	2.4 µg/L (GLI Tier II; 1 ACR, 11X)	NA	Two default ACRs of 18 used to derive GLI Tier II value

1.2.1.3 Oxamyl References

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1.2.2 Comparison of Aquatic Life Toxicity Values for Acephate: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) are described below. Toxicity data for acephate were gathered by OW in 2015 and combined with data from OPP's registration review document for acephate (U.S. EPA 2007).

1.2.2.1 Acephate Acute Toxicity Data

The acephate data include twelve LC_{50}s representing seven species in seven genera that were classified as "quantitative" data and twenty-six LC_{50}s representing eight species in eight genera classified as "qualitative" that appear to be acceptable tests given the available information. The final acute acephate dataset consisted of 45 LC_{50}s for 18 total species across 16 genera, of which seven were invertebrate species across seven invertebrate genera. Ranked invertebrate GMAVs from all data sources are listed in Table 2. Acute data for acephate are shown in Table 1.

Table 1. Acute toxicity of acephate to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
F	Ephemeridae[b]	-	3,136	3,136	3,136	ECOTOX 37219. Hussain et al. 1985	24hr. No species name
F	Pteronarcella	badia	21,200	10,883	10,883	ECOTOX 6797. Mayer and Ellersieck. 1986	
F	Pteronarcella	badia	6,400			ECOTOX 6797. Mayer and Ellersieck. 1986	
F	Pteronarcella	badia	9,500			ECOTOX 6797. Mayer and Ellersieck. 1986	
F	Isogenus	sp.	11,700	11,700	11,700	ECOTOX 6797. Mayer and Ellersieck. 1986	
F	Skwala	sp.	12,000	12,000	12,000	MRID 40094602. Johnson, W. and M. Finley. 1980	
D	Daphnia	magna	71,800	8,927	8,927	MRID 00014565. Wheeler. 1978.	
D	Daphnia	magna	1,110			MRID 40098001. McCann 1978	OPP Benchmark value, 75% formulation
E	Gammarus	pseudolimneaus	>50,000	>62,996	>62,996	ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
E	Gammarus	pseudolimneaus	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
E	Gammarus	pseudolimneaus	>100,000			Schotteger 1970	
F	Chironomus	plumosus	>1,000,000	>135,721	>135,721	Johnson and Finley 1980	No endpoint or duration reported
F	Chironomus	plumosus	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	48hr EC50
F	Chironomus	plumosus	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	
A	Oncorhynchus	mykiss	110,000	530,010	>185,523	ECOTOX 6797. Mayer and Ellersieck. 1986	
A	Oncorhynchus	mykiss	1,100,000			ECOTOX 6797. Mayer and Ellersieck. 1986	
A	Oncorhynchus	mykiss	783,840			ECOTOX 7317. Duangsawasdi. 1977.	

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
A	Oncorhynchus	mykiss	832,000			MRID 40094602. Johnson, W. and M. Finley. 1980	OPP Benchmark value
A	Oncorhynchus	clarkii	>50,000	>64,940		ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Oncorhynchus	clarkii	>60,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Oncorhynchus	clarkii	>100,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Oncorhynchus	clarkii	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Oncorhynchus	clarkii	>100,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Oncorhynchus	clarkii	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Salmo	salar	>50,000	>50,000	>50,000	ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Salmo	salar	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Salmo	salar	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Salmo	salar	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Salmo	salar	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Salmo	salar	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Salmo	salar	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Salmo	salar	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Salvelinus	fontinalis	>50,000	>70,711	>70,711	ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
A	Salvelinus	fontinalis	>100,000			MRID 40094602. Johnson, W. and M. Finley. 1980	Qualitative
B	Lepomis	macrochirus	>50,000	>91,028	>91,028	ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
B	Lepomis	macrochirus	>1,000,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
B	Lepomis	macrochirus	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
B	Lepomis	macrochirus	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
B	Lepomis	macrochirus	>50,000			ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
B	Ictalurus	punctatus	>1,000,000	>1,000,000	>1,000,000	ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
B	Perca	flavescens	>50,000	>50,000	>50,000	ECOTOX 6797. Mayer and Ellersieck. 1986	Qualitative
B	Pimephales	promelas	>1,000,000	>1,000,000	>1,000,000	MRID 40094602 Johnson 1980	
C	Ambystoma	gracile	8,816,000	8,816,000	8,816,000	Geen 1984	
C	Rana	catesbelana	>5,000	>5,000	>179,346	MRID 44042901. Hall & Kolbe. 1980	Qualitative
C	Rana	clamitans	6433000	6,433,000		Lyons et al. 1976	24hr, 90% formulation

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

b No species name provided; only Family provided

OPP Acute Benchmark Values

The invertebrate OPP acute benchmark is 550 µg/L, which is ½ of the *D. magna* LC_{50} of 1,110 µg/L cited in U.S. EPA (2007). The fish OPP acute benchmark is 416,000 µg/L, which is ½ of an *O. mykiss* LC_{50} of 832,000 µg/L cited in U.S. EPA (2007).

GLI Tier II Acute Value Calculation

The acceptable acute dataset for acephate fulfills seven of the eight MDRs, corresponding to the use of a Secondary Acute Factor (SAF) of 4.3. Applying the SAF to the lowest, most sensitive GMAV (i.e., 3,136 µg/L for mayfly (*Ephemeridae* family)), the calculated Secondary Acute Value (SAV) is 729.3 µg/L. The Secondary Maximum Criterion (SMC), which is calculated as half the SAV, is 364.7 µg/L. Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{3{,}136}{4.3} = 729.3\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{729.3}{2} = 364.7\ \mu g/L$$

Genus-Level Invertebrate-only HC_{05}

The genus-level invertebrate acute HC_{05} following the U.S. EPA (1985) methodology for the seven invertebrate genera in the acephate dataset (Table 2) was 2,138 µg/L (Table 3). The second most sensitive GMAV is for *Daphnia* and includes the OPP benchmark LC_{50} of 1,110 µg/L tested in a 75% formulation. Excluding the OPP acute benchmark LC_{50} above yields a genus-level invertebrate HC_{05} of 2,117 µg/L, calculated entirely from quantitative data.

Table 2. Acephate invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Chironomus	*plumosus*	>135,721[d]	>135,721[d]	7
Gammarus	*pseudolimneaus*	>62,996[c]	>62,996[c]	6
Skwala	*sp.*	12,000	12,000	5
Isogenus	*sp.*	11,700	11,700	4
Pteronarcella	*badia*	10,883	10,883	3
Daphnia	*magna*	8,927[b]	8,927[b]	2
Ephemeridae[a]	-	3,136	3,136	1

a Family. Species name not reported.
b Geometric mean of quantitative value and OPP invertebrate benchmark value from test with 75% formulation.
c Geometric mean of two qualitative values from U.S. EPA (2015) and third value from U.S. EPA (2007).
d Geometric mean of three values from U.S. EPA (2007).

Table 3. Genus-level invertebrate acute HC_{05} for acephate calculated following the U.S. EPA (1985) methodology including a formulation test for *D. magna*.

N	Rank	GMAV	ln(GMAV)	$ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
7	4	11,700	9.367	87.75	0.5000	0.7071
	3	10,833	9.290	86.31	0.3750	0.6124
	2	8,927	9.097	82.75	0.2500	0.5000
	1	3,136	8.051	64.81	0.1250	0.3536
	Sum:		35.81	321.6	1.250	2.173
	S^2 =	16.12				
	L =	6.770				
	A =	7.668				
	FAV =	**2,138**				

Table 4. Comparison of acute values for acephate.

Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)	Notes
Acephate	550 µg/L (2007; *Daphnia magna*)	364.7 µg/L (7 MDRs filled, 1.5X)	1,069 µg/L (7 genera, 0.51X)	The FIFRA ALB was based on an acute toxicity test that used 75% pure acephate in a wettable powder formulation, producing an EC_{50} value of 1,100 µg/L for water flea (*D. magna*). This acute toxicity test was not used in the GLI Tier II because the chemical purity was <90%.

Figure 1 shows a genus-level sensitivity distribution for the acephate dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values, GLI Tier II calculated value and invertebrate-only acute HC_{05}/2 are also included.

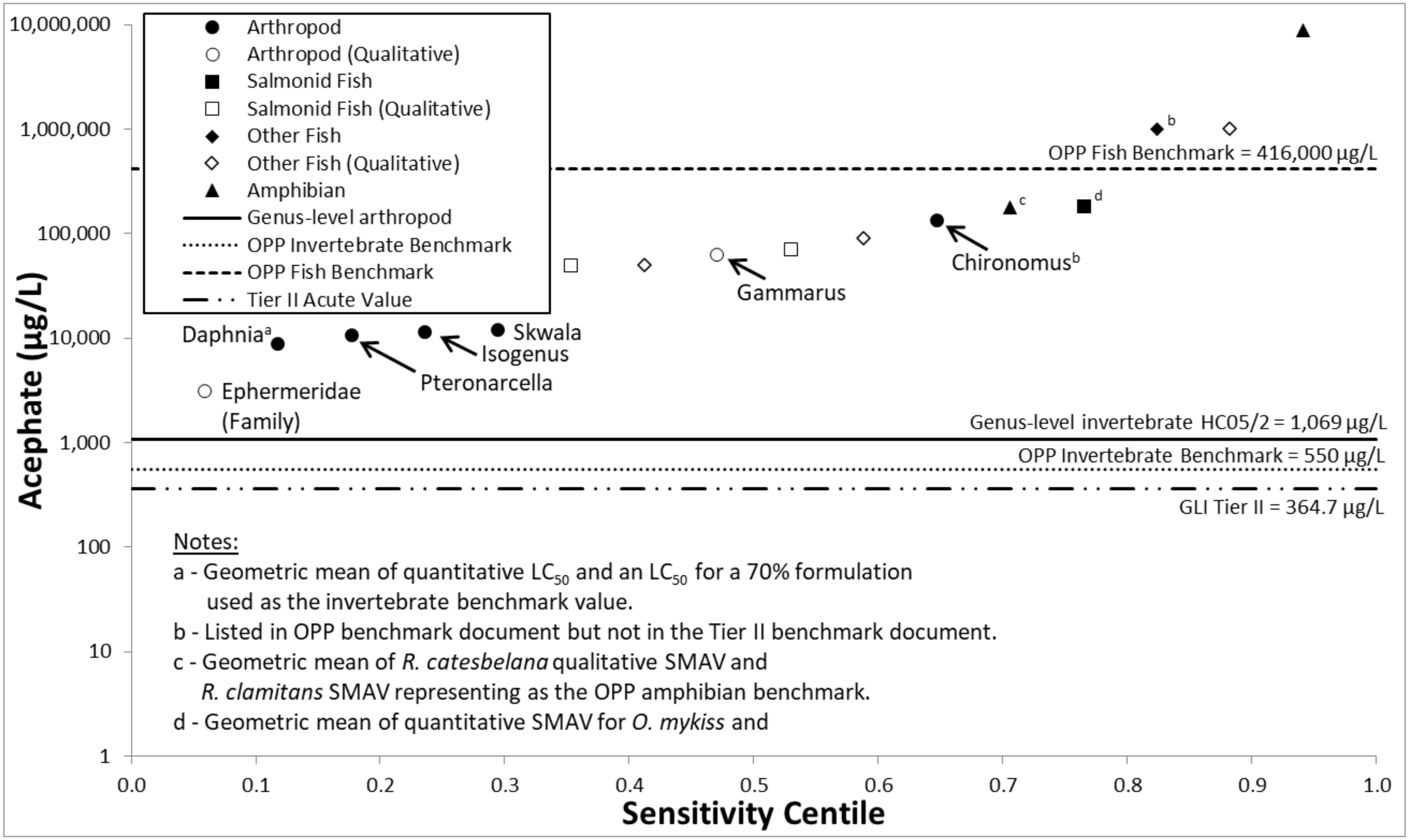

Figure 1. Acephate genus-level acute SD.

Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from an EPA literature search in 2015, supplemented the Office of Pesticide Programs (OPP) registration review document for acephate (U.S. EPA 2007).

1.2.2.2 Acephate Chronic Toxicity Data

Chronic Data Sources and Considerations

Chronic toxicity data for acephate were consolidated by OW in 2015 and combined with data from OPP's registration review document for acephate (U.S. EPA 2007). The final chronic acephate dataset consisted of one NOECs/LOEC for one invertebrate species (Table 5).

Table 5. Chronic toxicity data of acephate to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference	Comment
D	Daphnia	magna	150	375.0	Reduction in offspring	MRID 44466601; McCain. 1978	Supplemental

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark for acephate is 150 µg/L, which is the NOEC for *Daphnia magna*.

The OPP fish chronic benchmark is 5,760 µg/L, which is the estimated NOEC for *Oncorhynchus mykiss*, extrapolated using most sensitive acute 96-h LC50 for rainbow trout (832,000 µg/L) divided by 144.44 (highest rainbow trout ACR for organophosphates).

GLI Tier II Chronic Value Calculation

Quantitative chronic tests are not available for acephate. Therefore, per the GLI Tier II methodology, all three ACRs are the default value of 18, the geometric mean of which (i.e., the SACR) is 18. The calculated Secondary Chronic Value (SCV) for acephate is 40.52 µg/L. Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{18 * 18 * 18} = 18$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{729.3}{18} = 40.52\ \mu g/L$$

Table 6. Summary and comparison of chronic values for acephate.

Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Acephate	150 µg/L (2007, *Daphnia magna*)	40.52 µg/L (GLI Tier II; 0 ACRs, 3.7X)	NA	Three default ACRs of 18 used to derive GLI Tier II value.

1.2.2.3 Acephate References

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1.2.3 Comparison of Aquatic Life Toxicity Values for Dimethoate: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) are described below. Toxicity data for dimethoate were gathered by OW in 2015 and combined with data from OPP's registration review document for dimethoate (U.S. EPA 2008).

1.2.3.1 Dimethoate Acute Toxicity Data

The dimethoate acute data include six LC_{50}s representing five species in five genera that were classified as "quantitative" data, two 96-hour LC_{50}s for the species *Poecilia reticulata* classified as "qualitative" that appear to be acceptable tests given the available information; and two "qualitative" 48-hour LC_{50}s for species within the genus *Chironomus* included in order to calculate an invertebrate-only HC_{05}.

The final acute dimethoate dataset consisted of eight quantitative LC_{50}s and two "qualitative" LC_{50}s for eight total species across seven genera, of which five were invertebrate species across four invertebrate genera. Acute data for dimethoate are shown in Table 1. Ranked invertebrate GMAVs (both quantitative and qualitative) are listed in Table 2.

Table 1. Acceptable acute toxicity data of dimethoate to freshwater aquatic organisms

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
F	Chironomus	riparius	481	481	345.4	ECOTOX 102849. Domingues et al. 2007	Duration, 48hr
F	Chironomus	dilutus	248	248		ECOTOX 74947. Anderson and Zhu 2004	Duration, 48hr
D	Daphnia	magna	3,154	3,154	3,154	ECOTOX 18476. Song et al. 1997	Represents 8 tests
F	Pteronarcys	californica	43	43	43	MRID 00003503. Johnson and Finley. 1980	Represents 3 tests
E	Gammarus	lacustris	200	200	200	ECOTOX 6797. Mayer and Ellersieck 1986	Represents 2 tests
B	Poecilia	reticulata	548,800	429,798	429,798	ECOTOX 5180. Canton et al. 1980	OECD test-not publicly available
B	Poecilia	reticulata	336,600			ECOTOX 5370. Maas 1982	OECD test-not publicly available
B	Lepomis	macrochirus	6,000	6,000	6,000	ECOTOX 6797. Mayer and Ellersieck 1986	Represents 2 tests
A	Oncorhynchus	mykiss	8,600	7,302	7,302	ECOTOX 6797. Mayer and Ellersieck 1986	

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
A	Oncorhynchus	mykiss	6,200			ECOTOX 6797. Mayer and Ellersieck 1986	Represents 7 tests

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark is 21.5 µg/L, which is ½ of the *Pteronarcys californica* LC_{50} of 43 µg/L cited in U.S. EPA (2008).

The OPP fish acute benchmark is 3,100 µg/L, which is ½ of the *Oncorhynchus mykiss* LC_{50} of 6,200 µg/L cited in U.S. EPA (2008).

GLI Tier II Acute Value Calculation

The acceptable dataset for dimethoate represents five of the eight MDRs, corresponding to the use of a SAF of 6.1. Applying the SAF to the lowest, most sensitive GMAV (i.e., 43.0 µg/L for stonefly (*Pteronarcys californica*)), the calculated SAV is 7.0 µg/L. Half of the SAV is 3.5 µg/L. The SMC of 3.5 µg/L is lower than the most sensitive GMAV. Detailed calculations are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{43.0}{6.1} = 7.0\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{7.0}{2} = 3.5\ \mu g/L$$

Genus-Level Invertebrate-Only HC_{05}

The genus-level invertebrate-only acute HC_{05} following the U.S. EPA (1985) methodology for the four invertebrate genera in the dimethoate dataset (Table 2) was 4.296 µg/L (Table 3).

Table 2. Dimethoate invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Daphnia	*magna*	3,154	3154	4
Chironomus	*riparius*	481.0*	345.4	3
Chironomus	*dilutus*	248.0*		
Gammarus	*lacustris*	200.0	200.0	2
Pteronarcys	*californica*	43.00	43.00	1

* Qualitative values (48-hour LC_{50}s).

Note: SMAVs and GMAVs for *Chironomus* sp. are 48-hour tests that were classified as qualitative in but are added here to meet minimum requirements to calculate a genus-level invertebrate HC_{05}.

Table 3. Genus-level invertebrate acute HC_{05} for dimethoate calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$\ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
4	4	3154	8.056	64.906	0.8000	0.8944
	3	345.4	5.845	34.161	0.6000	0.7746
	2	200.0	5.298	28.072	0.4000	0.6325
	1	43.00	3.761	14.147	0.2000	0.4472
	Sum:		22.96	141.3	2.000	2.749
	S^2 =	85.34				
	L =	-0.608				
	A =	1.458				
	HC_{05} =	**4.296**				

Table 4. Summary and comparison of acute values for dimethoate.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW GLI Tier II values(# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)	Notes
Dimethoate	21.5 µg/L (2016; *Pteronarcys californica*)	3.5 µg/L (5 MDRs filled, 6.1X)	2.15 µg/L (4 genera*, 10X)	The FIFRA ALB is half the LC_{50} reported for stonefly (*P. californica*), which was used as the basis for the GLI Tier II acute value. The genus-level invertebrate value is lower than the FIFRA ALB because of the relatively steep slope and small sample size calculated from the Guidelines algorithm, while the FIFRA ALB is half of the most sensitive GMAV. * GMAV for *Chironomus* sp. is based on data classified as qualitative that were included to allow for sufficient sample size to calculate a genus-level invertebrate value. Tests were classified as qualitative because it was for a non-standard duration (48-hours).

Figure 1 shows a genus-level sensitivity distribution for the dimethoate dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values, GLI tier II calculated acute value, and invertebrate-only acute HC_{05}/2 are included.

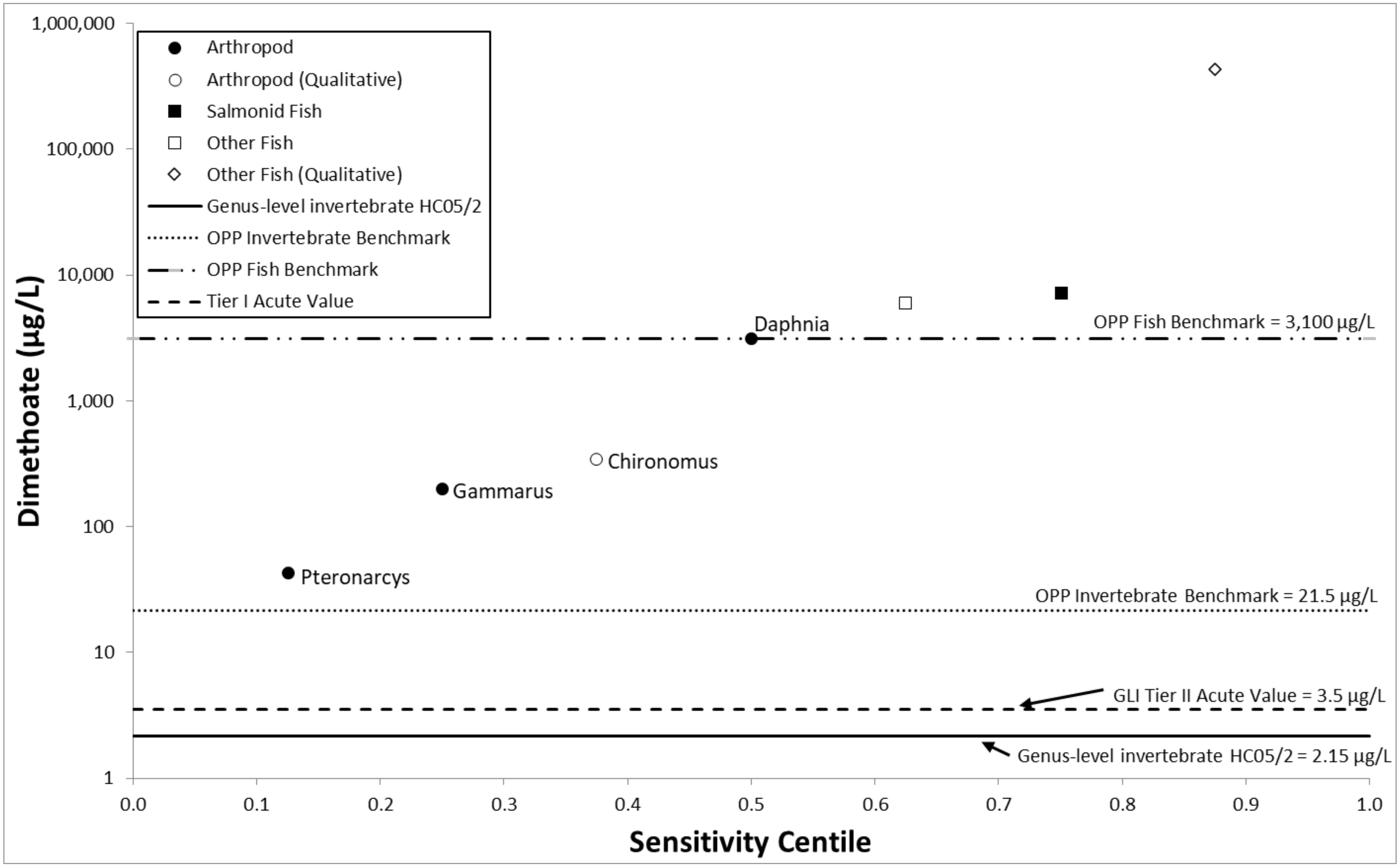

Figure 1. Dimethoate genus-level acute SD.
Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from an EPA literature search in 2015, supplemented the Office of Pesticide Programs (OPP) registration review document for dimethoate (U.S. EPA 2008).

1.2.3.2 Dimethoate Chronic Toxicity Data

Chronic Data Sources and Considerations

Chronic toxicity data for dimethoate were consolidated by OW in 2015 and combined with data from OPP's registration review document for dimethoate (U.S. EPA 2008). The final chronic dimethoate dataset consisted of two NOECs/LOECS for two species across two genera, of which one was an invertebrate and one was a vertebrate (Table 5).

Table 5. Chronic toxicity data of dimethoate to freshwater aquatic organisms

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference	Comment
D	Daphnia	magna	40	100	Reproduction, survival and growth	MRID 42864701	Quantitative
A	Oncorhynchus	mykiss	430	840	Impaired growth	MRID 43106301, 43106302, 43106303	Quantitative

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark is 0.5 µg/L, which is the estimated NOEC for *Pteronarcys californica* using the ACR for *D. magna*. *P. california* LC50 (43 µg/L) ÷ *D. magna* ACR (83) = 0.5 µg/L.

The OPP fish chronic benchmark is 430 µg/L, which is the NOEC for *Oncorhynchus mykiss*.

GLI Tier II Chronic Value Calculation

Quantitative dimethoate chronic and acute toxicity data were available for water flea (*Daphnia magna*) and rainbow trout (*Oncorhynchus mykiss*), allowing for the calculation of two ACRs. The default value of 18 was used to fulfill the third ACR per the GLI Tier II methodology. ACRs were calculated using the test with the lowest acute endpoint. The rainbow trout (*Oncorhynchus mykiss*) test with the lowest acute endpoint (i.e., 6,200 µg/L) was therefore used in the calculations.

The acute and chronic tests for water flea (*Daphnia magna*) and for rainbow trout (*Oncorhynchus mykiss*) were conducted in different laboratories, using water of different physical characteristics; therefore, the ACRs were calculated using the OPP methodology, which involves using the NOAEC as the chronic value. The calculated SCV is 0.3 µg/L. Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{14.4 * 79 * 18} = 27.4$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{7.0}{27.4} = 0.3\ \mu g/L$$

Table 6. Summary and comparison of chronic values for dimethoate.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Dimethoate	0.5 µg/L (2016, estimated NOAEC value for *Pteronarcys californica* calculated using the ACR for *Daphnia magna*)	0.3 µg/L (GLI Tier II; 2 ACRs, 1.7X)	NA	One default ACR of 18 used to derive GLI Tier II value.

1.2.3.3 Dimethoate References

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1.2.4 Comparison of Aquatic Life Toxicity Values for Phosmet: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) are described below. Toxicity data for phosmet were gathered by OW in 2015 and combined with data from OPP's registration review document for phosmet (U.S. EPA 2009).

1.2.4.1 Phosmet Acute Toxicity Data

Acute data for phosmet include thirty-four LC_{50}s representing ten species in eight genera that were classified as "quantitative" data and one 48-hour LC_{50} for the fairy shrimp *Streptocephalus sealii* classified as qualitative, but included here to increase the number of invertebrate genera to four, thereby allowing the calculation of an invertebrate genus-level HC_{05}. This test was classified as qualitative because it was for a non-standard duration (48-hours).

The final acute phosmet dataset consisted of 35 LC_{50}s for 11 species across nine genera, of which four were invertebrate species representing four different genera. Acute data for phosmet are shown in Table1. The ranked invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity data of phosmet to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
D	Streptocephalus	sealii	170	170.0	170.0	MRID 40094602
D	Daphnia	magna	5.6	5.6	5.6	Mayer and Ellersieck 1986
E	Gammarus	fasciatus	2.4	2.4	2.4	MRID 00063193; Sanders 1972
E	Caecidotea	brevicauda	72			Mayer and Ellersieck 1986
E	Caecidotea	brevicauda	90	80.50	80.50	Mayer and Ellersieck 1986
B	Pimephales	promelas	7,300	7,300	7,300	Mayer and Ellersieck 1986
B	Lepomis	macrochirus	1,000			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	1,400			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	1,000			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	640			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	200			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	22			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	60			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	70			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	180			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	560			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	200			Mayer and Ellersieck 1986
B	Lepomis	macrochirus	70	231.2	231.2	MRID 00063194; Julin and Sanders 1977
B	Micropterus	dolomieu	150.0	150.0	-	Mayer and Ellersieck 1986
B	Micropterus	salmoides	160.0	160.0	154.9	Mayer and Ellersieck 1986
A	Oncorhynchus	tshawytscha	150.0	150.0	-	Mayer and Ellersieck 1986

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
A	Oncorhynchus	mykiss	280.0			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	1,200			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	1,600			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	420.0			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	130.0			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	105.0			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	480.0			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	240.0			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	560.0			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	120.0			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	300.0			Mayer and Ellersieck 1986
A	Oncorhynchus	mykiss	513.9	352.5	229.9	Julin and Sanders 1977
B	Ictalurus	punctatus	10,600			Mayer and Ellersieck 1986
B	Ictalurus	punctatus	11,000	10,798	10,798	MRID 00063194; Julin and Sanders 1977

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Benchmark Acute Values

The OPP invertebrate acute benchmark is 4.32 µg/L, which is ½ of the *Daphnia magna* EC_{50} of 8.64 µg/L.

The OPP fish acute benchmark is 35 µg/L, which is ½ of the *Lepomis macrochirus* LC_{50} of 70 µg/L.

GLI Tier II Acute Value Calculation

The acceptable dataset for phosmet represents five of the eight MDRs, corresponding to the use of an SAF of 6.1. Applying the SAF to the lowest, most sensitive GMAV (i.e., 2.4 µg/L for scud (*Gammarus fasciatus*)), yields the SAV of 0.39 µg/L. Half of the SAV is 0.20 µg/L. The SMC of 0.20 µg/L. Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{2.4}{6.1} = 0.39\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{0.39}{2} = 0.20\ \mu g/L$$

Genus-Level Invertebrate-only HC_{05}

The genus-level invertebrate-only acute HC_{05} calculated following the U.S. EPA (1985) methodology for the four invertebrate genera in the phosmet dataset (Table 2) is 0.1480 µg/L (Table 3).

Table 2. Phosmet invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Streptocephalus	*sealii*	170.0	170.0	4
Caecidotea	*brevicauda*	80.50	80.50	3
Daphnia	*magna*	5.600	5.600	2
Gammarus	*fasciatus*	2.400	2.400	1

Note: The *S. sealii* GMAV is based on data classified as qualitative that were included to allow for a sufficient sample size to calculate an invertebrate genus-level HC_{05}.

Table 3. Genus-level invertebrate acute HC_{05} for phosmet calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$\ln(\text{GMAV})^2$	P=R/(N+1)	sqrt(P)
4	4	170	5.136	26.38	0.8000	0.8944
	3	80.50	4.388	19.26	0.6000	0.7746
	2	5.6	1.723	2.968	0.4000	0.6325
	1	2.4	0.8755	0.7664	0.2000	0.4472
	Sum:		12.12	49.37	2.000	2.749
	S^2 =	113.6				
	L =	-4.294				
	A =	-1.910				
	HC_{05} =	**0.1480**				

Note: The fourth most sensitive GMAV was classified as qualitative for the reason explained under *Data Sources and Considerations*.

Table 4. Summary and comparison of acute values for phosmet.

Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest $LC_{50}/2$) (Year published, species)	OPP GLI Tier II values (# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only $HC_{05}/2$ (# of genera, magnitude relative to ALB)	Notes
Phosmet	4.32 µg/L (2023; *Daphnia magna*)	0.20 µg/L (5 MDRs filled, 22X)	0.074 µg/L (4 genera*, 58X)	The FIFRA ALB is based on an acute toxicity test that used 51% TEP, producing an EC_{50} value of 8.64 µg/L for water flea (*D. magna*). This acute toxicity test was not used in the GLI Tier II or genus-level invertebrate value calculations as per the Guidelines. The genus-level invertebrate value is lower than the FIFRA ALB because the most sensitive SMAV is an EC_{50} of 2.4 µg/L for scud (*G. fasciatus*). This study was not used to derive the FIFRA ALB because it was categorized as "qualitative" as the raw data was not available. * GMAV for the spiny-tail fairy shrimp *Streptocephalus sealii* is based on data classified as qualitative that were included to allow for sufficient sample size to calculate a genus-level invertebrate value. The test was classified as qualitative because it was for a non-standard duration (48-hours).

Figure 1 shows a genus-level sensitivity distribution for the phosmet dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP benchmark acute values, the GLI Tier II calculated value, and invertebrate-only acute $HC_{05}/2$ are included.

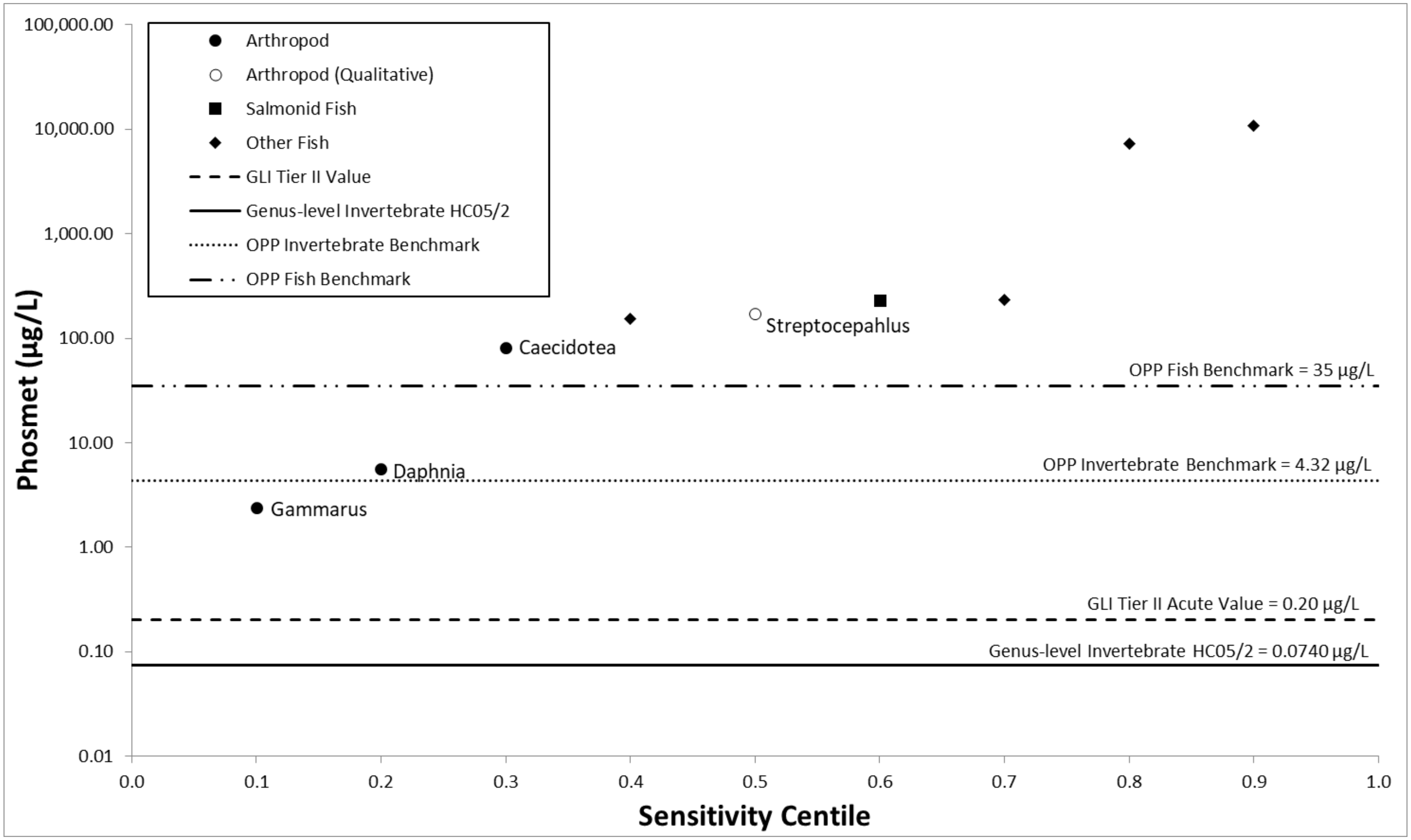

Figure 1. Phosmet genus-level SD.

Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from an EPA literature search in 2015, supplemented the Office of Pesticide Programs (OPP) registration review document for phosmet (U.S. EPA 2009).

1.2.4.2 Phosmet Chronic Toxicity Data

Chronic Data Sources and Considerations

Chronic toxicity data for phosmet were gathered from by OW in 2015 for phosmet and combined with data from OPP's registration review document for phosmet (U.S. EPA 2009). The final chronic phosmet dataset consisted of four NOECs/LOECS for four species across four genera. One test was an invertebrate genus and three were vertebrate genera (Table 5).

Table 5. Chronic toxicity data of phosmet to freshwater aquatic organisms

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference	Comment
D	Daphnia	magna	0.75	1.0	Reduced number of offspring	MRID 40652801; Burgess. 1988	Quantitative
A	Oncorhynchus	mykiss	3.2	6.1	Reduction in growth	MRID 40938701; Cohle. 1988	Quantitative
B	Pimephales	promelas	1.0	9.3	Survival and fertilization success	MRID 48673002; York. 2012	Acceptable
C	Xenopus	laevis	8.1	9.6	Metamorphosis	MRID 48673001; Lee. 2012	Acceptable

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark is 0.75 µg/L, which is the NOEC for *Daphnia magna*.

The OPP fish chronic benchmark is 1.0 µg/L, which is the NOEC for *Pimephales promelas*.

GLI Tier II Chronic Value Calculation

Quantitative phosmet chronic and acute toxicity data were available for rainbow trout (*Oncorhynchus mykiss*) and water flea (*Daphnia magna*), allowing for the calculation of two ACRs. The default value of 18 was used to fulfill the third ACR per the GLI Tier II methodology. The quantitative acute and chronic tests for the water flea (*Daphnia magna*) and rainbow trout (*Oncorhynchus mykiss*) were conducted in different laboratories, using water of different physical characteristics; therefore the ACRs were calculated using the OPP methodology, which involves using the NOAECs as the chronic values. Detailed calculations for the SCV, which was calculated as 0.02 µg/L, are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{7 * 32.8 * 18} = 16.0$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{0.39}{16.0} = 0.02\ \mu g/L$$

Table 6. Comparison of chronic values for phosmet.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Phosmet	0.75 µg/L (2023, *Daphnia magna*)	0.02 µg/L (GLI Tier II; 2 ACRs, 38X)	NA	One default ACR of 18 used to derive GLI Tier II value.

1.2.4.3 Phosmet References

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U.S. EPA. 2024. Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA). EPA-820-D-24-002

1.2.5 Comparison of Aquatic Life Toxicity Values for Terbufos: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for terbufos are described below. Toxicity data for terbufos were gathered by OW in 2015 and combined with data from OPP's registration review document for terbufos (U.S. EPA 2015).

1.2.5.1 Terbufos Acute Toxicity Data

The final acute terbufos dataset consisted of 33 LC_{50}s for nine species representing nine genera, of which five were invertebrate species representing five invertebrate genera. Acute data for terbufos are shown in Table 1. The invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity data of terbufos to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
D	Ceriodaphnia	dubia	0.139	0.1286	0.1286	ECOTOX 153854. Choung et al. 2011	Quantitative, >98% a.i.
D	Ceriodaphnia	dubia	0.119			ECOTOX 153854. Choung et al. 2012	Quantitative, >98% a.i.
E	Daphnia	magna	0.400	0.2608	0.2608	ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
E	Daphnia	magna	0.170			MRID 00101495	
E	Gammarus	pseudolimnaeus	0.200	0.2000	0.2000	ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
E	Procambarus	clarkii	5.782	6.801	6.801	ECOTOX 18475. Fornstrom et al. 1997	Qualitative, control mortality; organisms fed during experiment
E	Procambarus	clarkii	8.0			MRID 00085176	
F	Chironomus	plumosus	1.4	1.400	1.400	ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
A	Oncorhynchus	mykiss	10.00	10.45	10.45	ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
A	Oncorhynchus	mykiss	13.00			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
A	Oncorhynchus	mykiss	7.600			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
A	Oncorhynchus	mykiss	8.400			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
A	Oncorhynchus	mykiss	10.00			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
A	Oncorhynchus	mykiss	13.20			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
A	Oncorhynchus	mykiss	15.30			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
A	Oncorhynchus	mykiss	8.600			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
A	Oncorhynchus	mykiss	11.50			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
A	Oncorhynchus	mykiss	9.400			MRID 00037483. Sleight. 1972	Quantitative, 86.3% a.i.
A	Salmo	trutta	20	20.00	20.00	MRID 00087718	
B	Pimephales	promelas	12.870	70.85	70.85	ECOTOX 14097. Call et al. 1989	Qualitative, Source of test species unknown; dechlorinated tap water used; no replicate
B	Pimephales	promelas	390.0			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
C	Lepomis	macrochirus	1.700	1.569	1.569	ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
C	Lepomis	macrochirus	2.400			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
C	Lepomis	macrochirus	2.000			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
C	Lepomis	macrochirus	1.600			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
C	Lepomis	macrochirus	1.500			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
C	Lepomis	macrochirus	1.800			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
C	Lepomis	macrochirus	1.500			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
C	Lepomis	macrochirus	1.500			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
C	Lepomis	macrochirus	1.100			ECOTOX 6797. Mayer and Ellersieck. 1986	Quantitative, 88% a.i.
C	Lepomis	macrochirus	0.770			MRID 00087718. Roberts and Wineholt. 1976	Quantitative, 86% a.i.
C	Lepomis	macrochirus	3.80			MRID 00037483	
C	Lepomis	macrochirus	0.87			MRID 00085176	

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes

B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)

C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Benchmark Acute Values

The OPP invertebrate acute benchmark is 0.085 µg/L, which is ½ of the *Daphnia magna* acute test value of 0.17 µg/L.

The OPP fish acute benchmark is 0.385 µg/L, which is ½ of the *Lepomis macrochirus* acute LC_{50} of 0.770 µg/L.

GLI Tier II Acute Value Calculation

The Method B acute dataset for terbufos fulfills five of the eight MDRs, corresponding to the use of a Secondary Acute Factor (SAF) of 6.1. Applying the SAF to the lowest, most sensitive GMAV (i.e., 0.128 µg/L for water flea (*Ceriodaphnia dubia*)), yields the calculated Secondary Acute Value (SAV) of 0.021 µg/L. The Secondary Maximum Criterion (SMC), which is calculated as half the SAV, is 0.011 µg/L.

Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{0.128}{6.1} = 0.021\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{0.021}{2} = 0.011\ \mu g/L$$

Genus-Level Invertebrate-only Acute HC_{05}

The genus-level invertebrate-only acute HC_{05} calculated following the U.S. EPA (1985) methodology for the five invertebrate genera (Table 2) in the terbufos dataset is 0.0283 µg/L (Table 3).

Table 2. Terbufos invertebrate SMAV and GMAV (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Procambarus	*clarkii*	6.801	6.801	5
Chironomus	*plumosus*	1.400	1.400	4
Daphnia	*magna*	0.2608	0.2608	3
Gammarus	*pseudolimnaeus*	0.2000	0.2000	2
Ceriodaphnia	*dubia*	0.1268	0.1268	1

Note: The *Procambarus clarkii* SMAV and GMAV is the geometric mean of a qualitative LC_{50} used to fill an MDR group and an acceptable LC_{50} listed in the OPP registration review document.

Table 3. Genus-level invertebrate-only acute HC_{05} for terbufos calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
5	4	1.400	0.336	0.11	0.6667	0.8165
	3	0.2608	-1.344	1.81	0.5000	0.7071
	2	0.2000	-1.609	2.59	0.3333	0.5774
	1	0.1286	-2.051	4.206	0.1667	0.4082
	Sum:		-4.67	8.72	1.6667	2.5092
	S^2 =	35.285				
	L =	-4.893				
	A =	-3.565				
	HC_{05} =	0.0283				

Table 4. Comparison of acute values for terbufos.

Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OPP GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2 (# of genera, magnitude relative to ALB)
Terbufos	0.085 µg/L (2023; *Daphnia magna*)	0.011 µg/L (5 MDRs filled, 7.7X)	0.014 µg/L (4 genera, 6.1X)

Figure 1 shows a genus-level sensitivity distribution for the terbufos dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values, GLI Tier II calculated acute value and invertebrate-only acute HC_{05}/2 are included.

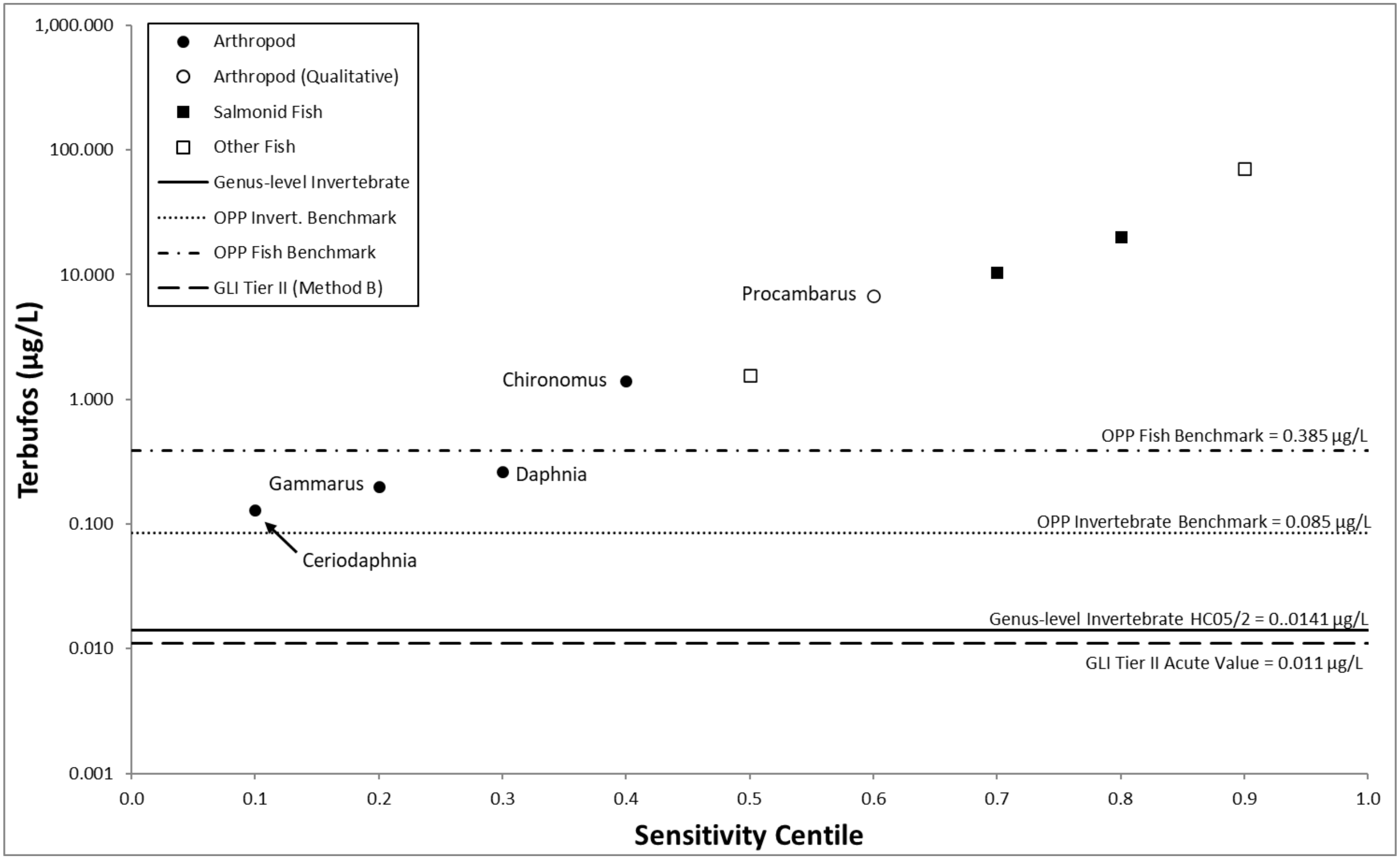

Figure 1. Terbufos genus-level acute SD.

Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from an EPA literature search in 2015, supplemented the Office of Pesticide Programs (OPP) registration review document for terbufos (U.S. EPA 2015).

1.2.5.2 Terbufos Chronic Toxicity Data

Chronic Data Sources and Considerations

Chronic toxicity data for terbufos were gathered by OW in 2015 for terbufos and combined with data from OPP's registration review document for terbufos (U.S. EPA 2015). The final chronic terbufos dataset consisted of two NOECs/LOECS for two species across two genera, of which one was an invertebrate and one was a vertebrate (Table 5).

Table 5. Chronic toxicity data of terbufos to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference
D	Daphnia	magna	0.030	0.076	Reductions in length and number of offspring	MRID 00162525; Forbis et al. 1986
A	Oncorhynchus	mykiss	0.640	1.400	Reduced length and wet weight	MRID 41475801; Tank et al. 1990; MRID 41475802; Rhodes and McCallister 1990

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark is 0.03 µg/L, which is the NOEC for *Daphnia magna*.

The OPP fish chronic benchmark is 0.10 µg/L, which is the estimated NOEC for *Lepomis macrochirus*. Bluegill sunfish sensitivity to terbufos on a chronic basis was estimated using an acute to chronic ratio (ACR) because it is the most acutely sensitive species. The ACR was based on rainbow trout (acute and chronic toxicity) and bluegill sunfish (acute toxicity) data.

GLI Tier II Chronic Value Calculation

Paired quantitative acute and chronic toxicity data were available for water flea (*Daphnia magna*) and rainbow trout (*Oncorhynchus mykiss*) allowing for the calculation of two ACRs. While the chronic tests used >90% pure terbufos, the acute tests did not. Per the GLI Tier II methodology, the default value of 18 was used to fulfill the remaining ACR. The acute and chronic tests for water flea (*Daphnia magna*) and rainbow trout (*Oncorhynchus mykiss*) were conducted in different laboratories, using water of different physical characteristics. Therefore, the OPP approach was used to calculate the SACR, which involves the use of the NOAEC value. The calculated SCV for terbufos is 0.0014 µg/L.

Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{13.33 * 14.69 * 18} = 15.22$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{0.021}{15.22} = 0.0014\ \mu g/L$$

Table 6. Summary and comparison of chronic values for terbufos.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Terbufos	0.03 µg/L (2023, *Daphnia magna*)	0.0014 µg/L (GLI Tier II; 2 ACRs, 21X)	NA	One default ACR of 18 used to derive GLI Tier II value.

1.2.5.3 Terbufos References

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1.3 DATA INSUFFICIENT PESTICIDES

1.3.1 Comparison of Aquatic Life Toxicity Values for Methamidophos: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for methamidophos Data were gathered by the EPA in 2015 and were also obtained from the OPP registration review document for methamidophos (U.S. EPA 2008).

1.3.1.1 Methamidophos Acute Toxicity Data

Acute data were gathered by the EPA in 2015 and were also obtained from the OPP registration review document for methamidophos (U.S. EPA 2008; See Table 1). The data review identified five LC_{50}s for three species representing three genera that were classified as "quantitative" data.

Four additional 48-hour LC_{50}s for *Daphnia magna* were classified as qualitative. Three LC_{50s} had standard duration (48-hr) and higher purity (>99% a.i. vs. 72-74% a.i. for the quantitative tests), and were classified as qualitative because water chemistry was not reported, control mortality was unknown, and specific test concentrations were not reported. The fourth (27 µg/L) was classified as qualitative because it was tested at 24˚C but included here because it was a standard duration test included in the OPP document. Two additional 96-hour LC_{50} for bluegill (*Lepomis macrochirus*) were classified as qualitative. One was a static test with insufficient information, and the other used polyethylene liners in test chambers. Both were included in the OPP document. A 96-hour LC_{50} for the common carp (*Cyprinus carpio*) was classified as qualitative because "chronic impacts observed by 48 hours", but included here because it was used to fulfill an MDR group.

The final acute methamidophos dataset consisted of 12 LC_{50}s for four species across four genera, of which one was an invertebrate species. The invertebrate SMAV and GMAV for (*Daphnia magna*) is listed in Table 2.

Table 1. Acute toxicity data of methamidophos to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
D	Daphnia	magna	26.00	32.74	32.74	MRID 00041311. Nelson and Roney. 1979	Quantitative, 74% a.i.
D	Daphnia	magna	50.00			MRID 00014110. Wheeler. 1978	Quantitative, 72% a.i.
D	Daphnia	magna	33.66			ECOTOX 99572. Lin et al. 2006.	Qualitative, >99.0 a.i., Basic water chemistry not reported; control mortality unknown; chemical application rates not reported; monitoring of concentrations not reported; test solution not described
D	Daphnia	magna	33.46			ECOTOX 99572. Lin et al. 2006.	Qualitative, >99.0 a.i., Basic water chemistry not reported; control mortality unknown; chemical application rates not reported; monitoring of concentrations not reported; test solution not described
D	Daphnia	magna	235.5			ECOTOX 99572. Lin et al. 2006.	Qualitative, >99.0 a.i., Basic water chemistry not reported; control mortality unknown; chemical application rates not reported; monitoring of concentrations not reported; test solution not described
D	Daphnia	magna	27.00			MRID 00014305. Nelson and Burke. 1977.	Qualitative, 74% a.i., Classified by OPP. Test temperature 24ºC
A	Oncorhynchus	mykiss	25,000	35,707	35,707	MRID 00041312. Nelson and Roney. 1979.	Quantitative, 74% a.i.
A	Oncorhynchus	mykiss	51,000			MRID 00014063. Schoenig. 1968.	Quantitative, 75% a.i.
C	Cyprinus	carpio	68,000	68,000	68,000	MRID 05008361. Further reference information is not available.	Qualitative, 75% a.i., Classified by OPP. Chronic impacts observed by 48 hours
B	Lepomis	macrochirus	34,000	41,287	41,287	MRID 00041312. Nelson and Roney. 1979.	Quantitative, 74% a.i.
B	Lepomis	macrochirus	45,000			MRID 44484402. USEPA. 1977.	Qualitative, 75.4% a.i., Classified by OPP. Static jar study with insufficient environmental information
B	Lepomis	macrochirus	46,000			MRID 00014063. Schoenig. 1968.	Qualitative, 75% a.i., Classified by OPP. Polyethylene liners used in test

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark is 13 µg/L, which is ½ of the *Daphnia magna* LC_{50} of 26 µg/L.

The OPP fish acute benchmark is 12,500 µg/L, which is ½ of the *Oncorhynchus mykiss* LC_{50} of 25,000 µg/L.

GLI Tier II Acute Value Calculation

The acceptable acute dataset for methamidophos fulfills four MDRs, corresponding to the use of a Secondary Acute Factor (SAF) of 7. Applying the SAF to the lowest, most sensitive GMAV (i.e., 36.06 µg/L for water flea (*Daphnia magna*), the calculated Secondary Acute Value (SAV) is 5.151 µg/L. The Secondary Maximum Criterion (SMC), which is calculated as half the SAV, is 2.575 µg/L.

Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{36.06}{7} = 5.151\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{5.151}{2} = 2.575\ \mu g/L$$

Genus-Level Invertebrate-Only Acute HC_{05}

No genus-level invertebrate acute HC_{05} could be calculated following the USEPA (1985) methodology because there was only one invertebrate genus (Table 2).

Table 2. Methamidophos invertebrate SMAV and GMAV (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Daphnia	*magna*	32.74	32.74	1

Table 3. Summary and comparison of acute values for methamidophos.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2	Notes
Methamidophos	13 µg/L (2016; *Daphnia magna*)	2.58 µg/L (4 MDRs filled, 5X)	NA (1 genus)	The Tier II value is approximately 20% of the FIFRA ALB despite both being based on the same species. This is because of the Tier II adjustment factor of 7 was applied to this dataset, which satisfied 4/8 MDRs.

Figure 1 shows a genus-level sensitivity distribution for the methamidophos dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values and GLI Tier II calculated value are included.

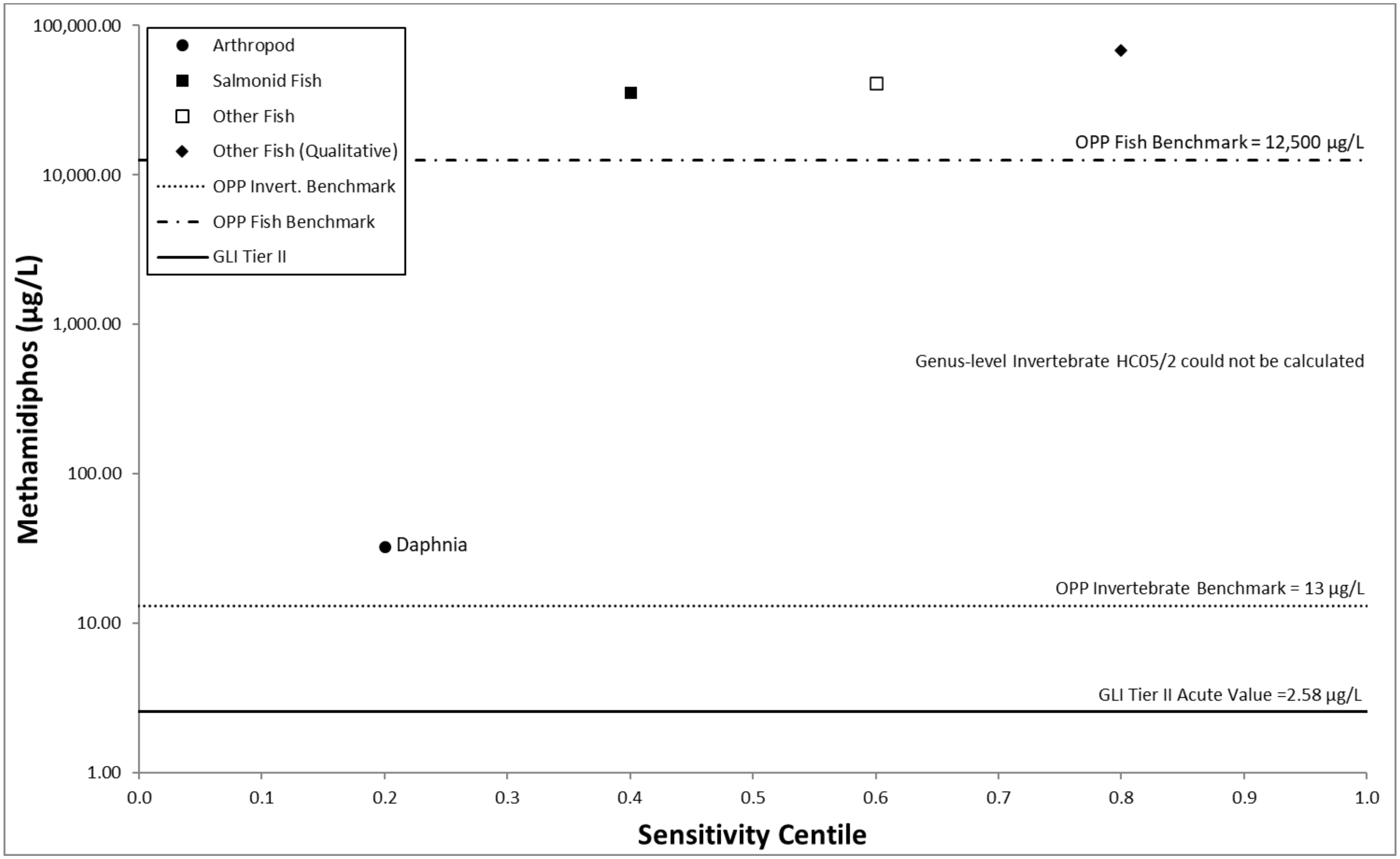

Figure 1. Methamidophos genus-level acute SD.

Symbols represent GMAVs calculated using all available data from the 2015 EPA literature search, supplemented with the OPP registration review document for methamidophos (U.S. EPA 2008).

1.3.1.2 Methamidophos Chronic Toxicity Data

Chronic data were gathered by the EPA in 2015 and combined with the OPP registration review document for methamidophos (U.S. EPA 2008). The final chronic methamidophos dataset consisted of one NOEC and one LOEC for a single species, which was an invertebrate (Table 4).

Table 4. Chronic toxicity data of methamidophos to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference	Comment
D	Daphnia	magna	4.490	5.320	Dry weight, immobility and reproduction	MRID 46554501. Kern et al. 2005	Quantitative / Supplemental

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark is 4.5 µg/L, which is the NOEC for *Daphnia magna*.

The OPP fish chronic benchmark is 173.6 µg/L, which is the estimated NOEC for *Oncorhynchus mykiss*. The *O. mykiss* NOEC was extrapolated by dividing the most sensitive acute 96-h LC50 for rainbow trout (25,000 µg/L) by 144 (highest rainbow trout ACR for organophosphates).

GLI Tier II Chronic Value Calculation

Paired quantitative chronic and acute toxicity data for methamidophos were available for the water flea, *Daphnia magna*. The paired acute and chronic *D. magna* data enabled the calculation of one ACR. The remaining two ACRs were fulfilled by the default value of 18. The acute and chronic tests were conducted in different laboratories using water of different physical characteristics; therefore, OPP's approach was used to calculate the ACR. OPP's approach involves the use of the NOAEC in the calculations. The calculated Secondary Chronic Value (SCV) for methamidophos is 0.418 µg/L.

Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{5.791 * 18 * 18} = 12.33$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{5.151}{12.33} = 0.418\ \mu g/L$$

Table 6. Summary and comparison of chronic values for methamidophos.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Methamidophos	4.5 µg/L (2016, *Daphnia magna*)	0.42 µg/L (GLI Tier II; 1 ACR, 11X)	NA	Two default ACRs of 18 used to derive GLI Tier II value.

1.3.1.3 Methamidophos References

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1.3.2 Comparison of Aquatic Life Toxicity Values for Profenofos: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for profenofos were gathered by the EPA in 2015 and were also obtained from the OPP registration review document for profenofos (U.S. EPA 2008).

1.3.2.1 Profenofos Acute Toxicity Data

Acute data were gathered by the EPA in 2015 and were also obtained from the OPP registration review document for profenofos (U.S. EPA 2008; See Table 1). Six LC_{50}s for five species representing five genera that were classified as "quantitative" data. Five LC_{50}s for four invertebrate species across three genera were classified as qualitative and are included here to allow for a sufficient sample size to calculate an invertebrate genus-level HC_{05}.

One 48-hour LC_{50} for *Chironomus plumosus* classified as qualitative because of duration used to fulfill an MDR group. One 48-hour LC_{50} for *Ceriodaphnia dubia* classified as qualitative because water quality characteristics were not reported and potential exposure from feeding may have occurred. Three 24-hour LC_{50}s for two species of *Culex* classified as qualitative because of duration. One 96-hour LC_{50}s for fathead minnow *Pimephales promelas* classified as qualitative because control mortality was not reported and feeding may have occurred. One 96-hour LC_{50} for the Western mosquitofish *Gambusia affinis* classified as qualitative because source water was unknown and control mortality was not reported.

The final acute profenofos dataset consisted of 13 LC_{50}s for 11 species representing 10 genera, of which six were invertebrate species representing five invertebrate genera. Ranked invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity data of profenofos to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
D	Ceriodaphnia	dubia	0.039	0.039	0.04	ECOTOX 158195; Woods et al. 2002	Qualitative, water quality characteristics not reported; potential exposure from feeding; source water type unknown
D	Daphnia	magna	1.400	1.14	1.14	ECOTOX 6797; Mayer and Ellersieck. 1986	Quantitative
D	Daphnia	magna	0.930			MRID 416273-04; Bellantoni. 1990	Quantitative
F	Culex	pipiens pallens	73	73.010	28.67	ECOTOX 61915; Lee et al. 1997	Qualitative
F	Culex	quinquefasciatus	5.13	11.26		ECOTOX 63336; Kasai et al. 1998	Qualitative
F	Culex	quinquefasciatus	24.7			ECOTOX 63336; Kasai et al. 1998	Qualitative
E	Gammarus	pseudolimnaeus	0.800	0.800	0.80	ECOTOX 6797; Mayer and Ellersieck. 1986	Quantitative
F	Chironomus	plumosus	1.000	1.000	1.00	ECOTOX 6797; Mayer and Ellersieck. 1986	Qualitative, duration
A	Oncorhynchus	mykiss	23.50	23.50	23.50	ECOTOX 6797; Mayer and Ellersieck. 1986	Quantitative
C	Pimephales	promleas	316.4	316.4	316.4	ECOTOX 68287; Baer et al. 2002	Qualitative, Dechlorinated tap water used; nominal; control mortality not reported; possible feeding during test
C	Gambusia	affinis	633.6	633.6	633.6	ECOTOX 100565; Rao et al. 2006	Qualitative, Control mortality unknown; source water
B	Lepomis	macrochirus	13.50	13.50	13.50	ECOTOX 6797; Mayer and Ellersieck. 1986	Quantitative
C	Ictalurus	punctatus	18.00	18.00	18.00	ECOTOX 6797; Mayer and Ellersieck. 1986	Quantitative

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)

G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark is 0.465 µg/L, which is ½ of the lowest *Daphnia magna* LC_{50} of 0.930 µg/L.

The OPP fish acute benchmark is 7.05 µg/L, which is ½ of the *Lepomis macrochirus* LC_{50} of 14.1 µg/L as it is reported in the OPP document. The value listed (14.1) is based on nominal concentration and is listed as a measured concentration (13.5) in Table 1.

GLI Tier II Acute Value Calculation

The acceptable acute dataset for profenofos fulfills six of the eight MDRs, corresponding to the use of a SAF of 5.2. Applying the SAF to the lowest, most sensitive GMAV (i.e., 0.800 µg/L for scud (*Gammarus pseudolimnaeus*), the calculated Secondary Acute Value (SAV) is 0.154 µg/L. The SMC, which is calculated as half the SAV, is 0.077 µg/L. Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{0.800}{5.2} = 0.154\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{0.154}{2} = 0.077\ \mu g/L$$

Genus-Level Invertebrate-Only Acute HC_{05}

No genus-level invertebrate acute HC_{05} could be calculated following the USEPA (1985) methodology, as there was only two invertebrate genera with quantitative data (Table 2).

Table 2. Profenofos invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Daphnia	*magna*	1.141	1.141	2
Gammarus	*pseudolimnaeus*	0.8000	0.8000	1

Table 3. Summary and comparison of acute values for profenofos.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest $LC_{50}/2$) (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only $HC_{05}/2$	Notes
Profenofos	0.465 µg/L (2008; *Daphnia magna*)	0.077 µg/L (6 MDRs filled, 6X)	NA (2 genera)	The FIFRA ALB is higher because the GLI Tier II value is based on *G. pseudolimnaeus* test in the open literature with a lower LC_{50}.

Figure 1 shows a genus-level sensitivity distribution for the profenofos dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values and GLI Tier II calculated acute value are included.

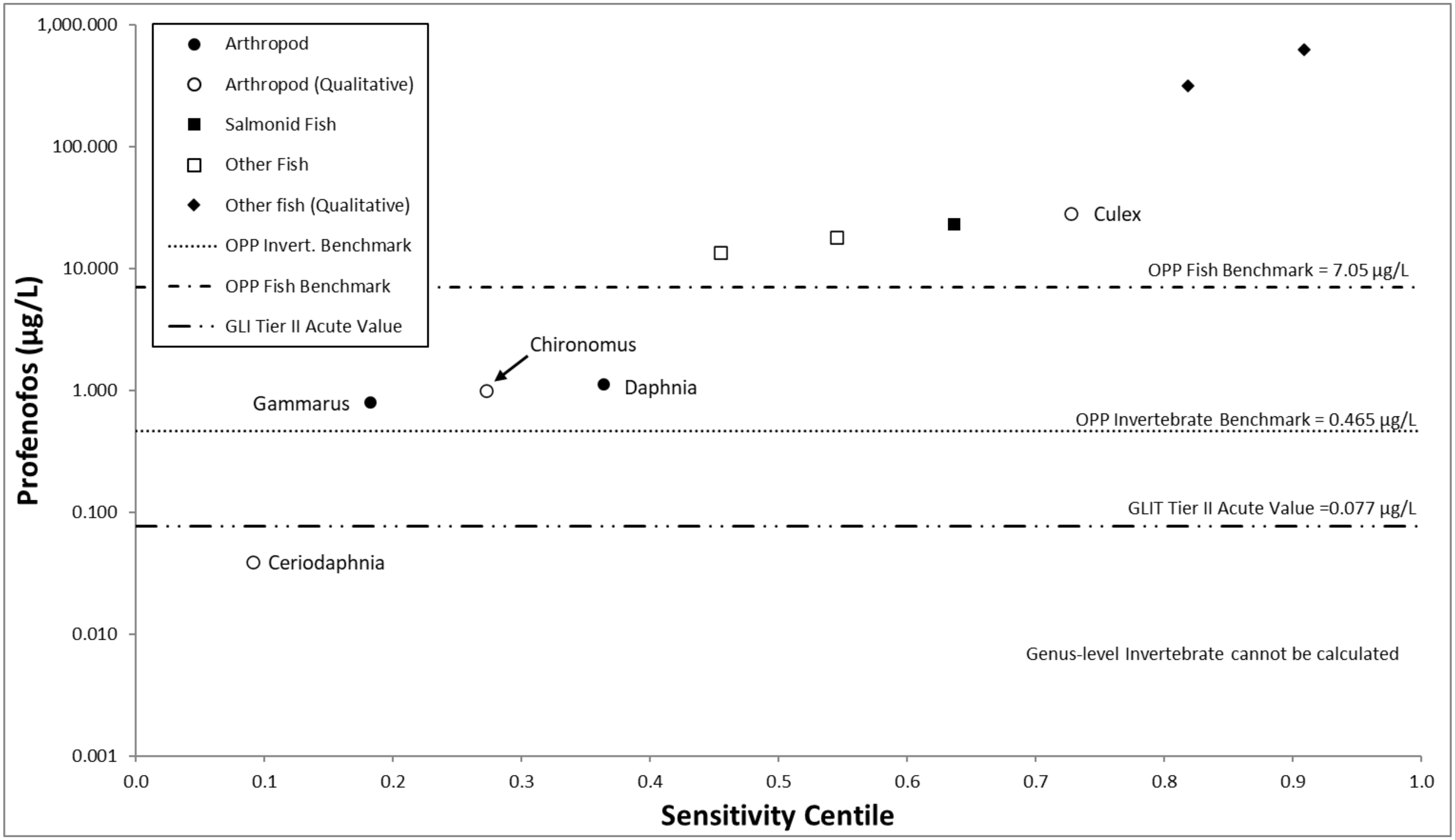

Figure 1. Profenofos genus-level SD.

Symbols represent GMAVs calculated using all available data from the 2015 EPA literature search, supplemented with the OPP registration review document for profenofos (U.S. EPA 2015).

1.3.2.2 Profenofos Chronic Toxicity Data

Chronic data were gathered by the EPA in 2015 and supplemented with the OPP registration review document for profenofos (U.S. EPA 2015). The final chronic profenofos dataset consisted of two NOECs/LOECS for two species across two genera, of which one was an invertebrate and one was a vertebrate (Table 5).

Table 5. Chronic toxicity data of profenofos to freshwater aquatic organisms

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference	Comment
D	Daphnia	magna	0.2	0.33	Survival of parent and offspring	MRID 000859-64; LeBlanc and Suprenant 1980	Quantitative
B	Pimephales	promelas	2.0	4.4	Not defined	MRID 000859-58; LeBlanc et al. 1979	-

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark is 0.2 µg/L, which is the NOEC for *Daphnia magna*.

The OPP fish chronic benchmark is 2.0 µg/L, which is the NOEC for *Pimephales promelas*.

GLI Tier II Chronic Value Calculation

Quantitative chronic toxicity data and an analogous acute test for profenofos are available for the water flea, *Daphnia magna*, enabling the calculation of one ACR. The default value of 18 was used to fulfill the second and third ACRs. The acute and chronic tests for water flea (*Daphnia magna*) were conducted in different laboratories using water of different physical characteristics; therefore, OPP’s approach was used to calculate the ACR, which involves the use of the NOAEC in the calculation. The calculated SCV for profenofos is 0.013 µg/L. Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{4.650 * 18 * 18} = 11.46$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{0.154}{11.46} = 0.013\ \mu g/L$$

Table 6. Summary and comparison of chronic values for profenofos.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Profenofos	0.2 µg/L (2016, *Daphnia magna*)	0.013 µg/L (GLI Tier II; 1 ACR, 15X)	NA	Two default ACRs of 18 used to derive GLI Tier II value.

1.3.2.3 Profenofos References

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1.3.3 Comparison of Aquatic Life Toxicity Values for Fenpropathrin: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for fenpropathrin were gathered by OW in 2015 and combined with data from the OPP document on which the benchmark values are based (U.S. EPA 2010) and information in an OPP (Sayer 2016) memo reviewing studies submitted in support of the fenpropathrin review was also considered below.

1.3.3.1 Fenpropathrin Acute Toxicity Data

Acute fenpropathrin data were gathered by OW in 2015. The OPP document on which the benchmark values are based (U.S. EPA 2010) and an OPP (Sayer 2016) memo reviewing studies submitted in support of the fenpropathrin review were also included in the data gathering (See Table 1). Four LC_{50}s representing four species in four genera were identified and classified as "quantitative" data. A 96-hour LC_{50} for rainbow trout (*Oncorhynchus mykiss*) was identified and classified as qualitative because it was an 89% a.i. solution but considered acceptable in the OPP document. Two 24-hour LC_{50}s for the Southern house mosquito (*Culex quinquefasciatus*) classified as qualitative for multiple reasons (duration, concentrations used not reported, control not reported, source of organisms unknown, tap water used), but included here to increase the number of invertebrate genera. Additionally, a review of studies submitted in support of a registration review was examined (Sayer 2016), and an acceptable 96-hour LC_{50} for the amphipod species, *Hyalella azteca*, was added.

The final acute fenpropathrin dataset consisted of eight LC_{50}s for seven species across seven genera, of which three were invertebrate species representing three invertebrate genera. Ranked invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity data of fenpropathrin to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
D	Daphnia	magna	0.530	0.53	0.53	MRID 249939	Quantitative
E	Hyalella	azteca	0.00305	0.00305	0.00305	MRID 49209502. Bradley. 2013.	
F	Culex	quinquefasciatus	0.27000	0.6148	0.6148	ECOTOX 10971	Qualitative: Duration, tap water, static, concentrations not reported, control mortality not reported (larvae)
F	Culex	quinquefasciatus	1.40000			ECOTOX 10971	Qualitative: Duration, tap water, static, concentrations not reported, control mortality not reported (pupae)
A	Oncorhynchus	mykiss	2.3	2.30	2.30	MRID 249939	Qualitative, 89% a.i.
B	Pimephales	promelas	2.370	2.37	2.37	MRID 41525901. Dionne and Suprenant. 1990 MRID 42360001. Dionne and Suprenant. 1992	Quantitative
B	Lepomis	macrochirus	2.200	2.20	2.20	MRID 249939 MRID 00127791	Quantitative
B	Ictalurus	punctatus	5.500	5.50	5.50	MRID 249939	Quantitative

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark is 0.0015 µg/L, which is ½ of the *Hyalella azteca* LC_{50} of 0.00305 µg/L.

The OPP fish acute benchmark is 1.1 µg/L, which is ½ of the *Lepomis macrochirus* LC_{50} of 2.2 µg/L.

GLI Tier II Acute Value Calculation

The acceptable acute dataset for fenpropathrin fulfills five of the eight MDRs, corresponding to the use of a SAF of 6.1. Applying the SAF to the lowest, most sensitive GMAV (i.e., 0.00305µg/L for *Hyalella azteca*), the calculated SAV is 0.0005 µg/L. The SMC, which is calculated as half the SAV, is 0.00025 µg/L.

Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{0.00305}{6.1} = 0.0005\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{0.0005}{2} = 0.00025\ \mu g/L$$

Genus-Level Invertebrate Acute HC_{05}

No genus-level invertebrate acute HC_{05} could be calculated using the USEPA (1985) methodology because there were only three invertebrate genera (Table 2).

Table 2. Fenpropathrin invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Culex	*quinquefasciatus*	6.148	6.148	3
Daphnia	*magna*	0.5300	0.5300	2
Hyalella	*azteca*	0.00305	0.00305	1

Note: The *Culex* GMAV is based on data classified as qualitative that was included to increase the number of invertebrate genera.

Table 3. Summary and comparison of acute values for fenpropathrin.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2	Notes
Fenpropathrin (Synthetic Pyrethroid)	0.0015 µg/L (2021; *Hyalella azteca*)	0.00025 µg/L (5 MDRs filled, 6X)	NA (2 genera)	The GLI Tier II value is lower than the FIFRA ALB despite both being based on the same species. This is because of the Tier II adjustment factor of 6.1 was applied to this dataset, which satisfied 5/8 MDRs.

Figure 1 shows a genus-level sensitivity distribution for the fenpropathrin dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values and the GLI Tier II calculated value are included.

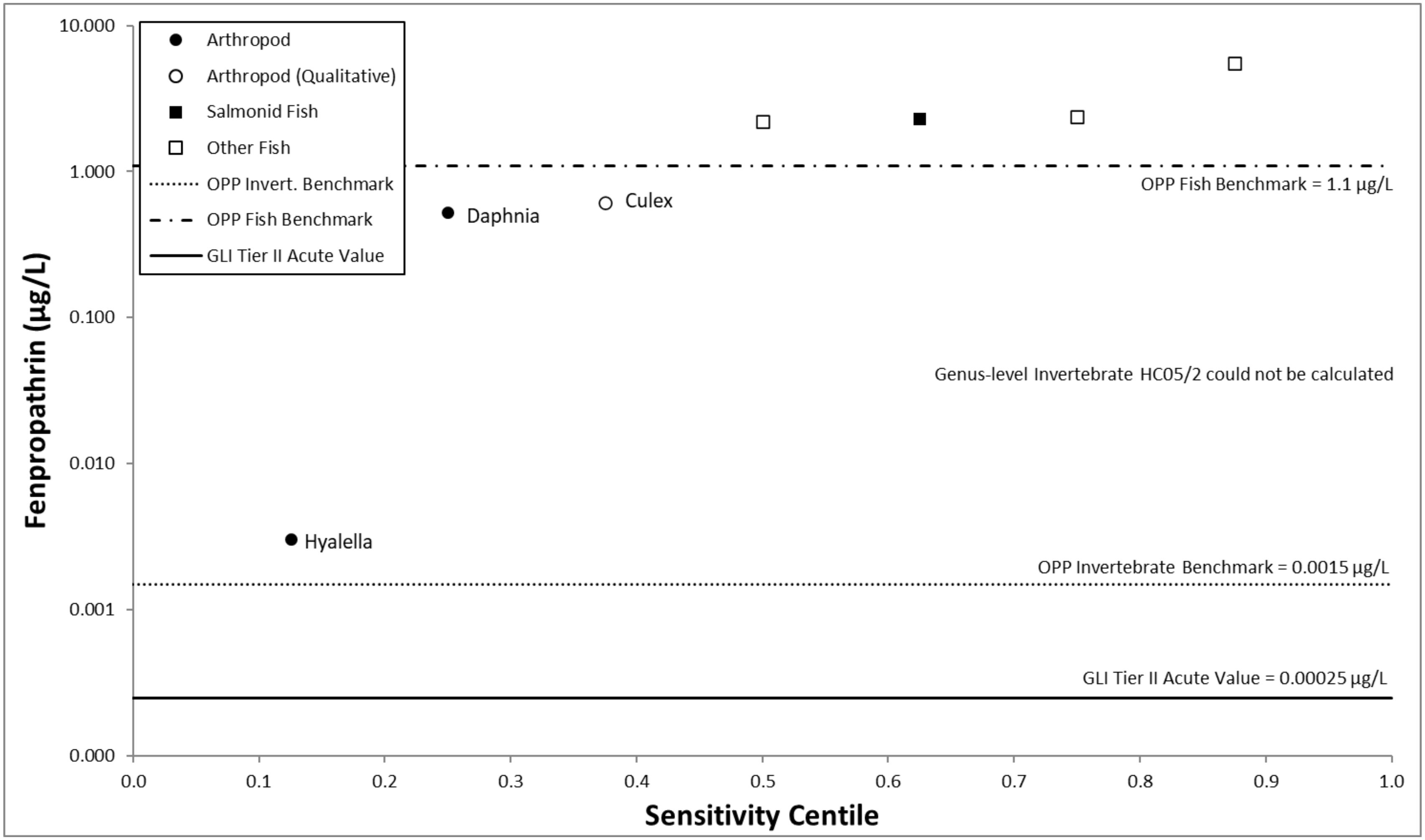

Figure 1. Fenpropathrin genus-level acute SD.
Symbols represent GMAVs calculated using all available data from the EPA 2015 literature search supplemented with the OPP registration review document for fenpropathrin (U.S. EPA 2010, Sayer 2016).

1.3.3.2 Fenpropathrin Chronic Toxicity Data

Chronic fenpropathrin data were gathered by OW in 2015 and combined with data from the OPP document on which the benchmark values are based (U.S. EPA 2010) and information in an OPP (Sayer 2016) memo reviewing studies submitted in support of the fenpropathrin review was also considered below.

The final chronic fenpropathrin dataset consisted of five NOECs/LOECS for four species across four genera, of which three were invertebrate genera and one was a vertebrate genus (Table 4).

Table 4. Chronic toxicity data of fenpropathrin to freshwater aquatic organisms

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference	Comment
D	Daphnia	magna	0.064	0.350	100% mortality at 0.350 µg/L; prior to mortality, significant decrease in fecundity (mean young/adult/reproduction day)	MRID 259678	Quantitative
E	Hyalella	azteca	0.004	0.0101	Survival	MRID 49243301	Acceptable
E	Hyalella	azteca	<0.0015	0.0015	Growth (length)	MRID 49368102	Supplemental - qualitative
F	Chironomus	dilutus	0.00578	0.01494	Emergence rate	MRID 49316005	Acceptable
B	Pimephales	promelas	0.06	0.091	Not reported	MRID 41525901	Supplemental

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark is <0.0015 µg/L, which is the NOEC for *Hyalella azteca*.

The OPP fish chronic benchmark is 0.6 µg/L, which is the NOEC for *Pimephales promelas*.

GLI Tier II Chronic Value Calculation

The acceptable dataset includes paired quantitative chronic and acute toxicity data for water flea (*Daphnia magna*), allowing for the calculation of one ACR. The GLI Tier II default value of 18 was used for the second and third ACRs. The acute and chronic water flea (*Daphnia magna*) tests were conducted in different laboratories using water of different physical characteristics; therefore, OPP's approach was used to calculate the ACRs. The Office of Pesticide Program's approach involves the use of the lowest (i.e., most sensitive) NOAEC for a given species in the

ACR calculations. The calculated SCV for fenpropathrin is 0.000036 µg/L. Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{8.281 * 18 * 18} = 13.90$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{0.0005}{13.90} = 0.000036\ \mu g/L$$

Table 5. Summary and comparison of chronic values for fenpropathrin.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Fenpropathrin	<0.0015 µg/L (2021, *Hyalella azteca*)	0.000036 µg/L (GLI Tier II; 1 ACR, 42X)	NA	Two default ACRs of 18 used to derive GLI Tier II value.

1.3.3.3 Fenpropathrin References

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MRID 49316005. Picard, C.R. Life-Cycle Toxicity Test Exposing Midges (*Chironomus dilutus*) to Fenpropathrin TG Applied to Sediment under Static-Renewal Conditions Following EPA Test Methods. Unpublished study conducted by Smithers Visient, Wareham, MA. Report No 12709.6334. Study sponsored by Valent USA Corporation, Walnut Creek, CA Study completed December 17, 2013.

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1.3.4 Comparison of Aquatic Life Toxicity Values for Fenbutatin Oxide: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for fenbutatin oxide were gathered by OW in 2015 and combined with data obtained from the OPP registration review document for fenbutatin oxide (U.S. EPA 2009).

1.3.4.1 Fenbutatin Oxide Acute Toxicity Data

Acute fenbutatin oxide data were gathered by the EPA in 2015 and were also obtained from the OPP registration review document for fenbutatin oxide (U.S. EPA 2009; See Table 1). Six LC_{50}s representing three species in three genera were identified and classified as "quantitative" data. One 24-hour LC_{50} for an unidentified insect species in the family *Chironomidae* was classified as qualitative but included here to increase the number of invertebrate genera. The *Chironomidae* test was classified as qualitative because of a non-standard exposure duration, the unidentified species, and the non-definitive (>4,400 µg/L) LC_{50} test result.

The final acute fenbutatin oxide dataset consisted of seven LC_{50}s for four species across four genera, of which two were invertebrate species representing two invertebrate genera. Ranked invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity data of fenbutatin oxide to freshwater aquatic organisms.

OW MDR Group[a]	Family	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
D	Daphniidae	Daphnia	magna	31.00	31.00	31.00	MRID 40473509. Hutton. 1987
F	Chironomidae	-	-	>4,400	>4,400	>4,400	MRID 47910407. Picard. 2005
A	Salmonidae	Oncorhynchus	mykiss	1.700	2.773	2.773	MRID 40098001. ECOTOX 6797. Mayer and Ellersieck. 1986.
A	Salmonidae	Oncorhynchus	mykiss	1.900			MRID 00113075. Johnson. 1973
A	Salmonidae	Oncorhynchus	mykiss	6.600			MRID 40473506. Hutton. 1987
B	Centrarchidae	Lepomis	macrochirus	4.800	4.800	4.800	MRID 40098001. ECOTOX 6797. Mayer and Ellersieck. 1986
B	Centrarchidae	Lepomis	macrochirus	4.800			MRID 00113076. Johnson and Jones. 1971

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes

B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)

C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)

D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)

E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)

F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)

G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)

H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark is 15.5 µg/L, which is ½ of the *Daphnia magna* LC_{50} of 31.00 µg/L.

The OPP fish acute benchmark is 0.85 µg/L, which is ½ of the *Oncorhynchus mykiss* LC_{50}s of 1.7 µg/L.

GLI Tier II Acute Value Calculation

The acceptable acute dataset for fenbutatin oxide fulfills three of the eight MDRs, corresponding to the use of a SAF of 8. Applying the SAF to the lowest, most sensitive GMAV (i.e., 2.773 µg/L for rainbow trout (*Oncorhynchus mykiss*), the calculated SAV is 0.347 µg/L. The SMC, which is calculated as half the SAV, is 0.173 µg/L.

Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{2.773}{8} = 0.347\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{0.347}{2} = 0.173\ \mu g/L$$

Genus-Level Invertebrate-only Acute HC_{05}

No genus-level invertebrate acute HC_{05} could be calculated following the USEPA (1985) methodology because there were only two invertebrate genera (Table 2).

Table 2. Fenbutatin oxide invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	Invertebrate GMAV Rank
Family Chironomidae		>4,400	>4,400	2
Daphnia	*magna*	31.00	31.00	1

Note: The Family Chironomidae GMAVs is based on data classified as qualitative that was included to increase the number of invertebrate genera.

Table 3. Summary and comparison of acute values for fenbutatin oxide.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Most Sensitive ALB (lowest $LC_{50}/2$) (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only $HC_{05}/2$
Fenbutatin Oxide (Organotin Acaricide)	0.85 µg/L (2009; *Oncorhynchus mykiss*)	0.173 µg/L (3 MDRs filled, 4.9X)	NA (1 genus)

Figure 1 shows a genus-level sensitivity distribution for the fenbutatin oxide dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values and GLI Tier II calculated acute value are included.

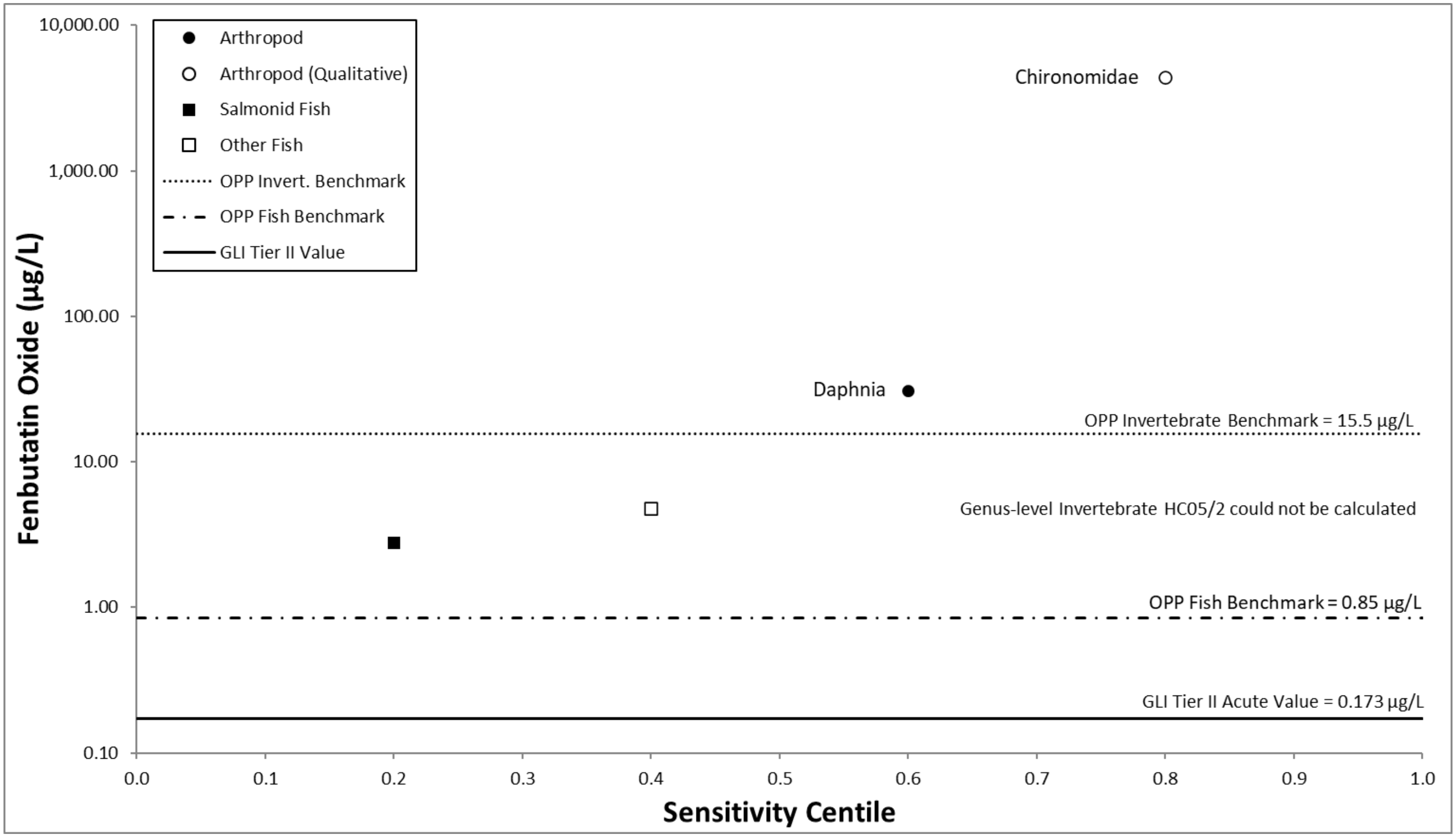

Figure 1. Fenbutatin oxide genus-level acute SD.
Symbols represent GMAVs calculated using all available data from the 2015 EPA literature search, supplemented with the OPP registration review document for fenbutatin oxide (U.S. EPA 2015).

1.3.4.2 Fenbutatin Oxide Chronic Toxicity Data

Data were gathered by the EPA in 2015, supplemented with the OPP registration review document for fenbutatin oxide (U.S. EPA 2015). The final chronic fenbutatin oxide dataset consisted of two NOECs/LOECS for two species across two genera, of which one was an invertebrate and one was a vertebrate (Table 4).

Table 4. Chronic toxicity data of fenbutatin oxide to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference	Comment
D	Daphnia	magna	16.00	39.00	Reduced growth and percent survival in adults and total number of young	MRID 40525901; Hutton 1988	Quantitative
A	Oncorhynchus	mykiss	0.310	0.610	Reduced larval survival and growth	MRID 40473512; Hutton 1987	Quantitative

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark is 16 µg/L, which is the NOEC for *Daphnia magna*.

The OPP fish chronic benchmark is 0.31 µg/L, which is the NOEC for *Oncorhynchus mykiss*.

GLI Tier II Chronic Value Calculation

The dataset of quantitative chronic toxicity data for fenbutatin oxide includes data for rainbow trout (*Oncorhynchus mykiss*) and water flea (*Daphnia magna*). Analogous quantitative acute tests are available for both species; therefore, two ACRs were calculated. The default value of 18 was used for the third ACR. The acute and chronic tests were conducted in different laboratories using water of different physical characteristics; therefore OPP’s approach was used to calculate the ACRs. OPP’s approach involves the use of the lowest (i.e., most sensitive) NOAEC for a given species in the ACR calculations. The calculated SCV for fenbutatin oxide is 0.060 µg/L. Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{1.938 * 5.484 * 18} = 5.761$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{0.347}{5.761} = 0.060\ \mu g/L$$

Table 5. Summary and comparison of chronic values for fenbutatin oxide.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Fenbutatin Oxide	0.31 µg/L (2009, *Oncorhynchus mykiss*). Note the vertebrate ALB is lower than the invertebrate ALB (16 µg/L)	0.06 µg/L (GLI Tier II; 2 ACRs, 5.1X)	NA	One default ACR of 18 used to derive GLI Tier II value.

1.3.4.3 Fenbutatin Oxide References

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U.S. EPA. 2024. Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA). EPA-820-D-24-002.

1.3.5 Comparison of Aquatic Life Toxicity Values for Methoxyfenozide: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for methoxyfenozide were gathered by OW in 2015 and supplemented with additional values described in the OPP document on which the benchmark values are based (U.S. EPA 2013).

1.3.5.1 Methoxyfenozide Acute Toxicity Data

Data were gathered by the OW in 2015 and supplemented with additional values described in the OPP document on which the benchmark values are based (U.S. EPA 2013). One LC_{50} for *Daphnia magna* determined to be "quantitative" data. Two 96-hour LC_{50}s for *Oncorhynchus mykiss* and *Lepomis macrochirus* were classified as qualitative because they were greater than toxicity values used to fulfill MDR groups, but otherwise considered acceptable. A 120-hour LC_{50} for the mosquito *Anophales gambiae* was classified as qualitative because of duration, uncharacterized source water, feeding during the test, and lack of replicates, but was included in order to increase the number of invertebrate genera.

The final acute methoxyfenozide dataset consisted of four LC_{50}s for four species representing four genera, of which two were invertebrate species representing two invertebrate genera (Table 1). The invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity data of methoxyfenozide to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
D	Daphnia	magna	3,700	3,700	3,700	MRID 44144411; Holmes and Swigert. 1993	Quantitative
F	Anaphales	gambiae	248	247.70	247.70	ECOTOX 165535; Morou et al. 2013	Qualitative: Duration; fed during experiment; tests conducted with unknown water type in plastic cups; no replicates.
A	Oncorhynchus	mykiss	>4,200	>4,200	>4,200	MRID 44144410; Graves and Swigert. 1995	Qualitative, greater than endpoint
B	Lepomis	macrochirus	>4,300	>4,300	>4,300	MRID 44144409; Graves and Swigert. 1995	Qualitative, greater than endpoint

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark is 28.5 µg/L, which is ½ of the calculated (estimated) *Chironomus riparius* acute test value of 57 µg/L. This acute value for *C. riparius* was calculated by multiplying the acute to chronic ratio from studies with *Daphnia magna* by the NOAEC for *Chironomus riparius* (Described in a footnote to Table 4.1 of U.S. EPA 2013). Briefly, The ACR for *D. magna* is 18.5**.** The *C. riparius* NOAEC (3.1 µg/L) served as the basis for the OPP invertebrate chronic benchmark and is used in the acute value calculation**.** The estimated/calculated acute value for *C. riparius* is 57 µg/L (i.e., 3.1 x 18.5). The OPP fish acute benchmark is >2,100 µg/L, which is ½ of the *Oncorhynchus mykiss* LC_{50} of >4,200 µg/L.

GLI Tier II Acute Value Calculation

The acceptable acute dataset for methoxyfenozide fulfills three of the eight MDRs, corresponding to the use of a Secondary Acute Factor (SAF) of 8. Applying the SAF to the lowest, most sensitive GMAV (i.e., the only GMAV available, 3,700 µg/L for water flea (*Daphnia magna*)), the calculated Secondary Acute Value (SAV) is 462.5 µg/L. The Secondary Maximum Criterion (SMC), which is calculated as half the SAV, is 231.3 µg/L. Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{3{,}700}{8} = 462.5\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{462.5}{2} = 231.3\ \mu g/L$$

Genus-Level Invertebrate Acute HC_{05}

No genus-level invertebrate Acute HC_{05} could be calculated following USEPA (1985) methodology because there were only two invertebrate genera (Table 2).

Table 2. Methoxyfenozide invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Daphnia	*magna*	3,700	3,700	2
Anaphales	*gambiae*	247.7	247.7	1

Note: The *A. gambiae* GMAV is based on data classified as qualitative that was included to increase the number of invertebrate genera.

Table 3. Summary and comparison of acute values for methoxyfenozide.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Genus Level Invertebrate-only HC_{05}/2	Notes
Methoxyfenozide (Insect Growth Regulator; Diacylhydrazine)	28.5 µg/L (2013; *Chironomus riparius*)	231.3 µg/L (3 MDRs filled, 0.0043X)	NA (2 genera)	FIFRA ALB value was calculated by multiplying the acute-to-chronic ratio from studies with *D. magna* by the NOAEC for *C. riparius*. The *C. riparius* NOAEC (3.1 µg/L) serves as the basis for the FIFRA ALB chronic benchmark. The Tier II value is approximately 10 times larger than the FIFRA ALB because it is based on the GMAV for *Daphnia*, which is 74 times larger than the calculated test value for *C. riparius* (57 µg/L).

Figure 1 shows a genus-level sensitivity distribution for the methoxyfenozide dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values and the GLI Tier II calculated value are included.

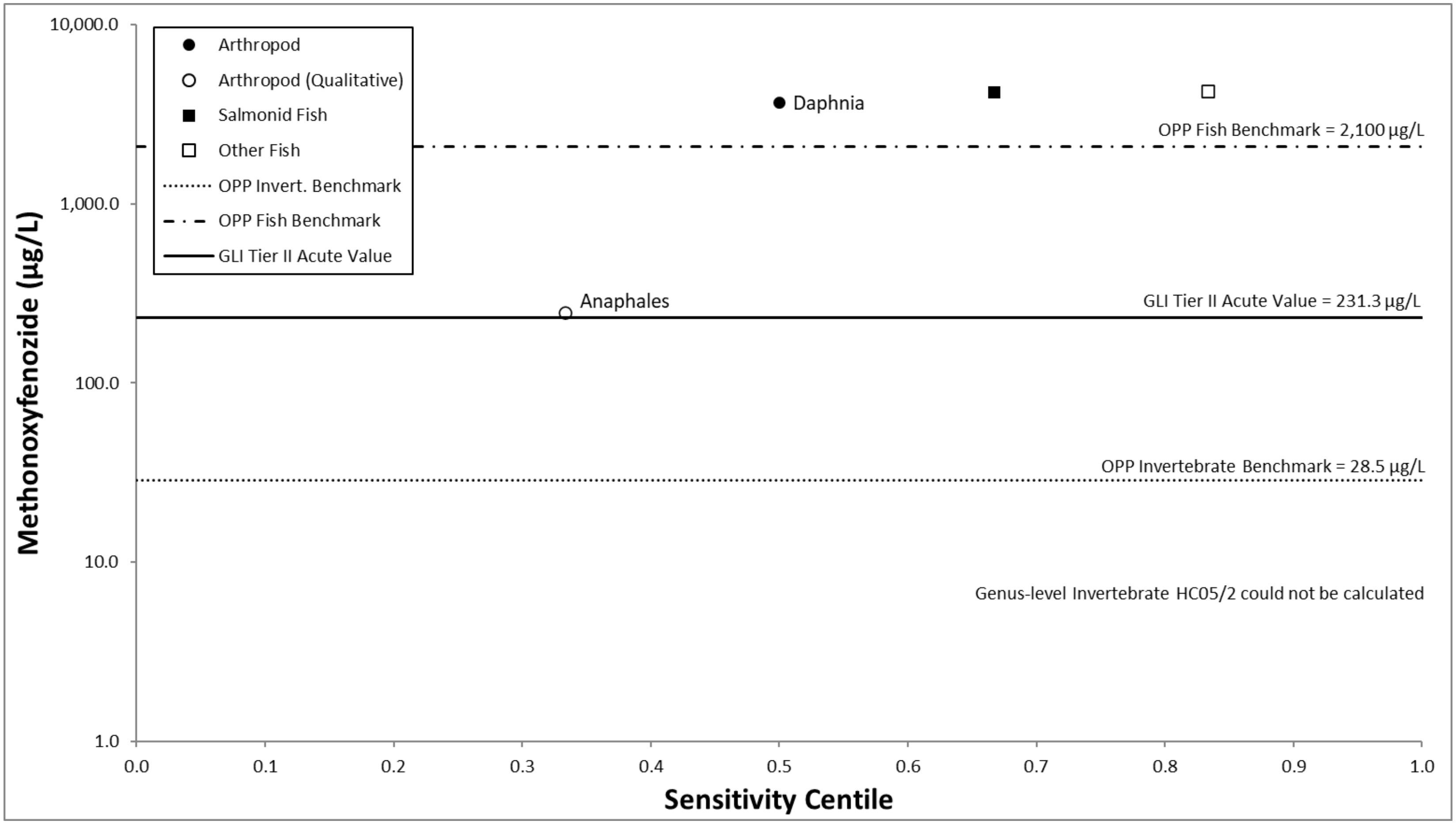

Figure 1. Methoxyfenozide genus-level acute SD.
Symbols represent GMAVs calculated using all available data from the 2015 EPA literature search, supplemented with the OPP registration review for methoxyfenozide (U.S. EPA 2013).

1.3.5.2 Methoxyfenozide Chronic Toxicity Data

Chronic methoxyfenozide data were gathered by the OW in 2015 and supplemented with additional values described in the OPP document on which the benchmark values are based (U.S. EPA 2013). The final chronic methoxyfenozide dataset consisted of three NOECs/LOECS for three species across three genera, of which two were invertebrate genera and one was a vertebrate genus (Table 4).

Table 4. Chronic toxicity data of methoxyfenozide to freshwater aquatic organisms

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference	Comment
D	Daphnia	magna	200.0	390.0	Survival	MRID 446177-14; Zelinka et al. 1993	Quantitative
F	Chironomus	riparius	3.1	6.3	Delayed emergence and development	MRID 450328-01; Kolk 2000	Supplemental (non-guideline)
B	Pimephales	promelas	530	1,000	Survival	MRID 446177-16; Rhodes and Hurshman 1998	Acceptable

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark is 3.1 µg/L, which is the NOEC for *Chironomus riparius*.

The OPP fish chronic benchmark is 530 µg/L, which is the NOEC for *Pimephales promelas*.

GLI Tier II Chronic Value Calculation

Paired quantitative chronic and acute toxicity data for methoxyfenozide were available for water flea (*Daphnia magna*), allowing for the calculation of one ACR. The remaining two ACRs were fulfilled by the default value of 18. The acute and chronic tests were conducted in different laboratories using water of different physical characteristics; therefore, OPP's approach was used to calculate the ACR. OPP's approach involves the use of the NOAEC) in the calculations. The calculated SCV for methoxyfenozide is 25.46 µg/L.

Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{18.50 * 18 * 18} = 18.17$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{462.5}{18.17} = 25.46\ \mu g/L$$

Table 5. Summary and comparison of chronic values for methoxyfenozide
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only ALC (FCV) (# of ACRs filled, magnitude relative to ALB)	Notes
Methoxyfenozide	3.1 µg/L (2019, C*hironomus riparius*)	25.5 µg/L (GLI Tier II; 1 ACR, 0.25X)	NA	Two default ACRs of 18 used to derive GLI Tier II value.

1.3.5.3 Methoxyfenozide References

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1.3.6 Comparison of Aquatic Life Toxicity Values for Norflurazon: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for norflurazon were gathered by OW in 2015. Additionally, three OPP documents (U.S. EPA 2008, 2012, 2017) on which the benchmark values are based also provided data. The OPP invertebrate and fish benchmark values were the same in all three documents.

1.3.6.1 Norflurazon Acute Toxicity Data

Acute norflurazon data were gathered by OW in 2015. Additionally, three OPP documents (U.S. EPA 2008, 2012, 2017) on which the benchmark values are based also provided data. (See Table 1.) The OPP invertebrate and fish benchmark values were the same in all three documents examined. Two LC_{50}s were classified as "quantitative" data and one 96-hour LC_{50} for *Daphnia magna* was classified as qualitative because of its duration and because it was a greater than value. This test was included to fulfill a MDR group, and because it serves as the basis for the OPP invertebrate benchmark value.

The final acute norflurazon dataset consisted of three LC_{50}s for three species representing three genera, of which one was an invertebrate species. The invertebrate GMAV for *Daphnia* is listed in Table 2.

Table 1. Acute toxicity data of norflurazon to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference	Comment
D	Daphnia	magna	>15,000	>15,000	>15,000	MRID 00035709; Vilkas and Browne. 1980	Qualitative, greater than value, duration
A	Oncorhynchus	mykiss	8,100	8,100	8,100	MRID 00087863; Stoll et al. 1981	Quantitative
B	Lepomis	macrochirus	16,300	16,300	16,300	MRID 0087862; Stoll et al. 1981	Quantitative

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark is >7,500 µg/L, which is ½ of the *Daphnia magna* test value of >15,000 µg/L.

The OPP fish acute benchmark is 4,050 µg/L, which is ½ of the *Oncorhynchus mykiss* LC_{50} of 8,100 µg/L.

GLI Tier II Acute Value Calculation

The acceptable acute dataset for norflurazon fulfills three MDRs, corresponding to the use of a SAF of 8. Applying the SAF to the lowest, most sensitive GMAV (i.e., 8,100 µg/L for rainbow trout (*Oncorhynchus mykiss*), the calculated SAV is 1,012.5 µg/L. The SMC, which is calculated as half the SAV, is 506.3 µg/L. Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{8{,}100}{8} = 1{,}012.5\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{1{,}012.5}{2} = 506.3\ \mu g/L$$

Genus-Level Invertebrate-only Acute HC_{05}

No genus-level invertebrate acute HC_{05} could be calculated using the USEPA (1985) methodology because there was only one invertebrate genus (Table 2).

Table 2. Norflurazon invertebrate SMAV and GMAV (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Daphnia	*magna*	>15,000	>15,000	1

Table 3. Summary and comparison of acute values for norflurazon. Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Most Sensitive ALB (lowest LC_{50}/2) (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2	Notes
Norflurazon (Pyridazine Herbicide)	4,050 µg/L (2023; *Oncorhynchus mykiss*)	506.3 µg/L 3 MDRs filled, 8X)	NA (1 genus)	The lowest OPP ALB is for nonvascular plants (6.03 µg/L), but the GLI Tier II value is based on *O. mykiss* so the vertebrate ALB is used in this comparison.

Figure 1 shows a genus-level sensitivity distribution for the norflurazon dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values and GLI Tier II calculated values are included.

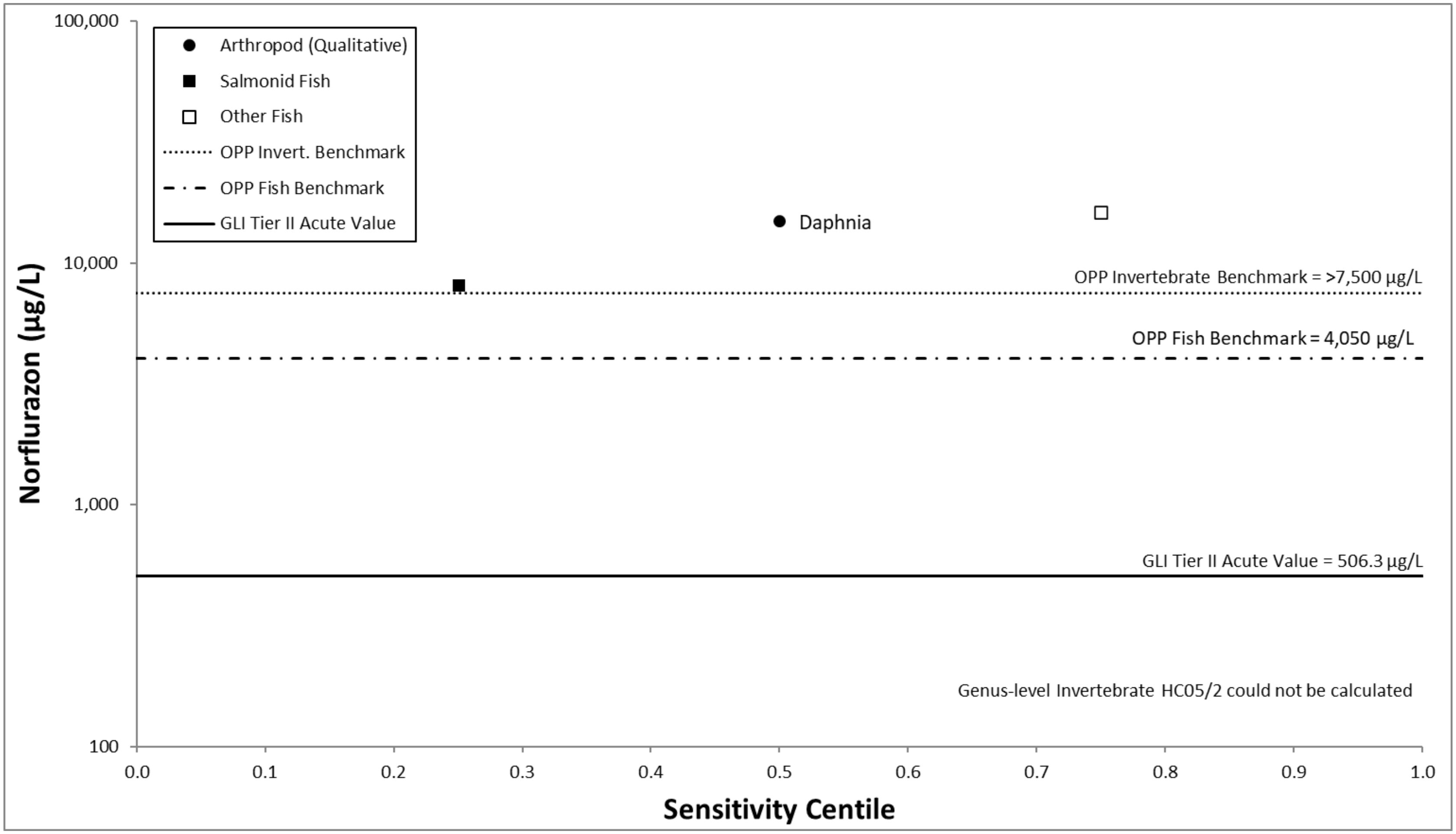

Figure 1. Norflurazon genus-level SD.
Symbols represent GMAVs calculated using all available data from the 2015 EPA literature search, supplemented the OPP registration review document for norflurazon (U.S. EPA 2017).

1.3.6.2 Norflurazon Chronic Toxicity Data

Chronic norflurazon data were gathered by OW in 2015. Additionally, three OPP documents (U.S. EPA 2008, 2012, 2017) on which the benchmark values are based also provided data.

The final chronic norflurazon dataset consisted of three NOECs/LOECS for three species across three genera, of which one was an invertebrate genus and two were vertebrate genera (Table 4).

Table 4. Chronic toxicity data of norflurazon to freshwater aquatic organisms

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference
D	Daphnia	magna	1,000	2,600	Reduced number of offspring	MRID 00118049; LeBlanc 1982
A	Oncorhynchus	mykiss	770	1,500	Growth	MRID 0018048; LeBlanc 1982
B	Pimephales	promelas	1,100	2,100	Growth	MRID 00118047; LeBlanc 1982

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark is 1,000 µg/L, which is the NOEC for *Daphnia magna*.

The OPP fish chronic benchmark is 770 µg/L, which is the NOEC for *Oncorhynchus mykiss*.

GLI Tier II Chronic Value Calculation

Paired quantitative chronic and acute toxicity data for norflurazon were not available for freshwater aquatic organisms; therefore, each of the three ACRs were fulfilled by the default value of 18. The calculated SCV for norflurazon is 56.25 µg/L.

Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{18 * 18 * 18} = 18$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{1{,}012.5}{18} = 56.25\ \mu g/L$$

Table 5. Summary and comparison of chronic values for norflurazon. Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	Most Sensitive OPP ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Norflurazon	770 µg/L (2023, *Oncorhynchus mykiss*).	56.3 µg/L (GLI Tier II; 0 measured-data based ACRs, 14X)	NA	Three default ACRs of 18 used to derive GLI Tier II value. Note the lowest ALB is for nonvascular plants (5.33 µg/L), but the GLI Tier II value is based on *O. mykiss* so the vertebrate ALB is used in this comparison.

1.3.6.3 Norflurazon References

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1.3.7 Comparison of Aquatic Life Toxicity Values for Propargite: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for propargite were gathered by OW in 2015 and supplemented with data from the OPP propargite document on which the benchmark values are based (U.S. EPA 2014).

1.3.7.1 Propargite Acute Toxicity Data

Acute propargite data were gathered by OW in 2015 and supplemented with data from the OPP document on which the benchmark values are based (U.S. EPA 2014; See Table 1). Five LC_{50}s across three species representing three genera were classified as "quantitative" data; Three LC_{50}s (one each for *Daphnia magna*, *Lepomis macrochirus*, and *Oncorhynchus mykiss*; the three species represented with quantitative test data) were classified as acceptable in U.S. EPA (2014). One 24-hour LC_{50}s for the yellow fever mosquito *Aedes aegypti* was classified as qualitative because of duration, feeding during the test, unknown control mortality, and lack of information in source or control water, but included here to increase the number of invertebrate genera.

The final acute propargite dataset consisted of nine LC_{50}s for four species representing four genera, of which two were invertebrate species representing two invertebrate genera. The invertebrate GMAVs are listed in Table 2.

Table 1. Acute toxicity data of propargite to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
D	Daphnia	magna	91	45.64	45.64	ECOTOX 344; U.S. Environmental Protection Agency, and Office of Pesticide Programs. 2013
D	Daphnia	magna	14			MRID 46015901; Knight and Allan. 2002
D	Daphnia	magna	74.6			MRID 43759002; Davis. 1995
F	Aedes	aegypti	780.0	780.0	780.0	ECOTOX 116328; Pridgeon et al. 2009
A	Oncorhynchus	mykiss	118	89.86	89.86	ECOTOX 344; U.S. Environmental Protection Agency, and Office of Pesticide Programs. 2013
A	Oncorhynchus	mykiss	43			MRID 41458301; Sousa. 1990
A	Oncorhynchus	mykiss	143			MRID 43759001; Davis. 1995
B	Lepomis	macrochirus	167	116.3	116.3	ECOTOX 344; U.S. Environmental Protection Agency, and Office of Pesticide Programs. 2013
B	Lepomis	macrochirus	81			MRID 46073301; Knight and Allan. 2002

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark is 7 µg/L, which is ½ of the *Daphnia magna* LC_{50} of 14 µg/L.

The OPP fish acute benchmark is 40.5 µg/L, which is ½ of the *Lepomis macrochirus* LC_{50} of 81 µg/L.

GLI Tier II Acute Value Calculation

The acceptable acute dataset for propargite fulfills three of the eight MDRs, corresponding to the use of a SAF of 8. Applying the SAF to the lowest, most sensitive GMAV (i.e., 35.69 µg/L for water flea (*Daphnia magna*), the calculated SAV is 4.462 µg/L. The SMC, which is calculated as half the SAV, is 2.231 µg/L.

Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{35.69}{8} = 4.462\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{4.462}{2} = 2.231\ \mu g/L$$

Genus-Level Invertebrate Acute HC_{05}

No genus-level invertebrate acute HC_{05} could be calculated using the USEPA (1985) methodology because there were only two invertebrate genera (Table 2).

Table 2. Propargite invertebrate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Aedes	*aegypti*	780.0	780.0	2
Daphnia	*magna*	45.64	45.64	1

Table 3. Summary and comparison of chronic values for propargite.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only HC_{05}/2
Propargite (OS Miticide)	7 µg/L (2021; *Daphnia magna*)	2.231 µg/L (3 MDRs filled, 3.1X)	NA (1 genus)

Figure 1 shows a genus-level sensitivity distribution for the propargite dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values and GLI Tier II calculated value are included.

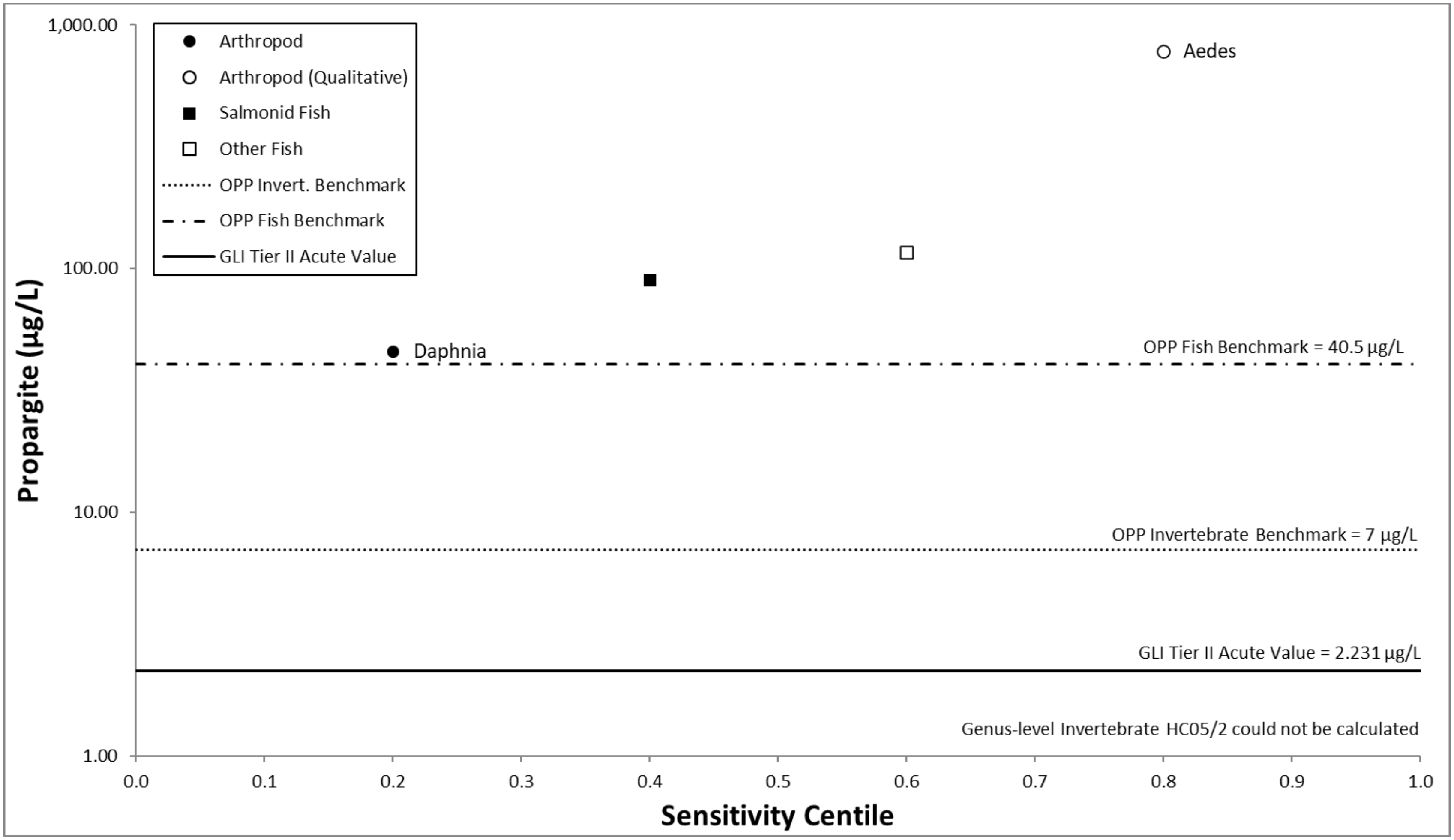

Figure 1. Propargite genus-level acute SD.

Symbols represent GMAVs calculated using all available data from obtained from the EPA's 2015 literature search, supplemented the OPP registration review document for propargite (U.S. EPA 2014).

1.3.7.2 Propargite Chronic Toxicity Data

Chronic data for propargite were gathered by OW in 2015 and supplemented with data from the OPP propargite document on which the benchmark values are based (U.S. EPA 2014).
The final chronic propargite dataset consisted of three NOECs/LOECS for three species across three genera, of which one was an invertebrate genus and two were vertebrate genera (Table 4).

Table 4. Chronic toxicity data of propargite to freshwater aquatic organisms

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference	Comment
D	Daphnia	magna	9.000	14.00	Growth (length)	MRID 0126738; Forbis et al. 1983 / MRID 00142594; Forbis and Franklin. 1984	Quantitative
A	Oncorhynchus	mykiss	14	21	Survival and growth (weight)	MRID 41458301; Sousa 1990	Supplemental
B	Pimephales	promelas	16	28	Survival and growth (weight)	MRID 00126739 / 00132605; Forbis et al. 1983	Acceptable

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark is 9 µg/L, which is the NOEC for *Daphnia magna*. The OPP fish chronic benchmark is 16 µg/L, which is the NOEC for *Pimephales promelas*.

GLI Tier II Chronic Value Calculation

Paired quantitative chronic and acute toxicity data for propargite were available for water flea (*Daphnia magna*), allowing for the calculation of one ACR. The remaining two ACRs were fulfilled by the default value of 18. The acute and chronic tests were conducted in different laboratories using water of different physical characteristics; therefore, OPP’s approach was used to calculate the ACR. OPP’s approach involves the use of the NOAEC in the calculations. The calculated SCV for propargite is 0.561 µg/L.

Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{1.556 * 18 * 18} = 7.958$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{4.462}{7.958} = 0.561\ \mu g/L$$

Table 5. Summary and comparison of chronic values for propargite.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only HC_{05} (# of ACRs filled, magnitude relative to ALB)	Notes
Propargite	9 µg/L (2021, *Daphnia magna*)	0.56 µg/L (GLI Tier II; 1 ACR, 16X)	NA	Two default ACRs of 18 used to derive GLI Tier II value. Note the lowest ALB is for nonvascular plants (1.27 µg/L), but the GLI Tier II value is based on *D. magna* so the invertebrate ALB is used in this comparison.

1.3.7.3 Propargite References

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1.3.8 Comparison of Aquatic Life Toxicity Values for Pyridaben: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) for pyridaben were gathered by the OW in 2015, supplemented with additional values from the OPP document on which the benchmark values are based (U.S. EPA 2010).

1.3.8.1 Pyridaben Acute Toxicity Data

Acute pyridaben toxicity data were gathered by the OW in 2015 and supplemented with additional values from the OPP document on which the benchmark values are based (U.S. EPA 2010; See Table 1). Four LC_{50}s across three species and three genera were identified and classified as "quantitative" data. Four LC_{50}s (two for *Oncorhynchus mykiss*, one for *Daphnia magna*, and one for *Pimephales*) were classified as acceptable in Appendix C of U.S. EPA (2010).

The final acute pyridaben dataset consisted of eight LC_{50}s for four species representing four genera, of which one was an invertebrate species. The invertebrate GMAV is listed in Table 2.

Table 1. Acute toxicity data of pyridaben to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	LC50/ EC50 (µg/L)	SMAV (µg/L)	GMAV (µg/L)	Reference
D	Daphnia	magna	0.530	0.7353	0.7353	MRID 42680111; Willis and Wilson. 1987
D	Daphnia	magna	1.02			MRID 43680404; Graves and Swigert. 1993
A	Oncorhynchus	mykiss	0.720	1.743	1.743	MRID 43680402; Ward. 1994
A	Oncorhynchus	mykiss	2.3			MRID 42680109; Willis and Wilson. 1987
A	Oncorhynchus	mykiss	3.2			MRID 43680403; Bootman et al. 1989
B	Lepomis	macrochirus	3.430	2.940	2.940	MRID 43680401; Ward. 1994
B	Lepomis	macrochirus	2.520			MRID 42680110; Willis. 1988
C	Pimephales	promelas	2.30	2.3	2.3	MRID 43792106; Rhodes et al. 1995

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP invertebrate acute benchmark is 0.265 µg/L, which is ½ of the *Daphnia magna* LC_{50} of 0.530 µg/L.

The OPP fish acute benchmark is 0.36 µg/L, which is ½ of the *Oncorhynchus mykiss* LC_{50} of 0.72 µg/L.

GLI Tier II Acute Value Calculation

The acceptable acute dataset for pyridaben fulfills three OW MDRs, corresponding to the use of a SAF of 8. Applying the SAF to the lowest, most sensitive GMAV (i.e., 0.530 µg/L for water flea (*Daphnia magna*), the calculated SAV is 0.066 µg/L. The SMC, which is calculated as half the SAV, is 0.033 µg/L.

Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{0.530}{8} = 0.066\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{0.066}{2} = 0.033\ \mu g/L$$

Genus-Level Invertebrate-only Acute HC_{05}

No genus-level invertebrate acute HC_{05} could be calculated using the USEPA (1985) methodology because there was only one invertebrate genus (Table 2).

Table 2. Pyridaben invertebrate SMAV and GMAV (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank
Daphnia	*magna*	0.7353	0.7353	1

Table 3. Summary and comparison of acute values for pyridaben.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (lowest LC_{50}/2) (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Genus-level Invertebrate-only ALC (FAV/2)
Pyridaben (Nicotinamide Inhibitor)	0.265 µg/L (2023; *Daphnia magna*)	0.033 µg/L (3 MDRs filled, 8X)	NA (1 genus)

Figure 1 shows a genus-level sensitivity distribution for the pyridaben dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values and GLI Tier II calculated acute value are included.

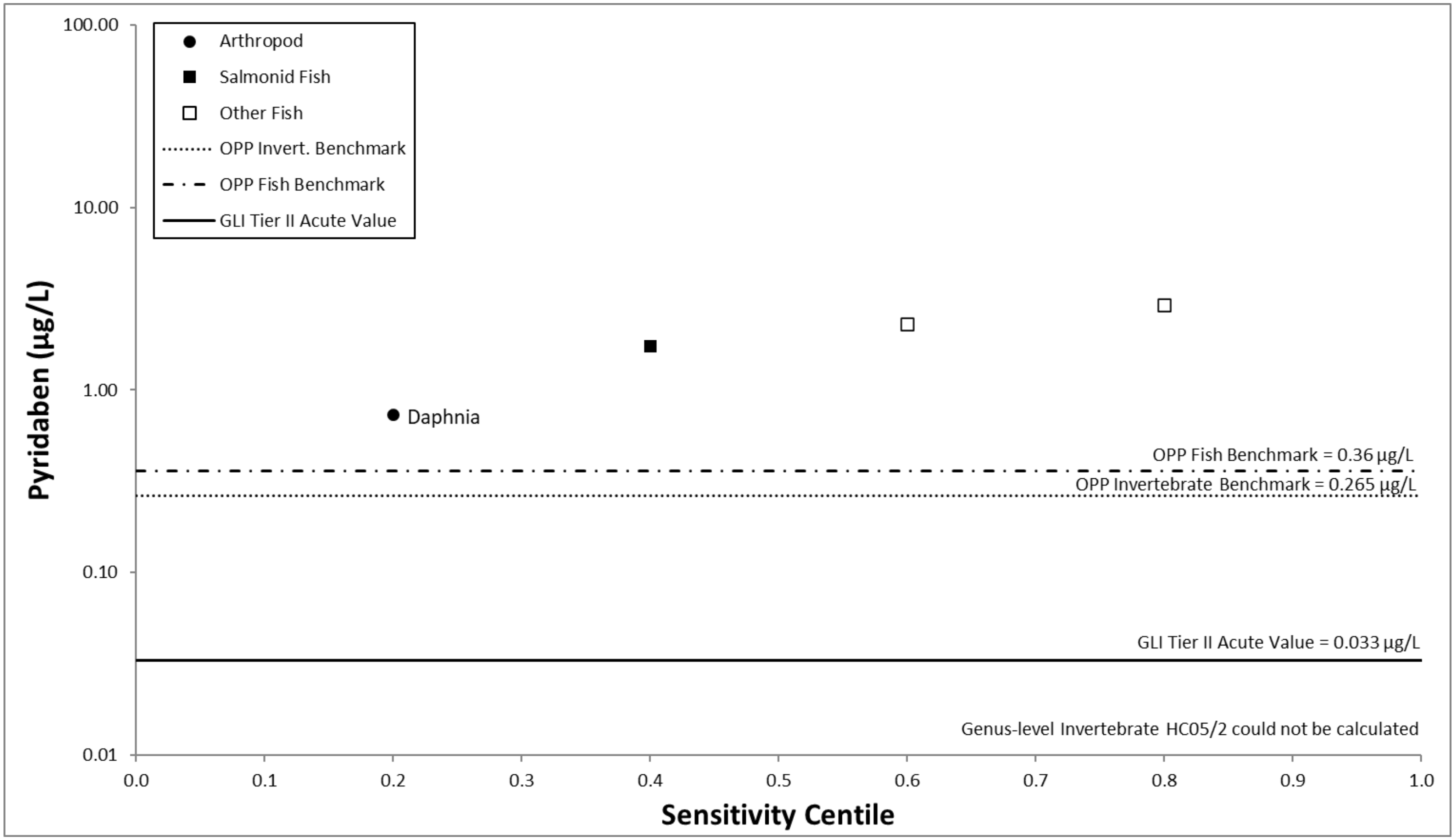

Figure 1. Pyridaben genus-level acute SD.

Symbols represent GMAVs calculated using all available data from EPA's 2015 literature search supplemented the OPP registration review document for pyridaben (U.S. EPA 2010).

1.3.8.2 Pyridaben Chronic Toxicity Data

Chronic pyridaben toxicity data were gathered by the OW in 2015 and supplemented with additional values from the OPP document on which the benchmark values are based (U.S. EPA 2010). The final chronic pyridaben dataset consisted of two NOECs/LOECS for two species across two genera, of which one was an invertebrate and one was a vertebrate (Table 4).

Table 4. Chronic toxicity data of pyridaben to freshwater aquatic organisms.

OW MDR Group[a]	Genus	Species	NOEC (µg/L)	LOEC (µg/L)	Endpoint	Reference	Comment
D	Daphnia	magna	0.044	0.086	Delayed time to reproduction	MRID 43680408; Drottar and Swigert 1994	Quantitative
B	Pimephales	promelas	0.277	0.555	Growth of F0 and F1 generation and F1 survival	MRID 43792106; Rhodes et al. 1995	Acceptable

a MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP invertebrate chronic benchmark is 0.044 µg/L, which is the NOEC for *Daphnia magna*.

The OPP fish chronic benchmark is 0.087 µg/L, which is the estimated NOEC for *Oncorhynchus mykiss*. The *O. mykiss* NOEC was estimated using *P. promelas* data. Acute and chronic toxicity data are available for *P. promelas* exposed to pyridaben (96-h LC50 = 2.3 µg/L; NOAEC = 0.277 µg/L; ACR = 8.3; MRID 43792106). Because the rainbow trout is more sensitive on an acute exposure basis, the ACR is used to derive a NOAEC for the rainbow trout (0.72 ÷ 8.3 = 0.0867 µg/L)

GLI Tier II Chronic Value Calculation

Paired quantitative chronic and acute toxicity data for pyridaben were available for water flea (*Daphnia magna*), allowing for the calculation of one ACR. The remaining two ACRs were fulfilled by the default value of 18. The acute and chronic tests were conducted in different laboratories using water of different physical characteristics; therefore, OPP's approach was used to calculate the ACR. OPP's approach involves the use of the NOAEC in the calculations. The calculated SCV for pyridaben is 0.004 µg/L.

Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{12.05 * 18 * 18} = 15.74$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{0.066}{15.74} = 0.004\ \mu g/L$$

Table 5. Summary and comparison of chronic values for pyridaben.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Invertebrate ALB (NOAEC) (Year published, species)	OW Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Invertebrate-only ALC (FCV) (# of ACRs filled, magnitude relative to ALB)	Notes
Pyridaben	0.044 µg/L (2023, *Daphnia magna*)	0.004 µg/L (GLI Tier II; 1 ACR, 11X)	NA	Two default ACRs of 18 used to derive GLI Tier II value.

1.3.8.3 Pyridaben References

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2 HERBICIDES

2.1 DATA-RICH HERBICIDES

2.1.1 Comparison of Aquatic Life Toxicity Values for Atrazine: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) were obtained from the Office of Pesticide Programs (OPP) registration review document for atrazine (U.S. EPA 2016) and an EPA ECOTOX Knowledgebase search conducted in 2021. No chronic comparative analysis was conducted for atrazine.

2.1.1.1 Atrazine Acute Toxicity Data

Acute data for atrazine are shown in Table 1. Ranked invertebrate GMAVs from all data sources are listed in Table 2.

Table 1. Acute toxicity data of atrazine to freshwater aquatic organisms.
(MDR specifies OW minimum data requirements under the Guidelines.)

OW MDR[a]	Species	LC50	SMAV	GMAV	Source	MRID / ECOTOX REF
F	*Acroneuria sp.*	6700	6700	6700	ECOTOX	17138
B	*Ameiurus melas*	35000	35000	35000	ECOTOX	7199
Plant	*Anabaena cylindrica*	3600	2078	585.0	ECOTOX	11659
		1200			ECOTOX	11659
Plant	*Anabaena flos-aquae*	230	230		OPP / ECOTOX	41065203a/ 344 / 103781
Plant	*Anabaena inaequalis*	100	54.77		ECOTOX	11659
		30			ECOTOX	11659
Plant	*Anabaena variabilis*	4000	4472		ECOTOX	11659
		5000			ECOTOX	11659
Plant	*Ankistrodesmus braunii*	60	60	60	ECOTOX	11424
H	*Arrenurus sp.*	<20	<20	<20	ECOTOX	153867
Plant	*Azolla caroliniana*	>100000	>100000	>100000	ECOTOX	176903
C	*Bufo americanus*	>48,000	>48000	>48000	ECOTOX	19124
B	*Carassius auratus*	60000	58181	>58181	OPP / ECOTOX	230303/ 80976
		56000			ECOTOX	80976
		58615			ECOTOX	80976
B	*Carassius carassius*	>100000	>100000		ECOTOX	7199
Plant	*Ceratophyllum sp.*			22	ECOTOX	152770
Plant	Ceratophyllum demersum	22	22		ECOTOX	19461
					ECOTOX	112909
D	*Ceriodaphnia dubia*	>30000	>30000	>30000	ECOTOX	3590
F	*Chironomus tentans*	720	>4900	>25	OPP	24377

OW MDR[a]	Species	LC50	SMAV	GMAV	Source	MRID / ECOTOX REF
		>28000			ECOTOX	156062
F	*Chironomus tepperi*	25	25		ECOTOX	153818
Plant	*Chlorella pyrenoidosa*	300	547.7	547.7	ECOTOX	11659
		1000			ECOTOX	11659
B	*Coregonus fera*	11200	17163	17163	ECOTOX	7792
		26300			ECOTOX	7792
B	*Cyprinus carpio*	2142	6346	6346	ECOTOX	170959
		18800			ECOTOX	6681
B	*Danio rerio*	6090	22048	22048	ECOTOX	174503
		15630			ECOTOX	174503
		34190			ECOTOX	174503
		29060			ECOTOX	170833
		39510			ECOTOX	170833
		30740			ECOTOX	170833
D	*Daphnia carinata*	22400	28367	25262	ECOTOX	74233
		23100			ECOTOX	74233
		24600			ECOTOX	74233
		25300			ECOTOX	74233
		26700			ECOTOX	74233
		60600			ECOTOX	160885
D	*Daphnia magna*	9400	22497		ECOTOX	50679
		72000			ECOTOX	89626
		16823			ECOTOX	170827
E	*Diporeia sp.*	>3000	>3000	>3000	ECOTOX	118745
E	*Echinogammarus tibaldii*	3300	3300	3300	ECOTOX	18621
Plant	*Elodea canadensis*	4.6	75.88	75.88	OPP	McGregor et al 2008
		79			ECOTOX	160884
		116			ECOTOX	160884
		305			ECOTOX	160884
		80			ECOTOX	9159
		75			ECOTOX	4634
		187.8			ECOTOX	154073
G	*Elliptio complanata*	>30000	>30000	>30000	ECOTOX	100597
E	*Gammarus italicus*	10100	10100	14168	ECOTOX	18621
E	*Gammarus kischineffensis*	18900	18900		ECOTOX	183521
E	*Gammarus pulex*	14900	14900		ECOTOX	5023
E	*Hyalella azteca*	1500	6594	6594	ECOTOX	118745
		13000			ECOTOX	89626
		14700			ECOTOX	17138
B	*Ictalurus punctatus*	220	220	220	ECOTOX	19124

OW MDR[a]	Species	LC50	SMAV	GMAV	Source	MRID / ECOTOX REF
G	*Lampsilis fasciola*	>30000	>30000	>30000	ECOTOX	100597
		>30000			ECOTOX	100597
G	*Lampsilis siliquoidea*	>30000	>30000		ECOTOX	99469
		>30000			ECOTOX	99469
		>30000			ECOTOX	100597
		>30000			ECOTOX	100597
Plant	*Lemna gibba*	43	49.51	74.63	OPP	43074803
		57			OPP	46150901
Plant	*Lemna minor*	5270	112.5		ECOTOX	176903
		60			ECOTOX	13695
		149.8			ECOTOX	174524
		188.8			ECOTOX	160947
		93.2			ECOTOX	174501
		114			ECOTOX	170972
B	*Lepomis macrochirus*	24000	36170	36170	OPP / ECOTOX	24717 / 80976
		54510			ECOTOX	344
C	*Lithobates boylii*	5517	5517	5517	ECOTOX	118706
C	*Lithobates catesbeiana*	410	>2561		ECOTOX	19124
		>16000			ECOTOX	89626
G	*Lumbriculus variegatus*	>37100	>37100	>37100	ECOTOX	17138
D	*Mesocyclops longisetus*	1085	1277	1277	ECOTOX	164050
		1503			ECOTOX	164050
Plant	*Myriophyllum aquaticum*	142.2	194.3	768.9	ECOTOX	164771
		154.5			ECOTOX	164771
		458.8			ECOTOX	164771
		93.5			ECOTOX	160947
		294			ECOTOX	170972
Plant	*Myriophyllum sibiricum*	2119	2119		ECOTOX	74985
Plant	*Myriophyllum spicatum*	1104	1104		ECOTOX	9159
Plant	*Najas sp.*	24	24	24	ECOTOX	19461
Plant	*Navicula pelliculosa*	60	60	60	OPP / ECOTOX	41065203b / 344 / 103781
A	*Oncorhynchus mykiss*	5300	5478	10769	OPP / ECOTOX	24716 / 344
		4500			OPP / ECOTOX	24716 pr 23-3-3 / 80976
		870			ECOTOX	19124
		13000			ECOTOX	89626
		6031			ECOTOX	80976
		5350			ECOTOX	80976
		17000			ECOTOX	7199

OW MDR[a]	Species	LC50	SMAV	GMAV	Source	MRID / ECOTOX REF
A	*Oncorhynchus kisutch*	12000	12000		ECOTOX	89626
A	*Oncorhynchus tshawytscha*	19000	19000		ECOTOX	89626
Plant	*Oscillatoria lutea*	<1	< 1	< 1	OPP	23544
E	*Pacifastacus leniusculus*	77900	77900	77900	ECOTOX	167249
B	*Perca sp.*	50000	50000	50000	ECOTOX	7199
G	*Physella virgata*	>34100	>34100	>34100	ECOTOX	17138
C	*Physalaemus cuvieri*	19690	19690	19690	ECOTOX	179653
B	*Pimephales promelas*	20000	20000	20000	OPP / ECOTOX	42547103 / 78794
Plant	*Potamogeton perfoliatus*	53	53	53	ECOTOX	4634
Plant	*Pseudanabaena galeata*	14	14	14	ECOTOX	6712
C	*Pseudacris regilla*	1686	1686	1686	ECOTOX	118706
D	*Pseudosida ramosa*	13500	17565	17565	ECOTOX	153837
		16900			ECOTOX	153837
		17400			ECOTOX	153837
		16400			ECOTOX	153837
		16900			ECOTOX	153837
		20900			ECOTOX	153837
		16400			ECOTOX	153837
		16400			ECOTOX	153837
		21600			ECOTOX	153837
		26000			ECOTOX	153837
		19900			ECOTOX	153837
		18700			ECOTOX	153837
		13400			ECOTOX	153837
		12300			ECOTOX	153837
		15200			ECOTOX	153837
		23500			ECOTOX	153837
		16900			ECOTOX	153837
		19700			ECOTOX	153837
Plant	*Raphidocelis subcapitata*	49	126.3	126.3	OPP	43074802
		120			ECOTOX	344
		53			ECOTOX	344
		58.7			ECOTOX	11780
		410			ECOTOX	11780
		200			ECOTOX	16010
		50			ECOTOX	17639
		235			ECOTOX	18093
		128.2			ECOTOX	18933
		159			ECOTOX	19285
		300			ECOTOX	19285

OW MDR[a]	Species	LC50	SMAV	GMAV	Source	MRID / ECOTOX REF
		110			ECOTOX	56747
		118			ECOTOX	62246
		220			ECOTOX	69584
		200			ECOTOX	69584
		200			ECOTOX	69584
		55			ECOTOX	69630
		115			ECOTOX	72626
		76.4			ECOTOX	82748
		89.9			ECOTOX	82748
		86.1			ECOTOX	82748
		63.4			ECOTOX	82748
		94.9			ECOTOX	82748
		81.4			ECOTOX	102060
		1,600			ECOTOX	118745
		277			ECOTOX	152770
		138			ECOTOX	152770
		103			ECOTOX	152770
		107			ECOTOX	152770
		65			ECOTOX	152770
		126			ECOTOX	152770
		196			ECOTOX	165277
		87.6			ECOTOX	174384
		130			ECOTOX	69631
B	*Rhamdia quelen*	10200	10200	10200	ECOTOX	111938
C	*Rhinella arenarum*	27160	27160	27160	ECOTOX	112588
B	*Rutilus kutum*	24950	26880	26880	ECOTOX	171062
		28960			ECOTOX	171062
Plant	*Scenedesmus abundans*	110	110	210.3	ECOTOX	11677
Plant	*Scenedesmus acutus var. acutus*	597.5	597.5		ECOTOX	164777
Plant	*Scenedesmus quadricauda*	100	141.4		ECOTOX	11659
		200			ECOTOX	11659
Plant	*Vallisneria americana*	163	163.0	163	ECOTOX	4634
G	*Villosa constricta*	>30000	>30000	>30000	ECOTOX	100597
G	*Villosa delumbis*	>30000	30000		ECOTOX	100597
C	*Xenopus tropicalis*	9620	9620	9620	ECOTOX	178499

a OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes

B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)

C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)

D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)

E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP non-vascular plant benchmark value for atrazine is <1 µg/L, which is the LC_{50} for *O. lutea*. The OPP vascular plant benchmark is 4.6 µg/L, which is the LC_{50} for *E. canadensis*.

The OPP invertebrate acute benchmark value for atrazine is 360 µg/L, which is ½ the LC_{50} for *C. tentans*.

The OPP fish acute benchmark value is 2,650 µg/L, which is ½ the LC_{50} for *O. mykiss*.

OW Acute Criterion

There is no acute criterion, criterion maximum concentration (CMC), for atrazine. An illustrative example was developed for this analysis, using all available data (Table 2). The FAV calculated following the U.S. EPA (1985) methodology for the 51 genera in the atrazine dataset was 11.47 µg/L (Table 3).

Table 2. Atrazine SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	Rank	Percentile	OW MDR Group
*Azolla**	*caroliniana*	>100,000	100,000	51	0.981	Plant
Pacifastacus	*leniusculus*	77,900	77,900	50	0.962	E
*Carassius**	*auratus*	58,181	76,277	49	0.942	B
Perca	*sp.*	50,000	50,000	48	0.923	B
*Bufo**	*americanus*	>48,000	48,000	47	0.904	C
*Lumbriculus**	*variegatus*	>37,100	37,100	46	0.885	G
Lepomis	*macrochirus*	36,170	36,170	45	0.865	B
Ameiurus	*melas*	35,000	35,000	44	0.846	B
*Physella**	*virgata*	>34,100	34,100	43	0.827	G
*Elliptio**	*complanata*	>30,000	30,000	42	0.808	G
*Lampsilis**	*fasciola*	>30,000	30,000	41	0.788	G
*Villosa**	*constricta*	>30,000	30,000	40	0.769	G
*Ceriodaphnia**	*dubia*	>30,000	30,000	39	0.750	D
Rhinella	*arenarum*	27,160	27,160	38	0.731	C
Rutilus	*kutum*	26,880	26,880	37	0.712	B
Daphnia	*carinata*	28,367	25,262	36	0.692	D
Danio	*rerio*	22,048	22,048	35	0.673	B
Pimephales	*promelas*	20,000	20,000	34	0.654	B
Physalaemus	*cuvieri*	19,690	19,690	33	0.635	C

Genus	Species	SMAV	GMAV	Rank	Percentile	OW MDR Group
Pseudosida	*ramosa*	17,565	17,565	32	0.615	D
Coregonus	*fera*	17,163	17,163	31	0.596	B
Gammarus	*italicus*	10,100	14,168	30	0.577	E
Oncorhynchus	*kisutch*	12,000	10,769	29	0.558	A
Rhamdia	*quelen*	10,200	10,200	28	0.538	B
Xenopus	*tropicalis*	9,620	9,620	27	0.519	C
Acroneuria	*sp.*	6,700	6,700	26	0.500	F
Hyalella	*azteca*	6,594	6,594	25	0.481	E
Cyprinus	*carpio*	6,346	6,346	24	0.462	B
*Lithobates**	*boylii*	5,517	3,759	23	0.442	C
Echinogammarus	*tibaldii*	3,300	3,300	22	0.423	E
*Diporeia**	*sp.*	>3,000	3,000	21	0.404	E
Pseudacris	*regilla*	1,686	1,686	20	0.385	C
Mesocyclops	*longisetus*	1,277	1,277	19	0.365	D
Myriophyllum	*aquaticum*	194.3	768.9	18	0.346	Plant
Anabaena	*cylindrica*	2,078	585.0	17	0.327	Plant
Chlorella	*pyrenoidosa*	547.7	547.7	16	0.308	Plant
*Chironomus**	*tentans*	>4,490	335	15	0.288	F
Ictalurus	*punctatus*	220	220	14	0.269	B
Scenedesmus	*abundans*	110	210.3	13	0.250	Plant
Vallisneria	*americana*	163.0	163.0	12	0.231	Plant
Raphidocelis	*subcapitata*	126.3	126.3	11	0.212	Plant
Elodea	*canadensis*	75.88	75.88	10	0.192	Plant
Lemna	*gibba*	49.51	74.63	9	0.173	Plant
Navicula	*pelliculosa*	60	60	8	0.154	Plant
Ankistrodesmus	*braunii*	60	60	7	0.135	Plant
Potamogeton	*perfoliatus*	53	53	6	0.115	Plant
Najas	*sp.*	24	24	5	0.096	Plant
Ceratophyllum	*demersum*	22	22	4	0.077	Plant
*Arrenurus**	*sp.*	<20	20	3	0.058	H
Pseudanabaena	*galeata*	14	14	2	0.038	Plant
*Oscillatoria**	*lutea*	<1	1	1	0.019	Plant

*****_(non-definitive value, less than value)_

a OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)

F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

Table 3. Genus-level acute HC_{05} for atrazine calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
51	4	22	3.091	9.55	0.0769	0.2774
	3	20	2.996	8.97	0.0577	0.2402
	2	14	2.639	6.96	0.0385	0.1961
	1	1	0.000	0.00	0.0192	0.1387
	Sum:		8.73	25.5	0.192	0.852
	S^2 =	604.19				
	L =	-3.056				
	A =	2.440				
	FAV =	**11.47**				
	CMC =	**5.7**				

Table 4. Summary and comparison of acute values for atrazine.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	Most Sensitive OPP ALB (Year published, species)	OW Illustrative ALC example (# of MDRs filled, magnitude relative to ALB)	OW Modified HC_{05} (# of MDRs filled, # of genera available, magnitude relative to ALB)
Atrazine[1]	< 1 µg/L (2016; *Oscillatoria lutea;* nonvascular plant)	5.7 µg/L (illustrative ALC example calculated for this analysis; 8 MDRs filled, 0.18X)	NA

[1]No 304(a) ALC recommendation available but has sufficient data to develop an illustrative ALC example for the purposes of these analyses only.

Figure 1 shows a genus-level sensitivity distribution for the atrazine dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values and the illustrative OW ALC example.

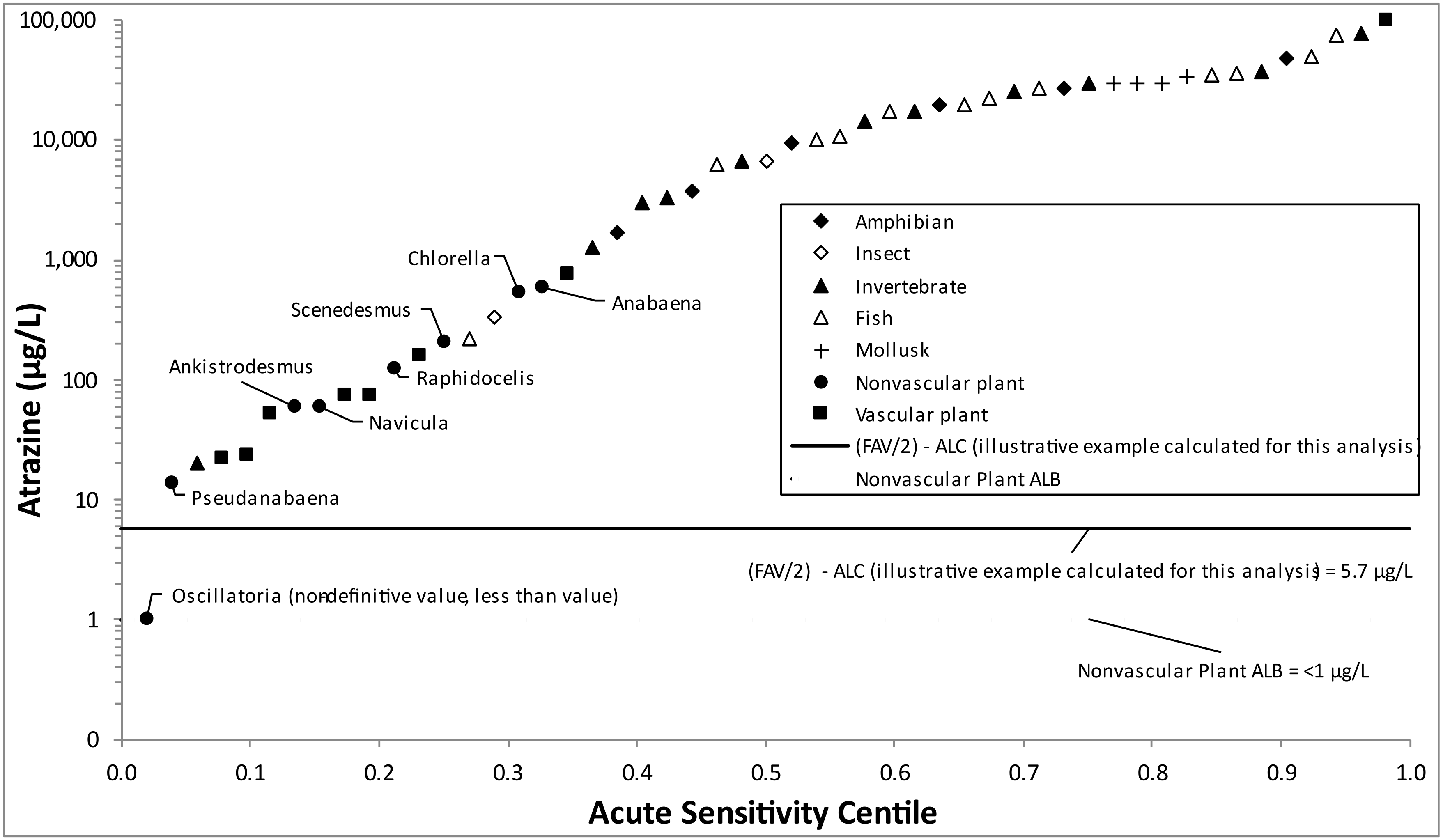

Figure 1. Atrazine genus-level acute SD.
Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from an Office of Water ECOTOX search in 2021 and the Office of Pesticide Programs (OPP) registration review document for atrazine (U.S. EPA 2016).

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2.1.2 Comparison of Aquatic Life Toxicity Values for Propazine: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) were obtained from the Office of Pesticide Programs (OPP) registration review document for propazine (U.S. EPA 2016) and an EPA ECOTOX Knowledgebase search conducted in 2021.

2.1.2.1 Propazine Acute Toxicity Data

Acute data for propazine are shown in Table 1. Ranked invertebrate GMAVs from all data sources are listed in Table 2.

Table 1. Acute toxicity data of propazine to freshwater aquatic organisms.
(MDR specifies OW minimum data requirements under the Guidelines.)

OW MDR[a]	Species	LC50	SMAV	GMAV	Source	MRID/ECOTOX REF
Plant	Blue Green Algae *(Anabaena flos-aquae)*	160	160	160	OPP / ECOTOX	44287312 / 344
Plant	Duckweed *(Lemna gibba)*	100	100	100	OPP/ ECOTOX	44287309 / 344
B	Bluegill Sunfish *(Lepomis macrochirus)*	>4380	>4440	>4440	OPP	48036203
		>4500			OPP / ECOTOX	178499
Plant	Freshwater Diatom *(Navicula pelliculosa)*	24.8	24.8	24.8	OPP/ ECOTOX	44287310 / 344
A	Rainbow Trout *(Oncorhynchus mykiss)*	5000	9083	9083	OPP	47452301
		16500			OPP	34123
Plant	Green Algae *(Raphidocelis subcapitata)*	29	29	29	OPP / ECOTOX	44287308 / 344
C	Western Clawed Frog *(Xenopus tropicalis)*	>5200	>5200	>5200	ECOTOX	178499

[a] OW MDR Groups – Freshwater:
- A. the family Salmonidae in the class Osteichthyes
- B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
- C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
- D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
- E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
- F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
- G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
- H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP non-vascular plant benchmark value for propazine is 24.8 µg/L, which is the LC_{50} for *N. pelliculosa*. The OPP vascular plant benchmark value is 100 µg/L, which is the LC_{50} for *L. gibba*.

The OPP invertebrate acute benchmark value is >2,660 µg/L, which is ½ the LC_{50} for *D. magna*.

The OPP fish acute benchmark value is >2,190 µg/L, which is ½ the LC_{50} for *L. macrochirus*.

GLI Tier II Acute Value Calculation

The acceptable acute dataset for propazine fulfills three of the eight MDRs, corresponding to the use of a Secondary Acute Factor (SAF) of 8. Applying the SAF to the lowest, most sensitive GMAV regardless of taxa (i.e., 28.4 µg/L for the freshwater diatom (*Navicula pelliculosa*)), the calculated Secondary Acute Value (SAV) is 3.1 µg/L. The Secondary Maximum Criterion (SMC), which is calculated as half the SAV, is 1.55 µg/L. Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{28.4}{8} = 3.1\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{3.55}{2} = 1.55\ \mu g/L$$

Modified Acute HC_{05}

The genus-level modified acute HC_{05} calculated following the U.S. EPA (1985) methodology for the four most sensitive genera regardless of taxa (Table 2) in the propazine dataset was 8.468 µg/L (Table 3).

Table 2. Propazine SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank	MDR Group
Oncorhynchus	*mykiss*	9,083	9,083	3	A
Xenopus	*tropicalis*	>5,200	>5,200	2	C
Lepomis	*macrochirus*	>4,440	>4,440	1	B
Anabaena	*flos-aquae*	160	160	4	Plant
Lemna	*gibba*	100	100	3	Plant
Raphidocelis	*subcapitata*	29	29	2	Plant
Navicula	*pelliculosa*	24.8	24.8	1	Plant

Table 3. Modified acute HC_{05} for propazine calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	ln(GMAV)^2	P=R/(N+1)	sqrt(P)
7	4	160	5.075	25.76	0.5000	0.7071
	3	100	4.605	21.21	0.3750	0.6124
	2	29	3.367	11.34	0.2500	0.5000
	1	24.8	3.211	10.31	0.1250	0.3536
	Sum:		16.26	68.6	1.250	2.173
	S^2 =	36.39				
	L =	0.787				
	A =	2.136				
	FAV =	**8.468**				
	CMC =	**4.2**				

Table 4. Summary and comparison of acute values for propazine.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	Most Sensitive OPP ALB (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Modified HC_{05} (# of MDRs filled, # of genera available, magnitude relative to ALB)
Propazine	24.8 µg/L (2022; *Navicula pelliculosa;* nonvascular plant)	1.55 µg/L (GLI Tier II; 4 MDRs filled*, 16X)	4.2 µg/L (3 MDRs, 7 genera, 5.9X)

Figure 1 shows a genus-level sensitivity distribution for the propazine dataset. Major taxonomic groups are delineated by different symbols. Lines denoting the OPP acute benchmark values, GLI Tier II calculated acute value, and modified HC_{05} value are included.

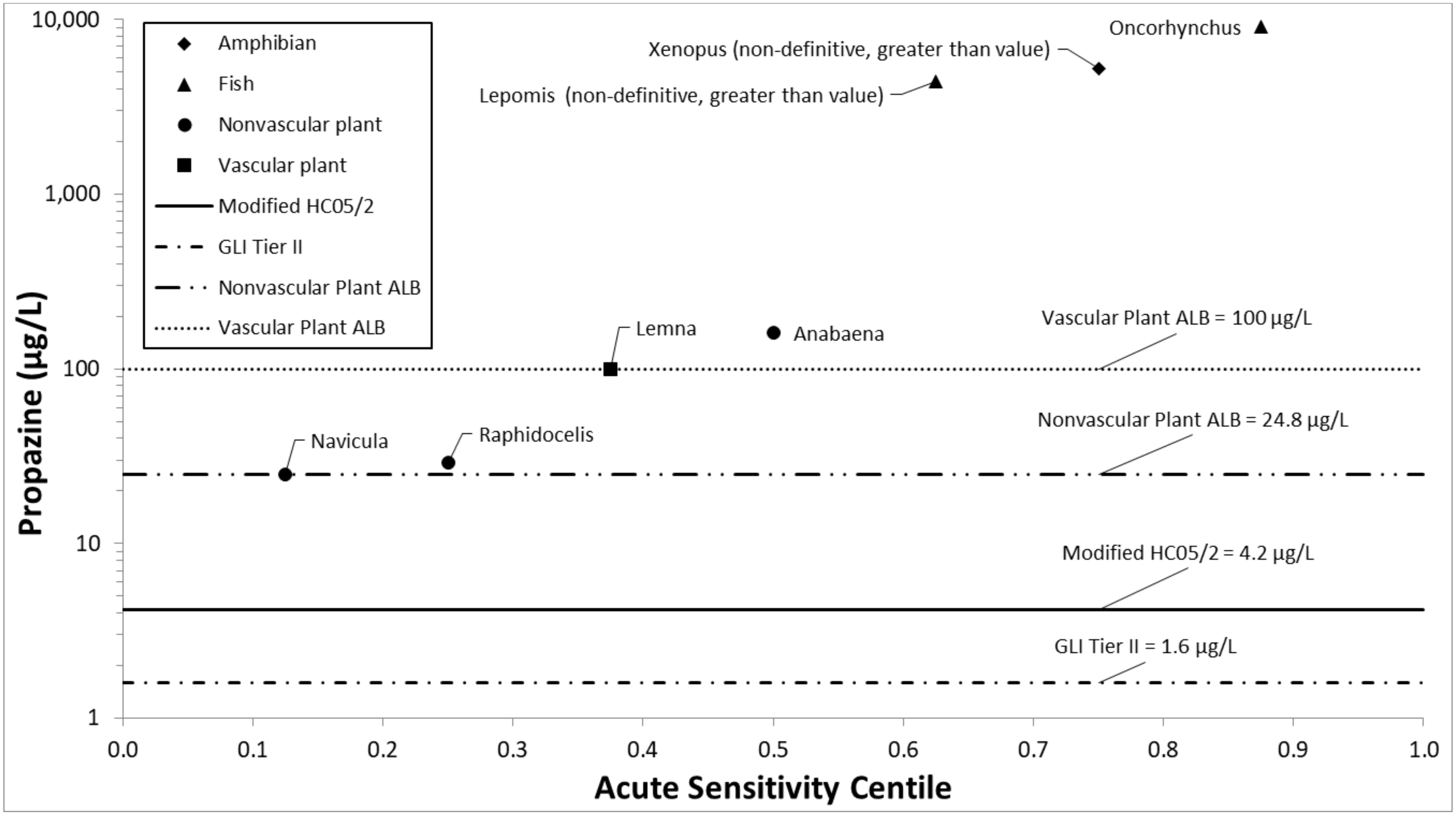

Figure 1. Propazine genus-level acute SD.

Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from an Office of Water ECOTOX search in 2021 and the Office of Pesticide Programs (OPP) registration review document for propazine (U.S. EPA 2016).

2.1.2.2 Propazine Chronic Toxicity Data

Data Sources and Considerations

Chronic toxicity data for propazine were consolidated by OW and combined with data from OPP's registration review document for acephate (U.S. EPA 2016). The final chronic propazine dataset consisted of NOECs/LOEC for seven species (Table 5).

Table 5. Chronic toxicity data of propazine to freshwater aquatic organisms.
(MDR specifies OW minimum data requirements under the Guidelines.)

OW MDR	Species	NOEC	LOEC	SMCV	GMCV	Source	MRID/ECOTOX REF
Plant	*Blue Green Algae (Anabaena flos-aquae)*	68		68	68	OPP / ECOTOX	44287312 / 344
D	*Water Flea (Daphnia magna)*	47	91	65.40	65.40	OPP/ ECOTOX	44327602 / 344
			370			ECOTOX	344
Plant	*Duckweed (Lemna gibba)*	22		22	22	OPP/ ECOTOX	44287309 / 344
Plant	*Freshwater Diatom (Navicula pelliculosa)*	6.5		6.5	6.5	OPP/ ECOTOX	44287310 / 344
B	*Fathead minnow (Pimephales promelas)*	560	1230	829.9	829.9	OPP	48036205
Plant	*Green Algae (Raphidocelis subcapitata)*	12		12	12	OPP / ECOTOX	44287308 / 344
C	*Western Clawed Frog (Xenopus tropicalis)*	101.7	1036.5	324.7	324.7	ECOTOX	178499

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP nonvascular plant benchmark value for propazine is 6.5 µg/L, which is the NOEC for *N. pelliculosa*. The OPP vascular plant benchmark value is 22 µg/L, which is the NOEC for *L. gibba*.

The OPP invertebrate chronic benchmark value is 47 µg/L, which is the NOEC for *Daphnia magna*.

The OPP fish chronic benchmark value is 560 µg/L, which is the NOEC for *Pimephales promelas*.

GLI Tier II Chronic Value Calculation

Paired quantitative acute and chronic toxicity data were available for the frog *Xenopus tropicalis* allowing for the calculation of one ACR. Per the GLI Tier II methodology, the default value of 18 was used to fulfill the remaining two ACRs. The resulting X. tropicalis ACR is 16.01, and the final SACR is 17.31. Dividing the SAV of 3.100 µg/L by the SACR of 17.31 results in a Secondary Continuous Value of 0.1791 µg/L, and a Secondary Continuous Concentration of 0.18 µg/L.

Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{16.01 * 18 * 18} = 17.13$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{3.100}{17.13} = 0.18\ \mu g/L$$

Modified Chronic HC_{05}

The genus-level modified chronic HC05 calculated following the U.S. EPA (1985) methodology for the four most sensitive genera regardless of taxa (Table 6) in the propazine dataset was 2.3 µg/L (Table 7).

Table 6. Propazine SMCVs and GMCVs (µg/L).

Genus	Species	SMCV	GMCV	GMCV Rank	OW MDR Group
Pimephales	*promelas*	829.9	829.9	7	B
Xenopus	*tropicalis*	324.7	324.7	6	C
Anabaena	*flos-aquae*	68	68	5	Plant
Daphnia	*magna*	65.40	65.40	4	D
Lemna	*gibba*	22	22	3	Plant
Raphidocelis	*subcapitata*	12	12	2	Plant
Navicula	*pelliculosa*	6.5	6.5	1	Plant

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes

B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)

C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

Table 7. Modified chronic HC_{05} for propazine calculated following the U.S. EPA (1985) methodology.

N	Rank	GMCV	ln(GMCV)	$\ln(GMCV)^2$	P=R/(N+1)	sqrt(P)
7	4	65.40	4.181	17.48	0.5000	0.7071
	3	22	3.091	9.55	0.3750	0.6124
	2	12	2.485	6.17	0.2500	0.5000
	1	6.5	1.872	3.50	0.1250	0.3536
	Sum:		11.63	36.7	1.250	2.173
	S^2 =	41.82				
	L =	-0.606				
	A =	0.840				
	FCV =	**2.316**				
	CCC=	**2.3**				

Table 8. Summary and comparison of chronic values for propazine.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison.

Pesticide	Most Sensitive OPP ALB (Year published and species)	OW GLI Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Modified HC_{05} (# of MDRs filled, # of genera available, magnitude relative to ALB)
Propazine	6.5 µg/L (2022; *Navicula pelliculosa;* nonvascular plant)	0.18 µg/L (GLI Tier II; 1 ACR filled, 36X)	2.3 µg/L (3 MDRs, 7 genera, 2.8X)

Figure 2 shows a chronic genus-level sensitivity distribution for the propazine dataset. Major taxonomic groups are delineated by different symbols. Lines denoting the OPP chronic benchmark values, GLI Tier II calculated chronic value, and modified HC_{05} value are included.

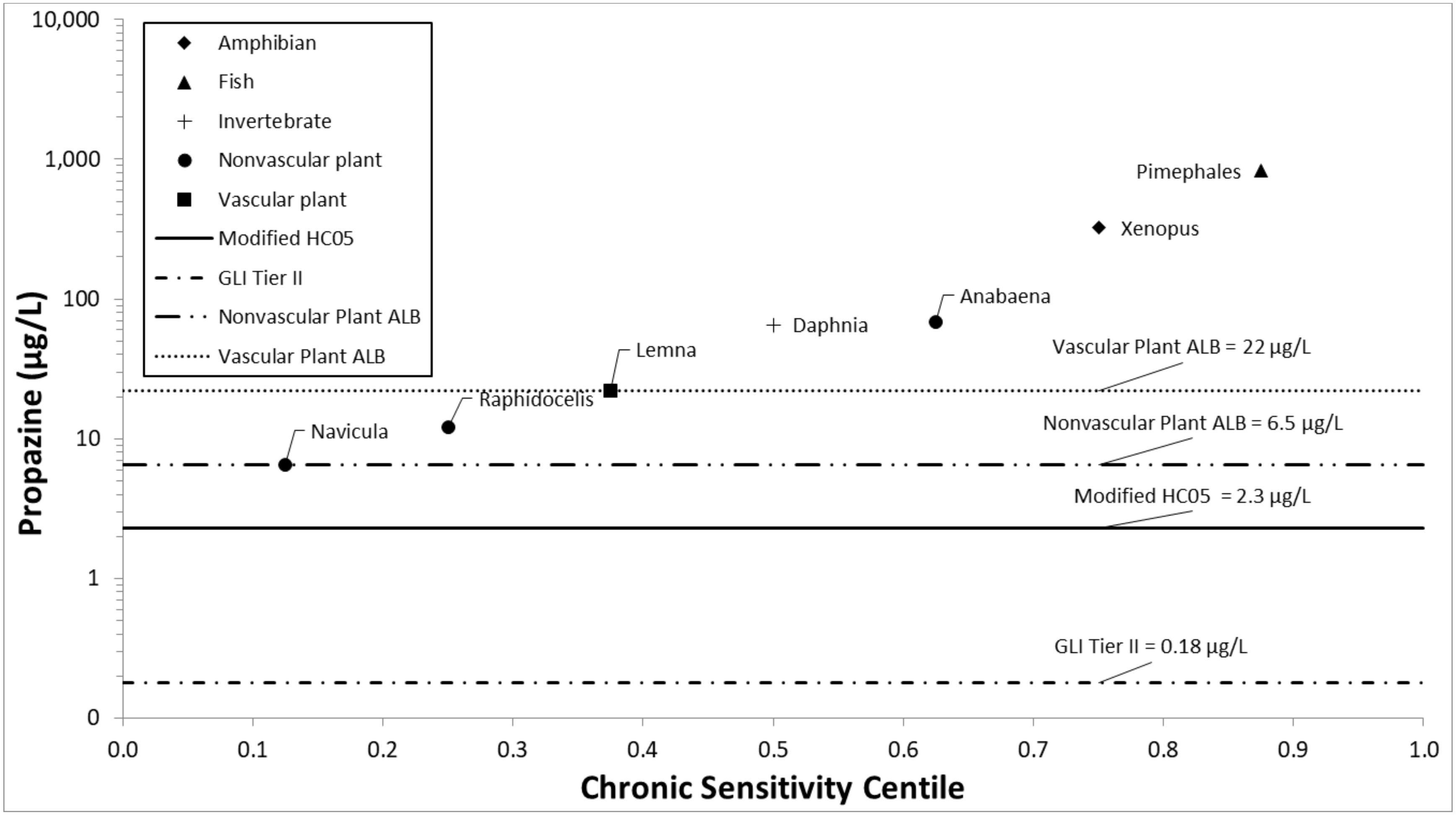

Figure 2. Propazine genus-level chronic SD.

Symbols represent Genus Mean Chronic Values (GMCVs) calculated using all available data from an Office of Water ECOTOX search in 2021 and the Office of Pesticide Programs (OPP) registration review document for propazine (U.S. EPA 2016).

2.1.2.3 Propazine References

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2.1.3 Comparison of Aquatic Life Toxicity Values for Simazine: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) were obtained from the Office of Pesticide Programs (OPP) registration review document for simazine (U.S. EPA 2016) and an EPA ECOTOX Knowledgebase search conducted in 2021.

2.1.3.1 Simazine Acute Toxicity Data

Acute data for simazine are shown in Table 1. Ranked invertebrate GMAVs from all data sources are listed in Table 2.

Table 1. Acute toxicity data of simazine to freshwater aquatic organisms.
(MDR specifies OW minimum data requirements under the Guidelines.)

OW MDR[a]	Species	LC50	SMAV	GMAV	Source	MRID / ECOTOX REF
Plant	Anabaena flos-aquae	36	36	36	ECOTOX	344
Plant	*Arthrospira platensis*	6	6	6	OPP	E17259
G	Branchiura sowerbyi	1,090,000	1,588,201	1,588,201	ECOTOX	70292
		1,700,000			ECOTOX	70292
		1,897,000			ECOTOX	70292
		1,810,000			ECOTOX	70292
B	*Carassius auratus*	>32,000	>32000	>32000	OPP/ ECOTOX	344
B	*Cirrhinus mrigala*	765,000	820,378	820,378	ECOTOX	70292
		1,050,000			ECOTOX	70292
		1,100,000			ECOTOX	70292
		895,000			ECOTOX	70292
		840,000			ECOTOX	70292
		608,000			ECOTOX	70292
		635,000			ECOTOX	70292
		800,000			ECOTOX	70292
E	*Cypridopsis vidua*	3700	3,700	3,700	OPP	4009801
D	*Daphnia magna*	1,000	>10192	>153213	OPP	45088221
		1,100			OPP	4009801
		>10,000			ECOTOX	6797
		>10,000			ECOTOX	6797
		>1,000,000			ECOTOX	89626
D	*Daphnia pulex*	424,000	153,213		ECOTOX	2897
		92,100			ECOTOX	2897
		92,100			ECOTOX	11881
E	*Gammarus fasciatus*	130,000	130,000	130,000	OPP / ECOTOX	4009801 / 6797
E	*Hyalella azteca*	270,000	270,000	270,000	ECOTOX	89626

OW MDR[a]	Species	LC50	SMAV	GMAV	Source	MRID / ECOTOX REF
Plant	*Lemna gibba*	140	140	152.4	OPP / ECOTOX	42503704 / 344
Plant	*Lemna minor*	166	166		ECOTOX	18093
B	*Lepomis macrochirus*	16,000	40,000	40,000	OPP / ECOTOX	25438 or 229607 / 344
		100,000			OPP / ECOTOX	4009801 / 6797
C	*Lithobates catesbeiana*	1,780,000	1,780,000	1,780,000	ECOTOX	89626
B	Morone saxatilis	250	>20,083	>20,083	ECOTOX	909
		>180,000			ECOTOX	5324
		>180,000			ECOTOX	5324
Plant	*Navicula pelliculosa*	90	90	90	OPP / ECOTOX	42503707 / 344
A	*Oncorhynchus kisutch*	330,000	330,000	>264441	ECOTOX	89626
A	*Oncorhynchus mykiss*	60,000	>61579		ECOTOX	344
		40,500			ECOTOX	344
		>10,000			ECOTOX	344
		>82,000			ECOTOX	344
		70,500			ECOTOX	344
		44,600			ECOTOX	344
		>100,000			ECOTOX	6797
		330,000			ECOTOX	89626
A	*Oncorhynchus tshawytscha*	910,000	910,000		ECOTOX	89626
E	*Pacifastacus leniusculus*	30,600	30,600	30,600	ECOTOX	167249
E	*Palaemonetes kadiakensis*	>5,600	>5600	>5600	OPP	4009801
B	*Pimephales promelas*	6,400	>31958	>31958	OPP / ECOTOX	33309 / 344
		>10,000			ECOTOX	6797
		510,000			ECOTOX	6797
F	*Pteronarcys californica*	1,900	1,900	1,900	OPP / ECOTOX	4009801 / 6797
Plant	*Raphidocelis subcapitata*	100	232.1	232.1	OPP / ECOTOX	42503706 / 344
		200			ECOTOX	16010
		100			ECOTOX	17639
		1,240			ECOTOX	18093
		100			ECOTOX	56747
		200			ECOTOX	69584
		220			ECOTOX	69584
		220			ECOTOX	69584
		748.5			ECOTOX	83543
		252			ECOTOX	165277
Plant	*Selenastrum sp.*	73.6	58.96	58.96	ECOTOX	84045

OW MDR[a]	Species	LC50	SMAV	GMAV	Source	MRID / ECOTOX REF
		57.3			ECOTOX	84045
		48.6			ECOTOX	84045
Plant	*Vallisneria americana*	67	67	67	OPP / ECOTOX	E164763 / 164763
G	*Viviparus bengalensis*	2,280,000	1,671,145	1,671,145	ECOTOX	70292
		1,676,000			ECOTOX	70292
		986,000			ECOTOX	70292
		2,070,000			ECOTOX	70292
C	*Xenopus tropicalis*	7,550	7,550	7,550	ECOTOX	178499

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP nonvascular plant benchmark value for simazine is 6 µg/L, which is the LC_{50} for *A. platensis*. The OPP vascular plant benchmark value is 67 µg/L, which is the LC_{50} for *V. americana*.

The OPP invertebrate acute benchmark value is 500 µg/L, which is ½ the LC_{50} for *D. magna*.

The OPP fish acute benchmark value is 3,200 µg/L, which is ½ the LC_{50} for *P. promelas*.

OW Acute Criterion

There is no criterion maximum concentration (CMC) for simazine. An illustrative example calculated was developed for this analysis, using all available data (Table 2). The Final Acute Value (FAV) calculated following the U.S. EPA (1985) methodology for the 22 genera in the simazine dataset was 10.36 µg/L (Table 3).

Table 2. Simazine SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank	OW MDR Group
Rana	*catesbeiana*	1,780,000	1,780,000	22	C
Viviparus	*bengalensis*	1,671,145	1,671,145	21	G/H
Branchiura	*sowerbyi*	1,588,201	1,588,201	20	G
Cirrhinus	*mrigala*	820,378	820,378	19	B
Hyalella	*azteca*	270,000	270,000	17	E

Genus	**Species**	**SMAV**	**GMAV**	**GMAV Rank**	**OW MDR Group**
Oncorhynchus	*kisutch*	330,000	>264,441	17	A
Oncorhynchus	*mykiss*	>61,597			A
Oncorhynchus	*tshawytscha*	910,000			A
Gammarus	*fasciatus*	130,000	130,000	16	E
Lepomis	*macrochirus*	40,000	40,000	15	B
Daphnia	*magna*	>10,192	>39,517	14	D
Daphnia	*pulex*	153,213			D
Carassius	*auratus*	>32,000	>32,000	13	B
Pimephales	*promelas*	>31,958	>31,958	12	B
Pacifastacus	*leniusculus*	30,600	30,600	11	E
Morone	*saxatilis*	20,083	20,083	10	B
Xenopus	*tropicalis*	7,550	7,550	9	C
Palaemonetes	*kadiakensis*	>5,600	>5,600	8	E
Cypridopsis	*vidua*	3,700	3,700	7	E
Pteronarcys	*spp*	1,900	1,900	6	F
Lemna	*gibba*	140	140	5	Plant
Raphidocelis	*subcapitata*	100	100	4	Plant
Navicula	*pelliculosa*	90	90	3	Plant
Vallisneria	*americana*	67	67	2	Plant
Arthrospira	*platensis*	6	6	1	Plant

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

Table 3. Genus-level acute HC_{05} for simazine calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
22	4	100	4.605	21.21	0.1739	0.4170
	3	90	4.500	20.25	0.1304	0.3612
	2	67	4.205	17.68	0.0870	0.2949
	1	6	1.792	3.21	0.0435	0.2085
	Sum:		15.10	62.3	0.435	1.282
	S^2 =	220.64				
	L =	-0.984				
	A =	2.338				
	FAV =	**10.36**				
	CMC =	**5.18**				

Table 4. Summary and comparison of acute values for simazine.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	Most Sensitive OPP ALB (Year published, species)	OW Illustrative ALC example (# of MDRs filled, magnitude relative to ALB)	OW Modified HC_{05} (# of MDRs filled, # of genera available, magnitude relative to ALB)
Simazine[1]	6 µg/L (2023; *Arthrospira platensis;* nonvascular plant)	5.2 µg/L (illustrative example calculated for this analysis; 8 MDRs filled, 1.2X)	NA

[1]No 304(a) ALC recommendation available but has sufficient data to develop an illustrative ALC example for the purposes of these analyses only.

Figure 1 shows a genus-level sensitivity distribution for the simazine dataset. Major taxonomic groups are delineated by different symbols, and invertebrate genera are identified by name. Lines denoting the OPP acute benchmark values and the illustrative OW ALC example.

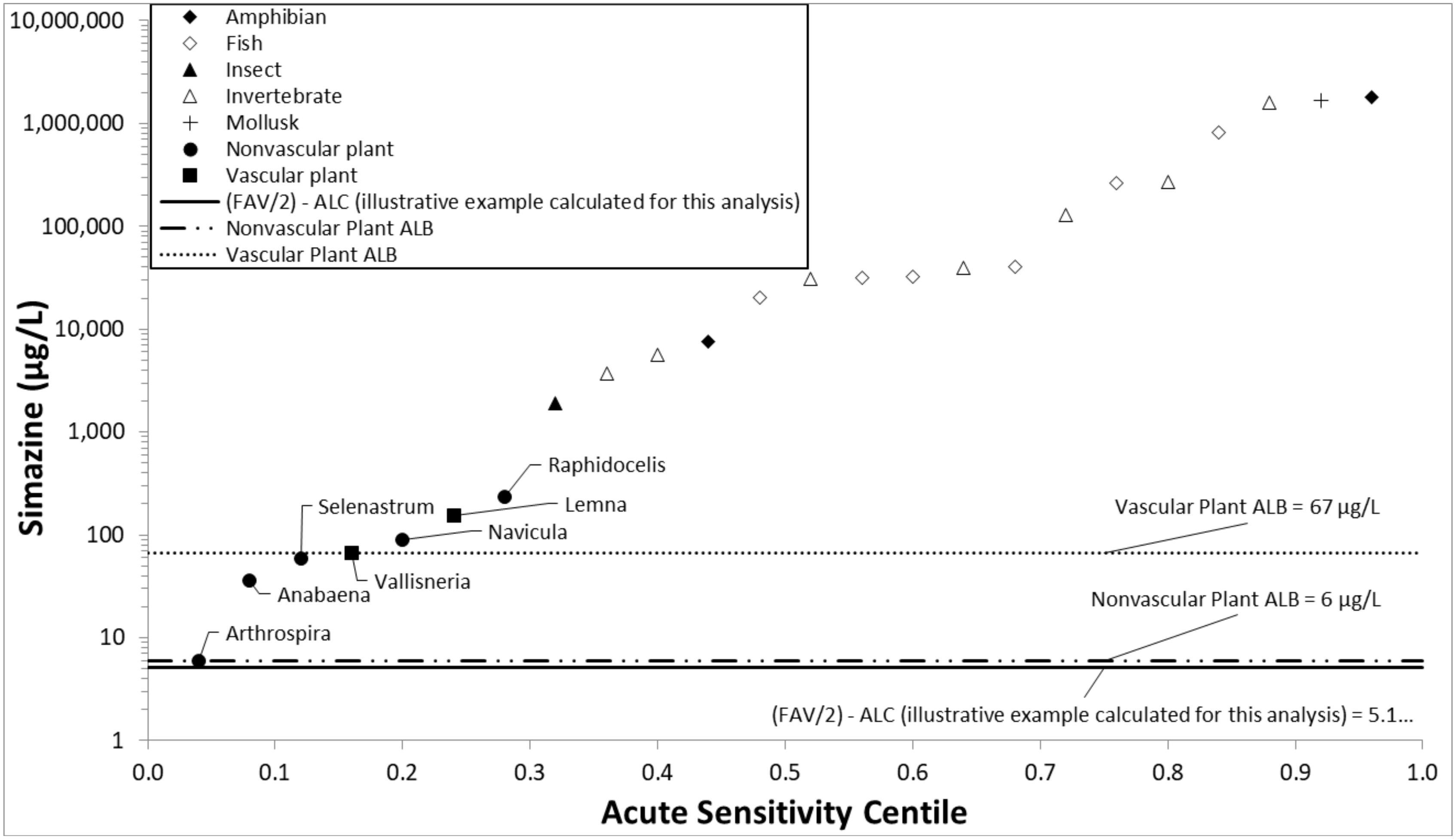

Figure 1. Simazine genus-level acute SD.

Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from an Office of Water ECOTOX search in 2021 and the Office of Pesticide Programs (OPP) registration review document for simazine (U.S. EPA 2016).

2.1.3.2 Simazine Chronic Toxicity Data

Data Sources and Considerations

Chronic toxicity data for simazine were consolidated by OW and combined with data from OPP's registration review document for acephate (U.S. EPA 2016). The final chronic simazine dataset consisted of NOECs/LOEC for 15 species (Table 5).

Table 5. Chronic toxicity data of simazine to freshwater aquatic organisms.
(MDR specifies OW minimum data requirements under the Guidelines.)

OW MDR	Scientific	NOEC	LOEC	SMCV	GMCV	Source	MRID
Plant	*Arthrospira platensis*	IC05=1.0		1	1	OPP	E17259
B	*Cyprinus carpio*	60	600	189.7	189.7	OPP / ECOTOX	Velisek et al 2012 / 197125
B	*Danio rerio*	60		60	60	ECOTOX	167124
D	*Daphnia magna*			40	40	OPP	43676
		40				OPP	based on ACR
Plant	*Lemna gibba*	50	110	50	61.24	OPP / ECOTOX	42503704 / 344
Plant	*Lemna minor*	75	150	75		ECOTOX	18093
Plant	*Myriophyllum aquaticum*	50	1,500	50	50	ECOTOX	68622
Plant	*Navicula pelliculosa*	30	70	30	30	OPP / ECOTOX	42503707 / 344
B	*Pimephales promelas*	960	2000	1,386	1,386	OPP	43675
Plant	*Pontederia cordata*	300	1,000	300	300	ECOTOX	59738
Plant	*Raphidocelis subcapitata*	93.2	>93.2	85.60	85.60	OPP	49389101
		30	70			OPP / ECOTOX	42503706 / 344
		600	1,200			ECOTOX	18093
		32	100			ECOTOX	165277
Plant	*Typha latifolia*	300	1000	300	300	ECOTOX	57010
Plant	*Vallisneria americana*	<58	<58	<58	<58	OPP / ECOTOX	E164763 / 164763
C	*Xenopus laevis*	1.2	11	3.633	30.87	ECOTOX	178652
C	*Xenopus tropicalis*	83	828.5	262.2		ECOTOX	178499

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP nonvascular plant benchmark value for simazine is 1 µg/L, which is the NOEC for *Arthrospira platensis*. The OPP vascular plant benchmark value is 67 µg/L, which is the NOEC for *L. gibba*.

The OPP invertebrate chronic benchmark value is 40 µg/L, which is the estimated NOEC for *Daphnia magna* (LC50 (rounded to 1,000 ug/L) divided by *D. magna* atrazine ACR of 25).

The OPP fish chronic benchmark value is 60 µg/L, which is the NOEC for *C. carpio*.

GLI Tier II Chronic Value Calculation

Paired quantitative acute and chronic toxicity data were available for *Pimephales promelas and Xenopus tropicalis* allowing for the calculation of two ACRs. Per the GLI Tier II methodology, the default value of 18 was used to fulfill the remaining one ACR. The resulting ACRs for *X. tropicalis* is 28.79 and *P. promelas* is 4.618, and the final SACR is 13.38. Dividing the SAV of 10.36 µg/L by the SACR of 13.38 results in a Secondary Continuous Value of 0.7742 µg/L, and a Secondary Continuous Concentration of 0.77 µg/L.

Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{28.79 * 4.618 * 18} = 13.38$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{10.36}{13.38} = 0.7742\ \mu g/L$$

Modified Chronic HC_{05}

The genus-level modified chronic HC_{05} calculated following the U.S. EPA (1985) methodology for the four most sensitive genera regardless of taxa (Table 6) in the simazine dataset was 0.8 µg/L (Table 7).

Table 6. Simazine SMCVs and GMCVs (µg/L).

Genus	Species	SMCV	GMCV	GMCV Rank	OW MDR Group
Pimephales	*promelas*	1,386	1,386	13	B
Typha	*latifolia*	300.0	300.0	12	Plant
Pontederia	*cordata*	300.0	300.0	11	Plant
Cyprinus	*carpio*	189.7	189.7	10	B
Danio	*rerio*	60	60	9	B
Daphnia	*magna*	40	40	8	D
Raphidocelis	*subcapitata*	85.60	85.60	7	Plant
Lemna	*gibba*	50	61.24	6	Plant

Genus	Species	SMCV	GMCV	GMCV Rank	OW MDR Group
Lemna	*minor*	75			Plant
Vallisneria	*americana*	<58	<58	5	Plant
Myriophyllum	*aquaticum*	50	50	4	Plant
Xenopus	*laevis*	3.633	30.87	3	C
Xenopus	*tropicalis*	262.2			C
Navicula	*pelliculosa*	30	30	2	Plant
Arthrospira	*platensis*	1	1	1	Plant

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

Table 7. Modified chronic HC_{05} for propazine calculated following the U.S. EPA (1985) methodology.

N	Rank	GMCV	ln(GMCV)	$ln(GMCV)^2$	P=R/(N+1)	sqrt(P)
13	4	40	3.689	13.61	0.2857	0.5345
	3	30.87	3.430	11.76	0.2143	0.4629
	2	30	3.401	11.57	0.1429	0.3780
	1	1	0.000	0.00	0.0714	0.2673
	Sum:		10.52	36.9	0.714	1.643
	S^2 =	233.54				
	L =	-3.646				
	A =	-0.229				
	FCV =	**0.7956**				
	CCC=	**0.80**				

Table 8. Comparison and summary of chronic values for simazine.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	Most Sensitive OPP ALB (Year published and species)	OW GLI Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Modified HC_{05} (# of MDRs filled, # of genera available, magnitude relative to ALB)
Simazine	1 µg/L (*Arthrospira platensis;* nonvascular plant)	0.77 µg/L (GLI Tier II; 2 ACRs filled, 1.3X)	0.8 µg/L (3 MDRs, 13 genera, 1.3X)

Figure 2 shows a chronic genus-level sensitivity distribution for the simazine dataset. Major taxonomic groups are delineated by different symbols. Lines denoting the OPP chronic benchmark values, GLI Tier II calculated chronic value, and modified HC_{05} value are included.

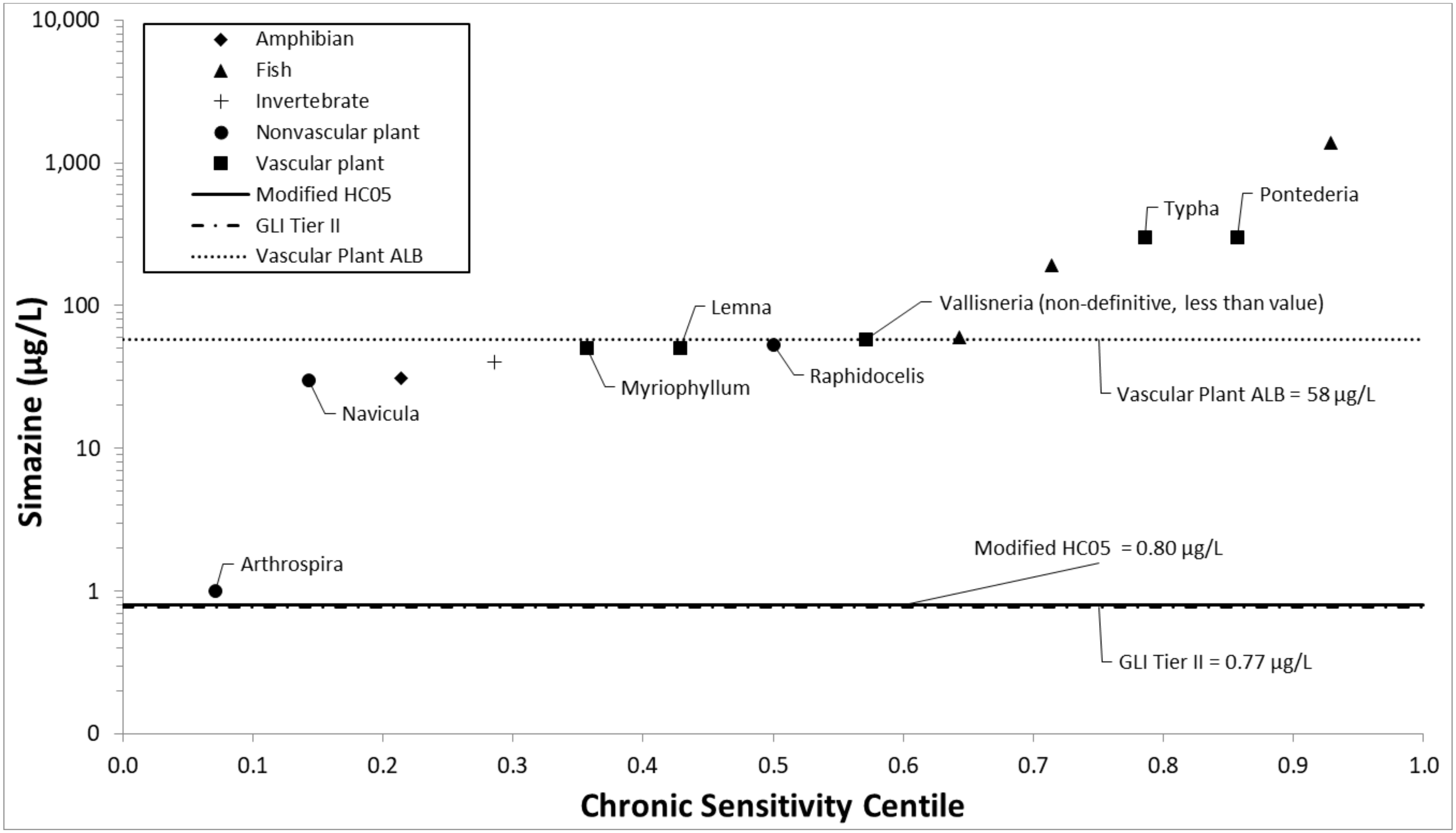

Figure 2. Simazine genus-level chronic SD.

Symbols represent Genus Mean Chronic Values (GMCVs) calculated using all available data from an Office of Water ECOTOX search in 2021 and the Office of Pesticide Programs (OPP) registration review document for propazine (U.S. EPA 2016).

2.1.3.3 Simazine References

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2.1.4 Comparison of Aquatic Life Toxicity Values for Bensulide: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) were obtained from the Office of Pesticide Programs (OPP) registration review document for bensulide (U.S. EPA 2016) and an EPA ECOTOX Knowledgebases search conducted in 2021.

2.1.4.1 Bensulide Acute Toxicity Data

Acute data for bensulide are shown in Table 1. Ranked invertebrate GMAVs from all data sources are listed in Table 2.

Table 1. Acute toxicity data of bensulide to freshwater aquatic organisms.
(MDR specifies OW minimum data requirements under the Guidelines.)

OW MDR[a]	Scientific	LC50	SMAV	GMAV	Source	MRID/ECOTOX REF
Plant	*Blue green algae (Anabaena flos-aquae)*	>3,580	>3580	>3580	OPP / ECOTOX	44720403 / 344
D	*Water Flea (Daphnia magna)*	580	580	580	OPP	159322
E	*Scud (Gammarus fasciatus)*	1,400	1,400	1,400	OPP / ECOTOX	40098001 / 6797
Plant	*Duckweed (Lemna gibba)*	160	149.7	149.7	OPP / ECOTOX	45334101 / 344
		140			OPP / ECOTOX	44720406 / 344
B	*Bluegill (Lepomis macrochirus)*	1,400	1065	1065	OPP / ECOTOX	157316 / 344
		810			OPP / ECOTOX	40098001 / 6797
Plant	*Diatom (Navicula pelliculosa)*	<690	<690	<690	ECOTOX	344
A	*Rainbow trout (Oncorhynchus mykiss)*	1,100	889.9	889.9	OPP / ECOTOX	157315 / 344
		720			OPP / ECOTOX	40098001 / 6797
Plant	*Green algae (Raphidocelis subcapitata)*	1800	1800	1800	OPP / ECOTOX	44720402 / 344
Plant	*Diatom (Skeletonema costatum)*	780	780	780	OPP	44720405

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP vascular plant benchmark value for bensulide is 140 µg/L, which is the LC_{50} for *L. gibba*. The OPP nonvascular plant benchmark value is 780 µg/L, which is the LC_{50} for *S. costatum*.

The OPP invertebrate acute benchmark value is 290 µg/L, which is ½ the LC_{50} of 580 µg/L for *D. magna*.

The fish acute benchmark value is 550 µg/L, which is ½ the LC_{50} of 1,100 µg/L for *O. mykiss*.

GLI Tier II Acute Value Calculation

The acceptable acute dataset for bensulide fulfills four of the eight MDRs, corresponding to the use of a Secondary Acute Factor (SAF) of 7. Applying the SAF to the lowest, most sensitive GMAV regardless of taxa (i.e., 149.7 µg/L for duckweed (*Lemna gibba*)), the calculated Secondary Acute Value (SAV) is 21.39 µg/L. The Secondary Maximum Criterion (SMC), which is calculated as half the SAV, is 10.7 µg/L. Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{149.7}{7} = 21.39\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{21.39}{2} = 10.7\ \mu g/L$$

Modified Acute HC_{05}

The genus-level modified acute HC_{05} calculated following the U.S. EPA (1985) methodology for the four most sensitive genera regardless of taxa (Table 2) in the bensulide dataset was 106.4 µg/L (Table 3).

Table 2. Bensulide SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank	OW MDR Group
Anabaena	*flos-aquae*	>3,580	>3,580	9	Plant
Raphidocelis	*subcapitata*	1,800	1,800	8	Plant
Gammarus	*fasciatus*	1,400	1,400	7	E
Oncorhynchus	*mykiss*	1,100	1,100	6	A
Lepomis	*macrochirus*	1,065	1,065	5	B
Skeletonema	*costatum*	780	780	4	Plant

Genus	Species	SMAV	GMAV	GMAV Rank	OW MDR Group
Navicula	*pelliculosa*	<690	<690	3	Plant
Daphnia	*magna*	580	580	2	D
Lemna	*gibba*	149.7	149.7	1	Plant

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

Table 3. Modified acute HC_{05} for bensulide calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$\ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
9	4	780	6.659	44.35	0.4000	0.6325
	3	690	6.537	42.73	0.3000	0.5477
	2	580	6.363	40.49	0.2000	0.4472
	1	149.7	5.009	25.09	0.1000	0.3162
	Sum:		24.57	152.6	1.000	1.944
	S^2 =	31.60				
	L =	3.410				
	A =	4.667				
	FAV =	**106.4**				
	CMC =	**53.21**				

Table 4. Comparison and summary of acute values for bensulide.

Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Most Sensitive ALB (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Modified $HC_{05}/2$ (# of MDRs filled, # of genera available, magnitude relative to ALB)
Bensulide	140 µg/L (2016; *Lemna gibba;* vascular plant)	10.7 µg/L (GLI Tier II; 4 MDRs filled, 13X)	53.21 µg/L (4 MDRs, 9 genera, 2.6X)

Figure 1 shows a genus-level sensitivity distribution for the bensulide dataset. Major taxonomic groups are delineated by different symbols. Lines denoting the OPP acute benchmark values, GLI Tier II calculated acute value, and modified $HC_{05}/2$ value are included.

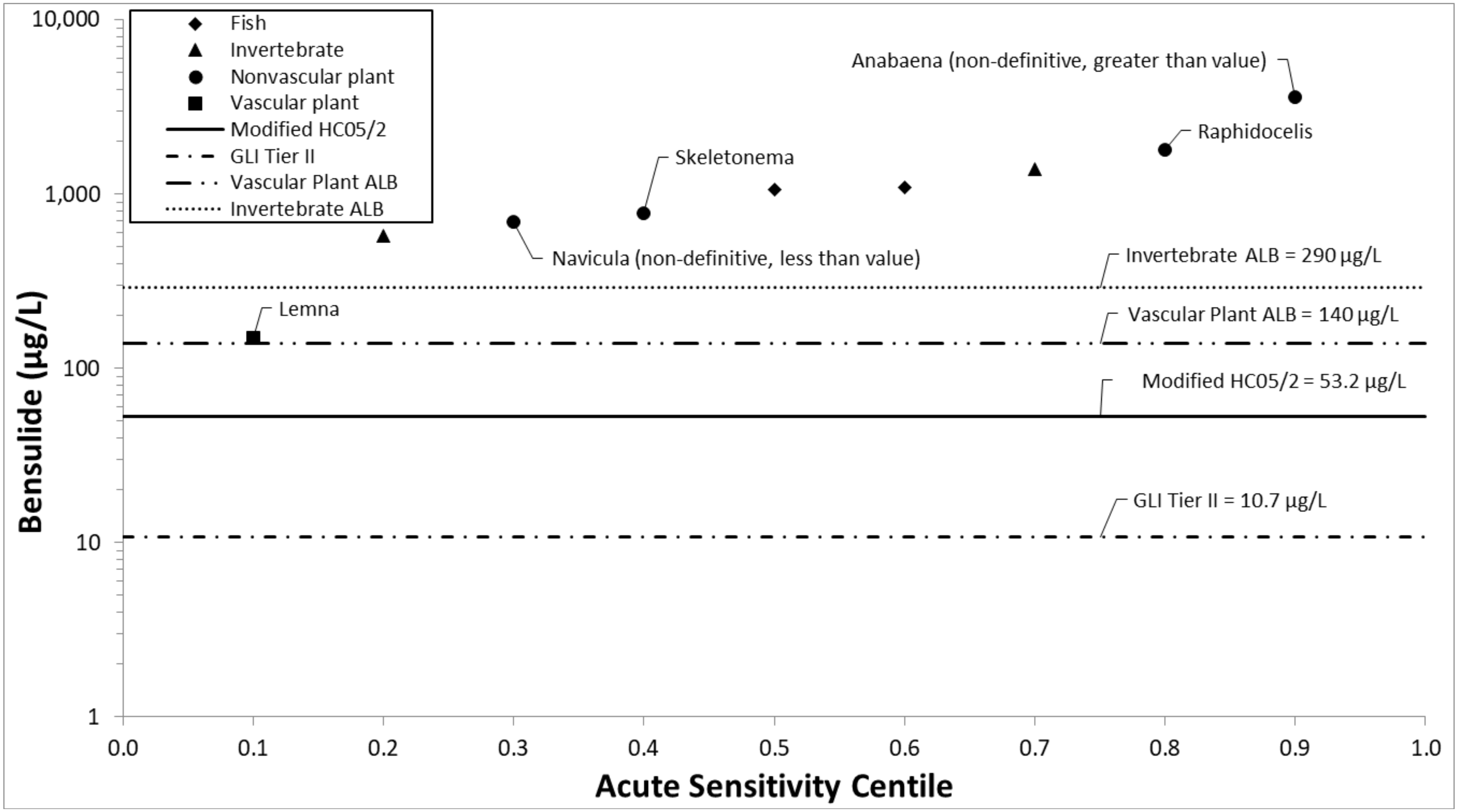

Figure 1. Bensulide genus-level acute SD.

Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from an Office of Water ECOTOX search in 2021 and the Office of Pesticide Programs (OPP) registration review document for bensulide (U.S. EPA 2016).

2.1.4.2 Bensulide Chronic Toxicity Data

Data Sources and Considerations

Chronic toxicity data for bensulide were consolidated by OW and combined with data from OPP's registration review document for acephate (U.S. EPA 2016). The final chronic bensulide dataset consisted of NOECs/LOEC for seven species (Table 5).

Table 5. Chronic toxicity data of bensulide to freshwater aquatic organisms.
(MDR specifies OW minimum data requirements under the Guidelines.)

OW MDR[a]	Species	NOEC	LOEC	SMCV	GMCV	Source	MRID/ECOTOX REF
Plant	Blue green algae *(Anabaena flos-aquae)*	3,580		3,580	3,580	OPP / ECOTOX	44720403 / 344
D	Water Flea *(Daphnia magna)*	10.9	16	<7.057	<7.057	OPP	49110401
		4.2	10			OPP / ECOTOX	45303101 / 344
		<4.2	4.2			OPP / ECOTOX	45063401 / 344
		<6.9	6.9			OPP / ECOTOX	44720407 / 344
Plant	Duckweed *(Lemna gibba)*	42.8		<42.4	<42.4	OPP / ECOTOX	45334101 / 344
		<42.1				OPP / ECOTOX	44720406 / 344
Plant	Diatom *(Navicula pelliculosa)*	<410		<410	<410	ECOTOX	344
B	Fathead minnow *(Pimephales promelas)*	200	369	384.2	384.2	OPP	49378102 and 49001601
		374	789			OPP	44720408
Plant	Green algae *(Raphidocelis subcapitata)*	EC_{05}=930		930	930	OPP / ECOTOX	44720402 / 344
Plant	Diatom *(Skeletonema costatum)*	635		635	635	OPP	44720405

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP vascular plant benchmark value is 42 µg/L, which is the NOEC for *Lemna gibba*. The OPP non-vascular plant benchmark value for bensulide is 635 µg/L, which is the NOEC for the diatom *(Skeletonema costatum)*.

The OPP invertebrate chronic benchmark for bensulide value is 11 µg/L, which is the NOEC for *Daphnia magna*.

The OPP fish chronic benchmark value is 169 µg/L, which is the NOEC for *Pimephales promelas*.

GLI Tier II Chronic Value Calculation

Paired quantitative acute and chronic toxicity data were available for *Daphnia magna* allowing for the calculation of one *D. magna* ACR of 43.92. Per the GLI Tier II methodology, the default value of 18 was used to fulfill the remaining two ACRs. The resulting final SACR is 24.23. Dividing the SAV of 21.39 µg/L by the SACR of 17.31 results in a Secondary Continuous Value of 0.8828 µg/L, and a Secondary Continuous Concentration of 0.88 µg/L. Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{43.92 * 18 * 18} = 24.23$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{21.39}{24.23} = 0.8828\ \mu g/L$$

Modified Chronic HC_{05}

The genus-level modified chronic HC05 calculated following the U.S. EPA (1985) methodology for the four most sensitive genera regardless of taxa (Table 6) in the bensulide dataset was 2.3 µg/L (Table 7).

Table 6. Bensulide SMCVs and GMCVs (µg/L).

Genus	Species	SMCV	GMCV	GMCV Rank	MDR Group
Anabaena	*flos-aquae*	3,580	3,580	7	Plant
Raphidocelis	*subcapitata*	930[a]	930[a]	6	Plant
Skeletonema	*costatum*	635	635	5	Plant
Navicula	*pelliculosa*	<410	<410	4	Plant
Pimephales	*promelas*	368.3	368.3	3	B
Lemna	*gibba*	<42.4	<42.4	2	Plant
Daphnia	*magna*	<7.057	<7.057	1	D

a - EC05 (NOAEC not reported)

Table 7. Modified chronic HC_{05} for bensulide calculated following the U.S. EPA (1985) methodology.

N	Rank	GMCV	ln(GMCV)	$ln(GMCV)^2$	P=R/(N+1)	sqrt(P)
7	4	410	6.016	36.19	0.5000	0.7071
	3	368.3	5.909	34.92	0.3750	0.6124
	2	42.4	3.747	14.04	0.2500	0.5000
	1	7.057	1.954	3.82	0.1250	0.3536
	Sum:		17.63	89.0	1.250	2.173
	S^2 =	162.60				
	L =	-2.521				
	A =	0.331				
	FCV =	**1.392**				
	CCC=	**1.4**				

Table 8. Summary and comparison of chronic values for bensulide.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	Most Sensitive OPP ALB (Year published and species)	OW GLI Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Modified HC_{05} (# of MDRs filled, # of genera available, magnitude relative to ALB)
Bensulide	11 µg/L (2016; *Daphnia magna;* invertebrate)	0.88 µg/L (GLI Tier II; 1 ACR filled, 12.5X)	1.4 µg/L (2 MDRs, 7 genera, 7.9X)

Figure 2 shows a chronic genus-level sensitivity distribution for the propazine dataset. Major taxonomic groups are delineated by different symbols. Lines denoting the OPP chronic benchmark values, GLI Tier II calculated chronic value, and modified HC_{05} value are included.

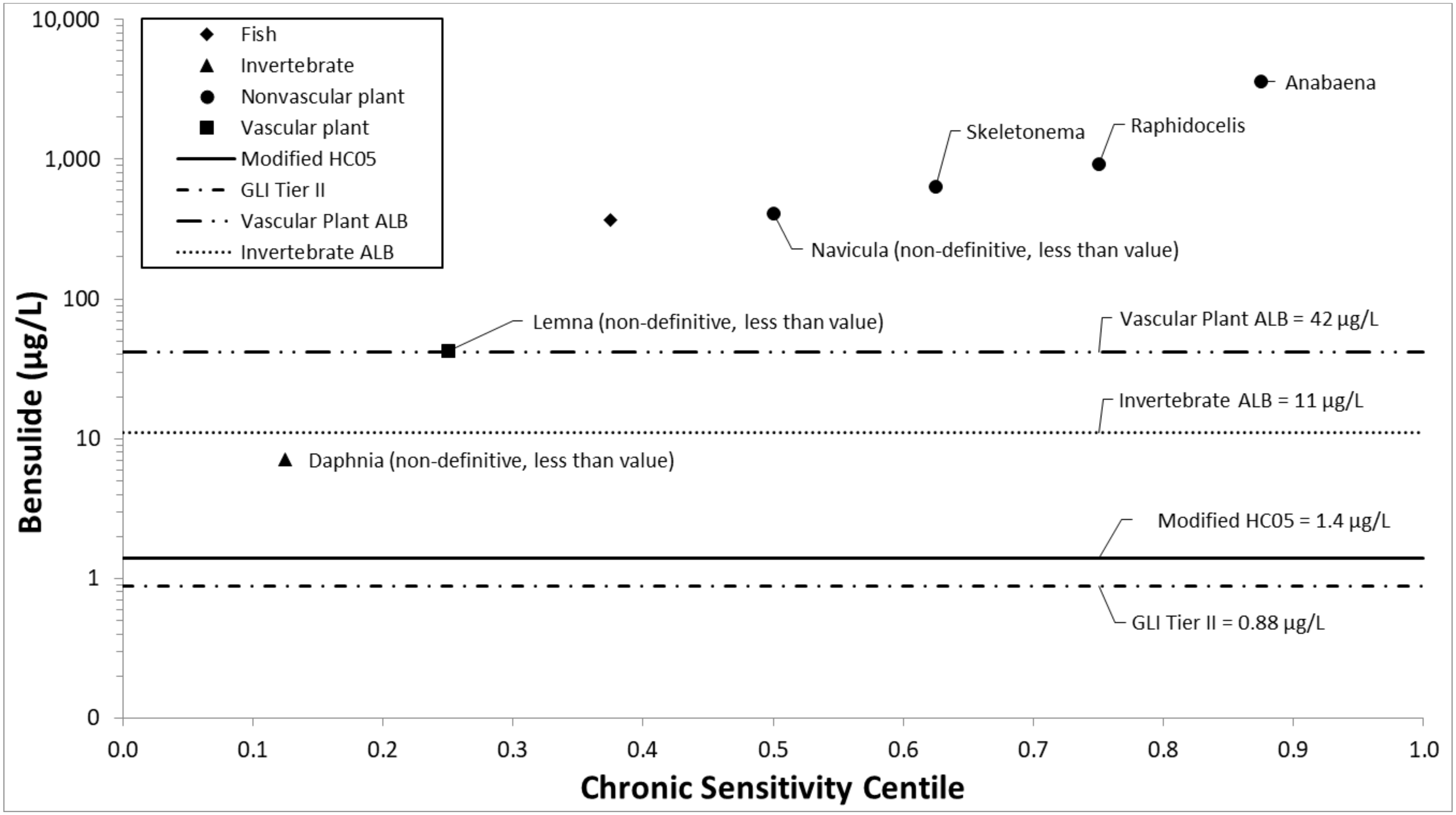

Figure 2. Bensulide genus-level chronic SD.

Symbols represent Genus Mean Chronic Values (GMCVs) calculated using all available data from an Office of Water ECOTOX search in 2021 and the Office of Pesticide Programs (OPP) registration review document for bensulide (U.S. EPA 2016).

2.1.4.3 Bensulide References

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2.1.5 Comparison of Aquatic Life Toxicity Values for Glyphosate: Data Sources and Considerations

Data used in the *Draft Comparison of Aquatic Life Protective Values Developed for Pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Clean Water Act (CWA)* (U.S. EPA 2024) were obtained from the Office of Pesticide Programs (OPP) registration review document for gylphosate (U.S. EPA 2009).

2.1.5.1 Glyphosate Acute Toxicity Data

Acute data for glyphosate are shown in Table 1. Ranked invertebrate GMAVs from all data sources are listed in Table 2.

Table 1. Acute toxicity data of glyphosate to freshwater aquatic organisms.
(MDR specifies OW minimum data requirements under the Guidelines.)

OW MDR[a]	Species	LC50	SMAV	GMAV	MRID REF
Plant	Cyanobacterium *(Anabaena flos-aquae)*	11720	13259	13259	40236904
Plant		15000			44320639
F	Midge *(Chironomus plumosus)*	13000	13000	13000	162296
D	Water Flea *(Daphnia magna)*	134000	134000	134000	44320631
Plant	Duckweed *(Lemna gibba)*	11900	19384	19384	44320638
Plant		24000			45773101
Plant		25500			40236905
B	Bluegreen sunfish *(Lepomis macrochirus)*	45000	45000	45000	44320630
Plant	Diatom *(Navicula peliculosa)*	39900	29896	29896	40236902
		22400			44320641
A	Rainbow Trout *(Oncorhynchus mykiss)*	77,600	101973	101973	44125705
A		134000			44320629
B	Fathead Minnow *(Pimephales promelas)*	67900	67900	67900	44125704
Plant	Green algae *(Raphidocelis subcapitata)*	12100	12855	12855	4023690
Plant		12540			40236901
Plant		14000			44320637

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Acute Benchmark Values

The OPP nonvascular plant benchmark value for glyphosate is 11,400 µg/L, which is the LC_{50} for the Green algae *(Raphidocelis subcapitata)*. The OPP vascular plant benchmark value is 11,900 µg/L, which is the LC_{50} for *L. gibba*.

The OPP invertebrate acute benchmark value is 26,600 µg/L, which is ½ the LC_{50} for *C. plumosis.*

OPP fish acute benchmark value is 21,500 µg/L, which is ½ the LC_{50} for *L. macrochirus*.

GLI Tier II Acute Value Calculation

The acceptable acute dataset for propazine fulfills four of the eight MDRs, corresponding to the use of a Secondary Acute Factor (SAF) of 7. Applying the SAF to the lowest, most sensitive GMAV regardless of taxa (i.e., 12,855 µg/L for the Green algae (*Raphidocelis subcapitata*)), the calculated Secondary Acute Value (SAV) is 3,213 µg/L. The Secondary Maximum Criterion (SMC), which is calculated as half the SAV, is 1,607 µg/L.

Detailed calculations for the SMC are shown below:

$$SAV = \frac{\text{Lowest GMAV}}{\text{SAF}}$$

$$SAV = \frac{12{,}855}{7} = 3{,}213\ \mu g/L$$

$$SMC = \frac{\text{SAV}}{2}$$

$$SMC = \frac{3{,}213}{2} = 1{,}607\ \mu g/L$$

Modified Acute HC_{05}

The genus-level modified acute HC_{05} calculated following the U.S. EPA (1985) methodology for the four most sensitive genera regardless of taxa (Table 2) in the glyphosate dataset was 9,816 µg/L (Table 3).

Table 2. Glyphosate SMAVs and GMAVs (µg/L).

Genus	Species	SMAV	GMAV	GMAV Rank	MDR Group
Daphina	*magna*	134,000	134,000	9	D
Oncorhynchus	*mykiss*	101,973	101,973	8	A
Pimephales	*promelas*	67,900	67,900	7	B
Lepomis	*macrochirus*	45,000	45,000	6	B
Navicula	*peliculosa*	29,896	29,896	5	Plant
Lemna	*gibba*	19,384	19,384	4	Plant
Anabaena	*flos-aquae*	13,259	13,259	3	Plant
Chironomus	*plumosus*	13,000	13,000	2	F
Raphidocelis	*subcaptata*	12,855	12,855	1	Plant

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

Table 3. Modified acute HC_{05} for glyphosate calculated following the U.S. EPA (1985) methodology.

N	Rank	GMAV	ln(GMAV)	$\ln(GMAV)^2$	P=R/(N+1)	sqrt(P)
9	4	19,384	9.872	97.46	0.4000	0.6325
	3	13,259	9.492	90.11	0.3000	0.5477
	2	13,000	9.473	89.73	0.2000	0.4472
	1	12,855	9.461	89.52	0.1000	0.3162
	Sum:		38.30	366.8	1.000	1.944
	S^2 =	2.13				
	L =	8.865				
	A =	9.192				
	FAV =	**9,816**				

Table 4. Comparison of acute values for glyphosate.

Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	OPP Most Sensitive ALB (Year published, species)	OW GLI Tier II value (# of MDRs filled, magnitude relative to ALB)	OW Modified HC_{05}/2 (# of MDRs filled, # of genera available, magnitude relative to ALB)
Glyphosate	11,900 µg/L (2016; *Lemna gibba;* vascular plant)	1,607 µg/L (GLI Tier II; 4 MDRs filled, 7.4X)	4,908 µg/L (4 MDRs, 9 genera, 2.4X)

Figure 1 shows a genus-level sensitivity distribution for the glyphosate dataset. Major taxonomic groups are delineated by different symbols. Lines denoting the OPP acute benchmark values, GLI Tier II calculated acute value, and modified HC_{05} value are included.

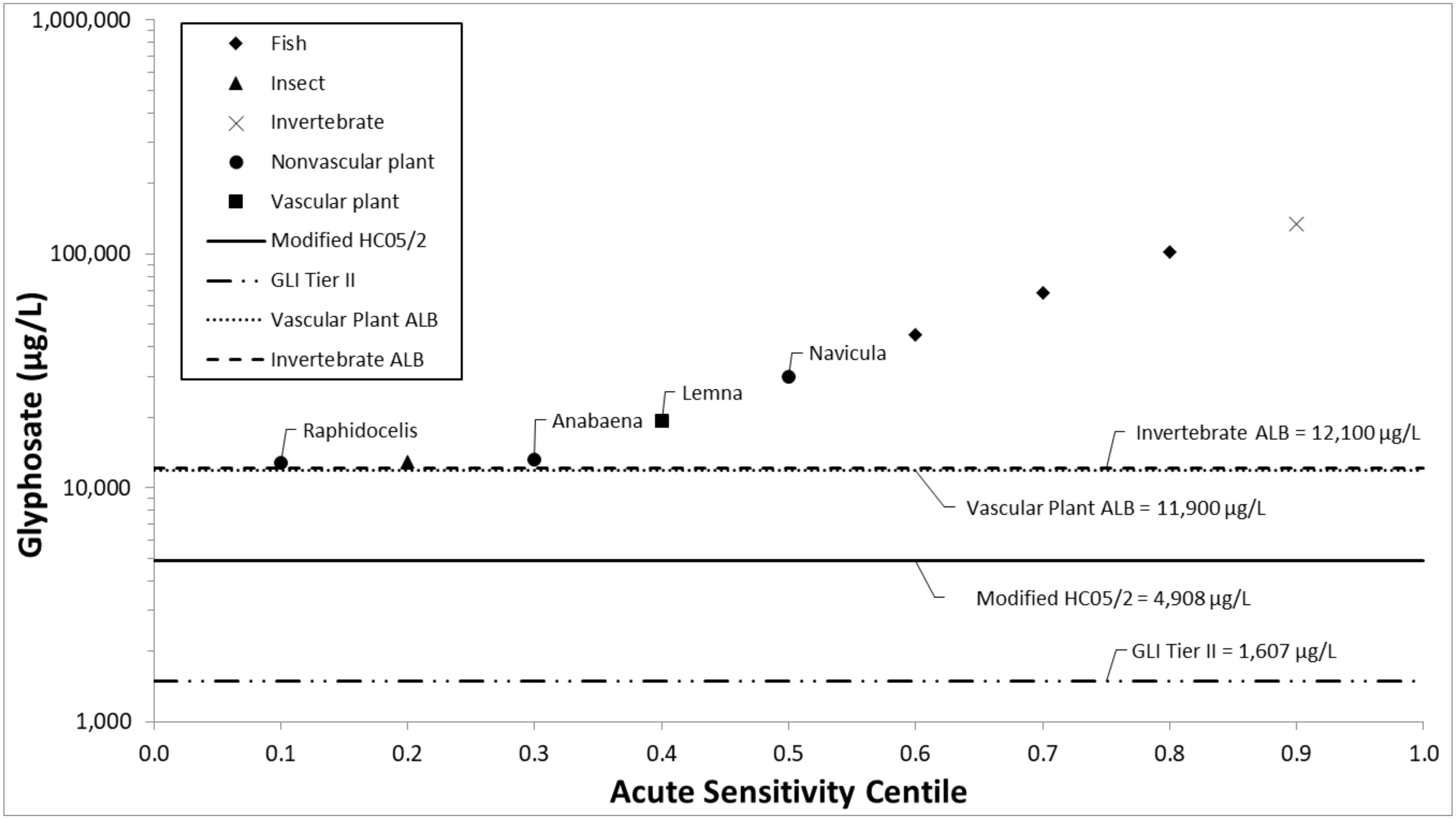

Figure 1. Glyphosate genus-level acute SD.

Symbols represent Genus Mean Acute Values (GMAVs) calculated using all available data from the Office of Pesticide Programs (OPP) registration review document for glyphosate (U.S. EPA 2009).

2.1.5.2 Glyphosate Chronic Toxicity Data

Data Sources and Considerations

Chronic toxicity data for glyphosate were obtained from OPP's registration review document for glyphosate (U.S. EPA 2009). The final chronic glyphosate dataset consisted of NOECs/LOEC for six species (Table 5).

Table 5. Chronic toxicity data of glyphosate to freshwater aquatic organisms. (MDR specifies OW minimum data requirements under the Guidelines.)

MDR	Species	NOAEC	LOAEC	SMCV	GMCV	MRID
Plant	Cyanobacterium *(Anabaena flos-aquae)*			12000	12000	40236904
Plant		12000				44320639
D	Waterflea *(Daphnia magna)*	49900	95700	69104	69104	124763
D		240000				
Plant	Duckweed *(Lemna gibba)*			7560	7560	44320638
Plant		7560	14100			45773101
Plant						40236905
Plant	Diatom *(Navicula peliculosa)*			18000	18000	40236902
Plant		18000				44320641
B	Fathead Minnow *(Pimephales promelas)*	>25700		> 25700	> 25700	108171
Plant	Green algae *(Raphidocelis subcapitata)*			10000	10000	4023690
Plant						40236901
Plant		10000				44320637

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)
H. a family in any order of insect or any phylum not already represented.

OPP Chronic Benchmark Values

The OPP vascular plant benchmark value for glyphosate is 1,300 µg/L. There is no OPP nonvascular benchmark plant value for glyphosate.

The OPP invertebrate chronic benchmark value is 49,900 µg/L, which is the NOEC for *Daphnia magna*.

The OPP fish chronic benchmark value is 25,700 µg/L, which is the NOEC for *Pimephales promelas*.

GLI Tier II Chronic Value Calculation

Paired quantitative acute and chronic toxicity data were available for *Pimephales promelas* and *D. magna / C. plumosus* allowing for the calculation of two ACRs. Per the GLI Tier II methodology, the default value of 18 was used to fulfill the remaining one ACR. The resulting *Pimephales promelas* and *D. magna / C. plumosus* ACR are 3.77 and 1.94, respectively, and the final SACR is 5.09. Dividing the SAV of 1,607 µg/L by the SACR of 5.09 results in a Secondary Continuous Value of 315.6 µg/L, and a Secondary Continuous Concentration of 316 µg/L.

Detailed calculations for the SCV are shown below:

$$SACR = Geometric\ Mean\ of\ the\ ACRs$$

$$SACR = \sqrt[3]{3.77 * 1.94 * 18} = 5.09$$

$$SCV = \frac{SAV}{SACR}$$

$$SCV = \frac{1{,}607}{5.09} = 316\ \mu g/L$$

Modified Chronic HC_{05}

The genus-level modified chronic HC05 calculated following the U.S. EPA (1985) methodology for the four most sensitive genera regardless of taxa (Table 6) in the glyphosate dataset was 5,087 µg/L (Table 7).

Table 6. Glyphosate SMCVs and GMCVs (µg/L).

Genus	Species	SMCV	GMCV	GMCV Rank	MDR Group
Daphnia	*magna*	69,104	69,104	6	D
Pimephales	*promelas*	>25,700	>25,700	5	B
Navicula	*peliculosa*	18,000	18,000	4	Plant
Anabaena	*flos-aquae*	12,000	12,000	3	Plant
Raphidocelis	*subcapitata*	10,000	10,000	2	Plant
Lemna	*gibba*	7,560	7,560	1	Plant

[a] OW MDR Groups – Freshwater:

A. the family Salmonidae in the class Osteichthyes
B. a second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species (e.g., bluegill, channel catfish, etc.)
C. a third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian, etc.)
D. a planktonic crustacean (e.g., cladoceran, copepod, etc.)
E. a benthic crustacean (e.g., ostracod, isopod, amphipod, crayfish, etc.)
F. an insect (e.g., mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
G. a family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca, etc.)

H. a family in any order of insect or any phylum not already represented.

Table 7. Modified chronic HC_{05} for glyphosate calculated following the U.S. EPA (1985) methodology.

N	Rank	GMCV	ln(GMCV)	$ln(GMCV)^2$	P=R/(N+1)	sqrt(P)
6	4	18,000	9.798	96.00	0.5714	0.7559
	3	12,000	9.393	88.22	0.4286	0.6547
	2	10,000	9.210	84.83	0.2857	0.5345
	1	7,560	8.931	79.76	0.1429	0.3780
	Sum:		37.33	348.8	1.429	2.323
	S^2 =	5.00				
	L =	8.035				
	A =	8.534				
	FCV =	**5,087**				

Table 8. Summary and comparison of chronic values for glyphosate.
Magnitude relative to ALB is the OPP ALB/OW value, the ratio for the OPP value/OW value for each value comparison. A ratio <1 indicates the OPP value is lower than the OW value and a ratio >1 indicates the OPP value is higher than the OW value.

Pesticide	Most Sensitive OPP ALB (Year published and species)	OW GLI Tier II value (# of ACRs filled, magnitude relative to ALB)	OW Modified HC_{05} (# of MDRs filled, # of genera available, magnitude relative to ALB)
Glyphosate	1,300 µg/L (*Lemna gibba;* vascular plant)	316 µg/L (GLI Tier II; 2 ACRs filled, 4.1X)	5,087 µg/L (2, MDRs, 6 genera, 0.26X)

Figure 2 shows a chronic genus-level sensitivity distribution for the glyphosate dataset. Major taxonomic groups are delineated by different symbols. Lines denoting the OPP chronic benchmark values, GLI Tier II calculated chronic value, and modified HC_{05} value are included.

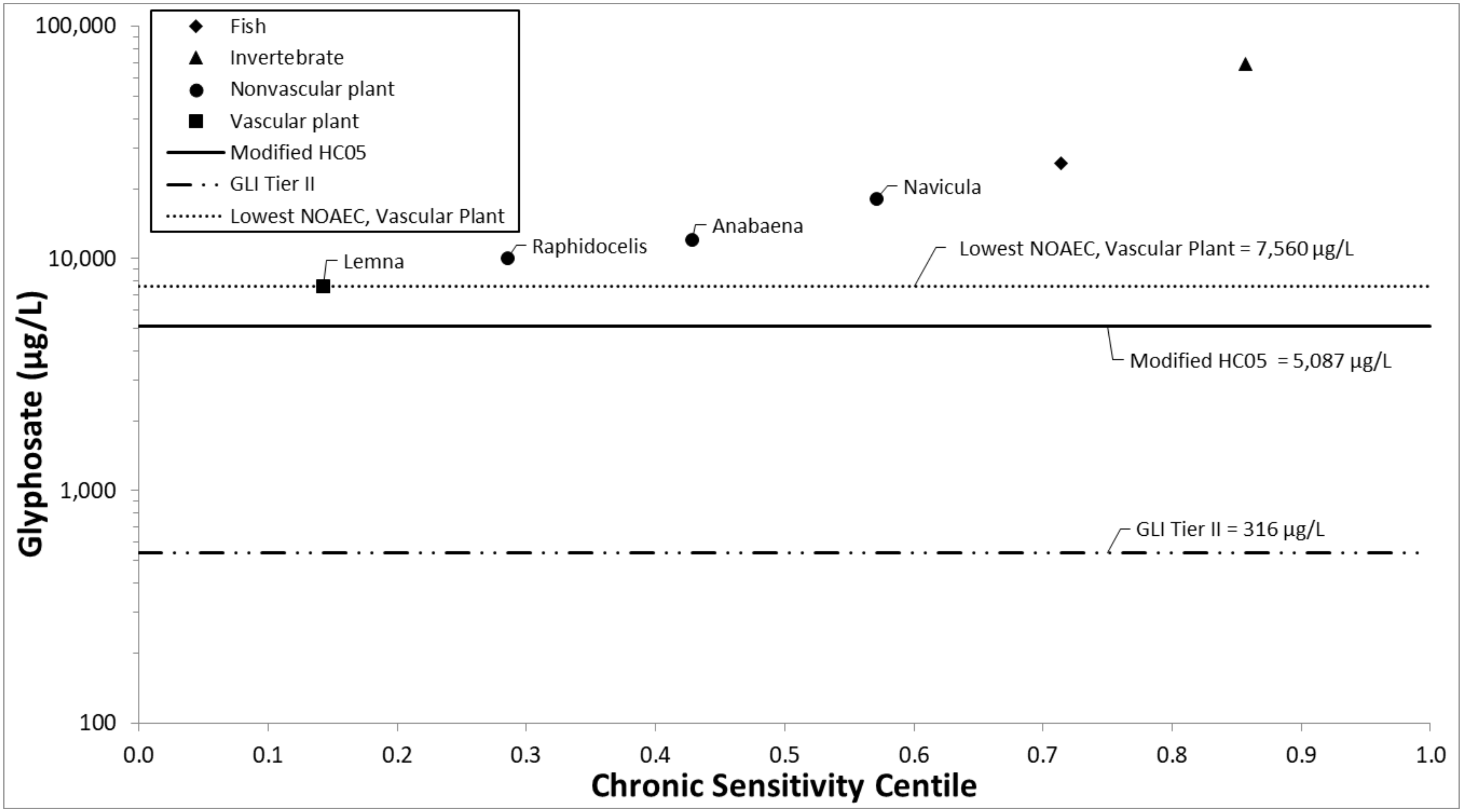

Figure 2. Glyphosate genus-level chronic SD.
Symbols represent Genus Mean Chronic Values (GMCVs) calculated using all available data from the Office of Pesticide Programs (OPP) registration review document for glyphosate (U.S. EPA 2009).

2.1.5.3 Glyphosate References

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